2018

A Text-book of Economic Entomology

Somali Natural Resource Research Centre

Mohamed Dayib

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(SONRREC)

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INTRODUCTION

Entomology is a branch of biology that deals with studding the insects. It may divide into four main braches such as: Agricultural entomology, Medical entomology, industrial entomology and forensic entomology. The agricultural entomology concerns the study of harmful and beneficial insects that effect agriculture products both in the field or storage e.g. Desert locust, Somali Blister beetle and Aphids , while medical entomology gives attention to insects that effect human and animal health directly or indirectly as a pathogen vector for example Mosquitoes, Tsetse fly , Sand fly and lice.

Industrial entomology elucidates insects that uses for genetic purpose like fruit fly Drosophila whereas forensic entomology explains the use of the insects that inhabit decomposing dead bodies to aid legal investigations. Insects also probably have the biggest biomass of the terrestrial animals because of they are the most diverse group of organisms.

SIGNIFICANCE OF STUDYING ECONOMIC ENTOMOLOGY

Economic entomology has direct and indirect role for human economic, genetics, military and nutritional value. Economically most south east Asian countries have early started raring silkworm as sericulture which they produce thousands tons of silk as of cocoon mad by last instars of Lepidoptera , each country gains millions of dollars per season. On the other hand a quantity of insects has short period of life cycle which makes suitable for applying genetic purpose for instance mutation experiments that caused by natural and anthropogenic impacts for genetic materials of animals specially drosophila insects.

Military engineers had designed modern weapons for case in point helicopters which is mimic some insects' flying performance for any directions, prototype for that order Odonata. Historically human being had used consuming locust as a food, recently researchers indicated that the protein contents of locust *schistocerca gregerea* has more nutritional value than that of livestock. Insect pests are dissipated all areas of agro-ecosystem in horn of Africa, where the main factors that organizes is the variation of the climate conditions within the fourth seasons. In addition to that, the crop types available in Somali country is another significant indicator.

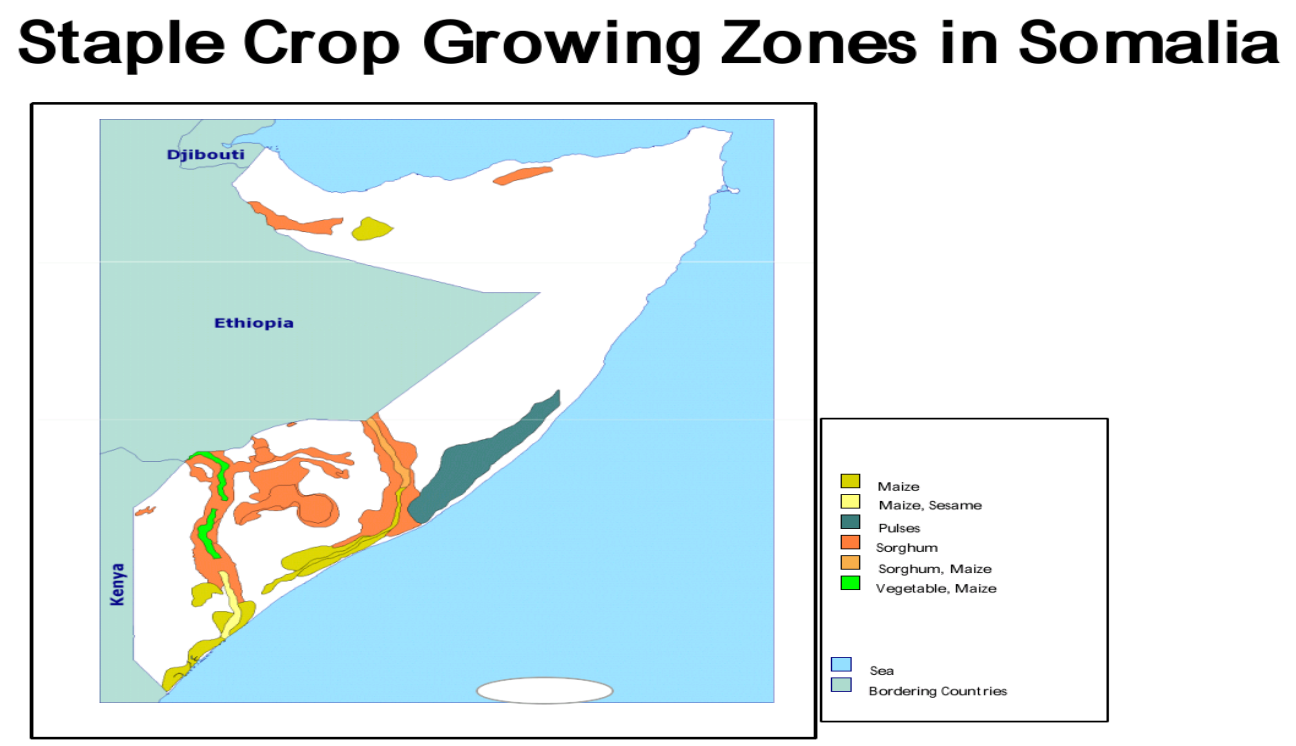
PHYTOPHAGY (OR HERBIVORY)

The majority of plant species support complex faunas of herbivores, each of which may be defined in relation to the range of plant taxa used. Thus, monophagesare specialists that feed on one plant taxon, oligophages feed on few, and polyphages are generalists that feed on many plant groups. The adjectives for these feeding categories are monophagous, oligophagous, and polyphagous. Gall-inducing cynipid wasps (Hymenoptera) exemplify monophagous insects. The monarch or wanderer

butterfly, *Danaus plexippus* (Nymphalidae), is an example of an oligophagous insect, with larvae that feed on various milkweeds, predominantly species of *Asclepias*. The polyphagous gypsy moth, *Lymantria dispar* (Lymantriidae), feeds on a wide range of tree genera and species. Many plants appear to have broad-spectrum defences against a very large suite of enemies, including insect and vertebrate herbivores and pathogens. These primarily physical or chemical defences.

Status of Agricultural Development

Agriculture is an imperative economic activity in Somalia ,roughly 40% of population's cereal requirements are met through domestic production, Agriculture is a major component particularly for two of the main rural livelihood systems in Somalia: Agro-pastoralist, which is the practice of agriculture that includes both the growing of crops and the raising of livestock. Crop production performance and its potential is determined by the bi-modal rainfall. The two main agricultural seasons are: Gu crop production, from April to June and Deyr crop production is from October to December. Two areas are considered high potential for crop production with rainfall ranging from 400mm to 600mm: a small area in the Northwest (west of Hargeisa) and a much larger inter- riverine area between the Shabelle and Juba river valleys.



Staple Crop Growing zones in Somalia. (Source: FAO)

There are four primary agricultural zones in Somalia:

1. Northwest in parts of Awdal and W. Galbeed - rainfed maize and sorghum with some livestock herdings 2. Coastal Cowpea Belt Zone in Central and Southern Somalia 3. Shabelle and Juba Riverine Valleys - rainfed and irrigated maize, with sesame cash crops 4. Sorghum Belt in Bay and Bakool Region - rainfed sorghum with livestock production. In Somalia, crop farming is an important economic activity that serves as a source of food and employment to millions of people. Historically, agricultural production has been concentrated in southern Somalia, particularly in the Shabelle and Juba valleys, as well as the inter-riverine regions of Bay and Bakool. Agriculture is also practiced in the Northwest, where vegetable production under irrigation and dry land farming is very common. Oasis farming for vegetable production is also very common in the North Eastern region.

The constrains that Somalia farming system faces are different types of insect pests, which invade the crop in the field or in the storage systems, mostly traditional storages, consequently the production yield and the quality declines. For this reason the author addressing miner and major insect pests that invade agricultural products in Somalia and their control.

PART I: HARMFUL INSECTS
ORTHOPTERA

LOCUST

The Orthoptera order of insects includes the grasshoppers, crickets, and Locust as gregarious


(Christiaan Kooyman/Wikipedia)

TYPES OF LOCUSTS

There is no taxonomic distinction between locust and grasshopper species; the basis for the definition is whether a species forms swarms under intermittently suitable conditions.



Desert locust ***Migratory Locust*** ***Red Locust***

(Christiaan Kooyman/Wikipedia)

FULL CLASSIFICATION OF DESERT LOCUST

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Orthoptera

Family: Acrididae

Genus: Schistocerca

Species: *S. gregaria*

The desert locust (*Schistocerca gregaria*) is a species of locust. Plagues of desert locusts have threatened agricultural production in Africa, the Middle East, and Asia for centuries. It is potentially the most dangerous of the locust pests because of the ability of swarms to fly rapidly across great

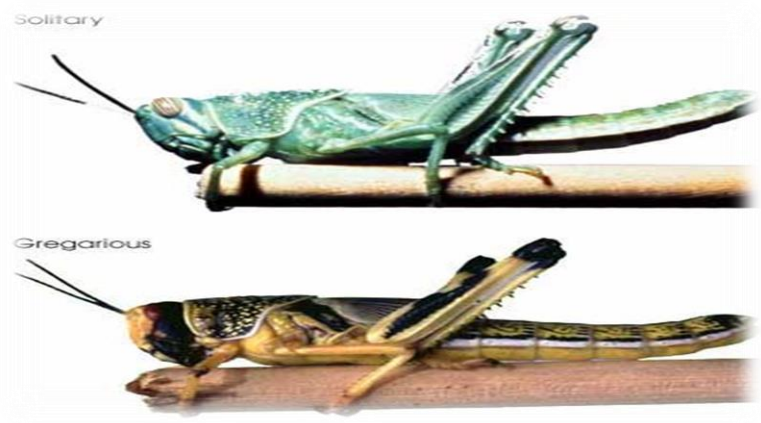
distances. It has two to five generations per year. The last major desert locust upsurge in 2004–2005 caused significant crop losses in West Africa and had a negative impact on food security in the region.

LIFE CYCLE AND ECOLOGY

The female then seeks suitable soft soil in which to lay her eggs, it probes the soil with her abdomen (ovipositor) and digs a hole into which an egg pod containing up to a hundred eggs is deposited.

It lays the eggs in 10 cm (4 in) below the surface of the ground. The eggs absorb moisture from the surrounding soil. The incubation period before the eggs hatch may be two weeks or much longer, depending on the temperature. The newly hatched nymph is known as a hopper. It soon begins to feed and is attracted to other hoppers and they group together. Desert locust nymph undergoes five moults before becoming a winged adult.

Hoppers are gregarious and form bands which feed, bask and move as cohesive units on the other hand desert locusts have two phases, the solitary phase and the gregarious phase. There are differences in morphology and behaviour between the two phases. In the solitary phase the hoppers do not group together into bands but move about independently.



Solitary and gregarious (sourceWikipedia)

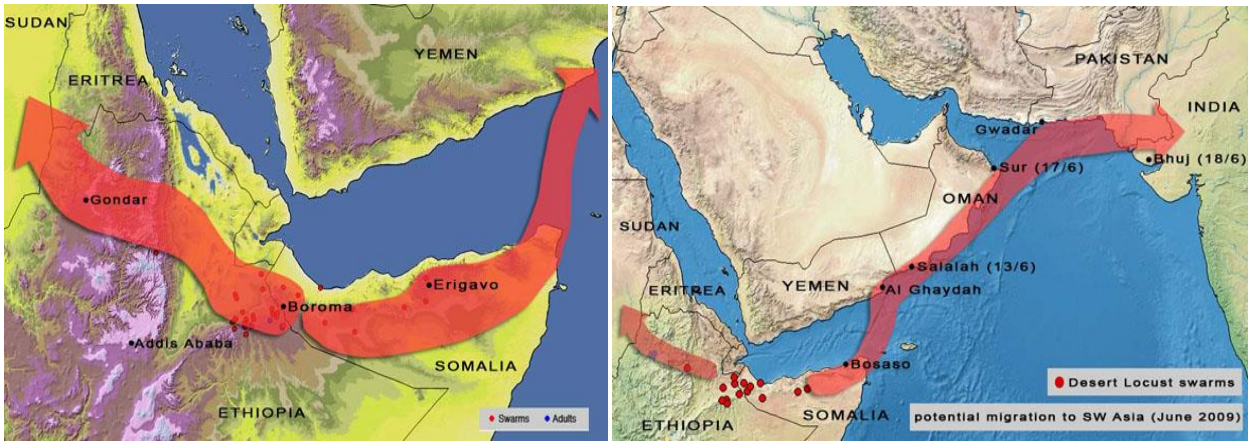
HOST

They are polyphagous and feed on leaves, shoots, flowers, fruit, seeds, stems and bark nearly all crops. It is estimated that desert locusts consume the equivalent of their body weight (2 g) each day in green vegetation. During the twentieth century, desert locust plagues occurred in 1926-1934, 1940–1948, 1949–1963, 1967–1969, 1987–1989 and 2003-2005.

MIGRATION

Temperature and wind influence the migration of both solitary adults and swarms. Swarms are thought to fly between 1,500 and 1,800 meters above the surface of the ground. In sunny warm weather, swarms tend to fly about 10 hours, but they have the ability to fly continuously for 13-20

hours. The locust swarms can migrate great distances in a short amount of time. They can stay in the air for long periods, for example, they regularly cross the Red Sea, a distance of more than 300 km, and sometimes move across the Sahara from Sudan to Mauritania to Morocco, a distance of nearly 5,000 km



Desert locust swarming and breeding site (source Fao)

RED LOCUST

SCIENTIFIC CLASSIFICATION

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Orthoptera

Family: Acrididae

Subfamily: Cyrtacanthacridinae

Genus: Nomadacris

Species: N. Septemfasciata

Binomial name *Nomadacris septemfasciata*

Audinet-Serville, 1883

The red locust (*Nomadacris septemfasciata*) is a large grasshopper species found in Sub-Saharan Africa. Its name refers to the colour of its hind wings

Adult of Nomadacris septemfasciata (sourceWikipedia)

ECOLOGY AND LIFECYCLE

Red locusts actively seek out moist environments such as seasonal floodplains, grains are their primary food source, and so grassy lowlands are prime habitat. It likes spending time in trees

AFRICAN MIGRATORY LOCUST

Locusta migratoria migratorioides, commonly known as the African migratory locust

SCIENTIFIC CLASSIFICATION

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Orthopter

Family: Acrididae

Subfamily: Oedipodinae

Genus: Locusta

Species: L. Migratoria

Subspecies: L. m. Migratorioides

Trinomial name

Locusta migratoria migratorioides

(Fairmaire & L.J. Reiche, 1849)

ECOLOGY AND LIFE CYCLE

It occurs in most of Africa; south of the Sahara desert, but its main breeding ground and the original source of most plagues, is on the floodplains much of the time this locust adopts a solitary lifestyle, but under certain conditions it becomes gregarious.

LIFE CYCLE

The eggs are laid in up to three pods over a period of days or weeks, the pods of a solitary insect contain about 65 eggs while those of a gregarious female average 39. The egg pods have a coating of foam to which sand particles adhere, forming a surrounding membrane. The hoppers usually develop through five stages, known as instars, separated by moults. But in the solitary phase there may be six or seven instars in very dry conditions and then it develops into Adult stage.

ORDER LEPIDOPTERA

STEM BORER

African maize stalk borer (*Busseola fusca*) is a species of moth that is also known as the maize stalk borer. It is known from Ethiopia. The wingspan is 35-40 mm. Adults are pale brown. The larvae feed on various grasses, as well as Zea mays, Sorghum and Saccharum species.

SCIENTIFIC CLASSIFICATION

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Family: Noctuidae

Genus: Busseola

Species: B. Fusca

Binomial name *Busseola fusca*

Adult of* Busseola fusca*. ©Georg Goergen (source CABI CPC)* , *The maize stalk borer. PICTURE: WIKIMEDIA

GEOGRAPHICAL DISTRIBUTION

Busseola fusca occurs throughout sub-Saharan Africa but not in Zanzibar and Madagascar in East Africa Similarly, in East Africa B. fusca occurs in all agro-ecological zones from the lowland semi arid and arid savannahs to the highland African wet mountain forests.

HOST PLANT RANGE

B. fusca was considered as a species feeding not only on maize, cultivated and wild sorghum but also on many wild grasses like.

REPRODUCTION AND LIFECYCLE

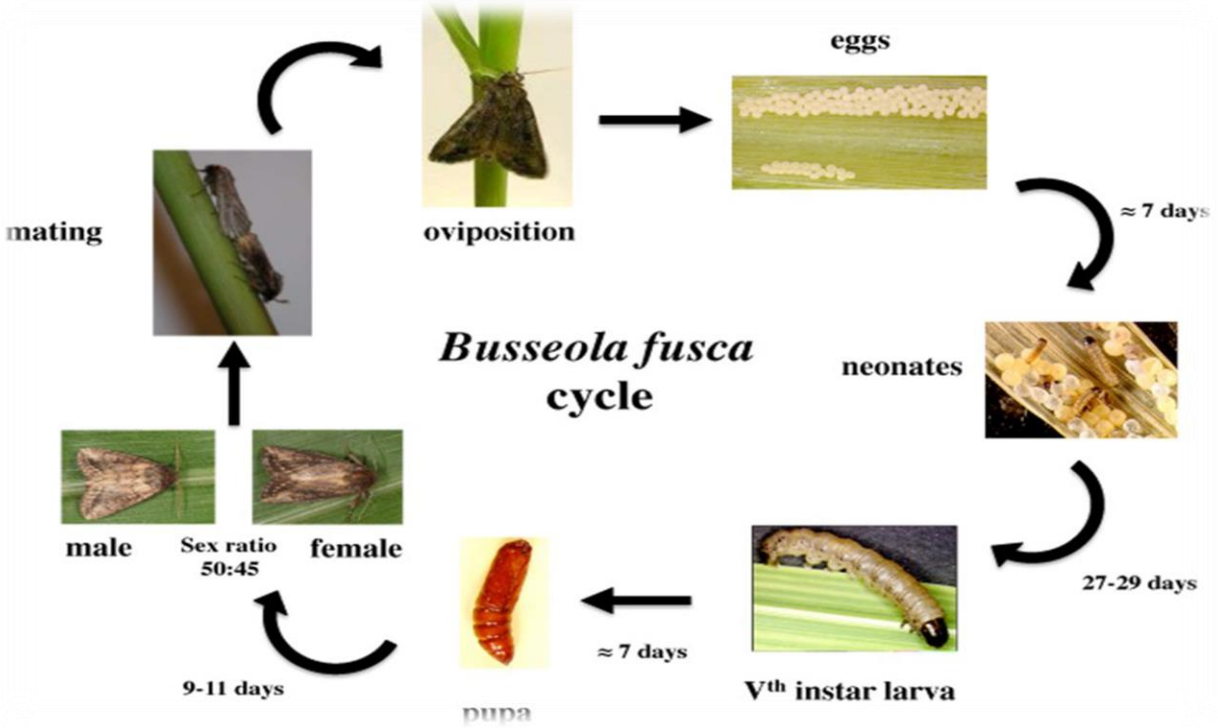
African stem borer has a highly variable number of laying eggs (from **100** up to **800**) of round and flattened eggs in batches. The batches are laid behind the vertical edges of leaf sheaths of pre-tasseling plants.

Larvae

Larvae hatch after about one week and they migrate first to the whorl where they feed on young and tender leaves deep inside the whorl. From the 3rd instar onwards, larvae migrate to the lower parts of the plant where they penetrate into the stem, and then the larvae develop to Pupa stage.

Adult

The adults emerge about 13-14 days after pupation, and they emerge mostly between sunset and midnight .The average life span of moths ranges between 8 and 10 days.



The life cycle of African stem borer (picture: wikimedia)

SPOTTED STALK BORER

Spotted stalk borer (*Chilo partellus)* is a pest that was introduced to Africa most likely from India in the early 20th century as it is one of the economically most damaging pests in Asia and Africa, attacking all parts of the plant except the roots.

Chilo partellus adult and larva mouth moth.set specimen. ©Georg Goergen (source CABI CPC)

SCIENTIFIC CLASSIFICATION

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Lepidoptera

Family: Crambidae

Genus: Chilo

Species: C. Partellus

Binomial name *Chilo partellus*

(Swinhoe, 1885)

REPRODUCTION AND LIFE CYCLE

Eggs are laid in batches of 10-80 eggs on the upper side and underside of leaf surfaces, usually close to the midrib. They hatch after 4-10 days. Younger larvae (caterpillars) will feed on the leaf whorl. Older larvae will tunnel into the stems, and it is within these tunnels that they feed and grow for about 2-3 weeks. When these larvae grow completely, they pupate and remain in the stem of the maize. After 1-2 weeks, the adults evolve from the pupae stage and emerge from the stem. They mate and lay eggs on other maize plants and continue to cause damage to the crop.

HOST DAMAGES

This pest causes US $334 million annual loss to sorghum alone in the semiarid tropics it is also attacks several grass species which can be both cultivated and wild. Cultivated crop hosts include but are not limited to **maize, sorghum, pearl millet, rice, and sugarcane**. Wild hosts include elephant grass

INTEGRATED MANAGEMENT OF BUSSEOLA FUSCA

Since *B. fusca* is an important pest of maize in sub-Saharan Africa, a wide range of methods have been researched, tested and implemented to manage this pest. These include among others control by pesticides, cultural practices, and host plant resistance as well as biological control agents.

CULTURAL CONTROL

Cultural control is a long-established method of modifying the habitat to make the environment unfavourable for the survival and reproduction of pests. Moreover, it is the most applicable and economic method of stem borer control available for resource-poor farmers in Africa. Example for this method includes techniques such as destruction of crop residues, intercropping, crop rotation, manipulation of planting dates, tillage methods and improvement of soil fertility.

HOST-PLANT RESISTANCE

Host-plant resistance has potential to provide effective control of *B. fusca* and has been indicated to be compatible with other control methods However; maize varieties resistant to this pest are still not available in Africa.

PLANT-DERIVED PESTICIDES

Plant-derived pesticides are one of the alternatives to chemicals and are considered environmentally friendly such as: Indian neem tree, *Azadirachta indica*

LEAF MINER

Leaf miners are different orders of insects that live in and eat the leaf tissue of plants and they are belong to moths (Lepidoptera), flies (Diptera), and some beetles exhibit this behaviour.

Tuta absoluta (tomato leafminer)

Description

Egg

The eggs are elliptical, and their colour varies from oyster-white to bright yellow, darkening in the embryonic phase and becoming almost black.

Larva

The first-instar larvae are whitish soon after eclosion, becoming greenish or light pink in the second to fourth instars according to food (leaflet or ripe fruit, respectively). There are usually four instars.

Pupa

Pupae are obtecta with greenish coloration at first, turning chestnut brown and dark brown near adult emergence.

Adult

Adult moths are about 10 mm long, with silverish-grey scales, filiform antenae, alternating light or dark segments.

Adult and larval stage of Tomato leaf miner (picture: Wikimedia)

CLASSIFICATION

Kingdom: Metazoa

Phylum: Arthropoda

Class: Insecta

Order: Lepidoptera

Family: Gelechiidae

Genus: Tuta

Species: Tuta absoluta

(Meyrick, 1917)

BIOLOGY AND ECOLOGY

The female of *T. absoluta* lays about 260 eggs during its life time. The peak of oviposition occurs in the first and second day after adult mating, when around 92% of the total eggs are laid. Hatching from the eggs depend on the climate factors (at 26-30ºC and 60-75 % RH) which occurs at about 5-7 days. The larvae under these conditions pass through four instars which are completed in around 20 days.

T. absoluta has a differentiated behaviour of pupating when occurring in processing tomato or fresh market tomato plants. In the first it pupates on the soil (1-2 cm deep) and in the last the larvae builds a cocoon and pupates on the leaf surface or inside mines. Pupation lasts about 10-11 days for females and 11-13 days for males.

RECOGNITION AND INSPECTION

T. absoluta is easily found on tomato plants because it prefers the apical buds, flowers or new fruits, where the black frass is visible. When there is a severe attack it colonizes the leaves on the other parts of the plant. Mines are evident on attacked leaves.

DAMAGE

T. absoluta has already caused extensive economic damage. The impact of the pest includes severe yield loss reaching 100%, increasing tomato prices, an increase in synthetic insecticide applications and disruption of integrated management programmes of other tomato pests.

Damage from leaf miner (source: department of agriculture,forestry and Fisherie republic of south africa)

CONTROL METHODS

Ploughing, manuring, irrigation, crop rotation, solarisation, and the elimination of symptomatic leaves and destruction of infested tomato plants have all been used to control this pest.

Chemical Control

The most common method of controlling *T. absoluta* in the worldwide countries is the application of insecticides, usually pyrethrin, carbaryl and deltamethrin.

Inherited sterility (sterile males)

Inherited sterility programmes which involve releasing irradiated sterile males were recently proposed as a possible method for control of this month.

Biological Control

Several bio-control agents are used to control the tomato leafminer in open field and greenhouse tomato cultivation. The most common predators against *T. absoluta* are the mirid bugs *Nesidiocoris tenuis*.

Bacillus thuringiensis (Bt)-based insecticide formulations have been used to control *T. absoluta* in its native and invaded regions. Several studies have demonstrated the effectiveness of Bt in controlling *T. absoluta*.

Host-Plant Resistance

Host-plant resistance was explored by developing tomato accessions with high zingiberene and/or acylsugar contents resulting on low ovipostion rates and larval feeding of *T. absoluta*

FALL ARMYWORM

Introduction

Fall armyworm is an insect indigenous to tropical and subtropical regions of the Americas. The caterpillar feeds 80 up to 100 plants of different species, including maize, sorghum, millet rice, wheat, sugarcane, vegetable crops, cotton and etc. The infestation can cause significant yield losses if not used appropriate integrated management. The adult female moth can fly up to 100 km per night; the lifecycle is complete metamorphoses where the eggs are laid overnight on the leaves of the crop, especially underside of the leaves and it glued as clusters of 100-300 eggs in some areas, 1000 eggs per female were reported. Fall armyworm was first observed in Western and Central Africa in early 2016 (Benin, Nigeria) .The first time that have been seen fall armyworm in Somalia was the end of 2017. The major infestation was seen in maize special south and North West Somali.

Description

Caterpillars are of light green to brown color with longitudinal scratches. At the hatching, they are green with black lines and stains. Old caterpillars are characterized by an inverse Y in yellow on the head, black dorsal pinnacles with long primary silk. and four black stems set into squares on the last abdominal segment. There is as usual six larva stages, sometimes five.

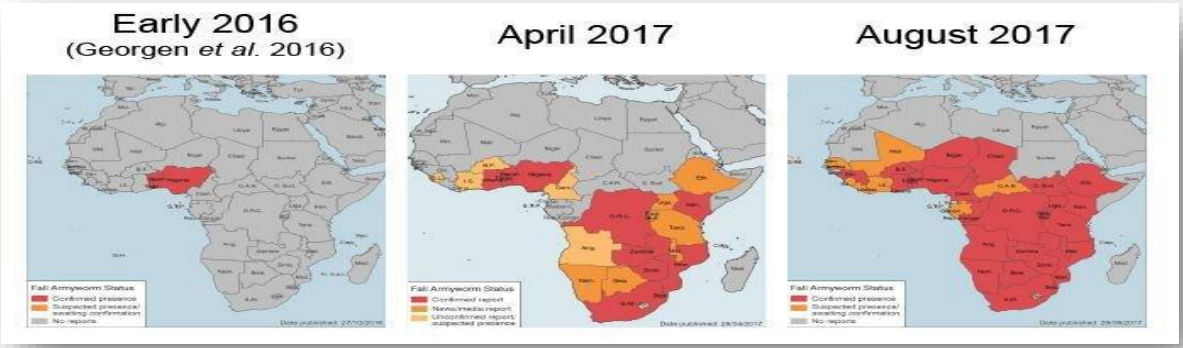
Immature stages of fall armyworm (***source Wikimedia)***

Fall armyworm larva and adult stage (Awdheegle Mubarak /Somalia) ,

FAW is a dangerous trans-boundary pest with a high potential of continuing to spread due to its natural distribution capacity and trade.

Distribution in Africa

Dispersal of Fall army worm is significant indicator of its' fast adaptation in Africa



Distribution map of Fall armyworm (source: CABI; FAO)

Biology and Ecology

The eggs are laid overnight on the leaves of the host plant, glued to the underside of the lower part of the leaves, in tight clusters of 100-300. Hatching requires 2 to 10 days (usually 3 to 5). Young larvae feed deep into the spiral (cornea). The first two larval instars feed gregariously on the underside of the young leaves, causing a characteristic skeleton.

The rate of larval development across the sixth stages is controlled by a combination of diet and temperature conditions, and usually takes 14 to 21 days. Larger larvae are nocturnal, unless they enter the legionary caterpillar stage when they are swarming and dispersing, seeking other sources of food.

Pupation takes place inside a soft cocoon in a soil cell, or rarely between the leaves on the host plant, and 9 to 13 days are required for development. Adults emerge at night and usually use their natural pre-oviposition period to fly several kilometers before settling for egg-laying, sometimes migrating over long distances. On average, adults live 12 to 14 days.

Scientific classification

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Lepidoptera

Family: Noctuidae

Genus: Spodoptera

Species: S. Frugiperda

Binomial name

Spodoptera frugiperda

(J.E. Smith, 1797)

Damage

In Brazil, annual loss of $400 million was reported. African countries are facing a maize shortage and losses running into 6.1 billions of dollars due to the devastation caused by the fall armyworm. A new report released by the Centre for Agriculture and Biosciences International (CABI) shows that improper management of the armyworm could cost. 10 of the continent's major maize producing economies between $2.2 billion and $5.5 billion per year in lost maize harvests.

In Kenya, the pest has attacked more than 250,000 hectares of agricultural land, accounting for 11 per cent of the country's maize crop, according to the latest statistics from the Ministry of Agriculture. 63,000 hectares have been destroyed, which represents over 80% of maize production in the territories along the Zambian border (OCHA 15/02/2017; Straits times 26/02/2017). As of August 2017, the spread of fall armyworms has destroyed crops in 50 out of the country's 145 territories. Between 50 to 80 percent of people in some of the areas affected by hunger.

In several areas, people only eat once a day, and their meals – based on corn, cassava or potatoes - do not meet their daily nutritional and calorie needs .(WFP, FAO, 14 Aug 2017).

Before and after infestationof fall armyworm on maize . Top: Ken Wilson; Bottom: FAO Lesotho

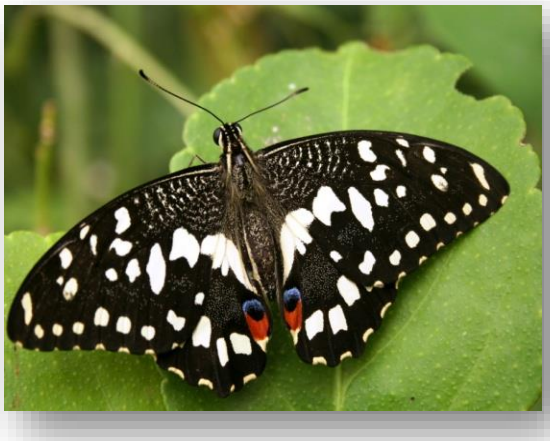
Infestation by fall armyworm. Photo: © FAO/ Leonard Makombe

Control

1- For early infestation when eggs are seen, foliar application of Fytomax PM with 0.1% Azadirachtin acts.

CITRUS SWALLOWTAIL

Papilio demodocus, the citrus swallowtail or Christmas butterfly, is a large swallowtail butterfly common to Sub-Saharan Africa. After hatching from theiregg,the caterpillar feeds on a few leaves on citrus trees before pupation. There are about 90 known species of Papilionidae in the continent of Africa of which 60 are placed in Papilio. Papilio demodocus is found across most of sub-Saharan Africa,



Papilio demodocus adult and pupal stage . (***by Robert Escoto***)

The Larval stage Papilio demodocus. (***by Robert Escoto***)

Lifecycle

Female butterflies lay their eggs singly on citrus leaves. After about six days, the egg hatches into an immature larva.

Immature larva

The immature larvae are black, yellow, and white with spikes as they resemble bird droppings. They grow to a length of 10 or 15 mm before changing into mature larvae. Eggs singly on citrus leaves. After about six days, the egg hatches into an immature larva.

Mature larva

Mature larvae are green with white or pink markings and eyespots. They grow to a maximum length of about 45 mm.

Pupa

The caterpillars attach themselves to branches with silk, transforming into pupae. They remain in the pupal form for two to three weeks before emerging as adults. Adult butterflies have black and yellow markings with red and blue eyespots. Female butterflies tend to be larger than males.

Scientific classification

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Lepidoptera

Family: Papilionidae

Genus: *Papilio*

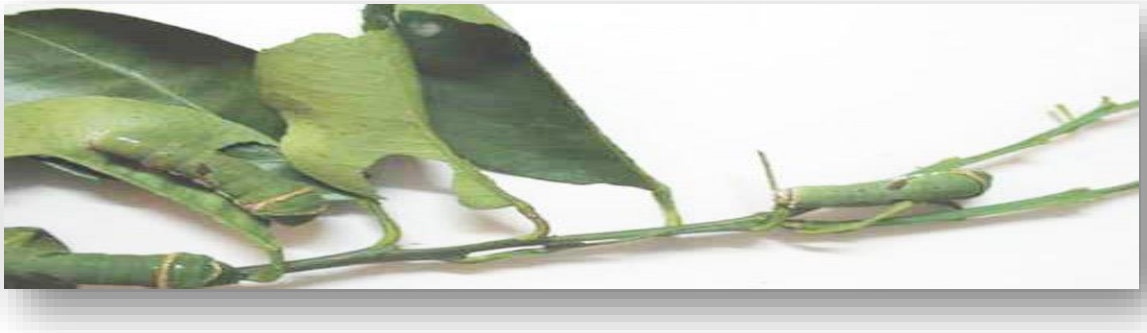
Species: ***P. demodocus***

Binomial name: ***Papilio demodocus***

Esper, 1798

Economic Importance

The larvae are a serious pest of citrus nursery stock . where they are capable of defoliating entire nurser, Larvae may utilize young leaf flush on more mature trees



Damage from larva of Papilio demodocus. (***Source SONRREC***)

Control methods

1- Low-level infestations can be controlled by hand-picking larvae.

2- chemical control

Severe infestations are generally controlled by applying chemical pesticides, etc or plant extracts to the foliage, e.g. carbaryl, phosalone, acephate, pirimiphos-methyl, fenitrothion, permethrin

3- biological control

The efficacy of different concentrations of the biopesticides *Bacillus thuringiensis and Beauveria bassiana*, as well as of neem seed kernel extract, neem oil and azadirachtin were teste

ORDER HEMIPTERA

APHIDS

Morphology of these insects can be recognized by its pear-like shape, a pair of cornicles at the posterior end of the abdomen and fairly long antennae; winged forms can usually be recognized by the venation and relative size of the front and hind wings. The cornicles of aphids are tube-like structures arising from the dorsal side of the fifth or sixth abdominal segment

Adult of Aphid feeding the leaves. (***Source SONRREC, lucViatour***)

Cotton aphid classification

Phylum: Arthropoda

Class: Insecta

Order: Hemiptera

Family: Aphididae

Genus: Aphis

Species: A. Gossypii

Binomial name: *Aphis gossypii*

Glover, 1877

Host range

Part from sweet potato, this species also damages citrus, cotton, cucurbits, eggplant, pepper and potato.

Economic significance: The adults and nymphs of the cotton aphid feed on the underside of leaves or on the growing tips of shoots, sucking juices from the plant.

The foliage may become chlorotic and die prematurely. Here is often a great deal of leaf curling and distortion which hinders efficient photosynthesis. Honeydew is excreted by the aphids and this

allows sooty moulds to grow, resulting in a decrease in the quantity and quality of the produce. The white fly and aphids are a vector of crinkle, mosaic, rosette, CTV and other virus diseases.

Biology and Ecology

Aphis gossypii reproduction is mostly asexual

Life Cycle

Young nymphs overwinter on the leaves of host plants. In late spring adult females deposit 200-400 eggs in circular clusters on the undersides of upper leaves. The eggs hatch in 5-10 days and first instar nymphs. 2nd, 3rd and 4^{th}. A non-feeding pupal stage follows and within a week, young adults emerge to repeat the cycle. There are many generations per year. Whiteflies develop from egg to adult in approximately 25 days at room temperature. Adults may live for one to two months.

Monitoring

Check your plants regularly for aphids—at least twice a week when plants are growing rapidly in order to catch infestations early, so you can knock or hose them off or prune them out. Many species of aphids cause the greatest damage in late spring when temperatures are warm.

Biological Control

Many predators also feed on aphids. The most well known are lady beetle adults and larvae, lacewing larvae, soldier beetles. Aphids are very susceptible to fungal diseases when it is humid. These pathogens can kill entire colonies of aphids when conditions are right.

Cultural Control

Before planting vegetables, check surrounding areas for sources of aphids and remove these sources. Some aphids build up on weeds. Where aphid populations are localized on a few curled leaves or new shoots, the best control may be to prune out these areas and dispose of them. In large trees, some aphids thrive in the dense inner canopy; pruning out these areas can make the habitat less suitable.

High levels of nitrogen fertilizer favor aphid reproduction, so never use more nitrogen than necessary. Instead, use a less soluble form of nitrogen and apply it in small portions throughout the season rather than all at once.

Chemical Control

Oils may include petroleum-based horticultural oils or plant-derived oils such as neem or canola oil. These products kill primarily by smothering the aphid, so thorough coverage of infested foliage is required. Apply these materials with a high volume of water, usually a 1 to 2% oil solution in water, and target the underside of leaves as well as the top.

Whitefly

Whiteflies are tiny Hemipterans that normally feed on the undersides of plant leaves. They are measuring between 0.6 and 2 mm in length. They are easily recognized because of their white appearance caused by a waxy powder on wings and body. However, not all species are white; a few are dark grey or black in appearance, as they are pests of a number of field crops, such as cotton, tobacco and sunflowers and also attack greenhouse crops and ornamental plants.

Scientific classification

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Hemiptera

Suborder: Sternorrhyncha

Superfamily: Aleyrodoidea

Family: Aleyrodidae

Subfamilies: Aleurodicinae, Aleyrodinae, Udamoselinae

Lifecycle

The eggs of whiteflies are usually laid on the underside of plant leaves. Whiteflies have two mobile stages, the adult and the first-instar nymph, which is also known as a "crawler". Newly emerged crawlers wander, normally on the same leaf where the eggs were laid, before they attach themselves to the leaf with their mouthparts and become sessile. The three subsequent nymphal stages are immobile and often covered with waxy excretions. The fourth and last nymphal stage is commonly though erroneously referred to as a "pupa". During this stage a tin-like pupal case is formed by wax excretions of species-specific structure, and the nymph transforms into the adult. Unlike in most groups of insects, it is the "pupae" and not the adults that are usually used for species identification. Whiteflies can have several generations per year.

Damage

Whiteflies feed by tapping into the phloem of plants, introducing toxic saliva and decreasing the plants' overall turgor pressure. Since whiteflies congregate in large numbers, susceptible plants can be quickly overwhelmed. Further harm is done by mold growth encouraged by the honeydew whiteflies secrete**,** where most whitefly species can transmit viral plant diseases.

Control

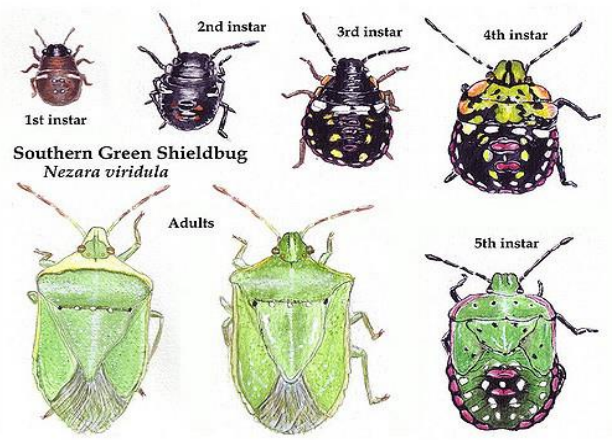
Whitefly control is difficult and complex, as whiteflies rapidly develop resistance to chemical pesticides. so only use of selective insecticides is advised.

Pesticides used for whitefly control usually contain neonicotinoid compounds as active ingredients: Rotation of insecticides from different families may be effective at preventing the building of tolerance to the product.

GREEN VEGETABLE BUG

Nezara viridula

Nezara viridula, commonly known as the southern green stink bug, Southern green shield bug or green vegetable bug, is a plant-feeding stink bug. Although believed to have originated in Ethiopia, it can now be found around the world. Adults are large green shield bugs, approximately 15 x 8 mm in size. They are uniform apple-green above and a paler shade of green below. The green colour may be replaced by a red-brown. Three small white dots are usually evident on the front edge of the scutellum, where it joins the prothorax.



Adult and nyphal instars . DSIR Photographers © Plant & Food Research

Classification

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Hemiptera

Family: Pentatomidae

Subfamily: Pentatominae

Genus: Nezara

Species: N. Viridula

Distribution and origin

Nezara viridula is a cosmopolitan species, living in tropical and subtropical regions of Americas, Africa, Asia, Australasia and Europe between 45 degrees north and 45 degrees south. Its' exact

origin is unknown, but it is believed to have originated from the Ethiopia region of East Africa, from where it has spread around the world.

Ecology and host plants

It is a highly polyphagous, able to feed on plants from over 30 families, both monocots and dicots. Although N. viridula is considered highly polyphagous, leguminous hosts are disproportionately represented. Several species of Cruciferae, Poaceae, Malvaceae and Solanaceae are also attacked. Green vegetable bug performance varies significantly across species. Furthermore, various suitable host species affect nymphs differently from adults.

Life cycle

Its' lifecycle is incomplete metamorphoses. The eggs are deposited in masses that range from 30 to 130 eggs per mass. The female oviposits on the undersurface of leaves in the upper portions of canopied crops and weeds. The eggs are white to light yellow in color and barrel shaped with flat tops with a disc shaped lid.

The nymph hatches from the egg by opening the disc shaped cap. The first instars aggregate by the empty eggs and do not feed. The possible benefits of aggregation are to deter predation from the pooling of their chemical defenses. The nymphs are light yellowish in color with red eyes and transparent legs and antennae. Feeding begins with the second instar. The second instar has black legs, head, thorax, and antennae. The abdomen is red and so are the spaces between the second, third, and fourth antennal segments. The thorax has a yellow spot on each outer side. The third and fourth instars differ from the second in size and an overall greenish color becoming apparent. Wing pads mark the arrival of the fifth instar.

The southern green stink bug can complete its life cycle in 65 to 70 days. It is most prevalent during the periods of October through December and again in March through April. The southern green stink bug is known to have up to four generations per year in warm climates.

Damage

The southern green stink bug has piercing-sucking mouthparts. The mouth consists of a long beak-like structure called the rostrum. Salivary fluid is pumped down the salivary duct and liquefied food is pumped up the food canal. All plant parts are likely to be fed upon, but growing shoots and developing fruit are preferred. Attached shoots usually wither or, in extreme cases, may die. The damage on fruit from the punctures is hard brownish or black spots. These punctures affect the fruit's edible qualities and decidedly lower its market value. Young fruit growth is retarded and the fruit often withers and drops from the plant. In addition to the observable damage caused by southern green stink bug feeding, the mechanical transmission of tomato bacterial spot may also result.

Action Threshold

The economic threshold for southern green stink bug in soybeans is reported as 36 stink bugs per 100 swings of a net. For cowpea (southern pea), a population level of 5000 southern green stink bugs per hectare would be large enough to downgrade peas from Grade A to Grade B. In cotton, an accepted threshold is three to four stink bugs per 100 swings with a sweep net.

Control measurements

Biological control: Parasites, usually wasps and flies, provide biological control of the southern green stink bug. a tachinid fly, Trichopoda pennipes, parasitizes adults and nymphs; and a wasp, Trissolcus basalis, parasitizes eggs.

Adult* Trichopoda pennipes*, a tachinid fly, that parasitizes the southern green stink bug,* Nezara viridula *(Linnaeus). Photograph by James Castner, University of Florida.

Chemical control. The use of trap crops is not a widely accepted idea for control of the southern green stink bug, but it has excellent potential as a type of control. The choice for trap crops in the summer would be leguminous plants such as cowpeas and beans. In the late fall and early spring cruciferous plants are recommended. The trap crop should be sprayed or plowed under before the developing southern green stink bugs become adults to prevent them from migrating to the main crop. Insecticides are commonly applied at blossom and fruit formation.

SCALE INSECTS

The scale insects are small insects of the order Hemiptera. There are about 8,000 described species of scale insects.

Soft Scale insect . (Source Wikipedia)

Hard Scale insect. (Source Wikipedia)

Invaded leaves by Scale insects. (Source Wikipedia)

Description

Scale insects vary dramatically in appearance; from very small organisms (1–2 mm) that grow beneath wax covers. Adult female scales are almost always immobile. They secrete a waxy coating for defence.

Scientific classification

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Hemiptera

Suborder: Sternorrhyncha

Superfamily: Coccoidea

Scale insects can be divided into two groups

1- HARD SCALE INSECT

(Hard) – Secrete a hard protective covering (1/8 inch long) over themselves, which is not attached to the body. Hard scale insect does not move about the plant. They do not secrete honeydew.

2- SOFT SCALE INSECTS

Soft – Secrete a waxy film (up to 1/2 inch long) that is part of the body. In most cases, they are able to move short distances (but rarely do). They produce abundant amounts of honeydew. Soft scales vary in shape from flat to almost spherical.

Life Cycle

Adult females lay eggs underneath their protective covering which hatch over a period of one to three weeks. The newly hatched nymphs (called crawlers) migrate out from this covering and move about the plant until a suitable feeding site is found Young nymphs insert their pi gradually they developing into immobile adults Females often reproduce without mating.

Integrated scale insect management (IPM)

1- When scale numbers are low they may be rubbed or picked off of plants by hand. ercing mouthparts into the plant and begin to feed.

2- Biological control

Commercially available beneficial insects, such as ladybugs and lacewing, are natural predators of the young larval or "crawler" stage.

3- Organic pesticides like insecticidal soap and d-Limonene can also be used to kill the larvae. However, these products have very little persistence in the environment,

. **4- Azamax contains azadirachtin**, it is insecticidal ingredient found in neem oil

5- Horticultural oils and other safe, oil-based insecticides work by smothering insects and will control all pest stages, including adults which are protected from most other insecticides by their scale coverings.

Some Scale insect families

Monophlebidae – cottony cushion scales

Xylococcidae

Matsucoccidae

MEALY BUG

Description

Mealy bugs are sexually dimorphic: females appear as nymphs, exhibiting reduced morphology, and lack wings, although unlike many female scale insects, they often retain legs and can move.

Mealy bug infestation (Source Wikipedia)

Scientific classification

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Hemiptera

Suborder: Sternorrhyncha

Superfamily: Coccoidea

Family: Pseudococcidae

Heymons, 1915

Genera

Acaciacoccus

Acinicoccus

Acrochordonus

Adelosoma

Agastococcus

Distribution

Mealy bugs occur in all parts of the world. Most occur naturally only in warmer parts, and get introduced into greenhouses and other buildings in cooler countries.

Damage

The most serious pests are mealy bugs that feed on citrus; other species damage sugarcane, grapes, coffee trees, cassava, and papaya, etc... Mealy bugs only tend to be serious pests in the presence of ants because the ants protect them from predators and parasites.

Control of mealy bugs

1- Ladybird larvae and adults feed on mealy bugs, and can be used to control an infestation
2- Mealy bugs can be controlled using the fungus *Lecanicillium lecanii* .
3- Diazinon can be used, but often requires multiple applications

SESAME SEED BUG

Introduction

The sesame seed bug *Elasmolomus sordidus* which belong to the order: Hemiptera and the family: Lygaeidae is a pest of economic importance in east Africa which attacks Some varieties of Sesame

Classification

Order: Hemiptera

Sub-order: Heteroptera

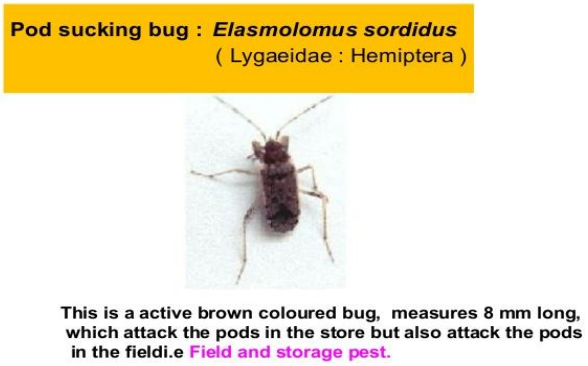
Family: Lygaeidae

Genus: Elasmolomus

Species: Elasmolomus sordidus (F.)

Morphology of adults

Adults are small sized bugs from 7-9 mm long upto 3 mm wide, (Corby 1947). The head and eyes are dark Brown or Black. The antennae are slender, 5-6 mm long and 4-jointed. The whole body is black or very dark brown beneath



Adult stage of sesame seed bug (Source the natural history museum)

Life Cycle

The egg is sausage-like, about 1.2 mm long and 0.45 mm in diameter. When laid they vary from very pale yellow to very pale brown but change through pink to full red during incubation. The first instar is not normally seen as it casts its skin when it hatches.

The average duration of the egg and the first 28 instar is about 6 days. The second instar varies from 1.5 mm to 1.8 mm in length, upto 1 mm in width and is pale pink as it emerges.

Average duration is about 8 days. The third instar, fourth, fifth and sixth vary in length as 2.0 to 2.7 mm, 2.5 to 4.0 mm, 3.5 to 5.5 mm and 5.0 to 7.8 mm respectively. Also vary in width as upto 1.5 mm, 1.7 mm, 2.5 mm and 2.9 mm. The duration was found to be about 11 days, 7 days, 5 days and 8 days respectively.

Host Range

The bug invade many plant in different areas, it may attack sesame, groundnut, millet, grasses, cotton, banana and Soybean.

Damage

Losses due to *Elasmolomus sordidus* (F.) include reduction of oil content, light seed weight and reducing germination power. Scientists recoded that recorded that adults and large nymphs were seen attacking kernels by thrusting their beaks through the jute sacks, where the damage in the field is

sufficiently severe. Sesame is usually attacked in the field after the plants have been cut and put together in stacks for drying.

Control Methods

1- Using chemicals such as Malathion or other organophosphates
2- Field sanitation and alternate host control: Sesame seed bugs live and reproduce in the threshed stacks, old grasses, weeds and other accumulated debris by feeding on the seed residues therefore, clearing or removing the grasses, debris, weeds and the residual seeds and burning the threshed stacks could be the best option for reducing the survival of sesame seed bugs from one season to the next season.
3- Crop rotation: could minimize bug outbreak by reducing host plants.
4- Plough the field soon after threshing: This is an indirect pest control measure that exposes pests, especially the eggs to the hot sun and natural enemies or other unfavourable environmental conditions.
5- Planting resistant Varieties.

THRIPS (ORDER THYSANOPTERA)

THRIPS

Thrips are minute (1 mm long or less), slender insects with fringed wings. Different thrips species feed on a large variety of plants. Many thrips species are pests of commercially important crops. Onion thrips is a native of the Mediterranean region but has become a major pest of agricultural crops throughout most of the world. Severe damage to various crops has been reported in Africa, Asia, Europe, North and South America and Australasia.

Adult and Nymph stage (Source planet natural research center,CSIRO Entomology)

Scientific classification
Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Thysanoptera

Family : Thripidae

Genus : Thrips

Species : T. Tabaci

Binomial : *Thrips tabaci*

Haliday, 1836

Geographic Distribution

Worldwide, it is an important pest of onions, other onion relatives and several crops in most parts of the world.

Biology and Ecology

Thrips can complete the life cycle in 14 to 30 days. When temperatures are over 30°C the life cycle can be shortened to 10 or 11 days .The adults may live up to 20 days. Thrips do not need to mate for reproduction. Females that do not mate will produce only female progeny

The lifecycle is Hemimetabola incomplete development (egg, nymph, adult)

Damage and Importance

Thrips are the most damaging insect pest of onions in the tropics. Thrips have a very peculiar feeding behaviour. They start the feeding by piercing and rasping the leaf surface with their mouth parts to release the liquids from the plant cells. In this process, thrips release substances that help predigest the onion plant tissue. Later, with their mouth they suck up the plant content. Thrips prefer to feed on the young plant tissue on the newest emerged leaves. When the leaf grows, the previous damage produced by the thrips enlarges, leaving empty spaces in the surface of the leaf.

The appearance of the damage is silvery patches or streaks on the leaves that shine in the sun. When damage is severe, these small patches can occupy most of the surface of the leaf and the plant cannot adequately photosynthesize. The plant loses more water than normal through the damaged tissues and plant pathogens penetrate the injured plant easily. In severe attacks the whole plant can turn white or silver and leaves can wither. In injured plants the bulbs may mature faster and the size becomes reduced. In some tropical countries up to 66% of the onion crop may be lost to thrips damage.

Thrips Damage (Source University of California)

Control Strategies:
Biological control: There are several natural enemies that help in the control of thrips

Planting season

In most cases thrips are not a problem in the rainsy season because the rain washes the tiny insects from the plant. At the end of the hot dry season, thrips populations are at their maximum. In some places it is better not to plant under these conditions because thrips control is almost impossible

Irrigation

Irrigation of the onions is very important to control thrips. In some places, such as Australia, farmers use overhead irrigation to simulate rainfall and control the thrips. Even more important is to maintain a good water supply to the plants during the whole season. If the onion plant is under water stress the thrips damage may be magnified because the plant is losing large amounts of water from the damaged tissue. Also proper fertilization may help to reduce the impact of the thrips in the plant. Remove unharvested plant parts Volunteer onion plants are an important source of infestation for thrips. Remove or destroy all the unharvested plants from the plots

Plant Resistance

Onion cultivars that have a more open growth characteristic (leaves separated from base rather than tightly bundled) are less attractive to thrips because they provide less refuge for them

INSECTARIUMS

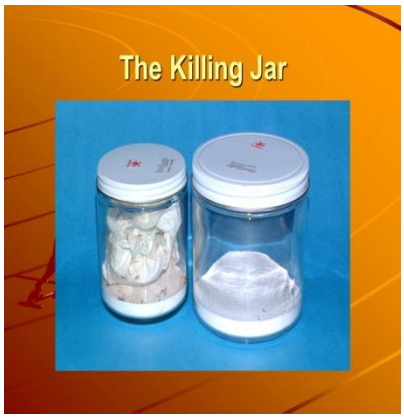
Collecting and preserving insects

Insect may collect as purpose of taxonomy for insect pests in agro-ecosystem and medical insects. There are number of steps for accomplishing insectariums preparing.

Equipment

1- killing jar
2- insect net
3- storage box
4- forceps
5- relaxing jar
6- spreading board and pinning block
7- insect pins and labels
8- Ethyl acetate or Ethanol

(source Wikipedia)

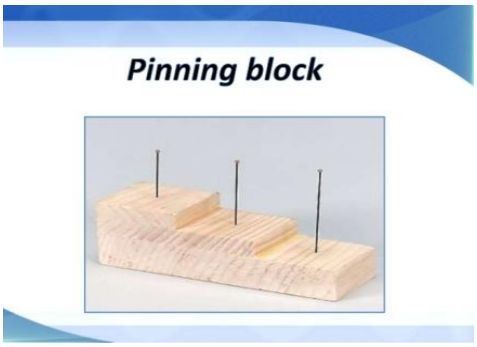


killing jar (Source Wikipedia)

Sweep nut (Source Wikipedia)

Aerial nets (Source Wikipedia)

Storage box (Source Étienne Boucher-Cazabon)



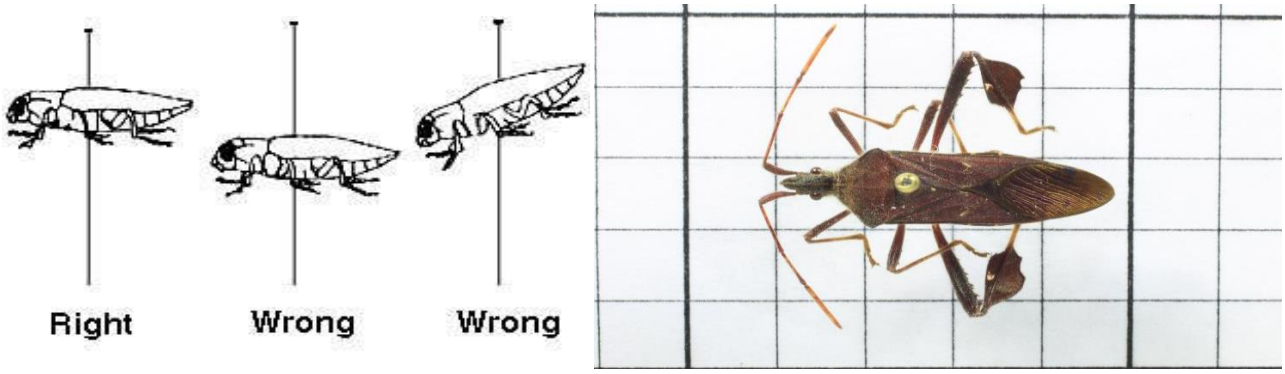
Forceps (Source Wikipedia)

Collecting insects

You can gather insects from almost anywhere, for example in the field, garden or nursery on the other hand it may also collect from natural vegetations. You can increase your chances of finding different insects by using different collecting methods.

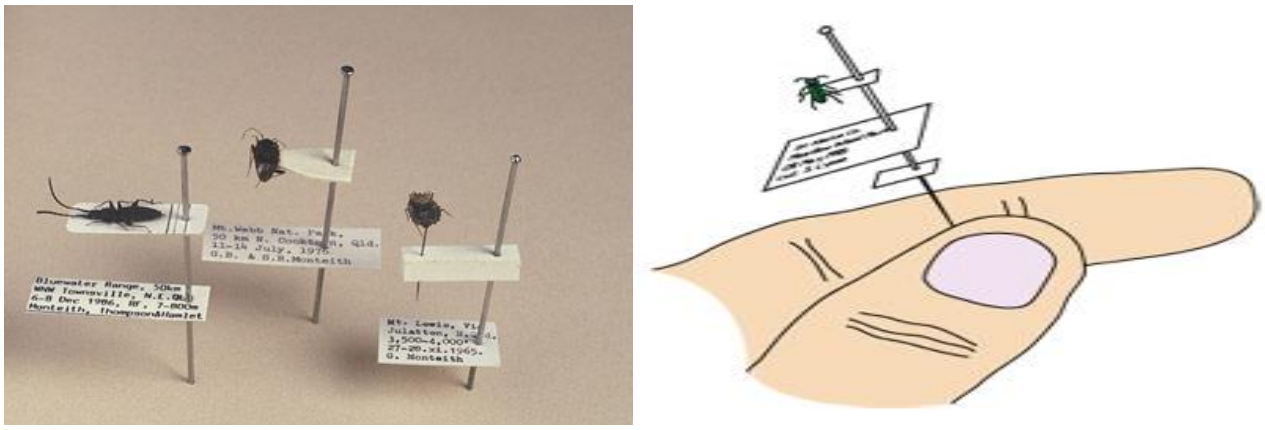
Pinning Insects

Rest the specimen on a pinning block and steady the insect by either holding it with your fingers or holding it in place with a forceps. Place the insect pin into the insect body. Insects are generally pinned through the thorax on the right side.



Proper insect pinning (Source Wikipedia)

Insects too small to pin can be placed on a paper point. Use stiff paper, such as an index card. Place an insect pin through the point on the wide end. The tip of the point can be left as is or bent. Apply a small drop of glue to the tip of the point.



Pinning small insects (source Wikipedia)

PRESERVING SOFT BODY INSECTS

Preserve larval instars of insects and other soft-bodied specimens immediately by dipping them directly into a 70 to 90 percent ethyl or isopropyl alcohol solution.

An even better method of preserving caterpillars, grubs, and maggots, is to carry them home alive in separate plastic or glass containers, then submerge them for 1 to 2 minutes in boiling water. After this they can be immediately placed in the vials of alcohol. This process kills bacteria in the digestive tract and prevents discoloration. After a day or two, the liquid may become discolored. When this happens, transfer the specimens permanently to fresh alcohol solution. Specimens in vials must be labelled exactly as described .


Preserving larval stage (Bee Informed Partnership ®)

Displaying Insects

After insects have been properly pinned and labelled, they are kept in specially designed insect boxes constructed with soft flooring into which pins can be inserted. Pinned insects cannot be stored in good condition for long unless they are placed in boxes to protect them from dust and damage.

A standard display box is 18 x 24 inches (outside measurements) and 21/2 to 3 inches deep to allow insect pins to stand upright. It is protected on top with a glass.

INSECT SURVEY IN LOWER SHEBELLE REGION


Collecting process of insects (Afgoye / Somalia) (Source SONRREC)

Insect collection (Orthopter) (Source SONRREC)

Lepidoptera(Source SONRREC)

Coleopteran(Source SONRREC)

Hymenoptera (Source SONRREC) ***Hemiptera or true bugs(Source SONRREC)***

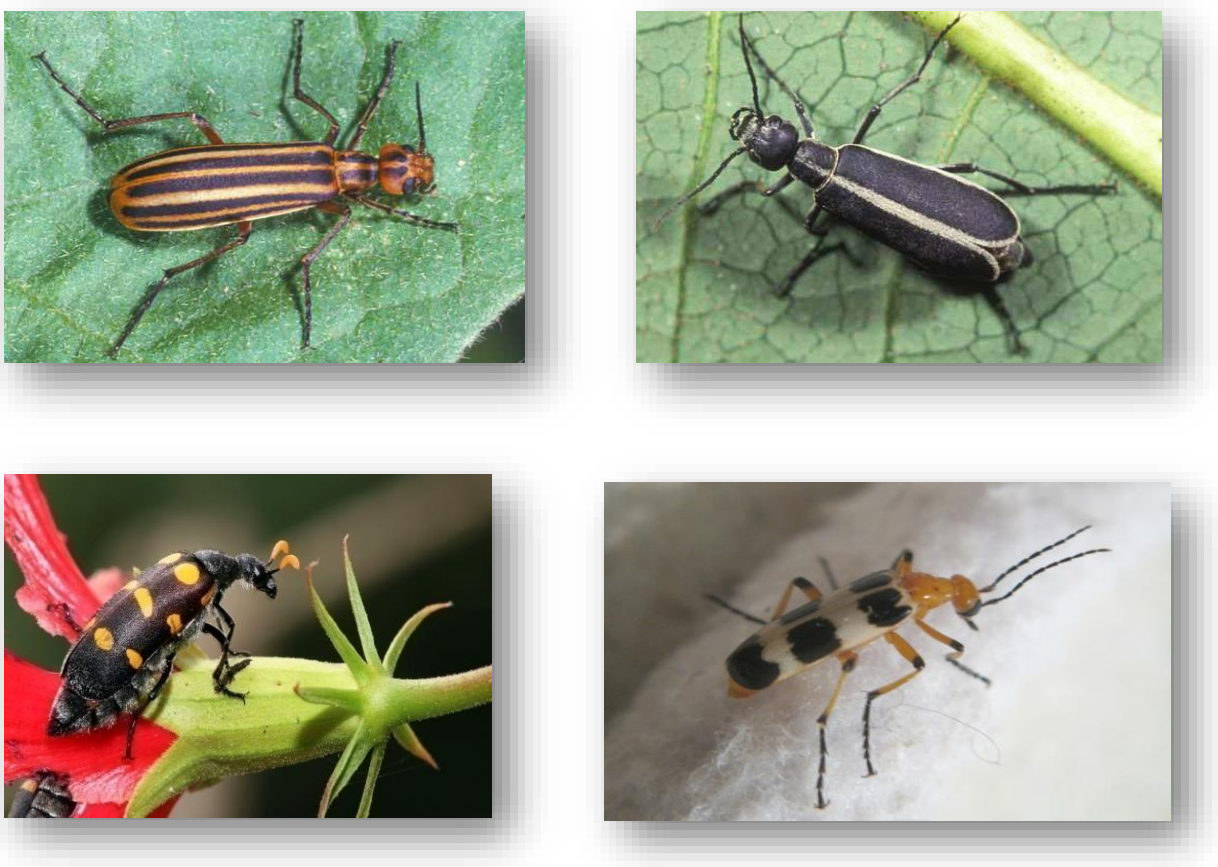
Collecting process of soft body insects (Afgoye / Somalia) (Source SONRREC)

Preserved larval stage for different pests from Afgoye /Somalia (Source SONRREC)

ORDER: COLEOPTERA

BLISTER BEETLE

Blister beetles are beetles of the family Meloidae, so called for their defensive secretion of a blistering agent, cantharidin. About 7,500 species are known worldwide.



Different species of Blister beetle. Photograph by James Castner, University of Florida.

Description

Adults are soft-bodied, long-legged beetles with the head deflexed, fully exposed, and abruptly constricted behind to form an unusually narrow neck, Body length generally ranges between 3/4 and 2 cm.

Scientific classification

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Coleoptera

Super family: Tenebrionoidea

Family: Meloida

Subfamilies : Eleticinae ,Meloinae ,Nemognathinae and Tetraonycinae

Life Cycle:

Complete metamorphosis; or hypermetamorphosis. Winter is spent in later all larval stages and pupation occurs in the spring. The pupal stage lasts about 2 weeks and adults appear in early summer. Female beetles lay clusters of eggs in the soil.

Crop Damage

Often the damage occurs on alfalfa, beet, potato, tomato, and other crops by defoliation. Because of the beetles' gregarious behaviour, their attacks can be locally catastrophic.

Blister beetles feeding the leaves. (joe boggs, OSU extension) ***Skin damage by the Cantharidin (source Wikipedia)***

MEDICAL AND VETERINARY IMPORTANCE

Blister beetles receive their common name from the ability of their hemolymph to produce blistering on contact with human skin.

Cantharidin is a poisonous chemical that causes blistering of the skin. The largest genus, Epicauta, contains many species toxic to horses; a few beetles consumed in a single feeding of alfalfa hay may be lethal. Modern harvesting techniques may contribute to cantharidin content in harvested forage.

The Control of Blister Beetles

Cultural control

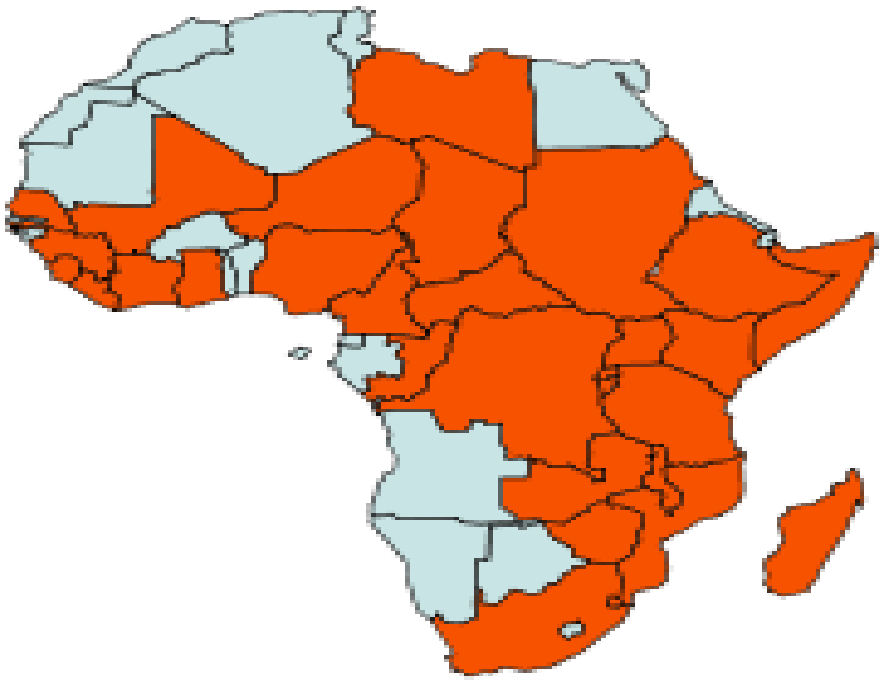
Blister beetles are attracted to blooming alfalfa. Therefore, to reduce the incidence of blister beetles in alfalfa, it should be followed these steps

1- Cutting the alfalfa as hay before peak bloom.
2- Hand picking, but it is important to wear gloves because these insects release chemicals that affect the skin.
3- spray the grass and mulch areas using CYONARA RTS

THE AFRICAN SWEET POTATO WEEVIL

The African sweet potato weevil *(Cylas puncticollis)* is one of the most important pests of sweet potato in tropical Africa, notably Uganda, Rwanda, Kenya and Cameroon. *Cylas brunneus* is known from West and Central Africa and some countries in East Africa (Rwanda, Burundi and Kenya). These two species are found together attacking sweet potatoes in East and West Africa.

Adult and Larval stage Sweet potato weevil larvae on sweet potato. (c) Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org



Geographical Distribution of the Sweet potato weevils in Africa (red marked). Adult and Larval stage Sweet potato weevil larvae on sweet potato. (c) Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org

Scientific classification

Kingdom: Animalia

Phylum : Arthropoda

Class : Insecta

Order : Coleoptera:

Family : Brentidae (=Curculionidae)

Genus : *Cylas*

Species: *C. puncticollis*

Life cycle

Egg

The egg is laid singly in small cavities on the sweet potato root or at the base of the vine. It hatches in about 3 to 7 days depending on the environmental conditions.

Larva

The **larva** is a legless grub, white in colour. The fully-grown grub is about 8 mm long. The head is comparatively large, and brown or pale-yellow. The body is slightly curved. The grub is found feeding on the vine near the base of the plant and goes down to the roots to feed. Larvae develop for 11 to 33 days before pupating.

Pupa and adult

The fully-grown grub turns into a pupa in an enlarged area of the feeding tunnel. The pupa is whitish and about 6 mm long. Initially it is white, but with time it becomes greyish in colour with darker eyes and legs. The pupa is similar to the adult in appearance, although the wings, the head and the long snout are bent downwards. Adults emerge after 7 to 28 days depending on the environmental conditions.

The length of the adult is between 6 to 8 mm. They vary in colour and in size according to the species. Cylas puncticollis is larger and entirely black. *Cylas brunneus* is brown with blue or bluish-green elytra (hard wings) and reddish legs, and is smaller than *C. puncticollis*. *Cylas formicarius* is as small as *C. brunneus* but has a bluish-black abdomen and a red thorax.

The weevils complete their lifecycle in the storage roots (tubers). They flying infrequently and generally only for short distances (500 to 1000 m). The development of the weevil from egg to adult takes 32 days in average.

Damage

Adult weevils feed on leaves, the underground **storage roots (tubers)** and the vines of sweet potatoes. They prefer to feed on storage roots, but at the beginning of the growing season, when the

plants have not yet produced storage roots, the adult weevils live on the **stem** and **leaves**. They lay eggs on vines and leaves, and the grubs will feed in the stem or the leaf and pupate inside the vines.

As the plant gets older and starts to form storage roots, the weevils search for exposed roots. Since they cannot dig, they reach the tubers through cracks in the soil. Weevils feed on the storage roots and lay eggs just below the surface of the root. Feeding and egg-laying punctures (numerous small holes) lower the quality of the root and can reduce the market price. If roots with egg punctures are stored they will serve as source of infestation for the clean roots stored beside them.

The grubs are more damaging, feeding, boring and making tunnels into the stems and roots. Damage to the stems may cause serious mortality to seedlings. Feeding in the vines causes thickening and malformation and often cracking of the tissue. A damaged vine is discoloured, cracked, or wilted. Stem damage is believed to be the main reason for yield loss, although damage to the vascular system caused by feeding, larval tunnelling and secondary rots reduce the size and number of roots.

Affected plant stages

Flowering stage, fruiting stage, post-harvest and vegetative growing stage.

Hosts range

The main host of all species of sweet potato weevil is sweet potato. *Cylas puncticollis* has also been reported on coffee, maize, cowpea and sesame

Control

1- Cultural control

Crop rotation

Avoid planting sweet potatoes in the same area for two to three successive seasons. It has been suggested that, if possible, sweet potatoes should be grown in a field only once every five years. Rice and sorghum are often used in rotation with sweet potatoes. This rotation will help break up the cycle of the weevil and will help to control sweet potato weevil, particularly if integrated with other management approaches.

Intercropping

Experimental studies in Taiwan showed that intercropping with chickpea, coriander, pumpkin, radish, fennel, black gram and yard long bean reduced weevil infestations considerably. However, intercropping with black gram, fennel, pumpkin, and yardlong bean also reduced sweet potato yields. The best results were obtained with coriander. Similarly, reduced weevil damage was observed when sweet potato was intercropped with proso millet and sesame, but sweet potato yield was also considerable reduced.

Use of clean cuttings

Carry-over of the weevils from an infested crop to the new planting could be reduced by carefully selecting fresh cuttings for planting a new crop. Use clean (insect-free) vines as planting material

Flooding of fields

Flooding of infested fields for at least 48 hours after completing harvest drowns weevils and induces rotting of the leftover plant materials and thereby reduces weevil densities from one planting to the next.

Storage pests

After the crop is harvested, it undergoes several operations that, if improperly done, may result in serious losses. Damage to grains may happen due to improper application of post-harvest practices such as threshing, drying or transporting. Insect pests inflict their damage on stored products mainly by direct feeding. Some species feed on the endosperm causing loss of weight and quality, while other species feed on the germ, resulting in poor seed germination and less viability.

Food and Agriculture Organization of U.N. predicts that about 1.3 billion tons of food areglobally wasted or lost per year. crop production contributes significant proportion of typical incomes in certain regions of the world (70 percent in Sub-Saharan Africa) and reducing food loss can directly increase the real incomes of the producers (World Bank, 2011).

COWPEA WEEVIL

Description

Adults are 2.-3.5 mm long. The adults emerge through windows in the grain, leaving round holes that are the main evidence of damage. The beetle is sexually dimorphic and males are easily distinguished from females. Females are darker overall, while males are brown. The plate covering the end of the abdomen is large and dark in color along the sides in females, and smaller without the dark areas in males. There are two morphs of C. maculatus, a flightless form and a flying form. The egg is clear, shiny, oval to spindle-shaped, and about 0.75 millimeters long .The larva is whitish in colour.

Adult stage of female and male cowpea weevil. (photographs by L. Blumer)

Scientific classification

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Coleoptera

Family: Chrysomelidae

Genus: Callosobruchus

Species: C. maculatus

Binomial name

Callosobruchus maculatus

(Fabricius, 1775).

Biology and ecology of Cowpea weevil

Eggs are small (0.75 mm long), clear, shiny and smooth, and oval or spindle shaped. They are firmly glued to the surface of pods and pulses. If the pods have opened, eggs are laid directly onto the seeds. Eggs hatch within 5-6 days of oviposition. The larvae are whitish and somewhat C-shaped with small heads. Upon hatching, they bite through the base of the eggs and bore into the seeds where they spend the whole lifecycle feeding on the seed. The larvae pupate inside the seed.

Pupation takes place in a chamber just under the testa of the seed. Pupation takes about 7 days to complete. The adult stage does not feed on stored produce. It is very short-lived. Usually it does not live longer than 12 days. During this time the female lay up to 115 eggs. The optimum temperature for egg-laying is about 30 to 35deg C. The whole lifecycle takes about 4 to 5 weeks.

Affected plant stages

Fruiting stage and post-harvest specially the seeds.

Damage

Cowpea weevils are important pests of pulses. Infestation commonly begins in the field, where eggs are laid on maturing pods. As the pods dry, the pest's ability to infest them decreases. Thus, dry seeds stored in their pods are quite resistant to attack, whereas the threshed seeds are susceptible to attack throughout storage. Infestation may start in the pods before harvest and carry over into storage where considerable losses may occur.

Levels of infestation in storage are strongly influenced by the type of storage structure and the variety of seed. Storage structures that maintain high levels of moisture in seeds are more prone to high levels of infestation.

Control measurement

Intercropping

Intercropping maize with cowpeas, and not harvesting crops late significantly reduced infestation by several species of cowpea weevil.

Sanitation

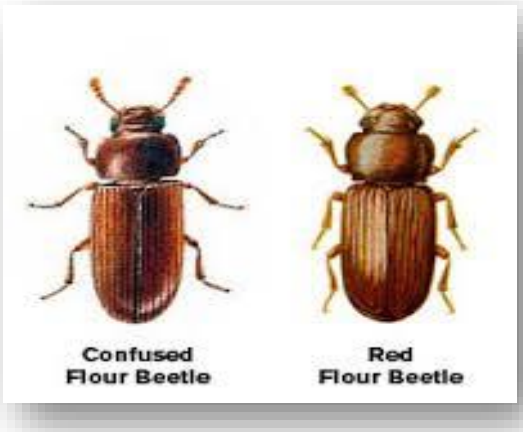
Good store hygiene plays an important role in limiting infestation by cowpea seed beetles. Remove infested residues from last season's harvest. General hygiene is also very important.

Solarisation

Solarisation (sun drying and heating) can be used to control infestations without affecting seed germination. When small lots are stored, sun-drying the beans can give substantial protection. Sun-dry the beans periodically in a thin layer for periods of up to 4 hours. Solar heaters or transparent bags of seeds left in the sun can provide excellent control of infestations.

RED FLOUR BEETLE

The red flour beetle *Tribolium castaneum* is a species of beetle in the family Tenebrionidae, It is a worldwide pest of stored products, particularly food grains. it attacks stored grain and other food products including flour, cereals, pasta, biscuits, beans, and nuts, causing loss and damage. It has been found that some "Tribolium" species may spread the parasite "Hymenolepis nana", a human platyhelmint parasite, as an intermediate host . *Tribolium castaneum & Tribolium confusum*, the confused flour beetle, are "the two most common secondary pests of all plant commodities in store throughout the world



Tribolium confusum and Tribolium castaneum - antennae comparison. Image: Unknown. http://www.floridabugs.com/FloridaInsects/Beetles/confused_flour_btls.html

Scientific classification

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Coleoptera

Family: Tenebrionidae

Genus: Tribolium

Species: T. Castaneum

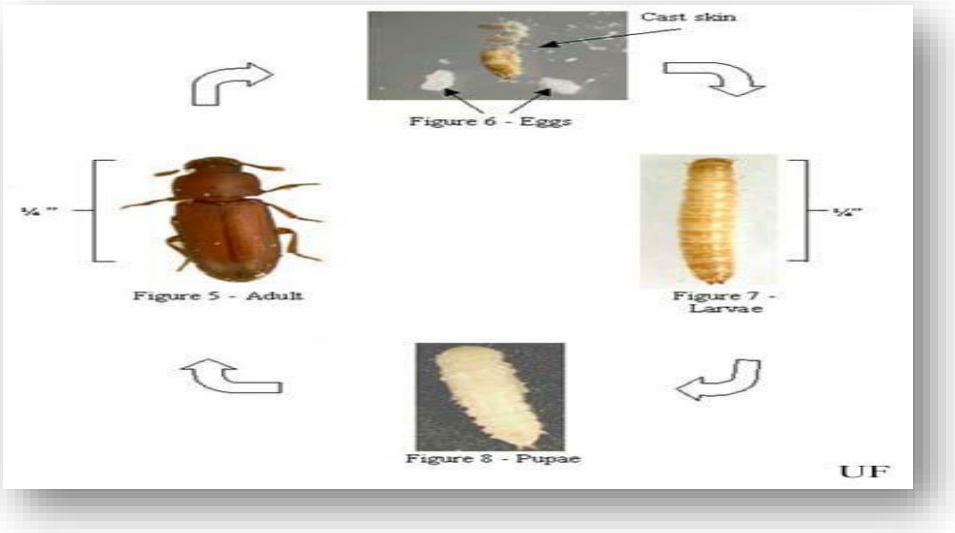
Binomial name

Tribolium castaneum

(Herbst, 1797

The life cycle of The red flour beetle

Both adults and larvae cause damage. . Female Red Flour beetles will deposit 200-500 eggs in food during a 1-2 year life span. Eggs hatch in 5-12 days . and the larvae can mature within 30 days or as long as 120 days depending on temperature. The life cycle of this species is shorter than the Confused Flour beetle . Both species attack maize, wheat, flour and other foodstuffs, but T. confusumdoes not seem to be as common as T.castaneumin tropical climates (see Hill, 1987; Mills & White, 1994). Members of genus Triboliumare known to produce toxic quinones whichcontaminate flour and flour products



life cycle of The red flour beetle. (Source Wikipedia)

Control Measures*:* Dispose of infested foods in wrapped, heavy plastic bags or in sealed containers. Examine foods like flour . Lightly heat infested or foods suspected to have infestations in shallow pan in the oven at 120 degrees F for one hour or at 130 degrees F for 30 minutes. Place in a deep freezer at 0 degrees F for four days, or heat in a microwave oven for five minutes. Heavily infested areas can be treated with proper insecticides and safe pest control techniques. Any possible insects that remain hidden in cracks and crevices can be treated with crack and crevice aerosols labeled for such use. Synergized pyrethrin aerosols and Baygon Aerosol are products used for crack and crevice work. Pyrethrins give a quick knock-down of insects in cracks and crevices.

KHAPRA BEETLE

The Khapra beetle (Trogoderma granarium), also called cabinet beetle. which originated in South Asia, is one of the world's most destructive pests of grain products and seeds.

Description of the insect

Adult beetles are brownish and 1.6–3 mm long. Immature larvae are up to 5 millimeters long and are covered in dense, reddish-brown hair. The eggs of the khapra beetle are cylindrical with one end more rounded and the other more pointed, about 0.7 mm long and 0.25 mm broad, weighing about 0.02 mg

Distribution

The khapra beetle is native to India and has become established in a number of Mediterranean, Middle Eastern, Asian and African countries.

Scientific classification

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Coleoptera

Family: Dermestidae

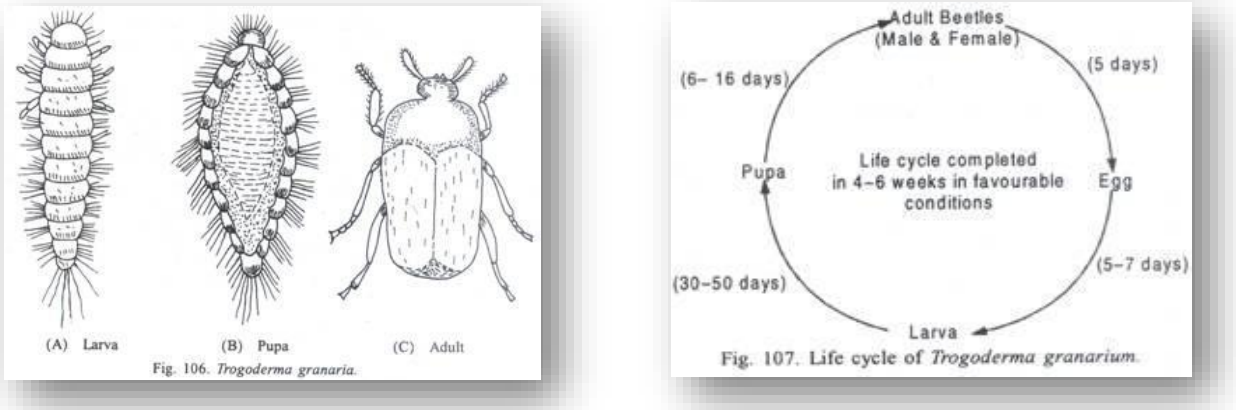
Genus: Trogoderma

Species: T. Granarium

Binomial name : *Trogoderma granarium*

Everts, 1898

Adult and larva of khapra beetle,* Trogoderma granarium *Everts. Photograph by S. Weingarten, University of Florida



Life cycle of Khabra Beetle (Source Wikipedia)

Life cycle

The life span of an adult khapra beetle is five to ten days. Larval development usually takes between four to six weeks, but can continue for up to seven years in adverse conditions. In optimal conditions, khapra beetles lay between 50 to 100 eggs in a year, which can create up to 10 generations of beetles in one year.

Economic Importance

Trogoderma granarium is a serious pest of stored products under hot dry conditions. Reproduction may be so rapid that larvae are found in large numbers in the surface layers of binned grain. Its discovery in a non-infested area usually leads to an immediate quarantine of suspected goods and an expensive eradication and control effort.

This beetle has never been observed to fly; therefore, its spread is probably dependent on movement of infested goods or in containers where it may be transported while in diapause

Detection and Management

The obvious signs of a khapra beetle infestation are the larvae and cast skins. However. The larvae look very similar to those of other relatively unimportant Trogoderma species, as well as some carpet beetles. Larvae and adults are best identified by microscopic examination.

Detection methods include examination of cracks and crevices and inspecting behind paneling on walls and under timbers, tanks, shelves, etc. Larvae are most likely to be seen just before dusk, since they tend to be more active at that time . Some fumigants give control at high dosages, even though this beetle is more resistant to fumigants than most stored product pests.

High concentrations of fumigant must be maintained over the fumigation period to allow penetration into all cracks and crevices. In an eradication program, both fumigants and surface sprays are used in combination with preventive measures, e.g., good sanitation practices and exclusion

MAIZE WEEVIL

The **maize weevil** (*Sitophilus zeamais)* can be found in numerous tropical areas around the world .This species attacks both standing crops and stored cereal products,. including wheat, rice, sorghum and maize

Maize weevil. (http://www.kznhealth.gov.za/environ/vector/maizeweevil.htm)

Description

the maize weevil has a length of 2.5 mm to 4 mm , This small, brown weevil has four reddish-brown spots on the wing covers.

Scientific classification

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Coleoptera

Family: Curculionidae

Subfamily: Dryophthorinae

Genus: *Sitophilus*

Species: *S. zeamais*

Binomial name : *Sitophilus zeamais*

Distribution

S. zeamais occurs throughout warm, humid regions around the world, especially in locations where maize is

Life cycle

The complete development time for the life cycle of this species averages 36 days. The female chews through the surface of the grain, creating a hole grown then deposits a small oval white egg, and covers the hole as the ovipositor is removed, with a waxy secretion that creates a plug. The plug quickly hardens, and leaves a small raised area on the seed surface. This provides the only visible evidence that the kernel is infested. Only one egg is laid inside each grain. When the egg hatches

into a white, legless grub, it will remain inside and begin feeding on the grain. The larvae will pupate while inside and emerge as an adult beetle. A single female may lay 300 to 400 eggs during her lifetime. Adults can live for 5 to 8 months Breeding conditions require temperatures between 15 and 34 °C and 40% relative humidity. When the adults emerge, the females move to a high surface and release sex pheromones. Males are then attracted to this pheromone

the life cycle of the maize weevil. (source WFP, http://foodqualityandsafety.wfp.org/types-of-insect-pests)

Damage and detection

Early detection of infestation is difficult. As *S. zeamais* larvae feed on the interior of individual grains, often leaving only the hulls, a flour-like grain dust, mixed with frass is evident. Infested grains contain holes through which adults have emerged.

A possible indication of infestation is grain, when placed in water, floating to the surface. In large stores of grain, an increase in temperature may be detected. The most obvious sign of infestation is the emergence of adults. One study recorded, 5 weeks after infestation, the emergence of 100 adults per kg per day.

NeemPro® relatively killed all the exposed weevils at 6 g/kg within 14 days

Control

Botanical pesticide

Host-Plant Resistance

Zea mays genotypes resistant to S. zeamais have been evaluated by Boica et al. The mechanism of resistance in maize to S. zeamais was investigated in relation to secondary chemistry and other biochemical and physical characteristics of maize genotypes. Phenolic acid content was correlated strongly with hardness of the grain.

WHITE GRUBS

Phyllophaga is a very large genus (more than 260 species). The adults are chafers, feeding on foliage of trees and shrubs. They may cause significant damage when emerging in large numbers. The larvae (called white grubs) feed on the roots of grasses and other plants.

Scientific classification

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Coleoptera

Family: Scarabaeidae

Subfamily: Melolonthinae

Genus: Phyllophaga

Harris, 1827

different types of white grubs. Typical white grub of the genus* Phyllophaga. *Photograph by John L. Capinera, University of Florida.

Lifecycle

The lifecycle takes about one year. Females lay 60 to 75 eggs over a period of about two weeks in midsummer. The white egg at first is elliptical (1.5 mm by 2.1 mm) but becomes more spherical as the larva inside develops. These hatch into white grubs about 18 days after laying. The newly hatched larvae are 8 mm long and grow to a length around 40 mm. They moult twice before winter. The third larval stage lasts nearly nine months, after which they pupate.

The greatest amount of damage occurs as the larvae move near the soil surface to feed on the roots of the plants. white grubs (Phyllophaga) . The Host plant species affected are Acacia (wattles) , Acacia decurrens (green wattle), Acacia nilotica (gum arabic tree), Capsicum, annuum (bell pepper), Citrus Coffea (coffee) ,Coffea arabica (arabica coffee) ,FicusFicus carica (fig), Saccharum officinarum (sugarcane),Sesamum indicum (sesame),Solanum lycopersicum (tomato) and Sorghum bicolor (sorghum) .

Symptoms

White grubs are polyphagous pests having a wide host range. There are a number of scarab beetles which cause damage in their adult and larval stages. The larvae of greatest importance are those which belong to the subfamily Melolonthinae.

Control Methods

Cultural Control

Cultural techniques are useful in reducing the number of larvae as well as adult populations. In endemic areas summer ploughing exposes the larvae of different stages which may then eaten by birds.The use of nitrogenous fertilizers, especially ammonia and urea, at high doses kill the first-instar larvae. Planting of resistant crop varieties also help to reduce white grub populations, especially in sugarcane . Mechanical Control Light traps can be used for collecting adult beetles during the night. The beetles can also be collected by shaking or jerking the host plants. The fallen beetles are collected and destroyed.

Biological Control

A number of biological control agents which attack white grubs in different parts of the world, have been reproduced Some pathogens such as Bacillus popilliae and Beauveria tenella [B. bassiana], and the nematodes Metarhizium anisopliae and Steinernema glaseri, have been very effective under field conditions for managing white grub populations orted by several workers.

Host-Plant Resistance

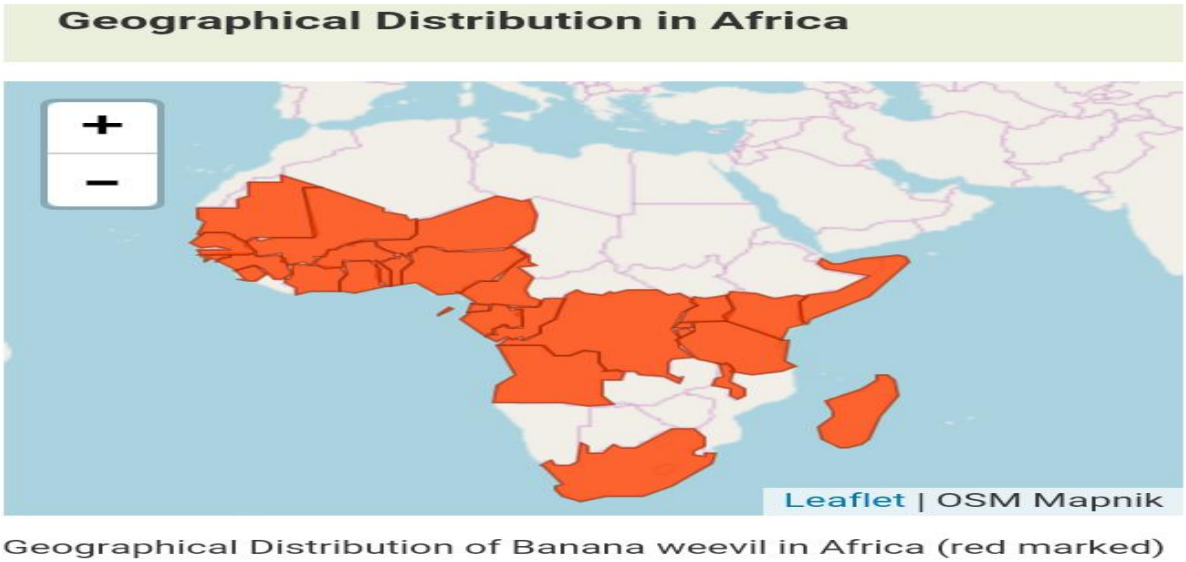
commercial varieties of sugarcane show partial resistance or tolerance to P. serrata (Melolontha).

BANANA WEEVIL

Cosmopolites sordidus (Germar), is a nocturnal insect which is not available in the day period for observation, Damage is mostly caused by the larvae, which burrow in the corm and pseudostem of the plant.

The banana weevil attack the xylem for interfering with water and nutrient absorption consequential in plant failure, reduced bunch weights, delayed maturation , and shortened plantation life. it is found in the soil at the base of the mat or related with crop residues.

Adult banana root borer, Cosmopolites sordidus (Germar). Photograph by G. McCormack, Cook Islands Biodiversity Database.



Geographical Distribution of Banana weevil in Africa (red marked)

Geographical distribution of Banana weevil borer. (Source Wikipedia)

Common Names:

Banana weevil borer, banana root weevil, banana root borer, banana rhizome weevil, banana borer

Scientific classification

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Coleoptera

Family: Curculionidae

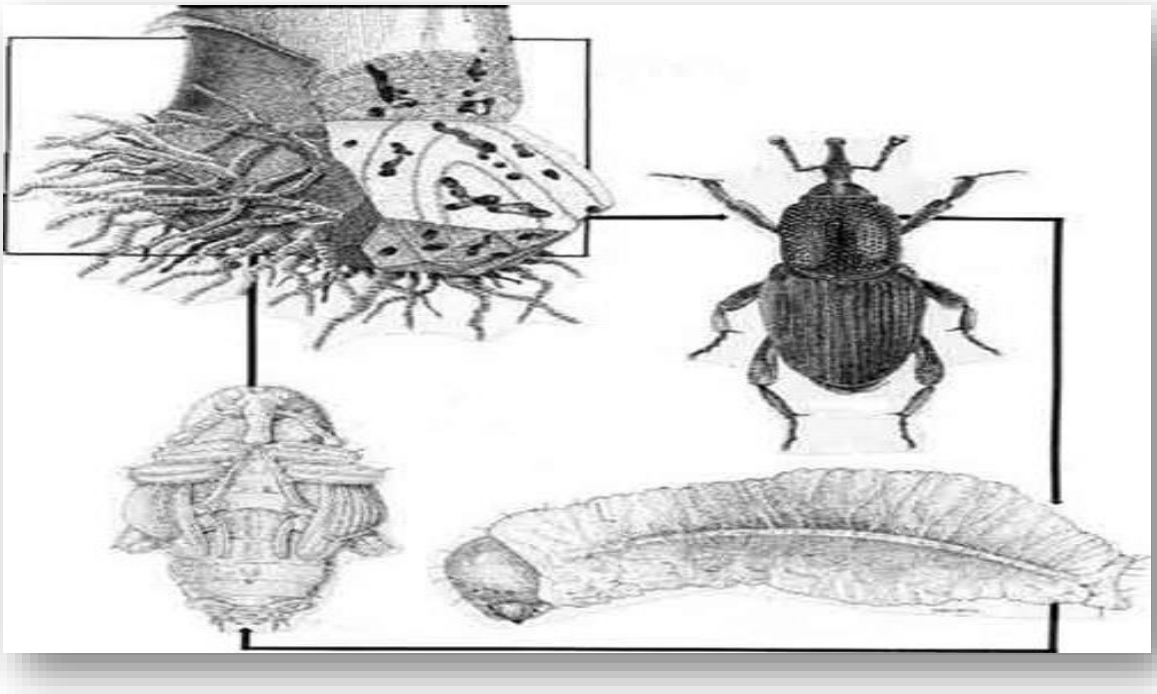
Genus: Cosmopolites

Species: *C. Sordidus*

Chevrolat, 1885

Life cycle

Mostly they lay their eggs between leaf sheaths at the pseudostem and in the region of the corm; the eggs are usually deposited singly with the newly hatched. According to the optimum temperature the egg hatches and the larva start boring into the corm. It passes through 5-8 instars. Pupation is in naked cells near the exterior of the host plant. The adults may survive for long periods without food.



Life cycle of the banana root borer, Cosmopolites sordidus (Germar). Clockwise from top right, adult, larva, pupa, and tunnels in the banana corm. Illustration by Cook Islands Biodiversity Database. EDIS - University of Florida

Control methods

There is not a perfect method to present complete control of banana weevil. Therefore, a broad integrated pest management must be applied for enhancing control technique.

Chemical control

The banana weevil has revealed the ability to build up resistance in most classes of chemicals insecticides.

Botanical pesticide

Botanical compounds may provide as substitutes for pesticides. Dipping suckers in a 25% neem seed solution which protects the juvenile suckers from weevil infestation by reducing oviposition through its repellent effect on adult female weevils. Egg existence rates may also be lowered in neem-treated plants.

ORDER: DIPTERA

FRUIT FLY

D. ciliatus is a major pest of a wide range of Cucurbitaceae in Africa, Asia and the Middle East. Adult flight and fruit transport are major means of dispersal.

Fruit fly species .(©RS. Copeland 2005)

Full classification

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Diptera

Family: Tephritidae

Genus: Dacus

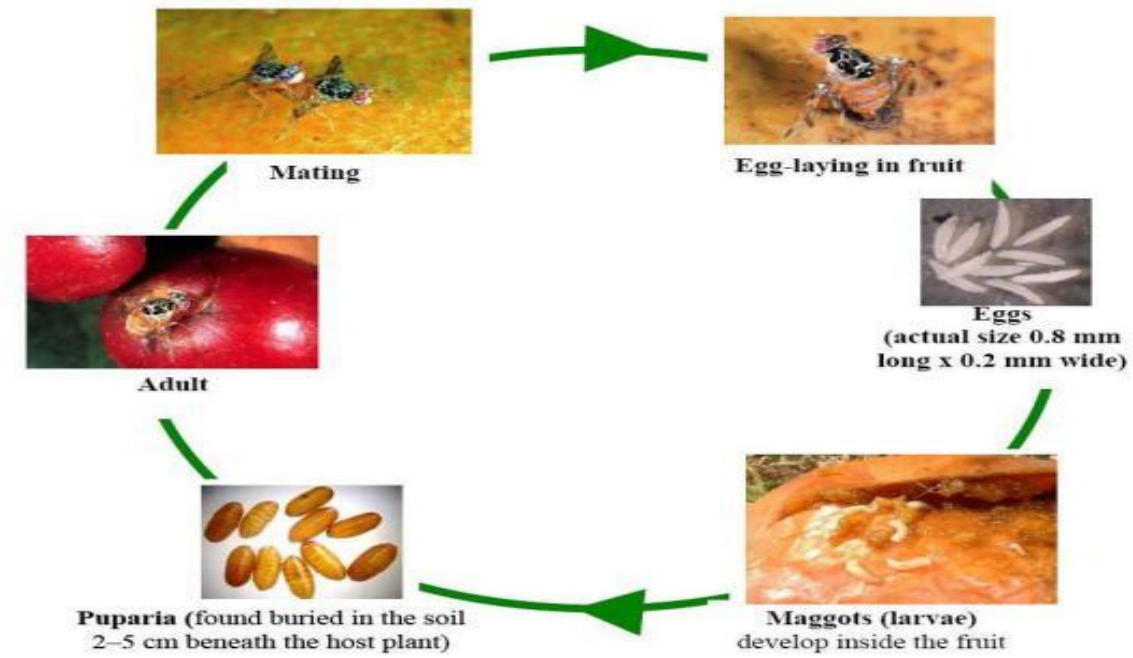
Species: Dacus ciliatus

Distribution

D. ciliatus is a major pest of cucurbits throughout Africa, Asia (Iran, Saudi-Arabia, Yemen, amongst others). New Zealand

Hosts/Species Affected
It affects wide range of Cucurbitaceae

Biology and Ecology
The fly undergoes a complete metamorphosis, with an egg stage, three larval stages, pupae and adult. D. ciliatus adults reach their sexual maturity at 14-15 days although there are data from Egypt stating that the adults reach their reproductive maturity). After 5-6 days during the summer and after 20-30 days during the winter (El Nahal et al., 1971). Females oviposit an average of 210 eggs
After the eggs hatch, the young larvae start to feed in the host, causing damage to the fruit. The final instar larvae of Dacus drop to the ground



the life cycle of fruit fly. ©S. Ekesi, icipe

Economic Impact
D. Ciliatus is a serious pest of cucurbit crops, It is reported to cause serious economic damage in Egypt (El Nahal et al., 197) . The global invasion of Tephritidae (fruit flies) attracts a great deal of attention in the field of plant quarantine and invasion biology because of their economic importance.

Control methods of Dacus spp
1-sterile male release technique

When 7 days old pupae were irradiated at 5 krad., partial sterility with normal longevity was observed in the adults while irradiation at doses of 8·5 and 10 krad. induced complete sterility with normal longevity and preoviposition period which lasted throughout their adult life

2- pirimiphos-methyl or trichlorphon were effective against *D. ciliatus*

Heterorhabditis bacteriophora (BA1) efficiently controlled *D. ciliatus* larvae and pupae, whereas treatment with profenofos and pirimiphos-methyl caused even higher mortality.

3- Plant Quarantine

GUAVA FRUIT FLY

Bactrocera correcta is a brightly colored little fly, predominately black with lateral yellow stripes approximately 5.4 mm in length. In his original description of *Bactrocera correcta* (as Chaetodacus correctus, Bezzi (1915))

male of bactrocera correcta. DPI Photograph by Jeff Lotx

Hosts

Recorded hosts include Citrus spp., Coffea canephora , guava

Full classification

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Diptera

Family: Tephritidae

Genus: Bactrocera

Species: correcta

Economic Significance

Adult fruit flies damage the fruit where they lay their eggs causing blemishes and discoloration. The maggots bore into the fruit, develop inside and pave the way for secondary invaders (fungi or bacteria), which cause extensive rotting and dropping of fruit.

Control

1- Cultural Control and Sanitary Methods

Collect and destroy affected fruit to reduce the inoculum. Rake the soil and flood fields for 24 hours to kill the pupae

2- Host-Plant Resistance

a few commercial guava varieties have shown resistance to or tolerance of B. correcta. The shape of the fruit influenced the damage

3- Chemical Control

A bait spray application of **malathion** killed congregating adults, Soil drenching with **azadirachtin** (a neem oil product) or neem seed kernal extract (NSKE) also killed pupating larvae

Damage from fruit fly . (http://preventfruitfly.com.au/why-is-fruit-fly-a-problem/)

VEGETABLE LEAF MINER

Liriomyza sativae, generally recognized as the vegetable leaf miner, it belonges to the family of Agromyzidae. The larvae of this fly mine invades a range of vegetables and weeds, but it favours different hosts such as Cucurbitaceae, Fabaceae and Solanaceae.

Description

Eggs of *L. sativae* measure roughly 0.25 by 0.12 mm and are transparent and whitish. The larvae are legless grubs, with no head capsule. They are translucent at first, but become yellowish-orange in later instars.

The pupae are oval and faintly flattened and vary in colour from yellowish-orange to a darker golden brown when the adults are nearly prepared to emerge. The adults are up to 1.7 mm long, with females being larger than males.

Adult and larval stage of Vegetable leafminer Liriomyza sativae. Adult of the American serpentine leafminer, *Liriomyza trifolii* (Burgess). Photograph by Lyle J. Buss, University of Florida.

Distribution

L. sativae occurs in the southern part of the United States, in Central America and in much of South America but recently it reported that it occurred in Kenya and many different parts of the world.

Scientific classification

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Diptera

Family: Agromyzidae

Genus: Liriomyza

Species: L. Sativae

Life cycle

The duration depends the temperature and climate factors; however he female lays eggs inside the leaf tissues of invaded plant, making small puncture holes. The developing larva feeds on the leaf tissue, creating a tunnel between the upper and lower surfaces as it advances.

After three instars, the larva cuts a slit, usually in the upper leaf surface, and falls to the ground where it pupates. The whole cycle takes twenty-five days. A female may lay several hundred eggs over the course of her life-span of a month.

Control methods

Leaf miners in general are kept under control by their natural enemies. The leaf miners quickly developed resistance to various insecticides used against them.

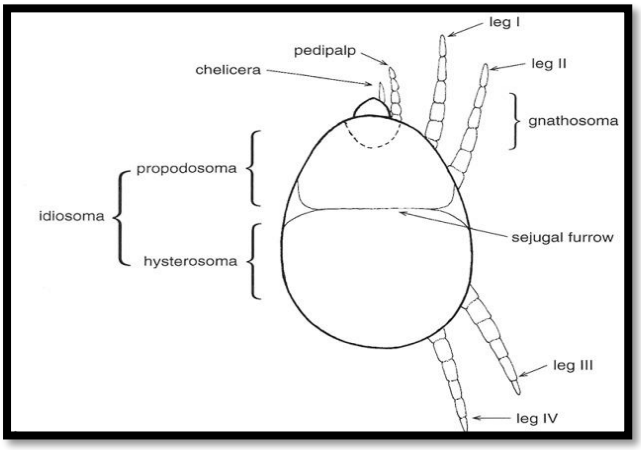
1- Application of entomopathogenic nematodes
2- Removing weeds around the cultivated crop

MITES

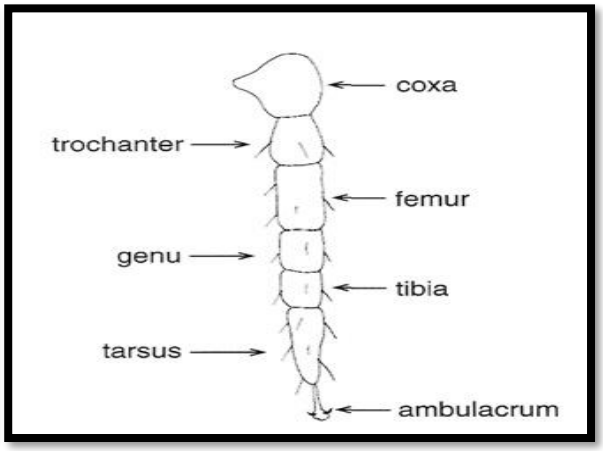
Mites form a subclass, known as the Acari, within the class Arachnida (phylum Arthropoda).

EXTERNAL FEATURES

Members of the Acari are minute or small arachnids and, although sharing many features of insects, usually lack obvious body segmentation. Unlike insects, mites have no antennae, compound eyes or wings, also, the body of a mite is composed of just two main sections. A gnathosoma (which bears a pair of segmented pedipalps and the mouthparts - including, ventrally, a beak-like hypostome) and a sac-like idiosoma (which bears the legs).



Structure of the body .(Source Wikipedia)



Segmentation of the leg of a mite. .(Source Wikipedia)

In some groups of mites, the idiosoma is subdivided by a sejugal furrow into an anterior propodosoma and a posterior hysterosoma .

DEVELOPMENT AND GROWTH

Most mites develop through an egg stage, a 6- legged so-called 'larval' stage and one, two or three 8-legged nymphal stages protonymphs, deutonymphs and tritonymphs, respectively. There are notable exceptions, for example: (a) in the super-family Eriophyoidea there is no larval stage; also, the adults and nymphs have just two pairs of legs . (b) in the family Tarsonemidae (order Prostigmata) the 6-legged larva, when fully fed, typically develops to adulthood through a sedentary and non-feeding, pupa-like .

SPIDER MITE

Spider mites are members of the Acari (mite) family Tetranychidae, which includes about **1,200** species.

Description

Spider mites are less than 1 millimetre (0.04 in) in size and vary in color. they lay small, spherical initially transparent eggs and many species spin silk webbing to help protect the colony from predators.

Red spider Mite. (http://www.canna.com.au/spider-mite-pests-diseases)

Scientific classification

Kingdom: Animalia

Phylum: Arthropoda

Class: Arachnida

Subclass: Acari

Order: Trombidiformes

Super family: Tetranychoidea

Family: Tetranychidae

Donnadieu, 1875 .

Hot, dry conditions are often associated with population build-up of spider mites. Under optimal conditions (approximately 80 °F or 27 °C), the two-spotted spider mite can hatch in as little as 3 days, and become sexually mature in as little as 5 days. One female can lay up to 20 eggs per day and can live for 2 to 4 weeks, laying hundreds of eggs.

populations to adapt quickly to resist pesticides, so chemical control methods can become somewhat ineffectual when the same pesticide is used over a prolonged period

Symptoms of red spider mites on plants. (http://www.canna.com.au/spider-mite-pests-diseases)

Control methods

IPM

1. Neem oil may provide control, when combined with a suitable surfactant and diluted with water. As with chemical control, repeated applications are required.
2. Predatory mites of the Phytoseiidae family, including *Phytoseiulus persimilis* eat adult mites, their eggs, and all developmental stages between. Predatory mites can consume as many as 5 adult spider mites per day, or 20 eggs per day .

Predator for red spider mite. (https://www.buglogical.com/spider-mite-predator/spider-mite-control-longipes/)

3- Cultural practices can have a significant impact on spider mites.

Dusty conditions often lead to mite outbreaks. Apply water to pathways and other dusty areas at regular intervals. Water-stressed trees and plants are less tolerant of spider mite damage. Be sure to provide adequate irrigation. Midseason washing of trees and vines with water to remove dust may help prevent serious late-season mite infestations.

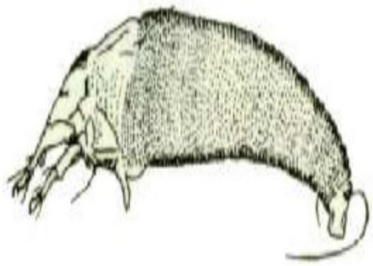
4- horticultural oil should be applied early in the season or late in the fall to destroy overwintering eggs

5- chemical control

If used carbaryl sevin, Spider mites frequently become a problem after applying insecticides. Such outbreaks are commonly a result of the insecticide killing off the mites' natural enemies but also occur when certain insecticides stimulate mite reproduction, For example, spider mites exposed to carbaryl (Sevin) in the laboratory have been shown to reproduce faster than untreated populations.

CITRUS BUD MITE

is a species of mite belonging to the family Eriophyidae. It feeds in leaf- and flower-buds of *Citrus* spp. causing deformation to leaves, flowers and fruit, and is a worldwide pest of citrus fruit production.



Citrus bud mite photo from CSIRO

Description

This minute yellowish or pinkish mite (reaching only 0.16 mm in length)

Scientific classification

Kingdom: Animalia

Phylum: Arthropoda

Class: Arachnida

Subclass: Acari

Order : Prostigmata

Family: Eriophyidae

Genus: *Aceria*

Species: *A. Sheldoni*

Binomial name

Aceria Sheldoni

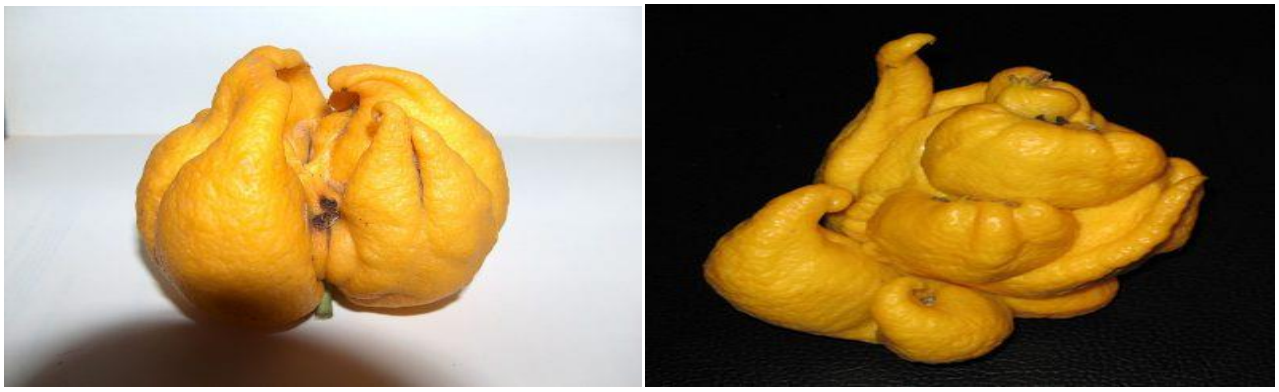
Ewing, 1937

Life cycle

Each female lays up to 50 eggs which hatch after 2–5 days. It goes through 4 pre-imaginal instars before reaching maturity.

Damage

Uncontrolled citrus bud mite damage may include deformed stems, leaves, flowers and buds; and leaf, flower or budgalls. The pests often feed inside the buds, resulting in malformed, stunted fruit. Although the mites attack all types of citrus, they are especially problematic in lemons.



Symptoms of Citrus bed mite (http://goldengategarden.typepad.com/golden_gate_gardener_/2009/04/lemon-sculpture.html)

Control

1- In backyard situations, predatory mites (*Phytoseiulus)* species usually keep bud mites under fairly good control.

2- 2- Horticultural oil sprays and insecticidal soaps are fairly effective citrus bud mite treatments when applied prior to bloom.

3- If the infestation is severe, use pesticides or miticides carefully and rotate chemical types every year to avoid development of chemical-resistant mites.

ROLE OF INTEGRATED PEST MANAGEMENT IN CROP PRODUCTION

IPM is a holistic approach to sustainable agriculture that focuses on managing insects, weeds and diseases through a combination of cultural, physical, biological and chemical methods that are cost effective, environmentally sound and socially acceptable.

Why Integrated pest management is significance for good crop production?

Because chemicals may Impact on environment. Pesticides can contaminate soil, water, grass, and other vegetation. In addition to killing insects or weeds, pesticides can be toxic to a host of other organisms including birds, fish, beneficial insects, and non-target plants .

1- IPM helps to keep a balanced ecosystem

2- Pesticide can be ineffective

3- IPM can save money

Legislation Legal Control

Preventing the entry and establishment of foreign plant and animal pest in a country or area and eradication or suppression of the pests established in a limited area through compulsory legislation .

Plant Quarantine

Legal restriction of movement of plant materials between countries and between states within the country to prevent or limit introduction and spread of pests and diseases in areas where they do not exist.

Biological Control

Biological control, in the sense used here, may be described as the regulation of pest populations by natural enemies (parasites, predators, and pathogens). The first known example of classical biological control occurred in the 18th century, when mynah birds imported from India were successfully used in the control of red locusts Biological control, when successful, generally has several advantages over control by insecticides. First, it is persistent; that is, once a control agent is established, it will exert a continuing influence on the population density of the pest. Secondlly , in part related to its persistence, biological control is cheap because one application of the control agent is usually sufficient.

Microbial Control

biological control is the using microorganisms (microbial control), specifically viruses, bacteria, protozoa, fungi, and nematodes . Good examples of introduced pathogens that work in this way are: (a) *Bacillus popilliae and B. lentimorbus, which cause milky disease* in the Japanese beetle. *B. thuringiensis (Bt) is by far the most successful microbial control agent, with several* million kilograms being produced annually. Commercial formulations of a number of its subspecies (notably *kurstaki, israelensis , and tenebrionis) are available for more than* 100 species, mostly lepidopterous and coleopterous pests of forest and agricultural (including stored products) pests, and for mosquitoes and black flies.The great advantage of Bt is that it can be cultured outside its hosts by liquid fermentation using cheap sources of protein such as soy meal.

Genetic Control

Methods for genetic control fall into two broad categories: (1) those by which pests are rendered less capable of reproduction and (2) those in which resistance is increased in the organism attacked by the pest. Included in this category is the genetically engineered introduction of microbial toxin genes into plants . A variety of genetic mechanisms are potentially applicable for regulation of a pest's reproductive capability, including dominant lethality[the basis of the sterile insect release method (SIRM).

The advantages of SIRM are its specificity, the permanency of its effect (though it may take several years to achieve this), and the fact that it does not pollute the environment.

Cultural Control

Cultural control, the use of various agricultural practices to make a habitat less suitable for reproduction and/or survival of pests, is a long-established method of pest control. Cultural control aims, therefore, to reduce rather than eradicate pest populations and is typically used in conjunction with other control methods .The agricultural practices used either may have a direct effect on the pest or may act

indirectly by stimulating population buildup of a pest's predators or parasites, or by making plants and animals more tolerant of pest attack .

Agricultural practices include:

(1) crop rotation to prevent buildup of pest populations

(2) planting or harvesting out of phase with a pest's injurious stage(s) which is especially important against species that have a limited period of infestation or for plants with a short period of susceptibility

(3) use of trap crops on which a pest will concentrate, making its subsequent destruction easy;

(4) soil preparation, so as to bury or expose a pest, or increase the crop's strength so that it can more easily tolerate a pest

Classification occurs according to universally applicable, internationally recognized rules established by the Swedish naturalist Carolus Linnaeus in his famous work *Systema Naturae,* published in 1735.

PATR TWO: BENIFICIAL INSECTS

HONEY BEE

Bees in the Animal Kingdom

Since then, all known living creatures have been divided into categories according to their different physiological and behavioral characteristics .

Apis is the genus, mellifera is the species, ligustica is the race, and spinola was the first person to describe this race.

The Colony and Its Organization

Honey bees are social insects, which means that they live together in large, well-organized family groups. Communication, complex nest construction, environmental control, defense, and division of the labor are just some of the behaviors that honey bees have developed to exist successfully in social colonies .

A honey bee colony typically consists of three kinds of adult bees: workers, drones, and a queen .

Honey bee . ©2006 Encyclopedia Britannica, Inc

QUEEN

Each colony has only one queen, except during and a varying period following swarming .It is the only sexually developed female, her primary function is reproduction. The queen produces both fertilized and unfertilized eggs. During peak production, queens may lay up to 1,500 eggs per day. They gradually cease laying eggs in early October and produce few or no eggs until early next spring

(January). One queen may produce up to 250,000 eggs per year and possibly more than a million in her lifetime. The queen can live for several years, sometimes for as long as **5**, but average productive life span is 2 to 3 years.

The second major function of a queen is producing pheromones that serve as a social "glue" unifying and helping to give individual identity to a bee colony. The queen mates, usually in the afternoon, with seven to fifteen drones at an altitude above 20 feet. Drones are able to find and recognize the queen by her chemical odor (sexy pheromone). The queen is constantly attended and fed royal jelly by the colony's worker bees.

DRONES

The drone's head is much larger than that of either the queen or worker, and its compound eyes meet at the top of its head , they have no stinger, pollen baskets, or wax glands. Their main function is to fertilize the virgin queen during her mating flight, but only a small number of drones perform this function.

drones eat three times as much food as workers, an excessive number of drones may place an added stress on the colony's food supply. When cold weather begins in the fall and pollen/nectar resources become scarce, drones usually are forced out into the cold and left to starve.

WORKERS

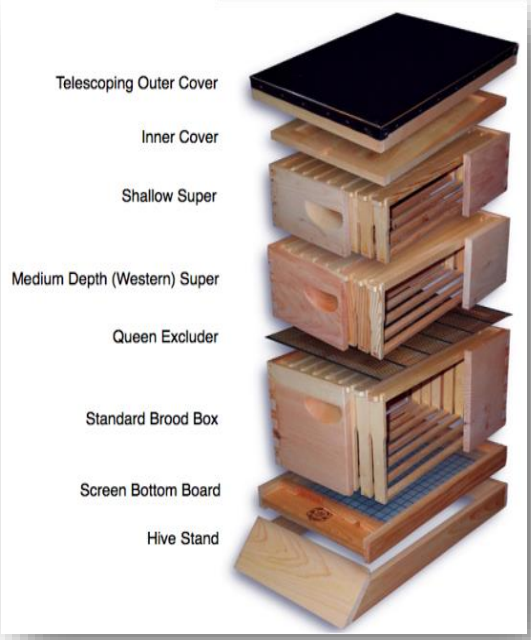
Workers are the smallest bodied adults and constitute the majority of bees occupying the colony. They are sexually undeveloped females and under normal hive conditions do not lay eggs. they have specialized structures, such as brood food glands wax glands, and pollen baskets, which allow them to perform all the labors of the hive.

Laying Workers

When a colony becomes queenless, the ovaries of several workers develop and workers begin to lay unfertilized eggs. Normally, development of the workers' ovaries is inhibited by the presence the queen because of her Phermons.

BEEKEEPING EQUIPMENT

Equipment vary with the size depending on your operation, number of colonies, and the type of honey you plan to produce. The basic equipment you need are the components of the hive, protective gear, smoker and hive tool. Today most beekeepers in the world use the Langstroth or modern ten-frame hive.

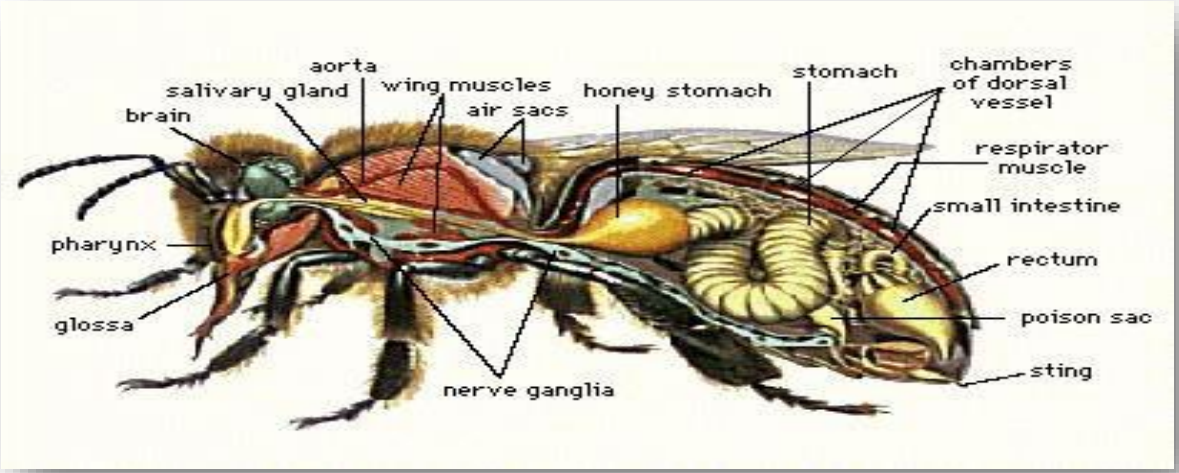


Bee hive. https://tapasrioja.es/es/blog/67_Top-diferencias-entre-las-colmenas-Langstroth.html

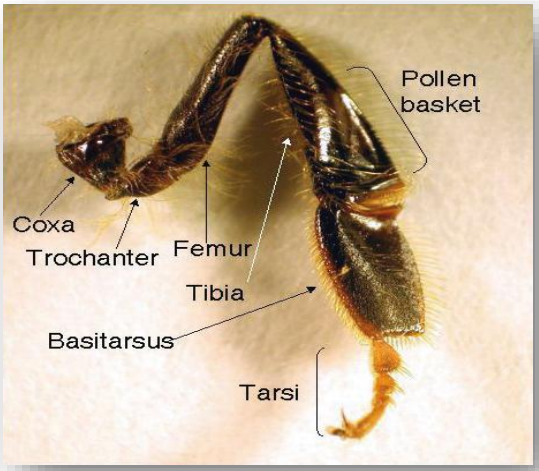
Bee hive smoker. https://www.walmart.com/ip/New-Bee-Hive-Smoker-Stainless-Steel-w-Heat-Shield-Beekeeping-Equipment-from-VIVO-BEE-V001/170544894

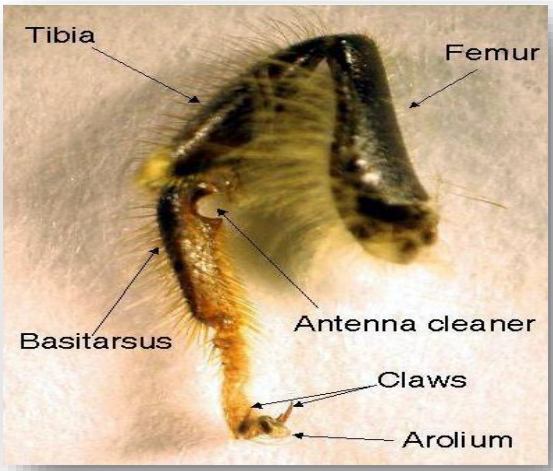
Hive tool . (http://www.beeware.co.za/shop2/index.php?

Anatomy Of A Honey Bee



Anatomy of honey bee. http://tweetboard.me/anatomy-of-a-bee-sting/anatomy-of-a-bee-sting-beepedia-stings-conceptual-learning-in-bees-proceedings-on/





Hind leg showing pollen basket and comb *where as* ***Front leg showing antenna cleaning notch****.*
http://articles.extension.org/pages/21756/thorax-of-the-honey-bee

The Effect of Bee Products on Human Health

Honey bee produces diffrent substance that influence the human health for healing or nutritiona aim. Main honey bee products are : Bee honey, Royal jelly, Bee pollen grain, Bee venom , Bee propolis and Bee wax.

Bee honey. (Source Wikipedia)

Royal jelly. (Source Wikipedia)

Bee pollen grain. (Source Wikipedia)

Bee venom. (Source Wikipedia)

Bee propolis. (Source Wikipedia)

Bee wax. (Source Wikipedia)

THE BENEFITS OF THESE PRODUCTS

Bee venom (BV) (api-toxin) has been widely used in the treatment of some immune-related diseases, as well as in recent times in treatment of tumors. Several cancer cells, including renal, lung, liver, prostate, bladder, and mammary cancer cells as well as leukemia cells, can be targets of bee venom peptides such as melittin and phospholipase A2 **.**

Recent research proved that one of the peptides in bee venom, melittin, has a strong inhibitory effect on the Lyme spirochete at very low doses. When the spirochete is inhibited it does not multiply and is vulnerable to the host's own immune system and to medication.

Fresh royal jelly has the capacity to mimic the functions of estrogen in humans (as showed in the Japanese study made in 2007), which leads to regulating hormones and balancing them, This may

explain its good results in women suffering from polycystic ovary syndrome (PCOS), and menstrual irregularities .

Researchers at Washington University in St. Louis (WU) say they've found a way to effectively destroy the HIV virus using a toxin found in bee venom , they used nanoparticles to distribute melittin in laboratory studies, the have seen that the toxin melittin is able to poke holes in the protective coating of HIV and other viruses , nanoparticles attack a crucial part of HIV's structure, they can kill before the virus has a chance to infect a person.

East african beekeepers

Somali professional beekeepers. (Source SONRREC)

TYPES OF BEES

There are nearly 20,000 known species of bees in seven recognized biological families.

Scientific classification

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Hymenoptera

Super-family: Apoidea

Family: Apidae

Includes: honey bees, bumblebees and stingless bees

SILKWORM

The silkworm is an economically important insect for producing silk, the larva or caterpillar after feeding mulberry leaves the secretion of the silk takes place. The silks are produced by labial glands, which are composed of a few tens or hundreds of large polyploidy cells that secrete polymerizing proteins which are stored in the gland lumen as a semi-liquid gel. The mechanism of long-term

storage of the silk dope inside the glands and its conversion into the silk fiber during spinning is not fully understood.

Description

An adult silkworm has a wingspan of 40 to 50 mm and has a thick bristly body; the adult male is less than the adult female.

Silkworm. (Source Wikipedia)

Scientific classification

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Lepidoptera

Family: Bombycidae

Genus: Bombyx

Species: *B. Mori*

The lifecycle

Silkworm life cycle . https://kullabs.com/classes/subjects/units/lessons/notes/note-detail/811

Popular Silkworm Breeds

Silkworm breeding seeks to accomplish superior performances in value of egg yield, cocoon raw silk yield, cocoon firmness, and production followed by spreading out to new areas besides others. Silkworm breeders carry on striving for an inherent gain in resistance by incorporating resistant genes into the genetic backgrounds of high yielding temperate.

Colour of different cocoons from different breed

Different colours of silkworm cocoon. https://www.artofsilk.com/blogs/news/6314356-an-introduction-to-silk-cultivation-sericulture#.W3lpzbBR2M8

Current conditions of the sericulture industry in East Africa

As defined by the African Development Bank, 11 countries constitute East Africa Comoros, Djibouti, Eritrea, Federal Democratic Republic of Ethiopia, Republic of Kenya, Republic of Madagascar, Mauritius, Republic of Seychelles, Federal Government of Somalia, United Republic of Tanzania, and Republic of Uganda.

Among these countries, rearing of silkworms occurs in Ethiopia, Kenya, Madagascar, and Uganda, while this silkworm is introduced from Asian countries. Sericulture in East Africa has a history of more than 30 years, but actual conditions in each country have not been successful because sericulture and silk reeling technologies are immature and the market cannot be secured.

Mulberry Cultivation

Mulberry trees succeed in warm temperate and subtropical regions of Asia, Africa, Europe, and the Americas. Mulberries are widely distributed because the berries are a favourite food of the birds that scatter the seeds in their droppings. There are many varieties of mulberry trees. Silkworms will only eat the leaves of the white mulberry tree *Morus alba*.

Plantation of white mulberry tree *Morus alba* started in china more than 4000 years ago,then it extensively dispersed in many parts in warm temperate area continents.

Sericulture in East Africa. http://www.smallstarter.com/get-inspired/10-extreme-african-business-opportunities-are-you-brave-enough/

Future demand for silk

The present global silk production is fluctuating around 70, 000 to 90, 000 M.T. and the demand for silk is annually rising by 5%. With the increase in population and also with the increased demand for designer clothing items due to fast changing fashion designs in developed countries, the demand for silk is bound to increase even more. For going up the silk production we need highly productive mulberry varieties and silkworm races and also silkworm races tolerant to adverse climatic conditions and diseases which can come mainly from the sericultural germplasm resources and also from the wild relatives of *Bombyx*available in the natural habitats.

Silkworm in east Africa

Studies show that mulberry plant can grow and thrive very well in East African countries (Kenya, Ethiopia and Tanzania) as well as it is anticipated that one metric ton of mulberry leaves is indispensable for the rearing of silkworms emerging out of one case of eggs which will yield about 25 kg to 30 kg of cocoons of high quality.

THE NUTRITIONAL VALUE OF SOME INSECTS

Locust

Species of locusts diverge in protein content from about 50 percent of dry weight to round about 60 percent, making them denser in protein than cows. Locusts also have sufficient amounts of iodine, thiamine, iron, phosphorus, niacin, riboflavin as well as traces of magnesium, selenium and calcium.

Locust prepared as food for human. (Source Wikipedia)

PARASITOID INSECTS

A parasitoid is an organism that spends a significant part of its life cycle attached to or within a single host organism in association where the host is eventually killed. About 10% of insect species behave as parasitoid lifestyle. They can be found in six orders: Diptera, Hymenoptera, Neuroptera, Coleoptera , Trichoptera, and Lepidoptera. Most of them are in the Hymenoptera, and the smaller amount of them being within the Trichoptera.

Aphidius colemani, Aphidius ervi and Aphelinus abdominalis are all natural aphid parasites and very useful and effective for the prevention and low-infestation management of various aphid species.

Aphidius colemani. https://greenmethods.com/aphidius/

NATURAL ENEMIES

TRICHOGRAMMA

Trichogramma wasps are tiny wasps that are endoparasitoids insect eggs of over 200 species of moths and caterpillars. Trichogramma lays its eggs inside the eggs of moths preventing the moth egg from hatching into a caterpillar. This prevents the damage caused by the feeding caterpillars, and also breaks the life cycle of the pest, effectively preventing the pest from reproducing. In some species of moth up to 5 parasite eggs may be laid in each moth egg. As the parasite develops within the egg, it turns black, and after about 10 days, an adult Trichogramma emerges. Adult Trichogramma can live up to 14 days after emergence.

Scientific classification

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Hymenoptera

Family: Trichogrammatidae

Genus: Trichogramma

Species: brassicae

Female laying egg inside the hosts' egg. © 2017 Regents of the University of California

The wasp larvae kill pests before they damage plants by consuming their eggs. Trichogramma wasps protect plants throughout the growing season. In general, regular releases of Trichogramma ensures generations of mated females ready to attack moth eggs, and improves levels of control. Releases should be started when moths are first detected. Although the Trichogramma is minute, it can search for moth eggs over considerable distances.

Description:
To describe Trichogramma wasps with one word: tiny. These wasps are one of the smallest insects on the planet. Trichogramma wasps have constricted abdomens, short antennae. Trichogramma wasps have two pairs of wings and an ovipositor (stinger) on the females. Since it is so small, not much is known to describe the eggs, larvae or pupae.

Ladybird beetles

Ladybird beetles are distributed throughout the world. They are commonly yellow, orange, or red with small black spots on their wing covers, with black legs, heads and antennae. However such colour patterns vary greatly. Coccinellids are best known as predators of aphids and scale insects. A single lady beetle may eat as many as 5,000 aphids in its lifetime.

Scientific classification

Kingdom:	Animalia
Phylum:	Arthropoda
Class:	Insecta
Order:	Coleoptera
Suborder:	Polyphaga
Superfamily:	Cucujoidea
Family:	Coccinellidae

Ladybird beetles adult and larval stage feeding their prey. University of Maryland Extension

Life cycle
Female ladybugs lay their eggs on the underside of leaves. This is to protect them from being seen by flying predators as well as from the weather. In most species of ladybird these eggs hatch into a larval state within a week. This state lasts 10 – 15 days, and they then go into a pupal stage before becoming an adult ladybird. The entire life cycle of the ladybird is only 4 – 7 weeks where the temperature is key factor.

Green lacewings

Green lacewings are delicate insects with a wingspan of 6 to over 65 mm, though the largest forms are tropical. The bodies are usually bright green to greenish-brown, and the compound eyes are conspicuously golden in many species.

Scientific classification

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

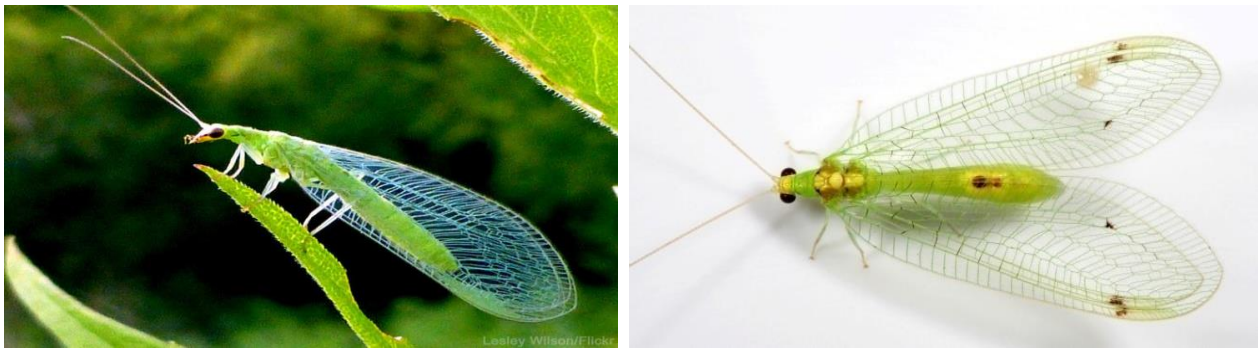
Order: Neuroptera

Family: Chrysopidae

Subfamilies

Apochrysinae

Chrysopinae



Adult stage of Green lacewings. https://www.marijuana.com/news/2016/08/grow-guide-biological-pest-control/

Egg and Larva of Green lacewings. https://nature.mdc.mo.gov/discover-nature/field-guide/green-lacewings

The adult stage typically feeds on pollen, nectar and honeydew; some species are predaceous as adults to a limited extent. Green Lacewing female lay their eggs at the end of long (about 1/4 inch) stalks, presumably to protect them from ants and other lacewing larvae. The larval stages are voracious predators. Green Lacewing larvae are called aphid lions for good reason, as they are

especially tender of aphids. They also prey on a wide variety of other soft-bodied insects and mites, including insect eggs, thrips, mealybugs, immature whiteflies and small caterpillars

CULTURING INSECTS

Many species of insects are kept regularly in culture for reason ranging from commercial sale to scientific research and even conservation and reintroduction to the wild. Much of our understanding of genetics and developmental biology comes from *D. melanogaster*, a species with a short generation time of about 10 days, high fecundity with hundreds of eggs in a lifetime, and simplicity of culture in simple yeast-based media. These characteristics allow large-scale research studies across many generations in an appropriate timescale. Other species of *Drosophila* can be reared in a comparable manner, although they often need more particular dietary requirements, as well as micronutrients and sterols. *Tribolium* flour beetles are reared exclusively on flour. However, many phytophagous insects can be reared only on a particular host plant, in a time- and space-consuming program, and the search for artificial diets is an important component of applied entomological research.

Edible insects:

Future prospects for Food and feed security

It is widely established that by 2050 the world will mass 9 billion people. To accommodate this number, current food production from pants and animals will necessitate to almost double. Land is limited and expanding the area devoted to farming is rarely a viable or sustainable option. Climate change, drought and related water shortages, Oceans are overfished all these situations could have profound implications for food production. There are nearly one billion chronically hungry people distributed worldwide.

Edible insects will turn out to be part of human diets, but in some culture there is a degree of find objectionable for their consumption. Although the Most of edible insects are collected from forest environment, innovation in mass-rearing systems has started in many countries.

More than 1 900 species have been used as food. e. Globally, the most normally consumed insects are beetles (Coleoptera) (31 percent), caterpillars (Lepidoptera) (18 percent) and bees, wasps and ants (Hymenoptera) (14 percent).

Environmental opportunities

In addition, insects can be reared on organic side-streams (including human and animal waste) and can help reduce environmental. Insects are reported to emit fewer greenhouse gases and less

ammonia than cattle or pigs, and they require significantly less land and water than cattle rearing contamination. Compared with mammals and birds, insects may also pose less risk of transmitting zoonotic infections to humans, livestock and wildlife, although this topic requires further research.

Nutrition for human consumption

Insects are a highly nutritious and healthy food source with high fat, protein, vitamin, fibre and mineral content. The nutritional value of edible insects is highly variable because of the wide range of edible insect species. Even within the same group of species, nutritional value may differ depending on the metamorphic stage of the insect, the habitat in which it lives, and its diet. For example, the composition of unsaturated omega-3 and six fatty acids in mealworms is comparable with that in fish (and higher than in cattle and pigs), and the protein, vitamin and mineral content of mealworms is similar to that in fish and meat.

Farming systems

The majority of edible insects are harvested in their natural habitat. Conversely, some insect species, such as bees and silkworms, have a long history of domestication for the reason of the value of their products. Insects are also reared in large numbers for the uses of biological control (e.g. as parasitoids and predators), health (e.g. maggot therapy) and pollination. The idea of farming insects for food is, however, relatively new.

Globally, 2 billion people consume insects, a practise known as entomophagy. It is more common in Africa than anywhere else in the world. The continent is home to the richest diversity of edible insects. The main insect eating countries are the Democratic Republic of the Congo, Congo, Zimbabwe, Uganda, Central African Republic, Cameroon, Nigeria Zambia, and South Africa

Eating insect as protein source. https://www.newsrimini.it/2015/11/finiremo-i-nostri-giorni-mangiando-insetti/

Insects as animal feed

Recent high demand and consequent high prices for fishmeal/soy, together with increasing aqua-cultural production, is approaching new research into the development of insect protein for aquaculture and poultry. Insect-based feed products could have a similar market to fishmeal and soy,

which are currently the key components used in feed formulae for aquaculture and livestock. Accessible evidence suggests that insect-based feeds are equivalent with fishmeal and soy-based feed formulae.

Processing

Insects are often consumed whole but can also be processed into granular or paste forms. Extracting proteins, fats, chitin, minerals and vitamins is also possible. At present, such extraction processes are too expensive and will require to be further developed to make them profitable and applicable for industrial use in the food and feed sect

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