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AN EXTENSIVE APPRAISAL OF LIFE CYCLES, ECOLOGICAL CHARACTERISTICS OF MULBERRY AND SILKWORM ASSOCIATED INSECT PESTS

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Abstract

Sericulture is the 'Siri' culture, which means it generates wealth, upon silkworm rearing and silk cocoon production. *Morus alba* (Mulberry), the sole food source of the silkworm (*Bombyx mori*) was one of the first domesticated forages in the world and has great economic importance to sericulture. The probability of sericulture and cocoon quality depends on the leaf quality of mulberry as it provides 70% of the protein involved in the silk protein production of the silkworms. Mulberry is prone to attack by many insect pests which cause quantitative and qualitative damage resulting in a decrease in sericulture productivity. Several species of insect pests belonging to different orders of Arthropods like Lepidoptera, Hemiptera and Coleoptera, Diptera, Orthoptera, Hymenoptera, Thysanoptera, have been reported as insect pests on mulberry. Among them leaf defoliators and sap suckers are treated to be major insect pests as they cause more damage to the mulberry. Addressing this concern, around 26 major mulberry pests are identified and their lifecycles are reviewed in detail to understand the underlying mechanisms and to explore effective pest management strategies for biological control and quality production of Mulberry leaf which directly enhances quality cocoon production and silk generation

Introduction

Mulberry leaves contain all the required nutrients, carbohydrates, and proteins that are required for the growth of silkworms. The quality of the silk cocoon and health of the silkworm directly depends on the quality of the mulberry leaf. The major factors that determine the mulberry crop are the genetic potential of the variety, suitable

nourishment, cultivation practice and plant protection measures. The most effective and cheapest method for superior-quality of leaf production is the cultivation of improved varieties of mulberry.

Phylum Arthropoda is the most diverse and ubiquitous phylum of super kingdom Eukaryota, where out of 5.57-9.8 million estimated animals in the world, about 4-8 million species are insects, which implies that three-fourths of the total described living organisms present on earth are insects (Lokeshwari and Shantibala, 2010). The origin of insects was dated to the early Ordovician period (~479 million years ago), insect flight to the early Devonian period (~406 Ma), and the major extant ancestry belong to the Mississippian period (~345 Ma) and the major diversification of the holometabolous insects to the early cretaceous period (Misof, 2014; Mayer *et al.*, 2014).

Global climatic atmosphere changed several times during the antiquity of Earth, along with the diversity of insects. The winged insects underwent a major radiation in the carboniferous (356 to 299 Ma) while the insects go through different life stages with metamorphosis undertake another major radiation in the Permian (299 to 252 Ma). During co-evolution, a number of highly successful insect groups- especially Butterflies (Lepidoptera), Beetles (Coleoptera), wasps, bees and ants (Hymenoptera) as well as many types Bugs (Hemiptera), Flies (Diptera) evolved during the Cretaceous (145 to 66 Mya), (Renne, Paul, R. *et al.*,2013).

Review

Insect Significance

Insects represent over half of the planet's biological diversification. Insects are important because of their diversity, influence on agriculture, human health, ecological role, and natural resources. They have been used in landmark studies in biomechanics, climatic change, developmental biology, ecology, evolution, genetics and physiology. Insects produce the biological foundation for all terrestrial ecosystems. In every terrestrial ecosystem, insects play key ecological roles in functionally various ecological processes including maintaining soil structure and fertility, nutrient cycling, seed dispersal, pollination and pest control, bioturbation. Insects, as drivers of ecosystem functions, play a vital role in agroecology, the management of the agricultural system in an ecologically sound and sustainable way by encouraging the existing ecosystem services (ES) (Jankielsohn, 2018).

Insects have always been predominantly considered as competitors in the race for their own survival. The dominant biotic relationship found to be existing in the ecosystem is the insect-plant relationship. Crop production possesses a direct proportion with ecosystem functions provided by insects, thus proving insects to be vital part of human survival. Globally, the insect pollination services estimated to contribute 9.5% to the total yield of crop production in the agriculture sector. Insects also improve fertility of agricultural soil by increasing calcium, potassium, nitrogen,

phosphorous, magnesium or total protein content which significantly elevates the crop yield.

Insect as Pests

Phytophagous insects can be potential pests that can have deadly effect on the host, but only less than 10% have reached the status of being minor pest. The insect defoliators have devastating effect on the growth and survival of the forest trees. Major insect pests in agriculture are usually introduced species without their natural biological control agents. A thorough knowledge of morphology, damaging stage, vulnerable stage of pest, nature of damage, pre disposing factors, susceptible stages of host, natural enemies and predators help in preventing and controlling them effectively. All insects belong to the class Insecta. Their body is segmented and mostly contain three main segments, i.e., head, thorax and abdomen. Insects have two pair of wings and three pair of legs. According to structure of wing, they are classified into different orders, such as coleopteran, Diptera, Hemiptera, Hymenoptera, Isoptera, lepidoptera and Orthoptera etc. All these insects belonging to different classes and orders may have different life cycles with different damaging stages and nature of damage in different fields. With a view to accomplish a better pest management, all these factors are important but the most important is nature of Damage and damage stage, they attack the host.

Insect Pests in Seri-ecosystem

About 300 insects and non-insect pests are known to inflict damage to mulberry in different places of the world. Several root, stem, leaf, diseases are caused by fungi, bacteria, viruses, mycoplasma and nematodes. Bacterial blight, leaf mosaic, powdery mildew, leaf spot, leaf rust, stem canker, violet root rot, white root rot, root knot and dwarfing are the major disease on mulberry. The foliar disease powdery mild dew, leaf spot, leaf rust, leaf mosaic and bacterial blight are considered to be serious diseases on mulberry because they cause direct damage to the plants leads to the considerably loss of yield.

The major diseases of mulberry are pink mealy bug (*Maconellicoccus hirsutus*), bihar hairy caterpillar (*Spilarctia obliqua*), papaya mealy bug (*Paracoccus marginatus*) and leaf webber or leaf roller (*Diaphania pulverulentalis*) Thrips (*Pseudodendrothrips mori*), Wingless Grasshopper (*Neorthacris acuticeps*) were reported to be the major pests of mulberry. The Minor Insect pests are aphids *(Toxoptera odinae) etc.* The information regarding, biological and life cycles of 26 insect pests of Seri-ecosystem are discussed in the current review.

Lepidopteran Insect pests

Various insect pest species belonging to the families namely Pyrilidae, and their lifecycles, habit and habitat forms, seasonal occurrence, symptoms and the biological control are tabulated in table 1. The pictorial representations of life cycles were also depicted.

S.No	Species Name	Seasonal Occurrence	Damage & Symptoms	Biological Control

1	***Diaphenia pulverulentalis*** **Family** Pyralidae **Habit** Nocturnal **Habitat** From the mulberry plant, in Phulambri and Gangapur mulberry fields, Aurangabad district, Maharashtra, and Mulberry fields of Palamaner mandal of Chittoor district, India.	The infestation is noticed on the onset of monsoon i.e., from June and lasts upto February. Peak period of infestation is November to February.	In Karnataka, Maharashtra, Andhra Pradesh, it is a major defoliator pest known to cause extensive damage to mulberry. The apical portion of the mulberry shoot is the leaf webber's target area. With the help of silken thread, the larva binds mulberry leaf blades in tender shoot portion, hides inside and devours the soft green tissue of the leaf surface. As this pest vandalize the apical shoot portion growth of plant is affected which leads to adverse impact on leaf production.	Infested portion along with the larva is cut off into polythene bag and destroy by burning or dipping in 0.5% soap solution. Flood irrigation helps to kill pupae. Release of larval parasitoid Barcon, Collect and burn the dry leaves to destroy pupae.

2	***Delias eucharis*** ***Habit*** Nomadic in behavior and found in variety of environments ***Habitat*** *Delias eucharis* found wherever there are trees, also in towns and cities. They are mostly found all over India except in desert tracts. Also found in the Sericulture districts of Andhra Pradesh and Tamil Nadu	Population of this insect was abundant during flowering and fruiting stages, i.e., November to March. (Nilanjan Roychoudhury *et.al., 2005*).	The caterpillars hatching from these eggs cause major damage to the crops, as they feed on leaves and stems voraciously.	Adult populations are monitored with pheromone traps, which allows to spot pest insects before damage occurs. *Trichogramma*, green lacewing, praying mantids and lady bugs can be used to destroy the eggs that are deposited on the leaves before they become damaging larvae. According to R.S. Mehrotra, the most common method of control is by hand picking the parasite in the early stages of growth or by sawing it off from the branches of its host, so that entire haustarial system is removed.

3	***Acraea violae*** **Family:** Nympalidae This is a colony forming species This is a colony-forming species. This is a moderately common species occurring primarily at low altitudes. The butterfly is seen in the highest numbers in the monsoon seasons and is quite a scare at the peak of the dry season. Mostly found in the sericulture districts of Andhra Pradesh and Tamil Nadu.	May – September (Carlos Eduardo Beserra Nobre *et al.*, 2012)	They cause damage generally by biting off pieces of leaves, stems, fruits, roots, seeds etc., as they have biting - chewing mouth parts in their immature stage.	The best way of controlling pest and diseases is routine check for visible occurrence and picking them off. Simple treatments of soap solution or spirited cotton applied to bug, caterpillar. However, if the plant really struggles for existence against intruders some organic surfactant, spray would be the best.
4	***Etiella behrii*** **Family: Pyralidae** These insects have varied food habits. Native of Hong Kong, Indonesia, Malaysia an d most of Australia. It is an invasive pest in India and intermittently found in the mulberry fields of sericulture districts of Andhra Pradesh and Tamil Nadu.	**Seasonal occurrence:** June – November, peak incidence is seen in August.	**Damage and symptoms:** Seeds are usually partially eaten, often with characteristi c pin-hole damage. Damaged seed is difficult to grade and its unattractive appearance reduces seed quality. *Etiella*-damaged pods can have aflatoxin	**Biological control:** Select varieties by the speed of maturity, and adjust planting times to avoid peak Etiella moth activity. Very few pesticides are registered against this pest in Queensland, Australia. Pesticides are relatively ineffective once the larva has entered the pod. Late irrigation reduces the

			levels 100 times greater than undamaged peanut pods.	risk of attack by wetting the surface soil.
5	***Eressa strepsimeris*** **Family:** Erebidae **Habit:** Polyphagous insect, and minor pest to mulberry fields. **Habitat:** They live from arid deserts and high mountaintops to marshes and tropical rain forests. (Family: Erebidae)	**Seasonal occurrence:** Pest incidence is more in dry season than in rainy season.	**Damage and symptoms:** Damage is mainly occurring to roots, leaves, flowers, and fruits, as they have biting and chewing mouth parts in their larval stage.	**Biological control:** Natural enemy augmentation is the best method for the eradication of *Eressa strepsimeris.* Hand picking and destroying the pest is the best way to control the population.
6	***Cleora repulsaria*** **Family:** Geometridae **Habit:** These moths are polyphagous insects and a minor pest to mulberry field. **Habitat:** These moths occur in variety of habitats. These species eat a very wide variety host plant.	May – September (Kyung San Choi *et al.*, 2011)	The caterpillar feeds on leaves causing severe defoliation.	**Biological control:** Natural enemy augmentation is the best way to control these pests.
7	***Olene mendosa*** **Family:** Eribidae **Habit:** It's a Polyphagous insect, and also a frivolous pest to mulberry. **Habitat:** Light trap surveys during recent times shows the species as infrequent from the lowlands (including mangrove) to 1620m, but its pest status indicates it may obtain much higher abundance on occasions, particularly in	Dry and rainy seasons	Caterpillar feed on leaves voraciously leads to severe damage of the crop.	**Biological control:** According to R.S. Mehrotra, the most common method of control is by hand picking the parasite in the early stages of growth or by sawing it off from the branches of its host, so that

	cultivated areas.			entire haustarial system is removed.
8	***Pyla impostor*** **Family:** Pyralidae **Habit:** These larvae feed on wide variety of plant products. It is seldom seen in mulberry garden. **Habitat:** They live in lentic habitats.	Occurs in late August and September and were associated with periods of rainfall (Knutson, T., Camargo *et al.*,2020).	These larvae feed on fruits and seeds, the wounds to the berry facilitate infection by fungal disease-causing agents (Chartier *et al.*, 2013).	**Biological control:** The best way of controlling pest and diseases is routine check for visible occurrence and picking them off. Simple treatments of soap solution or spirited cotton applied to bug, caterpillar.
9	***Tymbophora peltastis*** **Family**: Xylorictidae **Habit:** Natural feeding attractants for *Tymbophora* include Nectar, over-ripe, and rotting fruit, including mulberry berries. **Habitat:** *Tymbophora peltastis*, is found in most of Australia, and an invasive pest to Indian climatic conditions.	Late June to early September (Bossart, J.L., *et al.*,).	They cause damage by biting leaves, stems and fruits with their biting and chewing mouth parts.	**Biological control:** Collect and destroy egg masses and young caterpillars. Plough up the infested garden and dig near the base of mulberry plants to expose the pupae present in the soil to predators and sun light. (N. Shakthivel *et al.,2019)*
10	***Spodoptera litura*** Family: Noctuidae **Habit:** *Spodoptera litura* is a	The *Spodoptera litura* incidence occurs from	As the caterpillar hit shoots of young mulberry	**Biological control:** Collect and destroy egg masses and

	polyphagous pest with wide host range. It is ubiquitous pest on mulberry plants too. **Habitat:** *Spodoptera litura* is a notorious leaf feeding insect pest of more than one hundred plants around mostly found in Asia-Pacific region.	August to February. mainly in winter season (N. Shakthivel *et al.*,).	plants and cut them, it is called cutworm. the cut portion of the shoot dries up and falls off. they also feed on mulberry leaves voraciously (N. Shakthivel *et al.*,).	young caterpillars. Plough up the infested garden and dig near the base of mulberry plants to expose the pupae present in the soil to predators and sun light (N. Shakthivel *et al.*,).

Family : Pyralidae

S.No	Species Name	Seasonal Occurrence	Damage & Symptoms	Biological Control
	Paracoccus marginatus **Habit:** Mealybugs are Usually found in colonies, they are piercing-sucking insects closely related to soft scales but lack the scale covers. It's a major pest for mulberry too. **Habitat:** *Paracoccus marginatus* only been recorded feeding on above ground parts of its hosts, particularly on leaves and fruit (Miller, *et al.*,1999)	**Seasonal occurrence:** Occurs throughout the year but severity is more in summer months (N. Shakthivel *et al.*,).	It has piercing-sucking mouth parts and feeding on phloem sap of mulberry both from leaf and stem resulting in loss of moisture and decline in nutritional values. The pest also injects a toxic substance into plants while feeding. The symptoms appear on the leaves as chlorosis, deformation, pre mature drop, stunted growth followed by death of plants (N. Shakthivel *et al.*,).	**Biological control**: Clipping of the infested twigs and leaves and burning during early stage of infestation is the best method of eradication of the pest. All crop residues in the infested garden harbouring mealy bug populations should be removed and burnt (N. Shakthivel *et al.*,).
	Toxoptera odinae	**:** *Toxoptera* incidence	**Damage and symptoms:**	**Biological control:**

	Family: Aphididae **Habit:** *Toxoptera odinae* is a common sight throughout the Old-World tropics and subtropics on numerous plant species, especially those of shrubby habit (Roger Laurence, Blackman, *et al.*, 2011). **Habitat:** It is known as a mid grey-brown to reddish brown aphid forming dense colonies on young stems or on the undersides of leaves along the main veins, invariably attended by ants (Roger Blackman, *et al.*, 2011).	mainly occurs during February to April	Nymphs and adults feed on tender leaves, shoots, inflorescences, apples and nuts and suck the cell sap. They excrete honeydew on which sooty mould develops. The damage is heavier on young plantations and heavy infestation leads to shedding and drying of inflorescences or distorted and malformed nuts and apples. In other economically important crop plants, the aphids mainly cause reduced fruit yield and timber quality (Raychaudhuri *et al.*, 1981).	Aphids are controlled by removing the weeds and pet plants, as they are source for the aphid infestation. These are susceptible to many natural enemies including, aphid parasitoids or parasitic wasps.
	Acrosternum gramineum **Habit:** The pentatomids have piercing and sucking mouth parts and are polyphagous insects. It is found in gardens, woodlands and orchards, crop fields. Family: Pentatomidae	*Acrosternum* populations reach their peak in late summer. (Kamminga, K.L, *et al.*, 2006)	**Damage and symptoms:** Feeding by the stink bugs on stone fruit such as peaches, early in the season causes the flower or the developing fruit to abort. Mature fruits will have depressed lines and multiple corky areas resulting in a gnarled and mottled appearance. In grapes and other small fruits, feeding by stink bugs can cause blackened areas that reduce	**Biological control:** Stink bugs are vulnerable to multiple predators, parasites, and parasitoids. Mermithid nematodes have been reported as infesting stink bug adults and nymphs. spined soldier bugs, *Podisus maculiventris* and birds are common predators of stink bug (K.L.

			the quality of the fruit; however, severe infestations may cause entire clusters to shrivel from the extensive withdrawal of liquids.	Kamminga, *et al.*, 2006).
	Eocanthecona furcellata **Family**: Pentatomidae **Habit:** These are Polyphagous insects and frequently seen in mulberry garden too *Eocanthecona furcellata* is a common predatory stink bug in Southeast Asia, India, China, Taiwan, and Japan and has often been observed in cotton, chickpea, and vegetable fields.	This predatory bug is commonly noticed between September and March. (Vanitha K *et al.*, 2018.)	These are considered as agricultural pests, because they can grow into large populations that feed on crops, damaging production, and they are resistant to many pesticides.	**Biological control:** Birds are the natural enemies of *Eocanthecona* which can reduce their population
	Halyomorpha picus **Habit:** These are polyphagous insects, sucks on plant sap of mulberry plant stems. These are found in wide range of natural and agricultural habitats, but many species appear to prefer shrublands and woods.	Late July to October. (Kevin. B. Rice *et al.*, 2014)	Halyomorpha can cause significant injury to a wide range of vegetable crop species when bugs insert their feeding stylets into plant fruiting bodies which are often the marketable portion of the crop. It also transmits pathogenic bacteria or yeast such as *Eremothesium coryli*, which can cause fruit rot. (Kevin. B. Rice *et al.*, 2014)	**Biological control:** The number of Halyomorpha population can be reduced by introducing natural enemies like pathogens and parasites.

	Dieuches schmitzi **Family**: Rhyparochromidae **Habit:** These are polyphagous insects, native pests on mulberry plant too. **Habitat:** These are granivorous soil dwellers.	Spring to early summer (Yoshida k, *et al.*, 2014).	They cause crop loss by sucking the plant sap when they are very numerous. The major harm they do is indirect. They secrete large amounts of honey dew that support unsightly or harmful infestation of sooty mould.	These insects are controlled by introduction of predators or parasitoids. However, pesticides are recommended when they are in large number.
	Nezara viridula **Family:** Pentamidae **Habit:** After hatching, the first stage nymphs will remain on or near the egg mass. **Habitat:** From the mulberry plant, *Morus alba L.*, from all six mulberry fields, Aurangabad district, Maharashtra, and Anantapur districts of Andhra pradesh	occurs in all season	Nymphs and adults suck the cell sap from tender leaves and stems and devitalize the host plants.	**Biological control:** Parasites, usually wasps and flies, provide biological control of the southern green stink bug. In Florida a tachinid fly, *Trichopoda pennipes*, parasitizes adults and nymphs; and a wasp, *Trissolcus basalis*, parasitizes eggs. These two parasites have also been introduced as biological control agents in other areas, such as Australia and Hawaii, to control the southern green stink bug
	Aphis glycines **Family:** Aphididae **Habit:** Hemiptera insect pest of	May to July	Aphids have piercing-sucking mouthparts that are used to feed on phloem sap. Heavily infested	**Biological control:** A diverse community of natural enemies, which

	soyabeans. **Habitat:** Terrestrial, distributed in all soyabean growing areas		plants are stunted and may be covered with dark sooty mould growing on the sugary excretions ("honeydew") that aphids produce. Heavy infestations can result in, stunted plants and aborted pods, yellow and wrinkled leaves.	help suppress soybean aphid colonization and population growth. These natural enemies include minute pirate bugs, and entomophagous (insect-killing) fungi ladybeetles, lacewings.
	Maconellicoccus hirsutus **Family:** Pseudococcidae **Habit:** It is a polyphagous pest on a wide range of ornamental and agricultural plant species, and major pests in mulberry crop too. **Habitat:** While the primary host of *Maconellicoccus hirsutus* is the ornamental *Hibiscus rosasinensis.* Mulberry and woody plants.	They occur on mulberry throughout the year, but the incidence is higher in summer month's i.e., March to August. their population is negligible during rainy season. (N. Shakthivel *et al.*,)	The nymphs feed by sucking the sap from tender leaves and stem portion. Hence the affected apical shoots show bunchy appearance due to curling of leaves, shortening of internodes and thickening of stem. The symptom is popularly known as "Tukra" in India (N. Shakthivel *et al.*,).	**Biological control:** Clip off infested apical shoots and destroy by burning or dipping in soap solution. Do not grow alternate host plants of the mealybug in the vicinity of mulberry garden (N. Shakthivel *et al.*,).
	Aleurodicus dispersus Family: Aleyrodidae **Habit:** These are sap-sucking insects. **Habitat:** These are mostly found in underside of leaves	It is found to cause damage throughout the year with peak incidence during summer (N. Shakthivel *et al.,)*	It cause direct damage by sucking plant sap and indirect damage due to the honey dew and white waxy material produced by the insect as it remains on ventral surface of leaves in colonies. (N.	Remove and destroy the infested leaves and install yellow sticky traps@ 75 per acre. Spray of a strong jet of water in the affected mulberry garden will

			Shakthivel *et al.,)*	
	2.21 *" Calvia quaturodecimguttata* 42 Family: Coccinellidae **Habit:** The cream spotted lady beetle can fly and is mainly a solitary species. It is a major pest for mulberry. **Habitat:** Hedgerows, deciduous tress	The population level of the pest reaches its peak in August (M.G. Venkatesha, 2006.)	Economic damage is caused by larvae, adults or both. But often it is the larvae feeding that causes most damage.	**Biological control:** The number of eggs are reduced when their natural enemies parasitoid wasps are introduced into the field
	Cryptolaemus montrouzieri Family: Coccinellidae **Habit:** These are holometabolous insects. It is mealybug destroyer. **Habitat:** These insects found in all natural habitats, i.e., vegetative foliage from trees and their bark to leaves and flowers and underground roots.	April to August (Yasuko kawakami *et al.*, 2016)	It affects apical portions are initially and there after, it spreads all over the plant affecting even woody regions.	**Biological control:** The mass production and release of natural enemies such as parasitoids and predators controls the *Cryptolaemus* population.
	Calvia championorum **Family:** Coccinellidae **Habit:** They feed on herbaceous plants, and field mulberry plant sap. **Habitat:** Calvia championorum	May-August	The tiny small bugs usually suck sap from twigs, leaves and flowers. Infested fruits will have poor quality and uneven shapes are susceptible to secondary infections by pathogens.	**Biological control:** A soil dwelling bacteria are introduced into the field to reduce the insect population.

	is found in forests of deciduous trees and shrubs and agricultural land. This species also lives amongst flowering plants that are present in dry grass land.			
	Calvia punctata **Family:** Coccinellidae **Habit:** These are herbivorous insects and feeds on mulberry plant sap. **Habitat:** These insects are the pests of agricultural crops.	April-August (Sajad mohi-ud-in *et al.,* 2016.)	In additional to the physical damage, they also transmit bacterial diseases through saliva.	**Biological control:** The egg parasitoid trichogramma evanescens was introduced to the *calvia punctata* infested field.
	Coccinellidae sp. Family: Coccinellidae **Habit:** These are the herbivorous insects also prey on hemipteran aphids. They occur in practically all the major crop producing regions of temperate and tropical countries.	The population level of this species reaches its peak in the month of August	The insect in both the larval and adult stages will feed upon the leaves, flowers and pods of the plant, but the greatest amount of injury is done to the leaves. The larvae causes more damage than the adults.	**Biological control:** *Bacillus thurengenesis,* a soil dwelling bacterium, is the most widely applied species of bacteria used for the biological control of *Coccinellidae sp.*
	Attagenus fasciatus **Family**: Dermestidae These are the hemi metabolism insects, which feed on cocoon and silkworm pupae. **Habitat:** These insects occur in nearly every type of habitat, mostly live on plants. It gets attracted to the smell of the silkworm	They occur throughout the year but more prevalent during summer.	They feed by clinging to the lower surface of the leaves and eating irregular sections of lower leaf surface. The upper surface dries out after the lower surface was injured. In many cases small pods will be entirely destroyed.	**Biological control:** There are atleast 17 species of predators which feed on eggs,larvae and pupae of Attagenus species.

	pupae and attack the cocoons harvest.			

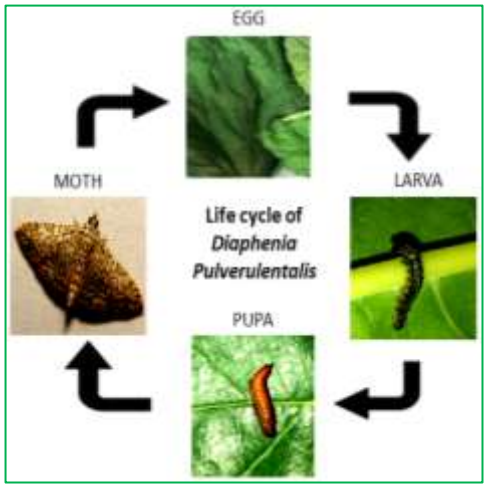
Coleoptera

	Illeis cincta: Family: Coccinellidae **Habit:** Polyphagous insect and a predominant one in the mulberry garden feeding on the leaves. **Habitat:** This is the most predominant species of coccinellid on mulberry.	This is abundant in the post monsoon and winter seasons	**Damage and symptoms:** All stages of the insect feed upon the leaves, flowers and pods, but greatest amount of injury is done to the leaves.	**Biological control:** The parasitoid wasps are introduced against the illies cinctata pests.
	Hexacentrus japonicus: **Habit:** These are nocturnal insects, causing major damage to the mulberry foliage. **Habitat:** These insects live in drier or stressful habitats. Family: Tettigoniidae	May-August (Sang-Rae Moon *et al.*, 2009)	They cause major damage by feeding on leaves, fruits and pods and roots.	**Biological control:** Introduction of native parasitoids, sacrophagid flies, have a significant impact on the control of hexacentrus species.
	Neothacris acuticeps: **Family:** Acrididae **Habit:** They feed only on grasses or native shrubs, sporty buds and tender leaves of mulberry crop. **Habitat:** These are wingless grasshoppers mostly found in peninsular India	Incidence of this pest coincides with onset of monsoon and continues still post monsoon periods. However peak infestation occurs during October and declines subsequently with no	**Damage and symptoms:** Both nymphs and adults feed voraciously on sprouting buds and leaves of mulberry.sometimes they also feed on green bark of affected plants. Branches of plants without leaves are observed in the mulberry garden in case of severe incidence.	**Biological control:** During early morning hours they are less active and hence can be collected and destroyed. Deep ploughing immediately after the onset of monsoon to expose egg masses to sunlight and predators. Field sanitation by keeping mulberry

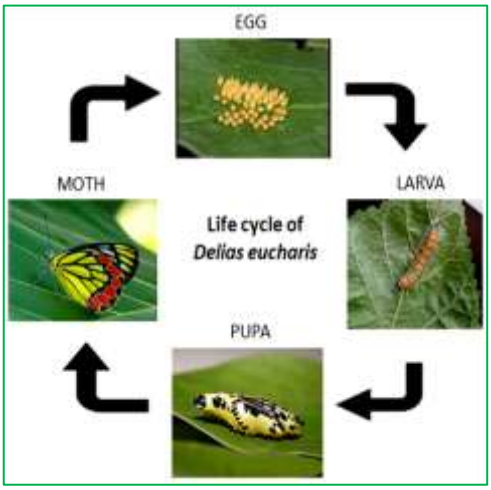
		occurrence from January till onset of monsoon.		garden free from weeds which serves as alternate host plants.
	***Sphenacris crassicornis*:** **Family:** Pyrgomorphidae **Habit:** These insects feed on grasses and weeds, also affects the mulberry stem on the ground level. **Habitat:** These are found in all terrestrial habitats.	Onset of monsoon to post monsoon seasons.	The extent of insect injury to above and below ground plant parts.	**Biological control:** The insects are collected and destroyed when they are inactive, i.e., early morning time. Ploughing is recommended after the onset of monsoon to expose eggs to sunlight and predators.
	***Spelobia bifrons*:** **Family:** Sphaeroceridae **Habit:** These are important pollinators and plant pests by feeding on the plant sap causing extensive damage to the silkworm rearing crop **Habitat:** They are most common in moist and humid environments.	These insects are abundant during February and March.	As these insects have sucking mouth parts, they suck the plant sap causing severe damage to the crops.	**Biological control:** The population of Sphaeroceridae can be controlled when eggs are exposed to sunlight and predators by deep ploughing.
	***Exorista sorbillans*:** **Family:** Tachinidae it is an endo parasite of silkworm, by laying eggs on the body of the larvae causing extensive damage.	it is abundant in rainy and winter seasons and negligible in summer months	Minute(Smaller than pin heads) creamy white, oval eggs are observed on the infested silkworm larvae. Black scars are seen on the larvae due to penetration of maggots and some times with an egg	**Biological control:** control of uzi fly through biological means, however, have a special relevance since the host itself Is an insect and

			shell at the centre of black scars.	insecticidal measures can not be taken against a pest associated with insect host.
	***Meranoplus magrettii*:** **Family**: Formicidae **Habit:** They mainly feed on aphids, honey dew etc. it feeds on mulberry leaves only on bottom side. **Habitat:** *Mearanoplus* inhabits Barelands, grass lands, sparse forests and nests in soil	Abundant in rainy season.	**Damage and symptoms:** The larvae cause damage by feeding on all plant parts. Young larvae initially eat one side of the surface of the leaf tissue, leaving the opposite side intact.	**Biological control:** *Meranoplus* insects are controlled by introduction of parasitoid wasps.
	Telamonia dimidiata **Family:** Salticidae **Habit:** Found on woody plants, shrubs and trees are sophisticated and active hunters. **Habitat:** It is found in trees, shrubs, vegetable gardens and paddy fields and mulberry fields of Uttar Pradesh, Madhya Pradesh and Andhra Pradesh	These insects are predominant during monsoon and winter.	Most of the spiders are act as predators.	**Biological control:** These spiders are act as biocontrol agents in agriculture and poultry.
	Odontomantis pulchra **Family:** Hymenopodidae **Habit:** It usually stands still on leaves waiting for	These are found mostly in summer.	It act as a minor pest in several plants.	**Biological control:** The insects are collected and destroyed when they are inactive, i.e., early morning time. Ploughing

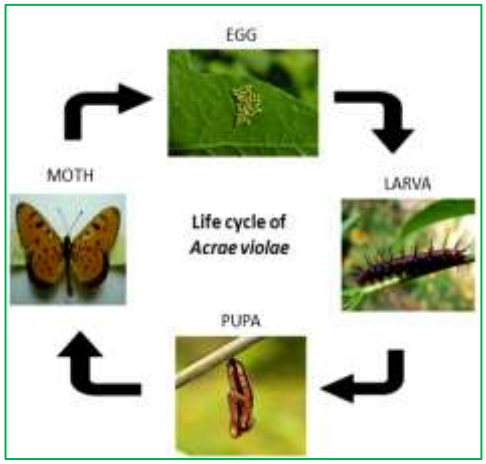
	prey to pass. If there is an assumed threat, it will quickly retreat to the bottom of its leaf, while adult males will not hesitate to fly. **Habitat:** *Odontomantis* is most common mantis throughout its range. it's found in mulberry crops, urban gardens and inhabiting ornamental plants.			is recommended after the onset of monsoon to expose eggs to sunlight and predators.



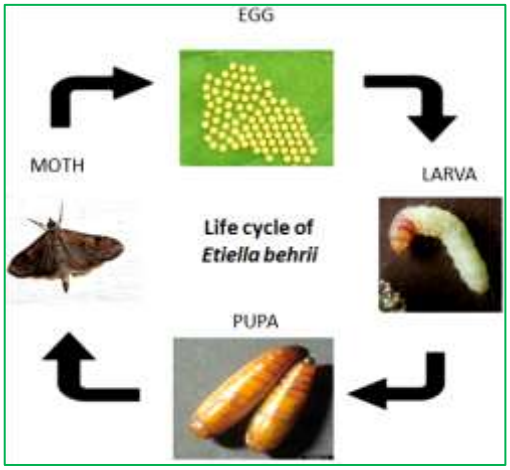
Diaphania pulverulentalis



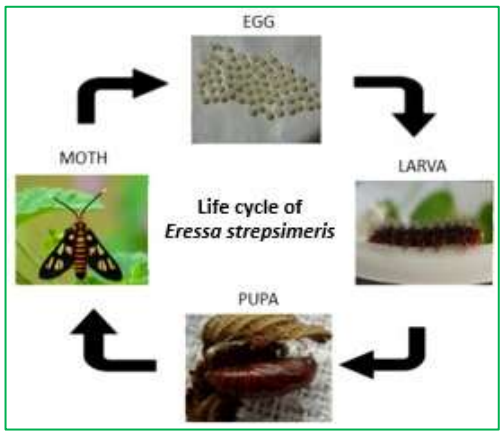
Delias eucharis



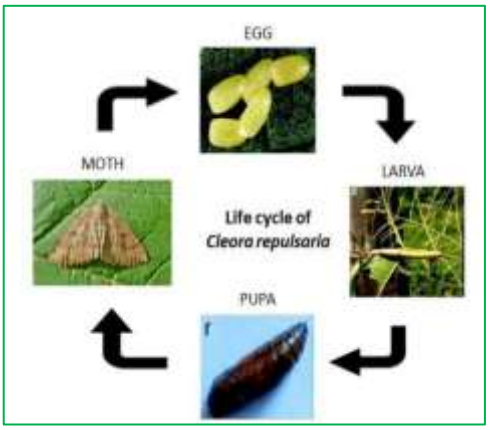
Acraea violae



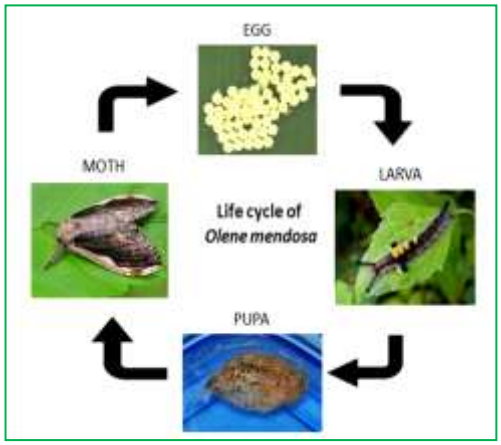
Etiella behrii



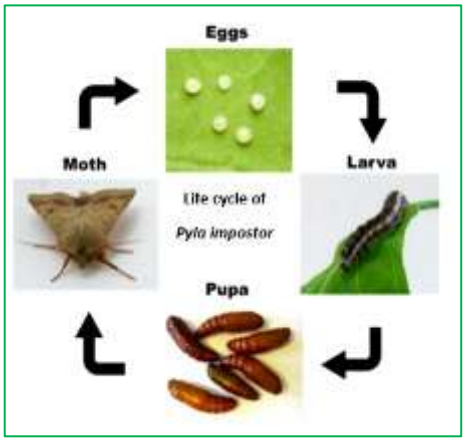
Eressa strepsimeris



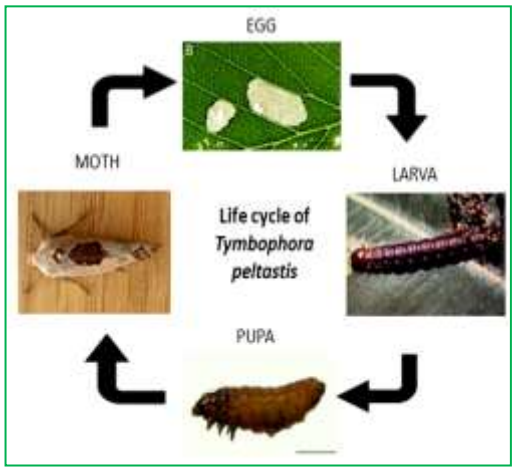
Cleora repulsaria



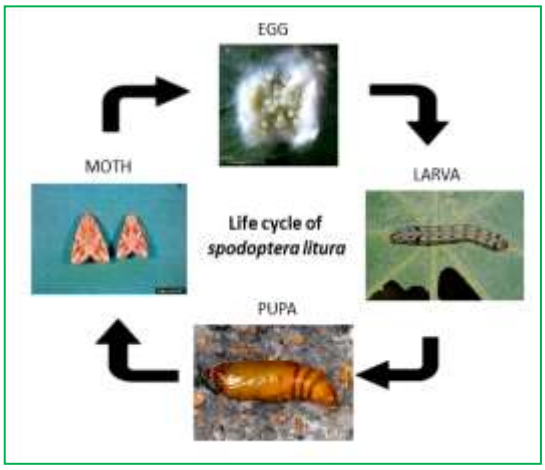
Olene mendosa



Pyla impostor

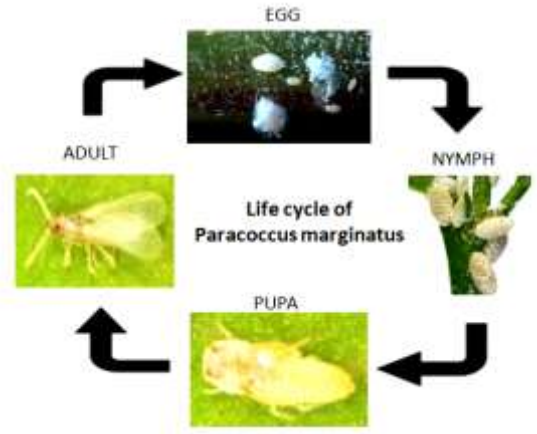


Tymbophora peltastis

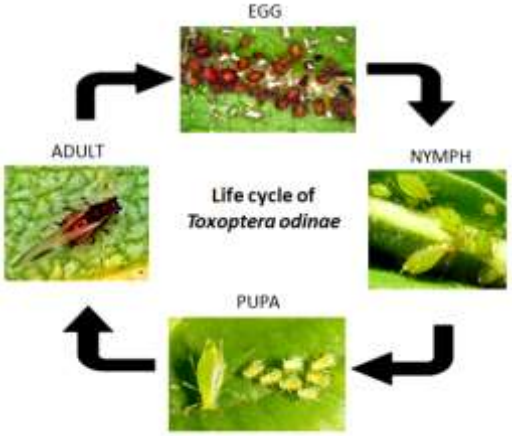


Spodoptera litura

Hemiptera

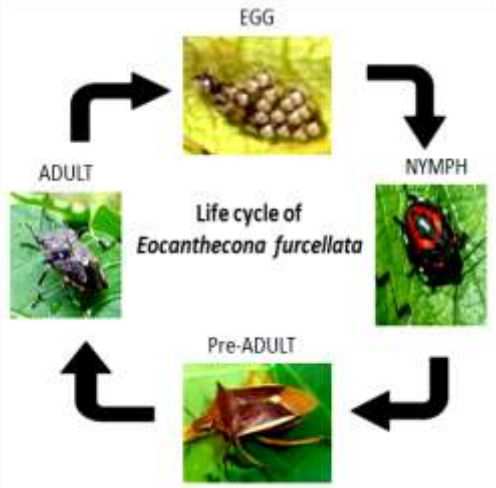


Paracoccus marginatus

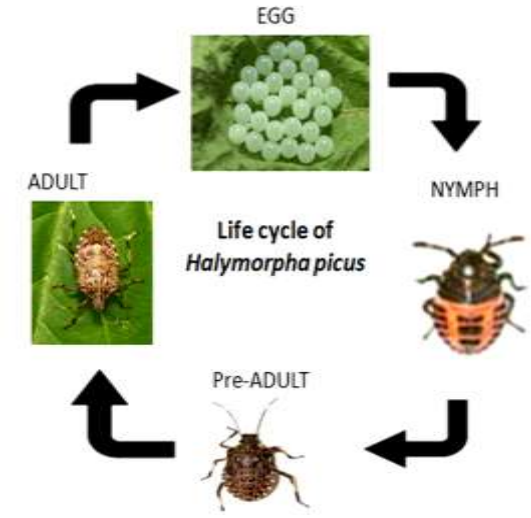


Toxoptera odinae:

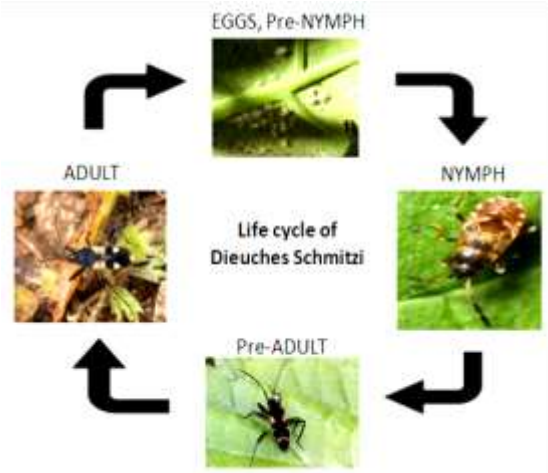
Acrosternum gramineum



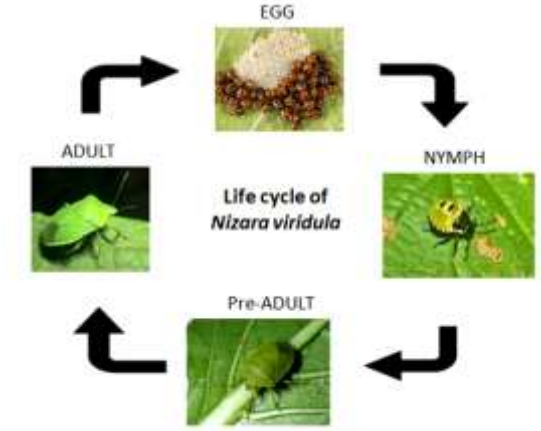
Eocanthecona furcellata



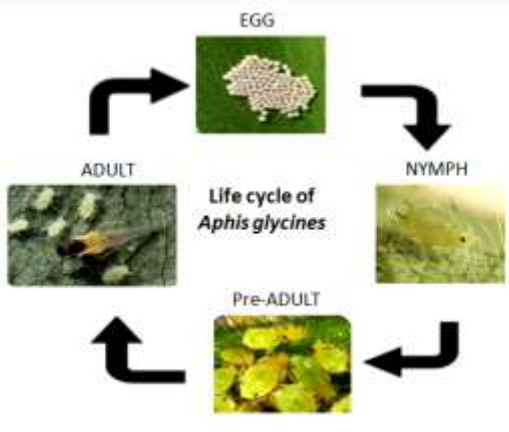
Halyomorpha picus



Dieuches schmitzi

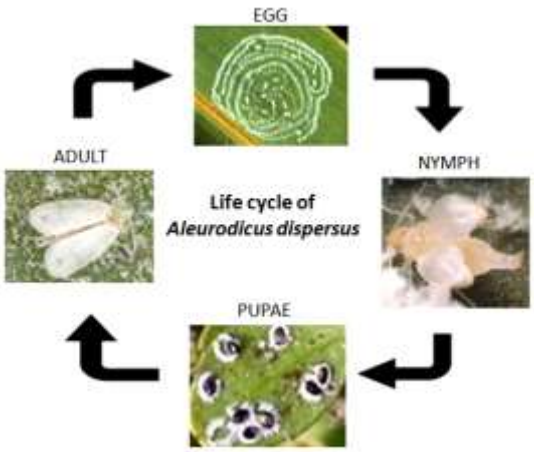


Nezara viridula

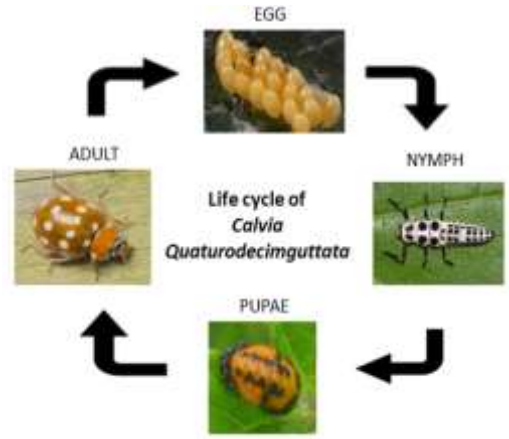


Aphis glycines

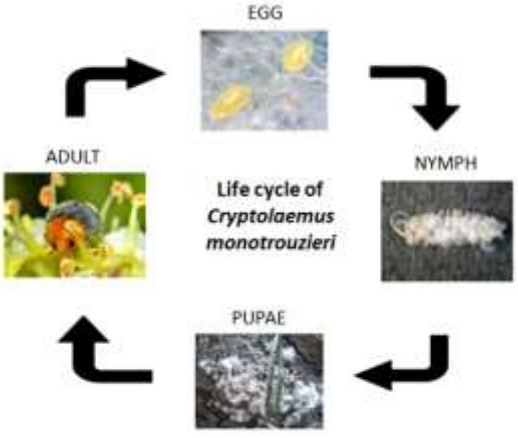
Maconellicoccus hirsutus



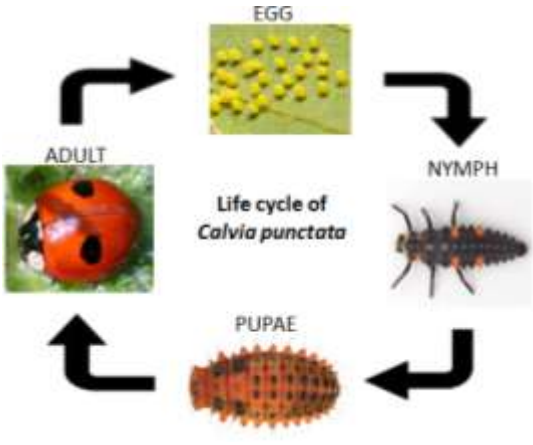
Aleurodicus dispersus



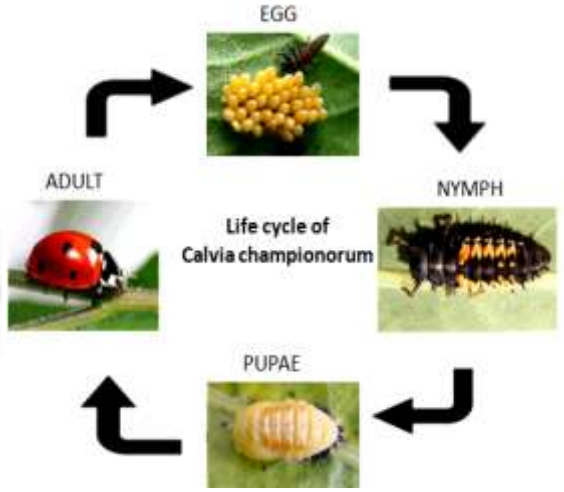
Calvia quaturodecimguttata



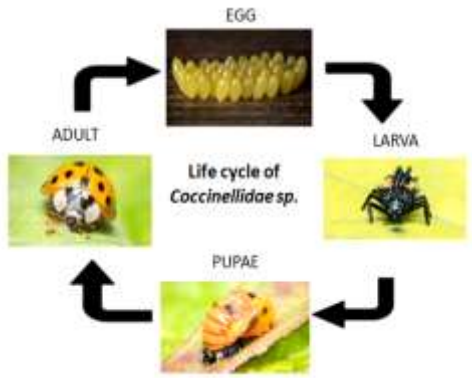
Cryptolaemus montrouzieri



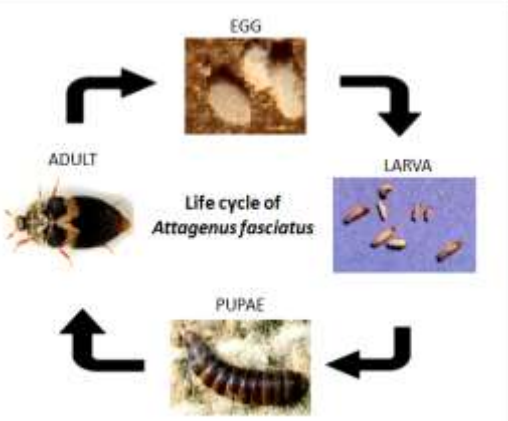
Calvia championorum



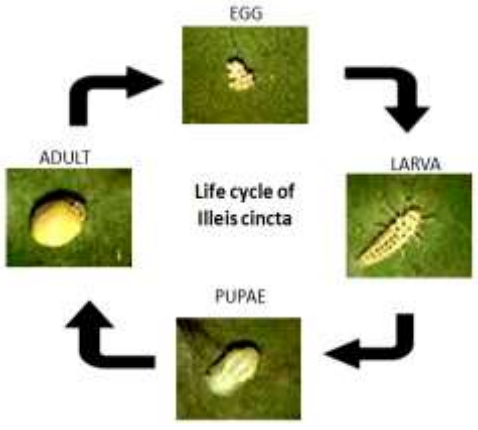
Calvia punctata



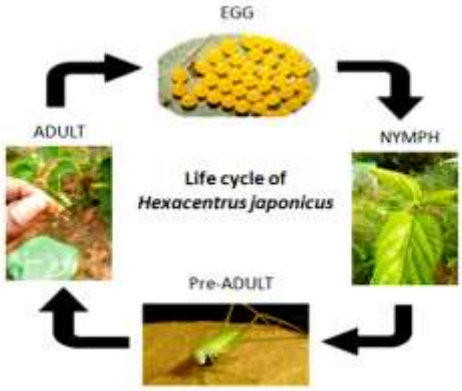
Coccinellidae sps.



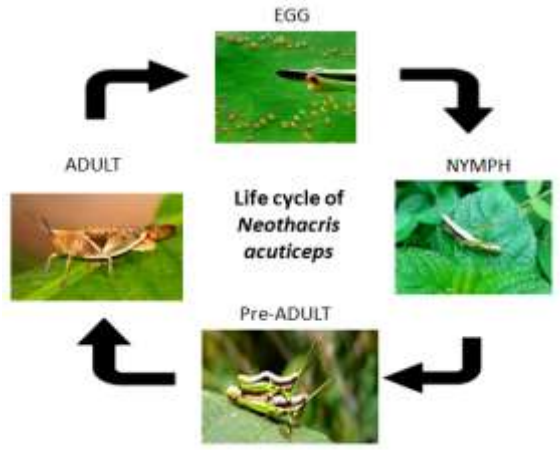
Attagenus fasciatus



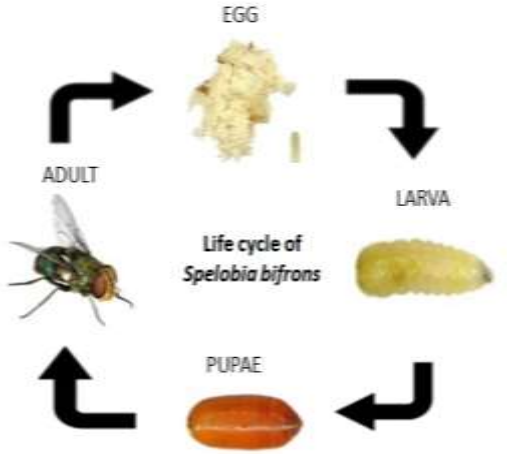
Illeis cincta



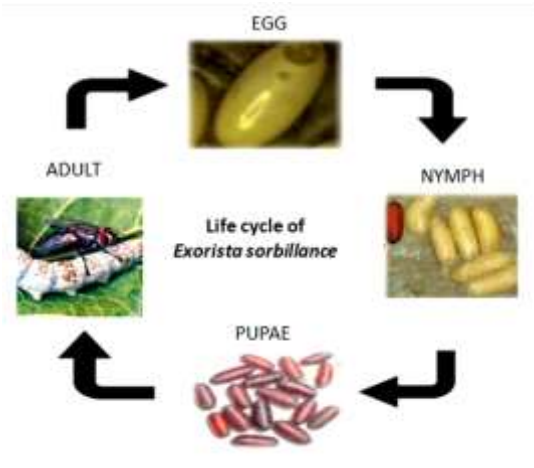
Hexacentrus japonicus



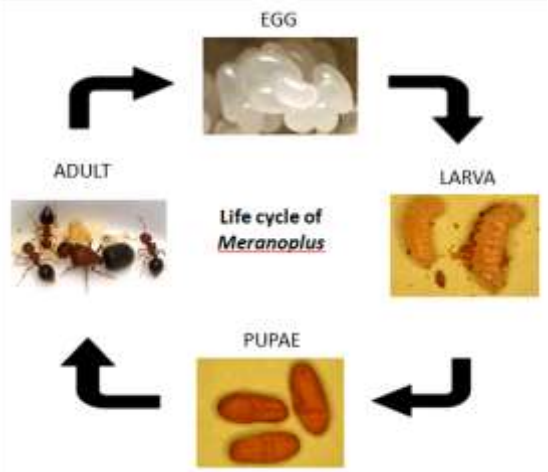
Neorthacris acuticeps



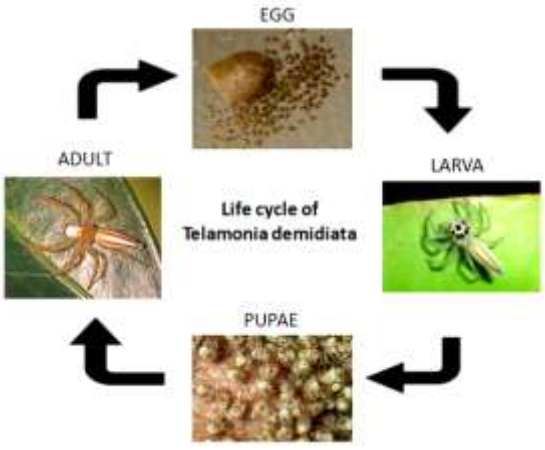
Spelobia bifrons



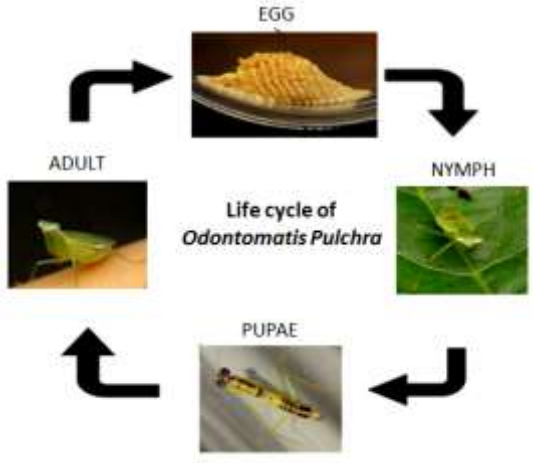
Exorista sorbillans



Meranoplus magrettii



Telamonia dimidiate



Odontomantis pulchra

Discussion

Classical Taxonomy Vs Molecular Taxonomy

Taxonomy is the basic science deals with the scientific study of identifying, naming and classifying different organisms existing in the world. A biologist who is working in any scientific field would be incapable to interpret their findings without

prior information regarding their target organisms. Thus, this field help to classify these millions of organisms existing in the planet into different categories like family, genus, species etc. for their easy study and proper understanding. Wilson *et al.,* (2003) reported that there about 5- 100 million species are waiting for their discovery and description and hence there exists an immediate urge to augment taxonomy in terms of need (Godfrey, 2002; Hebert, 2003). It helps us to understand what types of characters are present in organisms, its position in the evolutionary history of organisms, how each animal is different in their physical and mental development, their geographical distribution etc. It also makes a baseline data available for conservation and ecology studies, and affords humans the possibility to take advantage of the underutilized resources offered by the earths' biodiversity (Wilson, 2004). Taxonomy has been divided into 2 categories namely Classical Taxonomy and Molecular Taxonomy.

The branch of taxonomy in which members have categorized in specific group on the basis of their own similar morphological and anatomical characters is called classical or traditional taxonomy. Here each species is mainly classified on the basis of observable similarities. Appropriate taxonomic keys have used for the species identification and also for the proper management of biological collections. There exists a perfect hierarchal system for the classification of every organism starting from kingdom, domain, phylum, Class, order, family, genus, and finally to the species level. The main drawback of this method is its inability to identify immature, damaged or incomplete specimens and also to predict phenomena like cryptic morphology and polymorphism existing among different species. Hence traditional taxonomy requires high levels of expertise in any given group and is therefore restricted specialist.

Identification using conventional taxonomy is not easy due to the morphological changes in the organisms that occur by seasonal and geographical variations. They alter themselves physiologically and morphologically due to certain unfavorable conditions in the environment, these morphological variations get accumulate in the species concerned leading to a drastic change in the outlook or appearance. This in turn causes the misidentification of species (Pushparaj *et al.,* 2012). Actually, the traditional taxonomic methods make an intractable problem for cryptic and polymorphic species.

Thus, the adoption of manual taxonomy, on the basis of the above-mentioned limitations, leads to misidentification of the species in between. This trouble has thus influenced the emergence of the molecular taxonomic framework studies for the conformation and the betterment in the identification species. Molecular systematics is one of the most unexpectedly expanding fields in modern biology. Analysis of molecular statistics has been verified to be essential for the perception of Phylogenetic relationships, examining population structure within a species, and assigning unknown specimens. The use of molecular characters for fast Recognition of unspecified organisms has been substantiated to be advantageous and pretty effective. Because of their maternal inheritance, restrained recombination, and speedy evolution, the genes encoded in the mitochondrial DNA (mt DNA) have dominated in the field of molecular systematics.

The main steps used in most systematic studies include taxon sampling, choice of proper markers and analytical studies. Selecting ingroup and outgroup taxa are the key elements in designing a molecular systematic study. To study interspecific or even higher, sequencing is a more appropriate one. Other methods like restriction fragment length polymorphism (RFLP), single-stranded conformational polymorphism (SSCP), random amplification of polymorphic DNA (RAPD) etc., are also used nowadays. DNA sequencing has become dominant technique for generating molecular data for comparative analysis. The DNA sequences exhibit certain properties like inherent comparability of sequence data that facilitates the connectivity and unique insight towards evolutionary processes deriving diversification of DNA itself.

The use of molecular data in taxonomy has several advantages. First and foremost, the classification schemes for groups such as fungi, whose phylogeny has long confounded many taxonomists who rely upon more traditional morphological characters, can now be determined more easily. Secondly, organisms typically have many thousands of different genes, so there is a potential database of characters that is virtually unlimited in size. Thirdly, as the changes in morphology, the comparison of gene sequences allow the study of evolution at the most basic level. Comparative studies of morphology will continue to play an important role in taxonomy but gene sequences are becoming more widely used for easy differentiation in taxonomy.

Molecular techniques provide powerful tools for the study of insect systematics. Similar morphology and high genetic diversity influence problems in Phylogenetic studies of insects. To solve these problems, mitochondrial-based markers have been adopted and are increasingly used as molecular markers for phylogenetic studies.

Conclusion

The current review is on the insect pests that feed on mulberry and affect the quality and yield of the Crop. So, these pests become a major problem for the Seri farmers. Various management strategies including physical, chemical, and biological methods are followed to control the pests. Identifying more eco-friendly methods of pest control which would be effective more selective and safer. As insects form an important and diverse group in the field of agricultural entomology, classification at the molecular level provides more accuracy in identification, classification, and evolutionary studies.

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