# PESTS OF EXOTIC FRUIT CROPS IN KERALA

*by*

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## DECLARATION

I, hereby declare that this thesis entitled **"PESTS OF EXOTIC FRUIT CROPS IN KERALA"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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## LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| % | - | Per cent |
| °C | - | degree Celsius |
| / | - | per |
| cm | - | Centimeter |
| *et al.* | - | And others |
| etc. | - | Et cetera |
| Fig. | - | Figure |
| GKVK | - | Gandhi Krishi Vigyana Kendra |
| GOI | - | Government of India |
| h | - | Hours |
| ICAR | - | Indian Counsil of Agricultural Research |
| KAU | - | Kerala Agricultural University |
| Km/h | - | Kilometer per hour |
| min | - | Minutes |
| mm | - | Millimeter |
| NBAIR | - | National Bureau of Agricultural Insect Resources |
| SE | - | Standard error |
| sp. | - | Species |
| *viz.* | - | Namely |

# *Introduction*

# 1. INTRODUCTION

Exotic fruits are those that are not indigenous to the area in which they are produced. The term “exotic fruits” is used mostly in developed countries, referring mostly to some tropical fruits that are unknown to the consumers of the developed countries or many of them. India has an overall area of 8951.5 ha dedicated to theproduction of exotic fruits. Kerala is the only place in India where unique,rare exotic fruits are grown in a commercial scale.The projected total area in Kerala dedicated to exotic fruits is 920 ha which includes passion fruit (300 ha), dragon fruit (250 ha), rambutan (200 ha), strawberry (200 ha), mangosteen (60 ha) and avocado (40 ha) (GOI, 2021). Cultivation of exotic fruits such as rambutan and mangosteen is becoming popular in the western coast, particularly Kerala and Karnataka. Some of the widely accepted exotic fruits grown in Kerala are dragon fruit, mangosteen and rambutan. The retail price of the fruit ranges from 200 to 250 rupees per kg and rises once it reaches the markets of metro cities indicating that people are looking beyond traditional fruits (Krishnakumar, 2015).

The tropical fruit rambutan, Nephelium lappaceum (Linnaeus) belongs to the family Sapindaceae, is believed to have originated in Southeast Asia, specifically in Indonesia and Malaysia (Windarsih, 2022). The rambutan tree is a medium-sized evergreen that can reach a height of 12 to 15 meters (Wall, 2006). The incidence of pests like mealybug (*Planococcus citri* Risso), red borer (*Zeuzera* sp.), bostrichid beetle and fruit fly (*Bactrocera dorsalis* Hendel and *B. caryeae* Kapoor) have been reported from different rambutan growing tracts of South India (Mala *et al*., 2015).

Dragon fruit, *Selenicereus undatus* (Haworth) D. R. Hunt (Cactaceae), is emerging as a super crop even for marginal land, owing to its health and medicinal benefits worldwide. An estimated 12,000 tons of fruit are produced annually which is grown on 3,000 to 4,000 ha throughout Indian states (Wakchuare *et al*., 2020). In Florida, numerous kinds of thrips, leaf footed bugs (*Leptoglossus concolor* Walker), mealy bugs (*Ferrisia dasylirii* Cockerell) and aphids (*Aphis craccivora* Koch) are the main pests of dragon

fruit. Beet army worm (*Spodoptera exigua* Hubner) and scales on the stem are the minor pests reported (Duncan *et al*., 2021).

Mangosteen *Garcinia mangostana* (Linnaeus) of the family Clusiaceae and native to Malay Peninsula and South East Asia, is the most delicious tropical fruit and has been called the queen of fruits. Mangosteen is a dioecious tree and attains 6-25 m in height, has dark-brown bark and bitter latex (Ansori *et al*., 2020). Three potential pests were identified for mangosteen from Southeast Asia and they are *Hyposidra talaca* (Walker), *Phyllocnistis citrella* (Stainton) and *Stictoptera cucullioides* (Guenee) (Waterhouse, 1993).

Passion fruit *Passiflora edulis* (Sims) is a perennial woody fruit vine belongs to family Passifloraceae, native to Brazil. Passion fruit bears hermaphrodite, solitary flowers located at the leaf axils (Thokchom *et al*., 2017). Passion fruit is attacked by several species of insects and mites that feed upon all parts of the plant. Primary pests are lepidopterous defoliators, coreid bugs, stem weevil, flies and mites. Secondary pests are aphids, mealy bugs, scales and termites (Joy and Sherin, 2016).

These exotic fruits are vulnerable to a variety of insect pests such as borers, defoliators, flower feeders and sucking pests. Studies on the pests of exotic fruit crops have gained least momentum till this time. Presently, there have been frequent reports of insect infestation in these fruit crops across Kerala.A number of these pests, lower fruit yields and their marketable quality. Mala *et al*. (2015) recorded the incidence of mealybug *Planococcus citri* (Risso), red borer (*Zeuzera* sp.), bostrichid beetle and fruit fly, *Bactrocera dorsalis* (Hendel) and *B. caryeae* (Kapoor) from different rambutan growing tracts of South India. The major pests observed in rambutan growing tracts of Kerala are fruit borer, *Conogethes punctiferalis* (Guenee), fruit webber *Eublemma anguilifera* (Moore), leaf folder *Thalassodes quadraria* (Guenee) and mealy bug *Planococcus citri* (Risso) (Muhammed *et al*., 2016). Prathapan and Santhoshkumar (2022) reported the infestation of *Spodoptera litura* (Fabricius) on dragon fruit seedlings in Thiruvananthapuram, Kerala.

The area under exotic fruits and their production is increasing year by year in Kerala and these crops are becoming more susceptible to new pests in recent years which can result in significant losses to the cultivators. Even though there are few scattered information about the occurrence of insect pest in exotic fruits, a systematic study for documenting the pests of exotic fruits in Kerala is lacking. The present study entitled "Pests of exotic fruit crops in Kerala." was proposed to investigate the pests, its natural enemies and pollinators in exotic fruit trees like rambutan, dragon fruit, mangosteen, passion fruit and other minor exotic fruit crops with the following objective:

- Documentation of pests, its natural enemies and pollinators in exotic fruits of Kerala

# *Review of Literature*

# 2. REVIEW OF LITERATURE

Exotic fruits are those which are native to elsewhere and imported to our country. India is the world's second-largest producer of exotic fruits and the cultivation in India has always been growing due to the country's wide range of climate zones, from tropical totemperate. Farmers from Himachal Pradesh to southern regions of Kerala and Karnataka are also interested in growing exotic fruit crops. Especially in Kerala and Karnataka, farmers are cultivating rambutan, mangosteen, durian, and dragon fruit. (Nath *et al*., 2018). Available information about the pests, pollinators and natural enemies associated with rambutan *N. lappaceum*, dragon fruit *S. undatus*, mangosteen *G. mangostana* and passion fruit *P. edulis* are reviewed here.

## 2.1 Pests of Exotic Fruits

### 2.1.1 Rambutan

Rambutan is a fruit crop primarily cultivated in warm, humid tropical and subtropical areas. There are a number of insect pests that can quickly spread and cause significant damage in rambutan. Khoo *et al*. (1991) described 15 pests that attacked rambutan. A survey by Waterhouse (1993) listed 28 major pests of rambutan in South-East Asia. The incidence of pests like mealybug (*P. citri*), red borer (*Zeuzera* sp.), bostrichid beetle (*Sinoxylon* sp.) and fruit fly (*B. dorsalis* and *B. caryeae*) have been reported from different rambutan growing tracts of South India (Mala *et al*., 2015).

#### *2.1.1.1 Sucking Pests*

##### *2.1.1.1.1 Mealy bugs*

Mealybugs, belonging to the order Hemiptera and family Pseudococcidae, are the primary pests of rambutan and have a cosmopolitan occurrence. The adults and nymphs suck sap from inflorescence and other tender plant parts are associated with honey dew production which cause an indirect damage of sooty mold formation in plants. In Mexico, the introduction of the pink hibiscus mealybug, *Maconellicoccus hirsutus* (Green) happened to be a potential threat to rambutan cultivation. Another potential threat

is posed by the mealybug *Dysmicoccus brevipes* (Cockerell) (Villatoro-Moreno *et al*., 2016). Muhammed *et al*. (2016) documented the mealy bug, *P. citri*, in rambutan trees across Kerala. This mealy bug was observed both on the inflorescences and onfruits. Both nymphs and adult mealy bugsfed on the sap from the flowers and fruits. The mealy bugs, *P. citi* and *P. lilacinus* is prevalent on rambutan trees in the Philippines (Tripathi, 2021).

#### *2.1.1.1.2 Scale*

Osman and Chettanachitara (1987) reported the armoured scale (*Phenacaspis* sp.) having post-harvest importance in Southeast Asia. Muhammed *et al*. (2016) documented armoured scale of unknown species from Kerala.

### *2.1.1.2 Defoliators*

The lobster caterpillar *Neostauropus alternus* (Walker) has been recorded on the rambutan from northeast Himalayan region, Sundaland, as well as in the Philippines (Holloway, 1983; Meena *et al*., 2014). Muhammed *et al*. (2016) reported the *N. alternus* as minor pest of rambutan from Kerala.

According to Tripathi (2021) the leaf-eating caterpillar, *Oxyodes scrobicula* (Fabricius), posessed a significant threat to rambutan cultivation. The larvae of this pest primarily consume leaves and tender shoots.

In rambutan the leaf miner, *Crocercops cramerella* (Snellen) holds considerable postharvest significance in Southeast Asia. The larvae also burrow into the fruit near the peduncle (Osman and Chettanachitara, 1987).

### *2.1.1.3 Fruit Borers*

Astridge (2001) reported that the yellow peach moth *C. punctiferalis* consumes both green and mature fruits of rambutan during December to March in the coastal wet tropics of North Queensland. During this period, mature larvae bore into the fruit, rendering it unsuitable for marketing. Based on a study by Muhammed *et al*. (2016), *C.*

*punctiferalis* was observed during the fruiting season from May to August in Kerala, with an incidence rate of 66.32 per cent.

The cacao pod borer *Conopomorpha cramerella* (Snellen) is recognized as the predominant threat to cacao in South-East Asia and is notorious for its infestation in rambutan fruits (Tripathi, 2021).

Honeydew moth *Cryptophlebia gnidiella* (Milliere) has been identified for the first time attacking rambutan in Hawaii (McQuate, 2000). Previously, this pest was known to target two other Sapindaceous fruits, namely lychee *Litchi chinensis* (Sonn) and longan *Dimocarpus longan* (Lour) and later expanded its host range to rambutan. The moth laid eggs individually on the surface of the fruit, and upon hatching, the larvae penetrate through the skin to feed at the interface between the skin and pulp. Only one larva can be seen feeding within a single fruit.

### 2.1.2 Dragon Fruit

Dragon fruit, also known as pitaya, is a perennial climbing cactus that falls within the Cactaceae family. Originating from Southern Mexico, Guatemala, and Costa Rica, introduced to India in the late 1990s, and the cultivation area for this fruit has been progressively expanding (Karunakaran *et al*., 2019). There are no peer reviewed researches on insect pests of dragon fruit in India, and the crop there is virtually free of insect pests. However, the crop is infested byants, scale insects and mealy bugs (Wakchuare *et al*., 2020).

#### *2.1.2.1 Sucking Pests*

##### *2.1.2.1.1 Mealy bugs*

Sartiami *et al*. (2019) reported that four species of mealybugs are associated with dragon fruit in Indonesia. These include *Ferisia virgata* (Cockerell), *Planococcus minor* (Maskell), *Phenacoccus solenopsis* (Tinsley), and *Pseudococcus jackbeardsleyi* (Gimpel and Miller). Youssef *et al*. (2021) reported the occurrence of four pseudococcid species,

namely the cotton mealybug (*P. solenopsis*), the striped mealybug (*F. virgata*) and citrus mealybug (*P. citri*), on the stem and fruits of dragon fruit in Egypt. These insects suck the plant sap and release honeydew, resulting in the development of sooty mold.

#### *2.1.2.1.2 Thrips*

Various species of thrips belonging to order the Thysanoptera and family Thripidae have been documented on pitaya plants in southern Florida. The most frequently encountered species include *Frankliniella occidentalis* (Pergande), *Scirtothrips dorsalis* (Hood), *Thrips palmi* (Karny), *F. bispinosa* (Morgan), *F. kelliae* (Sakimura), and *F. insularis* (Duchassaing & Michelotti). These thrips create scars on the fruit during feeding, leading to deformities in the fruits (Childers and Nakahara, 2006). On dragon fruit flowers, two species of thrips were identified, namely *T. palmi* and *S. dorsalis* from Vietnam (Van Hoa and Muniappan, 2018).

#### *2.1.2.1.3 Leaf-Footed Bugs*

Leaf-footed bugs are typically regarded as minor pests, causing unsightly punctures during feeding that lead to a decline in the quality of the fruit. In southern Florida, these bugs are present year-round and feed on a variety of crops, including pitaya, guava, carambola, papaya, passion fruit, citrus, and vegetables during the fall and winter seasons (Pena *et al*., 2002). Two types of leaf-footed bugs, namely *Leptoglossus concolor* (Walker) and *Leptoglossus phyllopus* (Linnaeus) have been identified on pitaya fruits in southern Florida (Duncan *et al*., 2021).

#### *2.1.2.1.4 Aphids*

Two types of aphids, namely *Aphis craccivora* (Koch) and *Aphis gossypii* (Glover), were observed feeding on the blossoms and fruits of pitaya plants in southern Florida (Duncan *et al*., 2021).

#### *2.1.2.1.5 Scales*

*Philephedra tuberculosa* (Nakahara and Gill) (Hemiptera: Coccidae) of the order Hemiptera and family Coccidae was discovered for the first time on pitaya plants in southern Florida during June 2010. These insects extract plant sap and excrete honeydew, creating conditions favorable for the development of sooty mold. The presence of this mold obstructs photosynthesis and diminishes the marketability of the fruit (Duncan *et al*., 2021).

### *2.1.2.2 Stem feeders*

The insect known as the cactus moth, *Cactoblastis cactorum* (Berg), was initially discovered in the Florida during 1989 and has spread across the entire state. This moth posessed a significant threat to *Opuntia cacti* and has the potential to present challenges for pitaya growers (Habeck *et al*., 1998). Hoshino *etal*. (2021) reported recorded the cactus moth *C. cactorum* as a potential threat to dragon fruit in Brazil.

The beet army worm, *Spodoptera exigua* (Hubner) (Lepidoptera: Noctuidae) have been recorded on dragon fruit flowers. The caterpillars feed the flowers, and their presence is noted consistently throughout the entire year in Florida (Duncan *et al*., 2021). Prathapan and Santhoshkumar (2022) reported the infestation of *Spodoptera litura* (Fabricius) on dragon fruit in Thiruvananthapuram, Kerala. The young larvae feed by tunneling into the fleshy stem, leading to the release of thick sap, which serves as the primary indication of the infestation. In later stages, the larvae hide themselves in the soil during the daytime, emerging after sunset to ascend and voraciously consume the tender, growing stems.

Ants from the *Atta* and *Solenopsis* genera are well-known pests capable of causing significant harm to plants, flowers, and fruits of dragon fruit (Perween *et al*., 2018).

Dragon fruit was found to be infested by both the oriental fruit fly *B. dorsalis* and the melon fly *B. cucurbitae* (Coquillett) (Diptera: Tephritidae) (Iwaizumi *et al*., 1995).

### 2.1.3 Mangosteen

The mangosteen is a member of the Clusiaceae family and has its origins in Southeast Asia (Sobir *et al*., 2009). According to a survey conducted by Waterhouse, (1993) only three potential pests were identified for mangosteen from Southeast Asia and they are *Hyposidra talaca* (Walker), *Phyllocnistis citrella* (Stainton) and *Stictoptera cucullioides* (Guenee).

#### *2.1.3.1 Defoliators*

The looper caterpillar *H. talaca*is a major defoliator in tea and this caterpillar also defoliates mangosteen. The citrus leafminer *P. Citrella* mines the young leaves resulted in distortion and premature leaf drop. Its impact was particularly severe on young plants (Ooi *et al*., 2002). Another caterpillar responsible for significant harm to the young leaves of mangosteen trees in Hawaii had been identified as *S. cuculioides* (Guenee) (Lepidoptera: Noctuidae). These caterpillars were nocturnally active and could be seen feeding on young leaves until early or midmorning. *S. cucullioides* was known to exhibit voracious feeding habits on the young shoots of mangosteen (Nagao, 2004).

#### *2.1.3.2 Sucking Pests*

##### *2.1.3.2.1 Thrips*

There were two species of thrips associated with the mangosteen, *Scirtothrips dorsalis* (Hood) and *Selenothrips rubrocintus* (Giard). Their infestation caused scars on the mangosteen fruit (Emilda, 2009).

### 2.1.4 Pests of Passion Fruit

Passion fruit is a robust vine belonging to the Passifloraceae family. Commonly cultivated varieties include yellow, purple, and giant grandilla. Various insects and mites posessed threat to passion fruit, consuming all parts of the plant. Key pests include

lepidopterous defoliators, coreid bugs, stem weevils, flies, and mites. Aphids, mealybugs, scales, and termites are considered secondary pests (Joy and Sherin, 2013; 2016).

#### *2.1.4.1 Defoliators*

Ferreira *et al*. (2019) reported *Isia alcumena* (Berg), *Spodoptera cosmioides* (Walker) and *Spodoptera eridania (*Stoll) as pests affecting passion fruit cultivation in various regions of Brazil. The lepidopteran defoliators associated with passion fruit vines in Venezuela were *Dione juno* (Cramer), *Agraulis vanilla* (Linnaeus), and *Eueides isabella* (Stoll) (Dominquez- Gil and McPheron, 1992).

#### *2.1.4.2 Sucking Pests*

##### *2.1.4.2.1 Aphids*

A study conducted by Olango *et al*. (2014) in passion fruit orchards of Uganda revealed that viruses belonged to Potyvirus genus were naturally spread by various aphid species, including the green peach aphid *Myzus persicae* (Sulzer), cotton aphid *A. gossyphii*, spirea aphid *A. spiraecola* (Patch), and brown citrus aphid *Toxoptera citricidus* (Kirkaldy).

##### *2.1.4.2.2 Mealybugs*

The citrus mealybug, *P. citri* and the passion vein mealybug, *P. pacificus* (Cox) have been reported in passion fruit. Mealybugs tend to cluster on the plant, particularly at leaf nodes and beneath decaying leaves (Joy and Sherin, 2013).

#### *2.1.4.3 Scales*

The soft brown scale, *Coccus hesperidum* (Linnaeus), sporadically affect the leaves and stems of passion fruit. Meanwhile, the California red scale, *Aonidiella aurantii* (Maskell), was more prevalent on mature passion fruit vines (Swaine *et al.*, 1985).

## 2.2 NATURAL ENEMIES OF PESTS OF EXOTIC FRUIT CROPS

A comprehensive survey in the coastal wet tropics of North Queensland identified a total of forty-six beneficial insects on rambutan. This diverse group encompassed eight wasps and two bees (Hymenoptera), eight spiders (Acarina), eight predatory beetles (Coleoptera), eight damsel and dragonflies (Odonata), three predatory flies (Diptera), three bugs (Hemiptera), three lacewing species (Neuroptera), two mantids (Mantodea), and one earwig species (Dermaptera) (Astridge, 2006).

Duncan *et al*. (2021) reported predators like coccinellids and neuropterans on dragon fruit. Two parasitoids, namely *Lysiphlebus testaceipes* (Cresson) (Hymenoptera: Braconidae) and *Aphelinus* sp. (Hymenoptera: Aphelinidae), have been documented on the pests of dragon fruit in southern Florida. Santamaria *et al*. (2016) recorded parasitoids from the Hymenoptera families *viz.*, Braconidae, Diapriidae and Figitidae on *Dasiops* flies, which are pests of passion fruit in Colombia.

## 2.3 POLLINATORS OF EXOTIC FRUITS

### 2.3.1 Rambutan

The fragrant flowers of the rambutan are greatly enticing to various insects, including bees like *Apis* sp. and *Trigona*sp., butterflies, and hover flies such as *Eristalis* sp. and *Lucilia* sp. (Lan, 1984). Shivaramu *et al*. (2012) documented that the stingless bee (*Trigona iridipennis* Smith) and the Indian honeybee (*Apis cerana* Fabricius) were the most prevalent foragers from Karnataka, with mean number of 3.81 and 3.54 /panicle/10 min, respectively. Calliphorid flies, *Apis florae* (Fabricius), *A. dorsata* (Fabricius), and an unidentified wasp were also documented from rambutan and the foragers were most active during 1000 -1100 h.

### 2.3.2 Dragon Fruit

Pushpakumara *et al*. (2005) reported that *A. cerana* (honeybee), A. *florae* (dwarf honeybee), and *A. dorsata* (rock bee) species of Apidae were engaged in the successful pollination process of dragon fruit during early morning.

### 2.3.1 Passion Fruit

In Brazil, bees belonging to the genera *Xylocopa*, *Centris*, *Epicharis*, *Eulaema*, and *Bombus* have been documented as pollinators in passion fruit. Among them, *Xylocopa* sp. stand out as the most effective pollinator (Yamamoto *et al*., 2012). Passion fruit is protandrous and adapted to cross pollination by honey bees *A. mellifera* (Linnaeus), bumble bees and carpenter bee *X. sonorina*(Smith) (Das*et al*., 2013).Putra *et al*. (2023) reported that Asiatic honey bees *A. cerana*, stingless bees *T. laeviceps* (Smith), and carpenter bees *X. latipes* (Drury) were the major pollinators of the passion fruit flowers.

## 2.4 SEASONAL OCCURRENCE OF PESTS IN EXOTIC FRUITS

The study conducted by Astridge (2001) in North Queensland reported that the yellow peach moth *C. punctiferalis* and the fruit piercing moths *Eudocima salaminia* (Cramer) in rambutan, caused damage to the immature and mature fruits during December to March. The populations of red banded thrips *S. rubrocinctus* of mangosteen were reported during hot dry conditions between September and January. Thrips are active in mangosteen from flowering and will continue feeding on developing fruits up to harvest.

In South Florida, leaf-footed bugs *L. concolor* and *L. phyllopus*, aphids *A. craccivora* and *A. gossypii*, scale *P. tuberculosa* and mealybug *F. dasylirii* were present throughout the year on the dragon fruit plant (Duncan *et al*., 2021). In Kenya aphid population *A. gosypii*, *Ropalosiphum maidis* (Fitch), *Acyrthosiphon pisum* (Harris) and *Brevicoryne brassicae* (Linnaeus) on passion fruit were maximum during June to July and December to February (Kilalo *et al*., 2013).

# *Materials and Methods*

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# 3. MATERIALS AND METHODS

The study entitled “Pests of exotic fruit crops in Kerala.” was conducted at Department of Entomology, College of Agriculture, Vellayani during 2021-2023. The objective of the study includes documentation of pests, its natural enemies and pollinators in exotic fruits of Kerala. The materials and methods adopted for the study are detailed below.

## 3.1 DOCUMENTATION OF PESTS, ITS NATURAL ENEMIES AND POLLINATORS OF EXOTIC FRUITS IN KERALA

Five plants of rambutan *N. lappaceum*, dragon fruit *S. undatus*, mangosteen *G. mangostana* and passion fruit *P. edulis* were selected from the Instructional Farm Vellayani. In addition, College of Agriculture, Vellanikkara and farmers field in Thiruvananthapuram, Kollam, Kottayam and Malappuram were also visited multiple times for the documentation. Pests of other minor fruit crops like miracle fruit *Synsepalum dulcificum* (Daniell.), pulasan *Nephelium mutabile* (Blume.)**,** abiu *Pouteria caimito* (Schumach. and Thonn.), soursop *Annona muricata* (L.), litchi *Litchi chinensis* (Sonn.), velvet apple *Diospyros discolor* (Willd.) and longan *Dimocarpus longan* (Lour.) were also documented. Pollinators and natural enemies of pests associated with the exotic fruit crops were also collected, identified and documented.

### 3.1.1 Documentation of Pests

Pests associated with rambutan, dragon fruit, mangosteen, passionfruit and other minor fruits were collected both on the vegetative and flowering phases. During the flowering and fruiting phase, flower buds, inflorescence, immature and mature fruits were examined for the presence of pests. Meanwhile, during the vegetative stage, the entire

plants were observed to detect the presence of pests.The fruit plants were also monitored for the signs and symptoms of pest's damage resulting from their feeding activities.

The immature stages of these pests were collected and reared in the laboratory until they emerged as adult. Lepidopteran pests were collected using a sweep net, while coleopteran pests were manually picked by hand. Sticky traps were also deployed to capture small insects like whiteflies and leafhoppers. The collected specimens were subsequently dried and preserved for later identification. Soft bodied specimens were stored in 70% alcohol, and the identification was done with the help of expert taxonomists.

### 3.1.1.1 Biology of Pests

Biology oforiental fruit fly *B. dorsalis*, brown stink bug *Halyomorpha picus* (Fabricius) affecting dragon fruit and the gold tail moth *Sphrageidus xanthorrhoea* (Kollar) found on passion fruit, was studied in laboratory conditions at the Department of Entomology, Vellayani.

The initial population of oriental fruit flies were maintained using fruits that were already infested with fruit fly maggots which were placed in laboratory at the room temperature. Soil was provided for the later instars for pupation. The emerged adults were then transferred to rearing containers. Cotton swab soaked in honey solution was provided as food source for the adult flies. Two pairs of mated adults were transferred to containers having matured dragon fruit for oviposition.

The egg period was determined by noting the time from egg laying to hatching. The larval period was recorded by noting the time from egg hatching to prepupal stage. The pre-pupal period was calculated as the time between the transformation of the last instar larvae to the pupa.The pupal period was determined by noting the time from the pupation to adult emergence. To assess the lifespan of male and female adult flies, they were placed in ventilated plastic containers with honey solutions. Adult longevity was calculated as the time from the emergence of the adult fly to its death.

Gold tail moth (*S. xanthorrhoea*) caterpillars were collected from the field and were reared in rearing containers provided with fresh tender leaves of passion fruit. Two pairs of adults that emerged from the pupae of these caterpillars were again transferred to rearing bottles and provided with cotton swab containing honey solution as food. The rearing container covered with muslin cloth was left undisturbed for mating and oviposition. Once the larvae emerged, they were provided with fresh, tenderpassion fruit leaves as food. Larval instars, total larval period and pupal period were recorded subsequently. To determine the lifespan of adults, male and female adults were placed in well-ventilated rearing containers with honey solutions as food, and their longevity was measured from the moment they emerged as adults to their death.

To rear the brown stink bug (*H. picus*), adult insects were collected from the field and placed in plastic rearing containers with proper air circulation. These containers were provided with small stem of the dragon fruit plant, both for oviposition and as a food source. The containers were covered with muslin cloth and left undisturbed to facilitate egg-laying. Fresh food was given daily. When egg clusters were discovered, each cluster was placed in rearing containers separately and the hatched nymphs werecontinuously fed with fresh stems of the dragon fruit plant. This experimental setup was monitored daily, and the duration of various developmental stages was recorded, including the egg period, nymphal period, and the overall developmental period. The duration of nymphal instars was calculated by observing the exuviae of each moulting. The data was presented in the results from the observations made on 10 different egg masses.

### 3.1.2 Natural Enemies

During the study, both the predators and parasitoids associated with the pests of rambutan, dragon fruit, mangosteen, passionfruit and other minor fruits were recorded. Predators were collected and stored in 70% alcohol for identification. The field collected parasitized larvae and pupae were kept in a polythene cover until the adults emerged and got identified by the experts.

### 3.1.3 Pollinators

Study on pollinators of rambutan and passionfruit were done at the College of Agriculture, Vellayani during their respective flowering seasons. To assess the pollinator diversity, five rambutan plants were chosen from the fruit orchard and five inflorescences were randomly selected from these trees. Thefloral visitors were monitored through visual observations. Pollinators visiting the inflorescence were recorded for 5 min on these 5 trees at hourly intervals from 0600 to 1800 h. The data was then compiled, and the observations were expressed as the mean population per five inflorescences per five minutes. The observations were taken once in a week and repeated for four weeks in a month. The pollinators visiting the passion fruit flowers were also documented by the same method as mentioned above. Five plants were chosen and pollinator visiting 5 flowers in each plant was observed. Since the passion fruit flowers open during the mid-day, observations were taken for five minutes at hourly intervals from 1200 to 1800 h and were repeated once in a week for four weeks. For identifying the pollinators, they were collected using aerial nets and preserved for identification by taxonomist.

## 3.2 SEASONAL INCIDENCE OF MAJOR PESTS IN RAMBUTAN

For observing the seasonal incidence, five trees were chosen from the orchard, tagged-and deliberately left untreated with insecticides for the entire duration of the study. Occurrence of major pests was systematically recorded at biweekly intervals for one year. The data obtained was then correlated with the climatic parameters like temperature, average relative humidity, total rainfall, wind velocity and sunshine.

Table 1: The methodology adopted for assessing pest populations.

| **Pest** | **Methodology adopted** |
|---|---|
| Cow bug | Number of nymphs and adult per branch |
| Pod bug | Number of adult bugs per branch |
| Caterpillar | Number of larvae per branch |
| Flower beetle | Number of adults and grubs per inflorescence |

| | |
|---|---|
| Mealy bug | Number of nymphs and adults per one centimeter |

## 3.3 STATISTICAL ANALYSIS

Data obtained from all the experiments were transformed if required and analysed using appropriate statistical tools.

# *Results*

# 4. RESULT

The study entitled “Pests of exotic fruit crops in Kerala.” was conducted with the objective of documenting the pests, its natural enemies and pollinators in the exotic fruits of Kerala. In this chapter, the pests, natural enemies and pollinators along with the descriptions of different life stages (egg, young ones and adult) of the pests and their nature of damage and symptoms in exotic fruit crops were documented. The results are presented as follows

There were 60 different pests, 24 natural enemies and 14 pollinators recorded from commercially cultivated and minor exotic fruits across Kerala. Among these, 32 pests from rambutan *N. lappaceum*, 8 from dragon fruit *S. undatus*, 7 from mangosteen *G. mangostana*, 4 from passion fruit *P. edulis*and 10 from various minor fruit crops *viz*., miracle fruit *S. dulcificum*, pulasan *N. mutabile***,** abiu *P. caimito*, soursop *A. muricata*, litchi *L. chinensis*, velvet apple *D. discolor* and longan *D. longan*. Among the pests documented, 27 were from the order Hemiptera, 21 from Lepidoptera, 6 from Coleoptera, 4 from Hymenoptera, and 2 from Diptera. The natural enemies documented include 15 spiders, 3 parasitoids, and 6 insect predators.

## 4.1 DESCRIPTION OF PESTS, NATURE OF DAMAGE AND THEIR SYMPTOMS

### 4.1.1 Pests of Rambutan

A total of 32 pests, belonging to the order Lepidoptera (14), Hemiptera (11), Coleoptera (5), and Hymenoptera (2) were recorded from rambutan. The pests were listed in the table 2.

Table 2: Insect pests documented from rambutan, *Nephelium lappaceum*

| ORDER: HEMIPTERA | | | | |
|---|---|---|---|---|
| Sl. no | Common Name | Scientific Name | Family | Nature of feeding |
| 1 | Mealybug | *Planococcus lilacinus* Cockerell | Pseudococcidae | Sap feeder |
| 2 | Mealybug | *Crisicoccus hirsutus* Newstead | Pseudococcidae | Sap feeder |
| 3 | Striped mealybug | *Ferrisia virgata* Cockerell | Pseudococcidae | Sap feeder |
| 4 | Citrus mealy bug | *Planococcus citri* Risso | Pseudococcidae | Sap feeder |
| 5 | Florida wax scale | *Ceroplastes floridensis* Comstock | Coccidae | Sap feeder |
| 6 | Scale insect | *Icerya* sp. | Monophlebidae | Sap feeder |
| 7 | Bean bug | *Riptortus pedestris* Fabricius | Alydidae | Sap feeder |
| 8 | Cow bug | *Otinotus oneratulus* Walker | Membracidae | Sap feeder |
| 9 | Tree hopper | *Gargara* sp. | Membracidae | Sap feeder |
| 10 | Black plant hopper | *Ricania* sp. | Ricaniidae | Sap feeder |
| 11 | Flatid Plant hopper | *Flatormenis* sp. | Flatidae | Sap feeder |

Table 2: Insect pests documented from rambutan, *Nephelium lappaceum* (Contd.)

| ORDER: LEPIDOPTERA | | | | |
|---|---|---|---|---|
| Sl. no | Common Name | Scientific Name | Family | Nature of feeding |
| 1 | White looper moth | *Pingasa chlora* Stoll | Geometridae | Flower feeder |
| 2 | Slate flash | *Rapala manea* Hewitson | Lycaenidae | Flower feeder |
| 3 | Emerald moth | *Hemithea ritonaria* Walker | Geometridae | Flower feeder |
| 4 | Yellow-tail tussock moth | *Somena scintillans* Walker | Erebidae | Flower feeder |
| 5 | Tussock caterpillar | *Olene mendosa* Huebner | Erebidae | Flower feeder |
| 6 | Looper | *Comibaena cassidara* Guenee | Geometridae | Flower feeder |
| 7 | Pointed ciliate blue | *Anthene lycaenina* Felder | Lycaenidae | Flower feeder |
| 8 | Owl moth | *Avatha discolor* Fabricius | Erebidae | Defoliator |
| 9 | Flower feeding caterpillar | *Eublemma abrupta* Walker | Erebidae | Flower feeder |
| 10 | Flower webber | *Eublemma versicolor* Walker | Erebidae | Flower feeder |
| 11 | Flower webber | Unidentified | Unidentified | Flower feeder |
| 12 | Bark borer | Unidentified | Xyloryctidae | Bark feeder |
| 13 | Bark borer | Unidentified | Lecithoceridae | Bark feeder |
| 14 | Bag worm | Unidentified | Psychidae | Leaf feeder |

Table 2: Insect pests documented from rambutan, *Nephelium lappaceum* (Contd.)

| ORDER: COLEOPTERA | | | | |
|---|---|---|---|---|
| Sl. No | Common Name | Scientific Name | Family | Nature of feeding |
| 1 | Scarab beetle | *Popillia* sp. | Scarabaeidae | Flower feeder |
| 2 | Warty leaf beetle | *Exema salemensis* Bhasin | Chrysomelidae | Flower feeder |
| 3 | Leaf beetle | *Monolepta* sp. | Chrysomelidae | Flower feeder |
| 4 | Flower beetle | *Oxycetonia versicolor* Fabricius | Scarabaeidae | Flower feeder |
| 5 | Flower beetle | Unidentified | Bruchidae | Flower feeder |
| ORDER: HYMENOPTERA | | | | |
| 1 | Red ant | *Oecophylla smaragdina* Fabricius | Formicidae | Aphid association |
| 2 | Black ant | *Camponotus compressus* Fabricius | Formicidae | Cowbug association |

***4.1.1.1 Hemiptera***

***4.1.1.1.1 Mealybugs***

The mealybugs recorded on rambutan were *P. lilacinus* (Plate 1a), *C. hirsutus* (Plate 1b), *F. virgata* (Plate 1c) and *P. citri* (Plate 1d). Among the four *C. hirsutus*, *F. virgata* and *P. citri* were located mainly on inflorescence stalk while *P. lilacinus*

inhabited the spaces between the spinterns of fruits, sucking sap from both immature and ripe fruits. They excrete honeydew, leading to the development of sooty mold that eventually darkens into a black colour.

#### *4.1.1.1.2 Scale insects*

Florida wax scale *C. floridensis* and *Icerya* sp. were the two scale insects recorded on rambutan. Adult *C. floridensis* were reddish brown colour covered with wax having pinkish white tan (Plate 2a). They were found on midribs, stems, and twigs and suck sap from it. Adult *Icerya* sp. was white coloured soft scales and was observed on the inflorescence (Plate 2b).

#### *4.1.1.1. 3 Tree hoppers*

Cow bug *O. oneratulus* and *Gargara* sp. were the two tree hoppers identified on rambutan. The adult *O. oneratulus* along with nymphs and eggs were observed on the inflorescence stalks of rambutan. Females deposited eggs in clusters using a saw-like ovipositor inserting them into the inflorescence stalk. The eggs, initially white, changed to yellow and then to dark brown just before hatching. The nymphs had an extendable anal tube and exhibited bright colors. Adults were black grey in colour and have horn-like projections on the pronotum. When disturbed, they exhibited a spiral movement around the stalk and were associated with black ants that fed on the honey dew excreted by the bugs (Plate 3). The nymphs and adults of *Gargara* sp. were observed individually and fed on the sap from the inflorescence stalk. Adults were brown to greenish in color and they possessed an enlarged pronotum that forms a hood-like covering over the dorsal anterior part of their body (Plate 4).

#### *4.1.1.1.4 Plant hoppers*

*Ricania* sp. and *Flatormenis* sp. were the plant hoppers observed on rambutan. The adults of *Ricania* sp. were brown to black colour with wavy horizontal markings on their wings resembling moths. The adults laid small white triangular-shaped eggs on mid

rib of leaves (Plate 5a&b). The adult *Flatormenis* sp. was light green in color and nymphs were having waxy secretions attached on the abdominal end (Plate 5c). Both the adult and nymph of the plant hoppers were sap feeders.

#### *4.1.1.1.5 Bean bug* (*Riptortus pedestris* Fabricius)

These moderately-sized elongated bugs displayed primarily brown hue, accompanied by pale-yellow underside delicately infused with brown tones. The head had a triangular shape, and the antennae were notably lengthy, with the fourth segment being the most extended. The pronotum, forming a quadrangular shape, was slightly widened at the base and having humeral spines. The fore and mid legs appeared slender, while the hind legs featured swollen femora, characterized by a substantial number of granules and setae, along with a row of ventral spines on the hind femora. The adult bugs were observed on the inflorescence and fruits and caused damage by sucking sap resulting in the formation of brown feeding spots on the fruits surface (Plate 6).

### *4.1.1.2 Lepidoptera*

#### *4.1.1.2.1 Inflorescence feeders*

#### *4.1.1.2.1.1 White looper moth* (*Pingasa chlora* Stoll)

The adults were greyish white in colour with two dark zig-zag lines across each forewing, and one across each hindwing on the dorsal side. The ventral side exhibited a white coloration with wide black submarginal bands, accompanied by a dark dash near the midpoint of costa of each forewing. Pupae appeared as pale brown with black dots. The early instars of larvae were yellowish-green, while the later instars were green with yellow markings with the head capsule turning pale green colour (Plate 7). The larvae were inflorescence feeders.

#### *4.1.1.2.1.2 Slate flash* (*Rapala manea* Hewitson)

Adult males were having dark brown wings with a tint of purple on the cell area of the wings. The ventral surface of wing was greyish brown with two irregular bands. Females were lighter and had androconial patches at the costal margin of the hindwing. The larvae displayed a combination of dull red and green colors, while the pupae were having a mottled brown appearance with black markings. The larvae were inflorescence feeders (Plate 8).

#### *4.1.1.2.1.3 Emerald moth* (*Hemithea tritonaria* Walker)

Adult moths were light bluish green in colour with white wavy lines and white lines along the borders of both fore and hind wings. The looper larvae, which resembled sticks, were of a dirty green shade. The pupae were of light brown shade with distinct dark brown markings. The larvae fed both flowers and flower buds (Plate 9).

#### *4.1.1.2.1.4 Yellow-tail tussock moth* (*Somena scintillans* Walker)

They were medium sized moth with brown-coloured fore wings and yellow-coloured hind wings. The outer apical margins of fore wings were having yellow markings. The head and legs displayed yellow hue, accompanied by a tuft of yellow hairs. The thorax and abdomen were of a pale brown shade, featuring a yellow anal tuft. Eggs were round, orange coloured covered with yellow tuft of hairs, was observed on the inflorescence. The early larval instars were yellowish with a black line on the lateral side of the abdomen, while fully grown larvae were black with crimson lateral tubercles and tufts of grey hair on the dorsal side. Pupation occurred within a silken web of creamy-white threads, forming a cocoon. The obtect pupae were dark brown in colour. The larvae were voraciously feeding on the inflorescence and tender leaves (Plate 10).

#### *4.1.1.2.1.5 Tussock caterpillar* (*Olene mendosa* Huebner)

The forewings of adult moths were pale to dark brown, while the hind wings were brownish yellow in colour with a brown body. The hairy caterpillars were brown to black colour with rusty-brown head and legs. Two black hair pencils were seen on each side of

the head and one on the abdominal tip. Four white or brown dorsal tussocks were on the first four abdominal segments and four white black-coloured lateral tussocks were on the sides of the first two abdominal segments. Pupation occured within a silken cocoon. These larvae were observed feeding on the inflorescence (Plate 11).

#### *4.1.1.2.1.6 Looper* (*Comibaena cassidara* Guenée)

The medium sized moth was green coloured with copper coloured narrow band on the tornus of forewing and apex of hindwing. Small black discal spots were observed on both fore and hind wings. Forewing had an indistinct, pale antemedial line. The eggs were oval and bluish green colour. The larvae were greyish brown in colour with small conical spines and long setiferous fleshy projections over the thorax and abdomen. Both the early and late instar larvae were covered by dry rambutan flowers by means of silken threads. The larvae pupated in a loose, silken cocoon incorporating frass. The larvae were found feeding on the inflorescence (Plate 12).

#### *4.1.1.2.1.7 Pointed ciliate blue* (*Anthene lycaenina* Felder)

The adults were dark brown with bluish tint on the inner margins of both wings. On the ventral side of hind wing, a black spot encircled by white margin was seen near the costal margin. Another black spot present on the anal angle was topped by an orange marking. The discal and terminal transverse bands, along with their pale or white edges, were considerably more fragmented and irregular. The stout and dark green larvae, displayed two rows of cream-coloured patterns on the dorsal surface. The pupa was green in color. The larva was found feeding on the flowers of inflorescence (plate 13).

#### *4.1.1.2.1.8 Flower feeding caterpillar* (*Eublemma abrupta* Walker)

The adults were characterized by a pale red-brown coloration, with a dark chestnut hue on the head and collar. The forewings exhibited dark specks, a chestnut postmedial line, and an apical pale patch surrounded by dark suffusion. The hindwings displayed a double oblique medial line, along with postmedial and submarginal series of black and white specks. The larvae exhibited a reddish coloration with black streaks,

lateral dots, and transverse yellow stripes. Notably, there were paired oblique white stripes on the 9th and 10th segments. Dorsal prominences were observed on segments 5, 6, 7 and 11 while segments 3, 4, and 5 each featured four spatulate dorsal filaments. The pupation of the larvae occurred on the inflorescence, and the resulting pupae displayed a brown coloration. The larvae were observed feeding on both flowers and flower buds (Plate 14).

#### *4.1.1.2.1.9 Flower webber* (*Eublemma versicolor* Walker)

The adult moth with pale brown wings and a prominent dark line across both fore wing and hind wing. The caterpillar had a light brown head and the greenish-yellow tone of the body, transitioning to a pink color before entering the pupation stage. The larvae undergo pupation within a sturdy case, enveloped by dried floral components and excretory pellets. The larvae spin webs, shelter under the webs and fed on tender fruits and inflorescence (Plate 15).

#### *4.1.1.2.1.10 Flower webber (Unidentified)*

Moderate sized moths, featuring brown forewings adorned with a subtle yellow band in the basal region. The hind wings exhibited a cream color with brown margins. The larvae, characterized by a green hue with black lateral lines and small white hairs on the body surface and a brown colour head capsule. These larvae webbed the inflorescence and the pupation occurs within the web (Plate 16).

### *4.1.1.2.2 Leaf feeders*

#### *4.1.1.2.2.1 Owl moth* (*Avatha discolor* Fabricius)

Dark greyish brown moth with two small black triangles on the dorsal side of forewings. Hind wings with whitish cilia at apex and anal angle. The larvae exhibited an elongated shape with a subtle taper at both ends, displaying a dark brown hue. Pale white patches were noted on both the thorax and abdominal segments. It pupates within the

plant debris and was dark brown in colour. The larvae were found feed on the foliage (Plate 17).

#### *4.1.1.2.2.2 Bag worms (Unidentified)*

There were two species of bagworms found feeding on the foliage of rambutan (Plate 18).

#### *4.1.1.2.3 Bark feeders*

#### *4.1.1.2.3.1 Bark borer (Unidentified)*

The adults of the unidentified bark borers were a straw yellow to dark grey moths of 7- 9 mm wing span. Antenna straw coloured, extending a little beyond half of forewing. Palpi light yellow, upcurved. Head covered with light whitish yellow scales. Dark forms were with light grey scales on forewings in basal one third forming a light grey pattern, a diffused transverse band of light grey in distal one third and a similar band towards apex of forewing. Underside of forewing with dark grey scales. Fringes of forewing dark grey with lighter apex. Hind wings were dark grey with lighter fringes. Fore coxa exteriorly with dark scales, fore tibia anteriorly and apically with dark scales, rest of legs were light yellow in colour. Hind tibia laterally with tuft of long grey scales having white spatulate apex. Lighter form entirely yellow dorsally with scattered grey scales on forewing. Fringes of both fore and hind wings light yellow,tuft of setae on hind tibia distally dark with white apex.

The larvae were 6 to 7 mm long and yellowish-pink (Plate 19). The final instar larvae underwent pupation within a silk cocoon situated on crevices of bark. Damage symptoms initially appeared in the fork region, and extended to other regions. In cases of severe infestation, damage was observed all over the branches (Plate 20). In the present investigation incidence of the microlepidopteran bark borer was observed in the rambutan orchards at Ponkunnam, Kottayam and the infestation was about 45 percent.

#### *4.1.1.2.3.2 Bark borer (Unidentified)*

The adults were entirely white with a wing span of 2 cm , adorned with a sequence of small black spots along the apical margins of the forewings (Plate 21). The larvae exhibited a pink coloration with a crimson head, and had a brown patch behind the head capsule. The larvae were found feeding on the bark, creating tunnels by burrowing into it and concealing them with excreted materials (Plate 22). Pupation occurred within a hard case constructed from silk threads and excretory pellets, and the pupae were affixed to the bark's surface.

### *4.1.1.3 Coleoptera*

#### *4.1.1.3.1 Flower feeders*

Five flower beetles including an unidentified species were observed on the inflorescence of rambutan. The adult scarab beetles (*Popillia* sp.) measured approximately 1 cm in length and had metallic green colour with a coppery-brown hue on wings. Sternal region of abdomen was having white markings. The mature beetles fed the flowers of rambutan (Plate 23a).

Adult leaf beetles (*Monolepta* sp.) were small elliptical to oval shaped, cream-colored with yellow head and thorax. Adults were found feeding on the inflorescence (Plate 23b). The flower chafer beetle adults, *Oxycetonia versicolor* measuring 1-1.5 cm in length, possess brick-red elytra and prothorax adorned with black and white patches on their wings. The adults of flower chafer beetle were found feeding the flowers (Plate 23c).

The adult warty leaf beetles (*Exema salemensis*) were about 3–4 mm in length and black colour resembling caterpillar dropping. Females were entirely black, while males were black with a silvery patch on the dorsal side of their thorax. Females lay eggs individually on the inflorescence and between the spinters of fruits. After hatching, the grub stay within the case and the progression of their development can be observed as they expand their fecal cases. The larval case is sealed to the substrate prior to pupation

(Plate 24). Both the grubs and the adult beetles consume the inflorescence and fruits, and the feeding scars eventually darken in colour (Plate 25).

The unidentified beetles coming under the family Bruchidae were also found feeding on the flowers. The adults were black in colour with small white spots on the elytra (Plate 23d).

#### *4.1.1.4 Hymenoptera*

##### *4.1.1.4.1 Ants*

Red ant *Oecophylla smaragdina* (Fabricius) (Plate 26 a) was found associated with mealybug and black ant *Camponotus compressus* (Fabricius) (Plate 26 b) associated with cowbug and mealybugs.

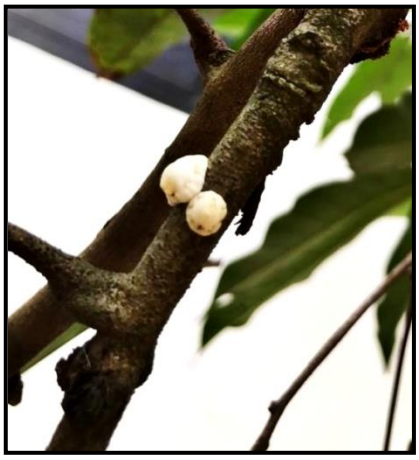
a. *Planococcus lilacinus*

b. *Crisicoccus hirsutus*

c. *Ferrisia virgata*

d. *Planococcus citri*

Plate 1. Mealybugs infesting *Nephelium lappaceum*



a. *Ceroplastis floridensis*

b. *Icerya* sp.

Plate 2. Scales infesting *Nephelium lappaceum*

Egg

Nymph

Adults

Plate 3. Life stages of cow bug, *Otinotus oneratulus* and its damage on *Nephelium lappaceum*

Plate 4. *Gargara* sp. feeding on *Nephelium lappaceum*

a. *Ricania* sp.

b. *Ricania* sp.

c. *Flatormenis* sp.

Plate 5. Plant hoppers infestation on *Nephelium lappaceum*

Adults feeding on flowers and fruits

Plate 6. *Riptortus pedestris* infestation on *Nephelium lappaceum*

Early instar larva

Late instar larva

Pupa

Adult – Dorsal view

Adult – Ventral view

Plate 7. Life stages of white looper moth, *Pingasa chlora* on *Nephelium lappaceum*

Larva feeding on inflorescence

Pupa

Adult – Ventral view

Adult – Dorsal view

Plate 8. Life stages of slate flash, *Rapala manea* on *Nephelium lappaceum*

Larva feeding on inflorescence

Pupa

Adult

Plate 9. Life stages of emerald moth, *Hemithea tritonaria* on *Nephelium lappaceum*

Egg

Early instar larva

Late instar larva

Pupa

Male and Female

Plate 10. Life stages of yellow-tail tussock moth, *Somena scintillans* on *Nephelium lappaceum*

Larva feeding on inflorescence

Pupa

Adult

Plate 11. Life stages of tussock caterpillar, *Olene mendosa* on *Nephelium lappaceum*

Egg

Larva

Pupa

Adult

Plate 12. Life stages of looper, *Comibaena cassidara* on *Nephelium lappaceum*

Larva feeding on inflorescence

Pupa

Adult – Dorsal view

Adult – Ventral view

Plate 13. Life stages of pointed ciliate blue, *Anthene lycaenina* on *Nephelium lappaceum*

Egg

Early instar larva

Late instar larva

Pupa

Adult

Plate 14. Life stages of Flower feeding caterpillar *Eublemma abrupta* on *Nephelium lappaceum*

Larva

Pupa

Adult

Damage caused by the larva on inflorescence

Plate 15. Life stages of flower webber, *Eublemma versicolor* and its damage on *Nephelium lappaceum*

Larva

Adult

Damage on inflorescence

Plate 16. Life stages of flower webber and its damage on *Nephelium lappaceum*

Larva

Pupa

Adult

Plate 17. Life stages of owl moth, *Avatha discolor* on *Nephelium lappaceum*

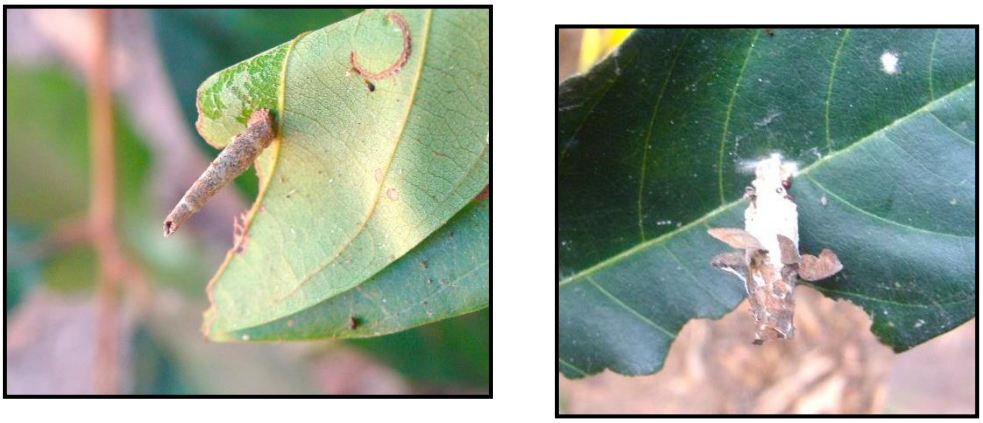


Plate 18. Bagworms observed on *Nephelium lappaceum*

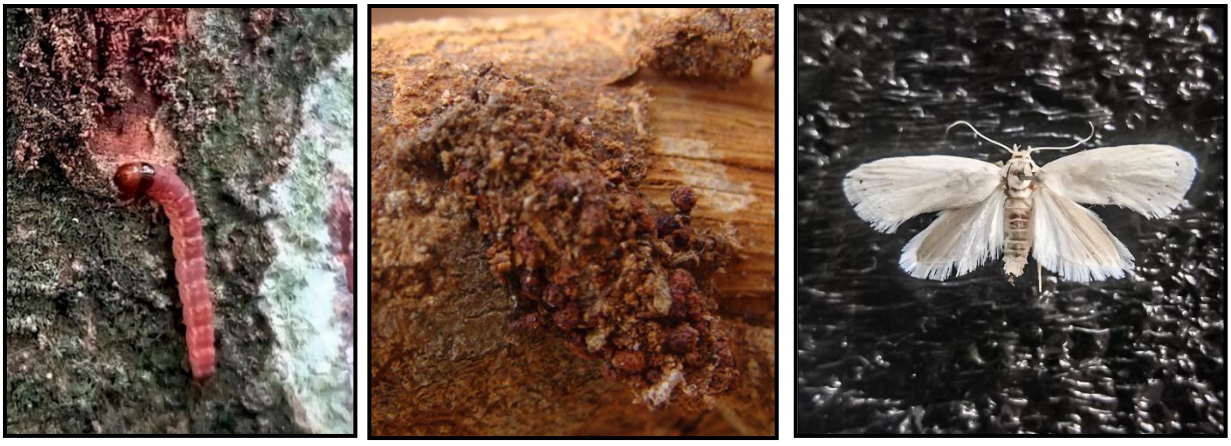
Larva Pupa

Adults

Plate 19. Life stages of bark borer on *Nephelium lappaceum*

Damage symptoms caused by larva

Plate 20. Damage of bark borer on *Nephelium lappaceum*



Larva Pupa Adult

Plate 21. Life stages of bark borer on *Nephelium lappaceum*

Plate 22. Damage symptoms caused by bark borer on *Nephelium lappaceum*

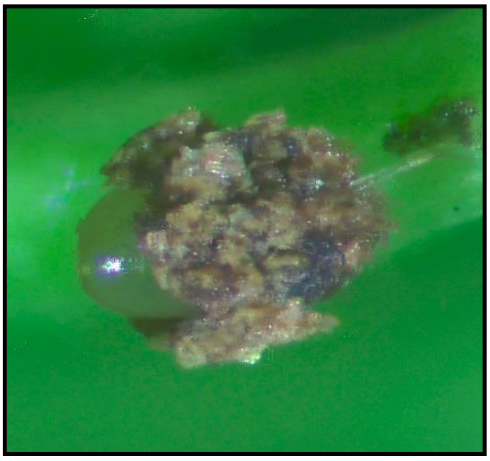
a. *Popillia* sp.

b. *Monolepta* sp.

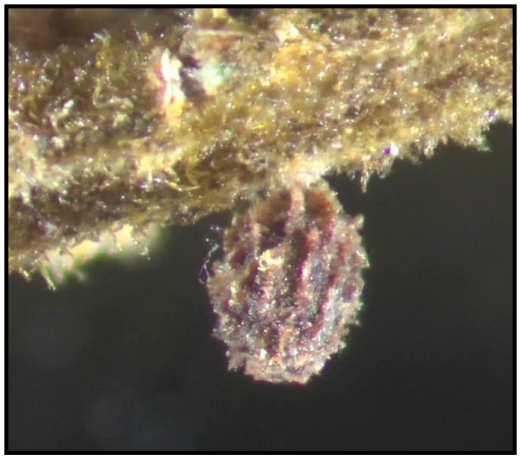
c. *Oxycetonia versicolor*

d. Unidentified

Plates 23. Beetles observed on inflorescence of *Nephelium lappaceum*



Transparent egg inside the case



Egg with case

Early instar grub

Late instar grub

Pupa

Adult

Adult – Male and Female

Plate 24. Life stages of warty leaf beetle, *Exema salemensis* on *Nephelium lappaceum*

Plate 25. Feeding scars of grubs and adults of warty leaf beetle on *Nephelium lappaceum*

a. *Oecophylla smaragdina* b. *Camponotus compressus*

Plate 26. Ants observed on *Nephelium lappaceum*

### 4.1.2 Pests of Dragon Fruit

A total of 8 pests were documented in dragon fruit, belonging to the order Hemiptera (5), Lepidoptera (1), Diptera (1), and Hymenoptera (1).

Table 3: Insect pests documented from dragon fruit *Selenicereus undatus*

| ORDER: HEMIPTERA | | | | |
|---|---|---|---|---|
| Sl. No | Common Name | Scientific Name | Family | Nature of feeding |
| 1 | Stink bug | *Halyomorpha picus* Fabricius | Pentatomidae | Sap feeder |
| 2 | Plant hopper | *Eurybrachis* sp. | Eurybrachidae | Sap feeder |
| 3 | Striped mealybug | *Ferrisia virgata* Cockerell | Psuedococcidae | Sap feeder |
| 4 | Black planthopper | *Ricania* sp. | Ricaniidae | Sap feeder |
| 5 | Green plant hopper | *Flatormenis* sp. | Flatidae | Sap feeder |
| ORDER: DIPTERA | | | | |
| 1 | Oriental fruit fly | *Bactrocera dorsalis* Hendel | Tephritidae | Fruit feeder |
| ORDER: LEPIDOPTERA | | | | |
| 1 | Tobacco cutworm | *Spodoptera litura* Fabricius | Noctuidae | Stem feeder |
| ORDER: HYMENOPTERA | | | | |
| 1 | Destructive trailing ant | *Trichomyrmex destructor* Jerdon | Formicidae | Foraging on fruit |

#### *4.1.2.1 Hemiptera*

##### *4.1.2.1.1 Stink bug* (*Halyomorpha picus* Fabricius)

The adult bugs were greyish brown with dark and densely marked punctuations. Brown spots were present on the head, anterior and lateral areas of the pronotum. The

ventral body surface and the legs displayed a pale yellowish hue, with punctuations on the lateral areas. The head was elongated, surpassing its width. The insect had thin filliform antennae, with a thick scape not extending to the tip of head. Both nymphs and adult caused damage by feeding the plant sap from the fleshy stem. The feeding symptom caused typical white patches on stem (Plate 27).

#### *4.1.2.1.2 Plant hoppers*

Three plant hoppers *viz., Eurybrachis* sp., *Ricania* sp. and *Flatormenis* sp. were recorded from dragon fruit. Adults of *Eurybrachis* sp. were of moderate size, measuring around 2-3 cm, and exhibited a green hue with distinctive white bands and red legs. They were frequently adorned with tufts of white fluff. The males, in contrast, displayed a brownish coloration with pink legs. The frons was wider than its length. The females laid clusters of yellow eggs on stems, typically arranged within a small, fingerprint-sized area covered in white waxy material (Plate 28).

The adults of *Ricania* sp. were characterized by brownish-black coloration, and their wings exhibited wavy horizontal markings like moths. The adult *Flatormenis* sp. was light green in colour. Adults and nymphs of plant hoppers sucked sap from fleshy stems of dragon fruit (Plate 29).

#### *4.1.2.1.3 Striped mealybug* (*Ferrisia virgata* Cockerell)

Mealybugs were present on the fleshy stem of dragon fruit, where they fed on sap. Adult mealybugs have an elongated oval body, characterized by a whitish-grey colour and covered in a white mealy wax coating (Plate 30).

#### *4.1.2.2 Diptera*

#### *4.1.2.2 .1 Fruit fly* (*Bactrocera dorsalis* Hendel)

The adult flies were small to medium with colorful markings on the body. They had a black thorax with a T-shaped dark marking on the abdominal segment. Additionally, their thorax and abdomen featured distinct yellow and black patterns. The

wings were transparent, characterized by a continuous costal band. The adult females laid their eggs just beneath the mature fruit skin, and the maggots fed the internal contents of the fruit. Ovipositional marks were visible on the fruit skin and the feeding of the maggots lead to the decay of internal contents emitting a foul smell (Plate 31).

#### *4.1.2.3 Lepidoptera*

##### *4.1.2.3.1 Tobacco cutworm* (*Spodoptera litura* Fabricius)

Adult moths had a size ranging from 1.5 to 2 cm and exhibited a grey-brown coloration. The forewings had intricate patterns characterized by dark gray and brown hues, while the hindwings featured a greyish-white color with a defined grey border. Female moths were marginally larger than their males, and the orbicular spot on the forewings was more obvious in males. The females laid round orange-brown color eggs and covered the egg clusters with hair scales, imparting a golden-brown appearance, and these egg masses were commonly found on young seedlings. Younger larvae typically displayed a lighter green shade, transitioning to a darker green or brown color as they mature. The larvae had a vibrant yellow stripe along the dorsal surface which made a distinctive character. Pupae, measuring approximately 1.5 cm in length, exhibit a reddish-brown color. Early instar larvae fed by scrapping the stem, while the later instars exhibited voracious feeding behavior, consuming the stem and creating bore holes (Plate 32).

#### *4.1.2.4 Hymenoptera*

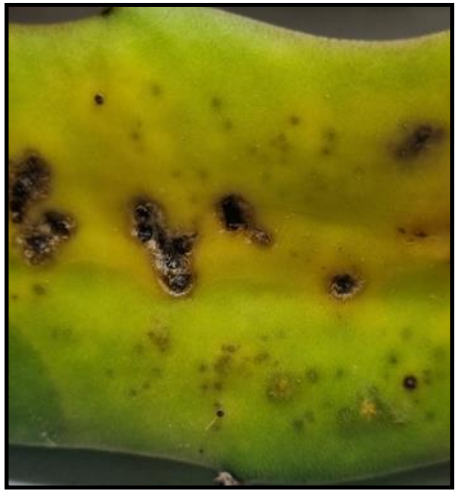
##### *4.1.2.4 .1 Destructive trailing ant* (*Trichomyrmex destructor* Jerdon)

The aggressive worker ants had a size range from 1.8 to 3.5 mm. The colour varied from light yellow to a darker brownish-yellow, often with a dark brown hue. The body was predominantly smooth and shiny, featuring upright setae. These ants were observed foraging on fruits, flowers, and stems (Plate 33).

Egg

Different nymphal stages of stink bug

Adult



Damage symptoms

Plate 27. Life stages of stink bug, *Halyomorpha picus* and its damage on *Selenicereus undatus*

Egg Male Female

Plate 28. Plant hopper *Eurybrachis* sp. observed on *Selenicereus undatus*

*Flatormenis* sp. *Ricania* sp.

Plate 29. Plant hoppers observed on *Selenicereus undatus*

Plate 30. Striped mealybug, *Ferrisia virgata* observed on *Selenicereus undatus*

Egg

Maggot

Pupa

Adult

Damage symptoms

Plate 31. Life stages of fruit fly, *Bactrocera dorsalis* and its damage on *Selenicereus undatus*

Egg

Larva

Adults

Early instar damage

Late instar damage

Plate 32. Life stages of tobacco cutworm, *Spodoptera litura* and its damage on *Selenicereus undatus*

Destructive trailing ant

Damage symptoms on fruit

Plate 33. Destructive trailing ant *Trichomyrmex destructor* on *Selenicereus undatus*

### 4.1.3 Pests of Mangosteen

A total of 7 insect pests were documented from mangosteen, belonging to the order Hemiptera (3), Lepidoptera (3), and Hymenoptera (1).

Table 4: Insect pests documented from mangosteen, *Garcinia mangostana*

| ORDER: HEMIPTERA | | | | |
|---|---|---|---|---|
| Sl. No | Common Name | Scientific Name | Family | Nature of feeding |
| 1 | Brown soft scale | *Coccus hesperidum* Linnaeus | Coccidae | Sap feeder |
| 2 | Mealy bug | *Crisicoccus hirsutus* Newstead | Pseudococcidae | Sap feeder |
| 3 | Mealy bug | *Planococcus citri* Risso | Pseudococcidae | Sap feeder |
| ORDER: LEPIDOPTERA | | | | |
| 1 | Leaf eating caterpillar | *Agrotera flavobasalis* Inoue | Crambidae | Defoliator |
| 2 | Mangosteen caterpillar | *Stictoptera* sp. | Euteliidae | Flower feeder |
| 3 | Flower feeding caterpillar | *Homona* sp. | Totricidae | Flower feeder |
| ORDER: HYMENOPTERA | | | | |
| 1 | Red ant | *Oecophylla smaragdina* Fabricius | Formicidae | Mealy bug association |

### *4.1.3.1 Hemiptera*

#### *4.1.3.1.1 Mealybugs*

*P. citri* and *C. hirsutus* were the two mealybugs documented on mangosteen. *P. citri* was observed below the perianth of fruits and *C. hirsutus* on underside of leaves. Adult *P. citri* had a pinkish-white oval body covered in a wax coating (Plate 34 a). Adult *C. hirsutus* distinguished by their white appearance and young mealybug nymphs, which have a slight yellow coloration, are situated on the undersides of leaves (Plate 34b). Red ant *O. smaragdina* helps in the transport of mealybugs to different plant parts. Adults and nymphs of mealybugs were sap feeders.

#### *4.1.3.1.2 Brown soft scale* (*Coccus hesperidum* Linnaeus)

The mature female scale insect possessed an oval, dome-shaped body, measuring approximately 3 to 5 mm in length, pale yellowish-brown to greenish-brown colour, marked with irregular brown speckles, which become more pronounced as the insect matures. Both nymphs and adult insects were observed along the midrib of leaves and were sap feeders (Plate 34c).

### *4.1.3.2 Lepidoptera*

#### *4.1.3.2 .1 Leaf eating caterpillar* (*Agrotera flavobasalis* Inoue)

The adult moths were yellow colour with distinctive brown and white pattern on both their forewings and hind wings. The larvae, characterized by a dark brown coloration, featured small yellow dots on their lateral sides and had a light brown head. Pupation occurred within the foliage and pupae were brown in colour. These larvae defoliated the younger leaves of mangosteen (Plate 35).

#### *4.1.3.2.2 Mangosteen caterpillar* (*Stictoptera* sp.)

The caterpillar was light green with stripes and dark spots more evidenced just before pupation. The last larval instar had a length of 2.5-4 cm. These larvae were observed feeding on mangosteen flowers (Plate 36).

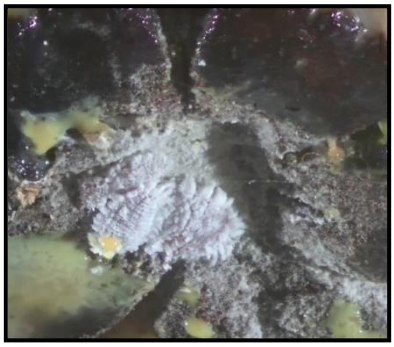
#### *4.1.3.2.3 Flower feeding caterpillar* (*Homona* sp.)

The adult moths were bell shaped dark brown in colour with pale brown patterns on the forewings. The caterpillars green in colour, with brown head capsule were observed consuming unopened flowers resulted in failure of blooming. Pupation occurred within the unopened flowers (Plate 37).

### *4.1.3.3 Hymenoptera*

#### *4.1.3.3.1 Red ant* (*Oecophylla smaragdina* Fabricius)

Red ant was found associated with mealybug *C. hirsutus* (Plate 38).



a. *Planococcus citri*

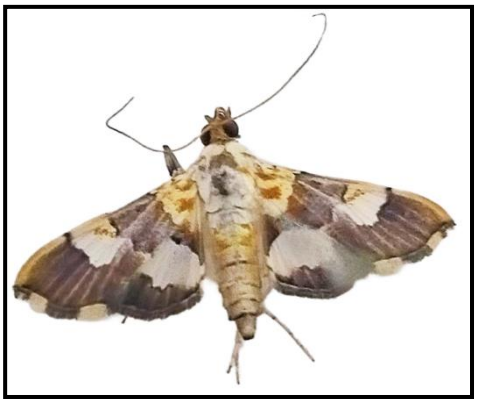
b. *Crisicoccus hirsutus*

c. *Coccus hesperidum*

Plate 34. Sucking pests observed on *Garcinia mangostana*

Larva feeding on leaves

Pupa



Adult

Plate 35. Life stages of leaf eating caterpillar, *Agrotera flavobasalis* and its damage on *Garcinia mangostana*

Plate 36. Mangosteen caterpillar, *Stictoptera* sp. feeding on the flower of *Garcinia mangostana*

Larva feeding on flower Damaged Flower Adult

Plate 37. Flower feeding caterpillar, *Homona* sp. observed on *Garcinia mangostana*

Plate 38. *Oecophylla smaragdina* associated with mealy bug on *Garcinia mangostana*

### 4.1.4 Pests of Passion Fruit

Lower pest infestation was noticed in passion fruit when compared to other exotic fruits. A total of 4 pests were documented in passion fruit, belonging to the order Hemiptera (2), Lepidoptera (1) and Diptera (1).

Table 5: Insect pests documented on passion fruit *Passiflora edulis*

| ORDER: HEMIPTERA | | | | |
|---|---|---|---|---|
| Sl. No | Common Name | Scientific Name | Family | Nature of feeding |
| 1 | Barnacle scale | *Ceroplastes cirripediformis* Comstock | Coccidae | Sap feeder |
| 2 | Rugose spiraling whitefly | *Aleurodicus rugioperculatus* Martin | Aleyrodidae | Sap feeder |
| ORDER: LEPIDOPTERA | | | | |
| 1 | Gold tail moth | *Sphrageidus xanthorrhoea* Kollar | Erebidae | Defoliator |
| 2 | Leaf miner | Unidentified | | Leaf feeder |

#### *4.1.4.1 Hemiptera*

##### *4.1.4.1.1 Barnacle scale* (*Ceroplastes cirripediformis* Comstock)

The barnacle scales were reddish-brown and entirely coated with a dense layer of pearly-grey wax. Depressed lines divided this wax into top, front, and side plates, each plate has a small, darker, spot usually surrounding a tiny button of wax. A large rear plate

had three buttons. Early instar nymphs were observed aligning on the veins on upper surface of leaves while the late instars and adult on stem, feeding its sap (Plate 39).

#### *4.1.4.1.2 Rugose spiraling whitefly* (*Aleurodicus rugioperculatus* Martin)

The adult rugose spiraling whiteflies were larger in size compared to other whiteflies and had a pair of irregular light brown bands across their wings, congregating on the lower surface of leaves. Eggs, arranged in a concentric circular or spiral pattern, were laid on the underside of leaves and covered with a layer of white waxy material. The eggs were elliptical and creamy white to dark yellow in colour. The crawlers and adults were sap feeders (Plate 40).

### *4.1.4.2 Lepidoptera*

#### *4.1.4.2.1 Gold tail moth* (*Sphrageidus xanthorrhoea* Kollar)

The adult moths were small and white in colour. Both male and female moths had a bipectinate antennae and distinctive yellow hairs on the abdominal tip. Eggs laid on the lower leaf surface were spherical, yellowish orange in colour and were covered with the abdominal hairs. The early instar caterpillars, covered with black hairs were yellowish brown with a black patch on the first and second abdominal segments, along with two black lateral lines on the abdomen. The later instar larvae became black with a yellow longitudinal stripe and orange-colored tubercles on the lateral sides of each abdominal segment. Pupae, brown in colour, pupate within a silken cocoon nestled within the leaves. These larvae were found feeding on the foliage (Plate 41 & 50).

### *4.1.4.3 Diptera*

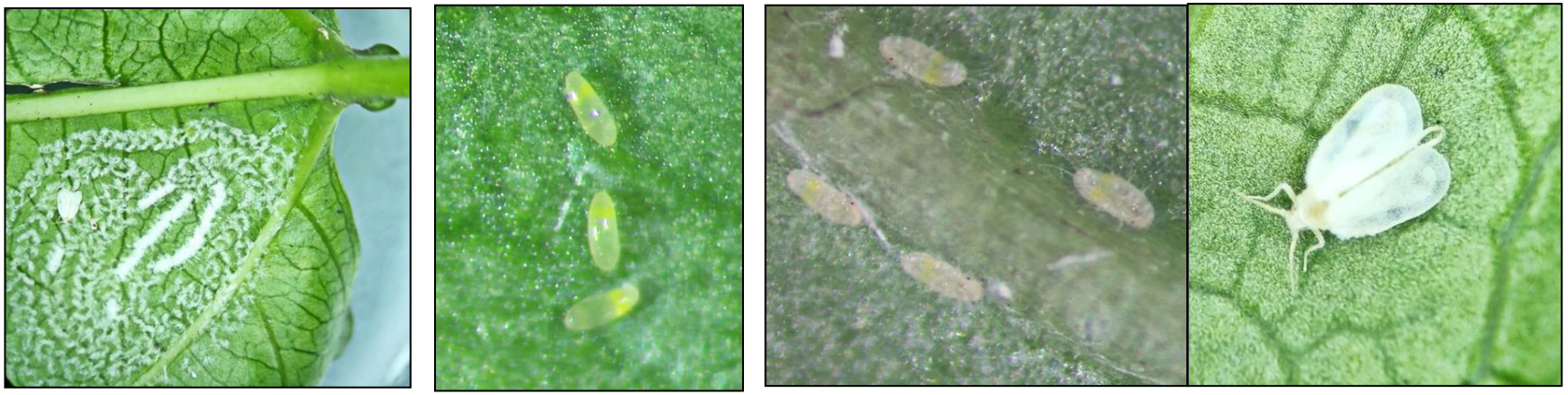
#### *4.1.4.3.1 Leaf miner (Unidentified)*

Maggots were found mining on the young leaves creating a distinctive pattern on the foliage. Maggots were yellow in colour, apodous with distinctive black mouthparts. The pupae were black in colour seen inside the mines. The adult flies were small and black in colour (Plate 42).

Early instar scales on the leaves

Late instar scales on leaf and stem

Plate 39. Barnacle scale, *Ceroplastes cirripediformis* on *Passiflora edulis*



Spiral colony Egg Nymph Adult

Plate 40. Life stages of rugose spiraling whitefly, *Aleurodicus rugioperculatus* on *Passiflora edulis*

Egg Larva feeding on leaves Pupa Adult

Plate 41. Life stages of gold tail moth, *Sphrageidus xanthorrhoea* and its damage on *Passiflora edulis*

Maggot

Pupa

Adult

Plate 42. Life stages of leaf miner and its damage on *Passiflora edulis*

### 4.1.5 Pests of other Minor Exotic Fruits

A total of 10 pests were documented on other minor exotic fruits, belonging to the order Hemiptera (6), Lepidoptera (3) and Coleoptera (1).

Table 6: Insect pests documented on minor exotic fruits

| ORDER: HEMIPTERA | | | | | |
|---|---|---|---|---|---|
| Sl. No | Host | Common Name | Scientific Name | Family | Nature of feeding |
| **1** | Miracle fruit | Mealy bug | *Planococcus lilacinus* Cockerell | Pseudococcidae | Sap feeder |
| **2** | Pulasan | Mealy bug | *Planococcus citri* Risso | Pseudococcidae | Sap feeder |
| **3** | Abiu | Helmet scale | *Saissetia coffeae* Walker | Coccidae | Sap feeder |
| **4** | Litchi | Scale | *Ceroplastes floridensis Comstock* | Coccidae | Sap feeder |
| **5** | Soursop | Soft scale | *Discochiton expansum* Green | Coccidae | Sap feeder |
| **6** | Longan | Scale | *Ceroplastes destructor* Newstead | Coccidae | Sap feeder |
| ORDER: LEPIDOPTERA | | | | | |
| **1** | Velvet apple | Tiger moth | *Brunia antica* Walker | Erebidae | Defoliator |
| **2** | Longan | Leaf roller | *Statherotis* sp. | Tortricidae | Defoliator |
| **3** | Longan | Monkey Puzzle | *Rathinda amor* Fabricius | Lycaenidae | Defoliator |
| ORDER: COLEOPTERA | | | | | |
| **1** | Longan | Leaf beetle | *Monolepta* sp. | Chrysomelidae | Leaf feeder |

#### *4.1.5.1 Hemiptera*

##### *4.1.5.1.1 Scales*

The scale insects observed on minor fruits were *Saissetia coffeae* (abiu), *Ceroplastes destructor* (longan), *Ceroplastes floridensis* (litchi) and *Discochiton expansum* **(**Soursop). Adults of *S. coffeae* were Smooth, shiny, brown soft scales were discovered affixed to the underside of abiu leaves (Plate 43a). *C. destructor* were soft white wax scales and they were observed on the twigs of longan (Plate 43b). *C. floridensis* were reddish-brown in colour and were covered with a wax that had a pinkish-white tint. They typically inhabited leaf midribs, stems, and twigs of litchi (Plate 43c). Adults were yellowish brown colored soft scales and nymphs were transparent. Nymphs and adults were on the upper surface of leaves of soursop (Plate 43d). Both the nymphs and adults of these scales were sap feeders.

##### *4.1.5.1.2 Mealybugs*

The mealybugs observed on minor fruits were *P. lilacinus* (miracle fruit) and *P. citri* (pulasan). Nymphs and adults of *P. lilacinus* were observed extracting sap from both the leaves and fruits of the miracle fruit (Plate 43e). Nymphs and adult *P. citri* were observed on the inflorescence stalk of pulasan (Plate 43f). These mealybugs were already described under rambutan.

#### *4.1.5.2 Lepidoptera*

##### *4.1.5.2.1 Tiger moth* **(*Brunia antica* Walker)**

Adult moths were medium sized with grey colored forewings having a yellow band on the costal margin and hind wings were uniformly yellowish brown without any patterns. Larva was brown coloured hairy caterpillar and were found feeding on the leaves of velvet apple (Plate 44).

#### *4.1.5.2.2 Leaf roller* (*Statherotis* sp.)

The adult moth was bell-shaped, featuring black forewings and hind wings. Distinctive pale brown markings were present on the costal margin of the forewings. The larva was dark green color, and pupation occurs within the folds of foliage and was dark brown obtect type. The larva was found feeding within the leaf rolls of longan (Plate 45).

#### *4.1.5.2.3 Monkey Puzzle* (*Rathinda amor* Fabricius)

The caterpillars exhibited a pale green color and had fleshy, red protuberances on the dorsal side along the length of the body. As the chrysalis matures, it changed its color from green to brown. It was affixed to foliage by a solitary stalk at its tail end. The fore wings were brownish-black colour with yellowish white spots, and the hindwing with two black spots between the tails , third black spot in the next interspace, and all the three spots were capped with orange colour. The tails were black and terminated with a white tip. On the ventral side, the wings had yellowish-brown tone, adorned with distinctive black and white markings (Plate 46).

### *4.1.5.3 Coleoptera*

#### *4.1.5.3.1 Leaf beetle* (*Monolepta* sp.)

Adults were small elliptical to oval shaped cream-colored beetles with yellow head and thorax. Adults were found feeding on the young foliages of longan (Plate 47).

a. *Saissetia coffeae* - Abiu

b. *Ceroplastes floridensis* - Longan

c. *Ceroplastes floridensis* - Litchi

*d. Discochiton expansum* - Soursop

e. *Planococcus lilacinus*- Miracle fruit

f. *Planococcus citri* - Pulasan

Plate 43. Sucking pests observed on different minor exotic fruits

Larva feeding on leaves

Adult

Plate 44. Life stages of tiger moth, *Brunia antica* on velvet apple

Larva feeding on leaves

Pupa

Adult

Plate 45. Life stages of leaf roller, *Statherotis* sp**.** and its damage on longan

Larva feeding on leaves

Pupa

Adult – Dorsal view

Adult – Ventral view

Plate 46. Life stages of monkey puzzle *Rathinda amor* and its damage on longan

Plate 47. Leef beetle, *Monolepta* sp. feeding on leaves of longan

## 4.2 BIOLOGY OF PESTS OF DRAGON FRUIT AND PASSION FRUIT

### 4.2.1 Oriental Fruit fly *Bactrocera dorsalis*

Biology and life cycle of oriental fruit fly *B. dorsalis* presented in Table 7 and Plate 48.

#### *4.2.1.1 Egg*

*B. dorsalis* laid elongated, transparent, glossy, banana shaped eggs tapering at both the anterior and posterior ends (Plate 31 &48). These eggs were seen in clusters just beneath the surface of fruits. The average incubation period was found to be 1.6 ± 0.40 days.

#### *4.2.1.2 Maggot*

The fruit fly had three larval instars. First instar maggot was very small and white in colour, the second instar maggot was medium sized and was characterized by a distinct black-colored retractable mouth hook. As the larvae reached third instar, they exhibited rapid and agile movement, and were pale yellow in colour. The third instar larvae possessed the ability to jump. These larvae fed voraciously within the pulp of the fruit, creating tunnels and holes in both the pulp and peel. After completing their stages inside the fruit they came out from the fruit for pupation. The average larval developmental period was 8.0 ± 0.40 days.

#### *4.2.1.3 Pupa*

Upon reaching maturity, the fully grown maggots left-the fruit and enter a period of inactivity before transitioning to the pupal stage. Pupation took place in moist soil and were barrel shaped coarctate type. The newly formed pupa was yellowish-brown in colour that gradually changed to dark brown over time. The average pupal period observed was 8.0 ± 0.31 days.

#### *4.2.1.4 Adult*

The adult flies were small to medium with colorful markings on the body. They had a black thorax with a T-shaped dark marking on the abdominal segment. Additionally, their thorax and abdomen featured distinct yellow and black patterns. The wings were transparent, characterized by a continuous costal band. The male fruit flies had an average longevity of 6.4 ± 0.50 days, while the females live longer, with an average lifespan of 9.6 ± 0.50 days.

The average life cycle for female fruit fly was found to be 28.4 ± 1.32 days and male fruit fly was 25.4 ± 1.28 days.

Table 7: Biological parameters of oriental fruit fly, *Bactrocera dorsalis* on dragon fruit

| Parameters | No. of days | | Mean ± SE |
|---|---|---|---|
| | Minimum | Maximum | |
| Egg period | 1 | 3 | 1.6± 0.40 |
| Larval period | 7 | 9 | 8.0 ± 0.40 |
| Prepupal period | 1 | 2 | 1.2 ± 0.20 |
| Pupal period | 7 | 9 | 8.0 ± 0.31 |
| Adult longevity | | | |
| Male | 5 | 8 | 6.4 ± 0.50 |
| Female | 8 | 11 | 9.6 ± 0.50 |
| Total life cycle | | | |
| Male | 21 | 26 | 25.4 ± 1.28 |
| Female | 24 | 32 | 28.4 ± 1.32 |

SE- Standard Error

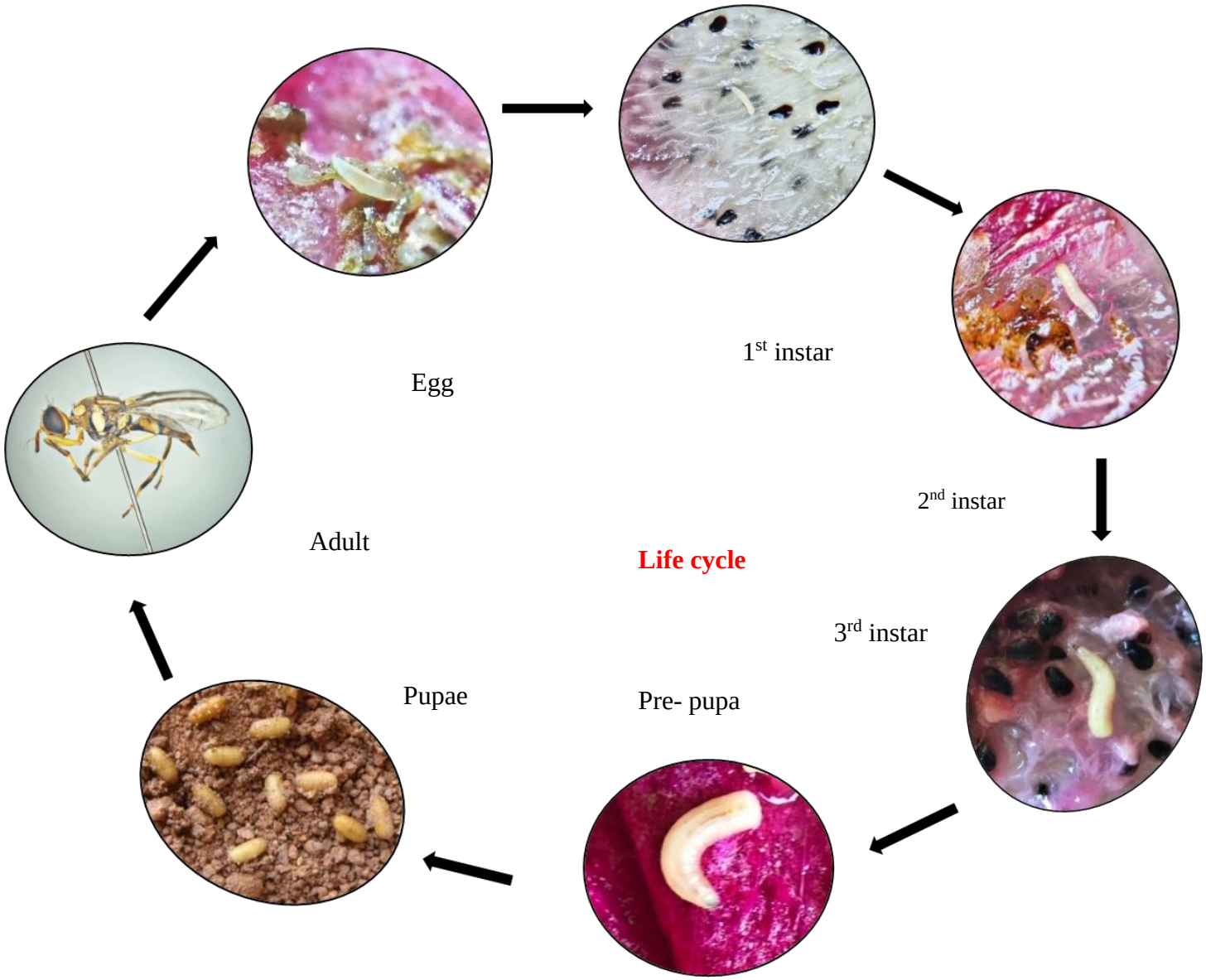



Plate 48. Biology of *Bactrocera dorsalis* on *Selenicereus undatus*

### 4.2.2 Stink bug *Halyomorpha picus*

Biology and life cycle of stink bug *H. picus* is presented in Table 8 and Plate 49.

#### *4.2.2.1 Egg*

The female bug deposited clusters of eggs on the stems, with each cluster comprising 16-17 eggs. These eggs were spherical in shape and white in colour. The stink bug had an average incubation period of 5.2 ± 0.20 days.

#### *4.2.2.2 Nymph*

There were five nymphal instars in the metamorphosis of *H. picus*. Upon hatching, nymphs congregated over the eggshell and had black and yellow colouration. Then subsequently the colour changed to red and black and it took nearly six days for the first instar to molt into the second instar. The second instar was larger in size and completely black in colour. Subsequent instars (second to fifth) shared similar shape and colour, differing primarily in size. The nymphal instars had white markings on the ventral surface of their body. The antennae were having white colouration at the base of flagellar segments. The average nymphal durations of the first, second, third, and fourth instars were 5.6 ± 0.24, 5.8 ± 0.37, 7.6 ± 0.40 days, respectively. Total nymphal period was 46.8 ± 2.53 days. Total developmental period from egg to adult took 52 ± 2.66 days.

#### *4.2.2.3 Adult*

Adult bugs were greyish-brown in colour, with dense dark punctuations. Distinctive brownish spots adorned the head, anterior segment, and lateral regions of the pronotum. The underside of the body and the legs exhibited a pale yellowish tint, featuring punctuations along the lateral areas. The insect had a slender antenna, with the first segment being thicker and not extending to the tip of the head.

Table 8: Biological parameters of stink bug, *Halyomorpha picus* on dragon fruit

| Parameters | No. of days | | Mean± SE |
|---|---|---|---|
| | Minimum | Maximum | |
| Egg period | 5 | 6 | 5.2 ± 0.20 |
| 1st instar | 5 | 6 | 5.6 ± 0.24 |
| 2nd instar | 5 | 7 | 5.8 ± 0.37 |
| 3rd instar | 7 | 9 | 7.6 ± 0.40 |
| 4th instar | 8 | 13 | 11.2 ± 1.11 |
| 5th instar | 14 | 18 | 16.6 ± 0.74 |
| Total nymphal period | 38 | 53 | 46.8 ± 2.53 |
| Total developmental period | 44 | 59 | 52 ± 2.66 |

SE- Standard Error

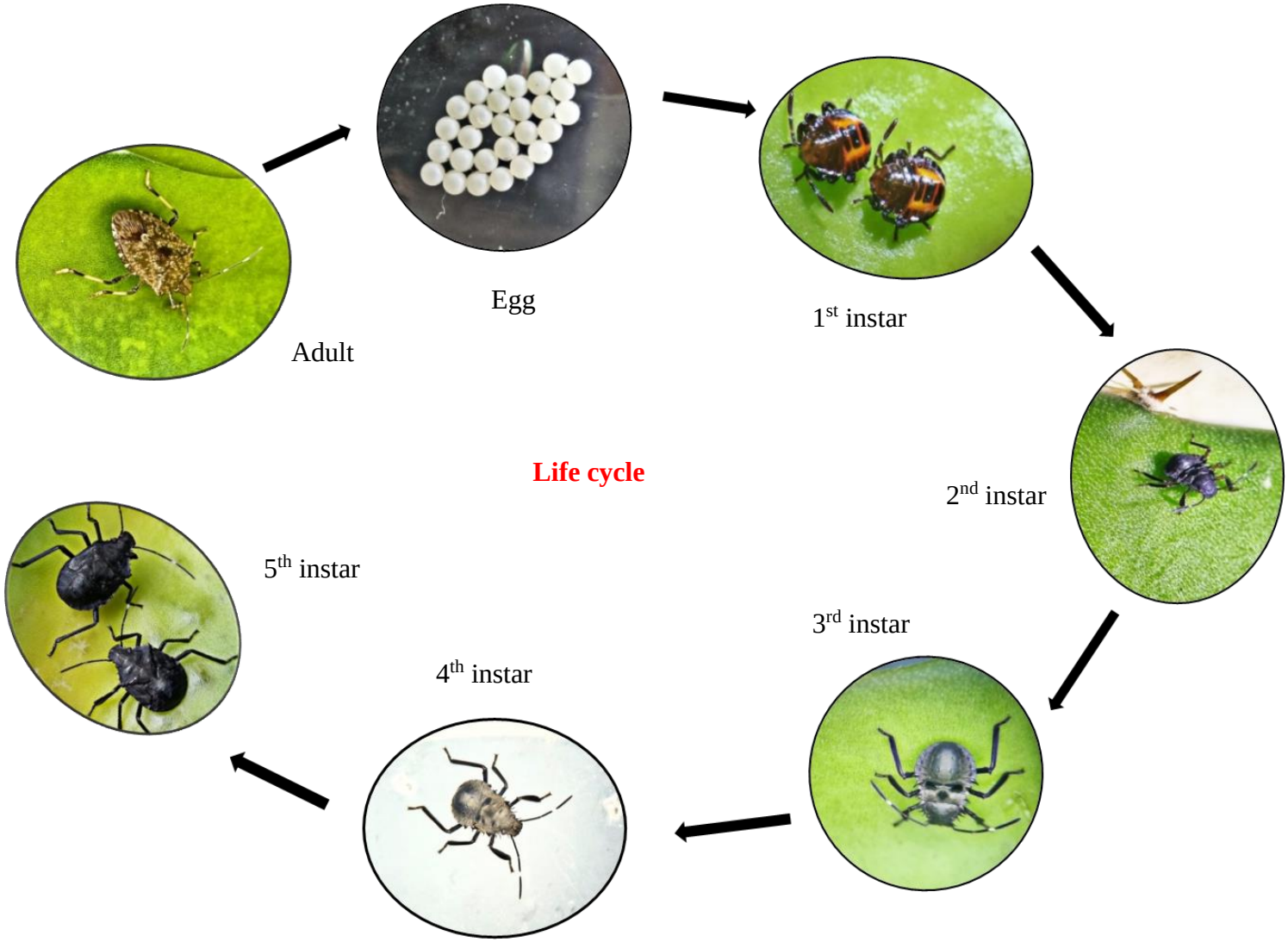



Plate 49. Biology of *Halyomorpha picus* on *Selenicereus undatus*

### 4.2.3 Gold tail moth *Sphrageidus xanthorrhoea*

Biology and life cycle of gold tail moth *S. xanthorrhoea* is presented in table 8 and plate 50.

#### *4.2.3.1 Egg*

The female deposited egg clusters on the undersides of leaves, covering them with yellow-colored abdominal hairs. These eggs were oval in and yellowish-orange in color. The incubation period observed was 6.8 ± 0.37 days.

#### *4.2.3.2 Larva*

The larvae progressed through five instars in their development. The first instars were yellowish-brown in color with a black head capsule, featuring two black lateral lines on the abdomen and a complete covering of black hairs. The first and second instars shared similar appearances but differ in size. From the third instar onward, the caterpillars were uniformly black with a prominent yellow longitudinal stripe and orange tubercles on the lateral sides of each abdominal segment. They remain entirely covered with black hairs. The average duration of the first, second, third, fourth, and fifth instars were 3.6 ± 0.24, 5.4 ± 0.24, 5.6 ± 0.37, 4.6 ± 0.24, and 5.4 ± 0.20 days, respectively. The total larval period was observed to be 25.6 ± 1.20 days.

#### *4.2.3.3 Pupa*

Following the larval phase, the insects proceeded to a prepupal stage lasting for 2 to 3 days, during which they did not engage in feeding activities. Pupation happened within a silken cocoon within the leaves, and the pupa was brown and obtect type. The average pupal period lasts for 6.6 ± 0.37 days.

### *4.2.3.4 Adult*

The adult moths were medium sized and were white in colour. Both male and female moths had a bipectinate antenna, possessing yellow hairs at abdominal tip. Females were larger than the males, and the hind wings of males displayed a greyish patch on the costal margin. The average lifespan of male moths was observed to be 4.4 ± 0.24 days, while females lived longer with duration of 6 ± 0.44 days.

The duration of life cycle is longer in females lasting for 35.4 ± 0.50 days, while the males completed their life cycle in 33.8 ± 0.37 days.

Table 9: Biological parameters of gold tail moth, *Sphrageidus xanthorrhoea* on passion fruit

| Parameters | No of days | | Mean ±SE |
|---|---|---|---|
| | Minimum | Maximum | |
| Egg period | 6 | 8 | 6.8 ± 0.37 |
| 1st instar | 3 | 4 | 3.6 ± 0.24 |
| 2nd instar | 5 | 6 | 5.4 ± 0.24 |
| 3rd instar | 5 | 7 | 5.6 ± 0.37 |
| 4th instar | 4 | 5 | 4.6 ± 0.24 |
| 5th instar | 4 | 5 | 5.4 ± 0.20 |
| Prepupal period | 2 | 3 | 2.4 ± 0.24 |
| Total larval period | 23 | 30 | 25.6 ± 1.20 |
| Pupal period | 6 | 7 | 6.6 ± 0.37 |

| | | | |
|---|---|---|---|
| Adult longevity | | | |
| Male | 4 | 5 | 4.4 ± 0.24 |
| Female | 5 | 7 | 6 ± 0.44 |
| Total life cycle | | | |
| Male | 33 | 35 | 33.8 ± 0.37 |
| Female | 34 | 37 | 35.4 ± 0.50 |

SE- Standard Error

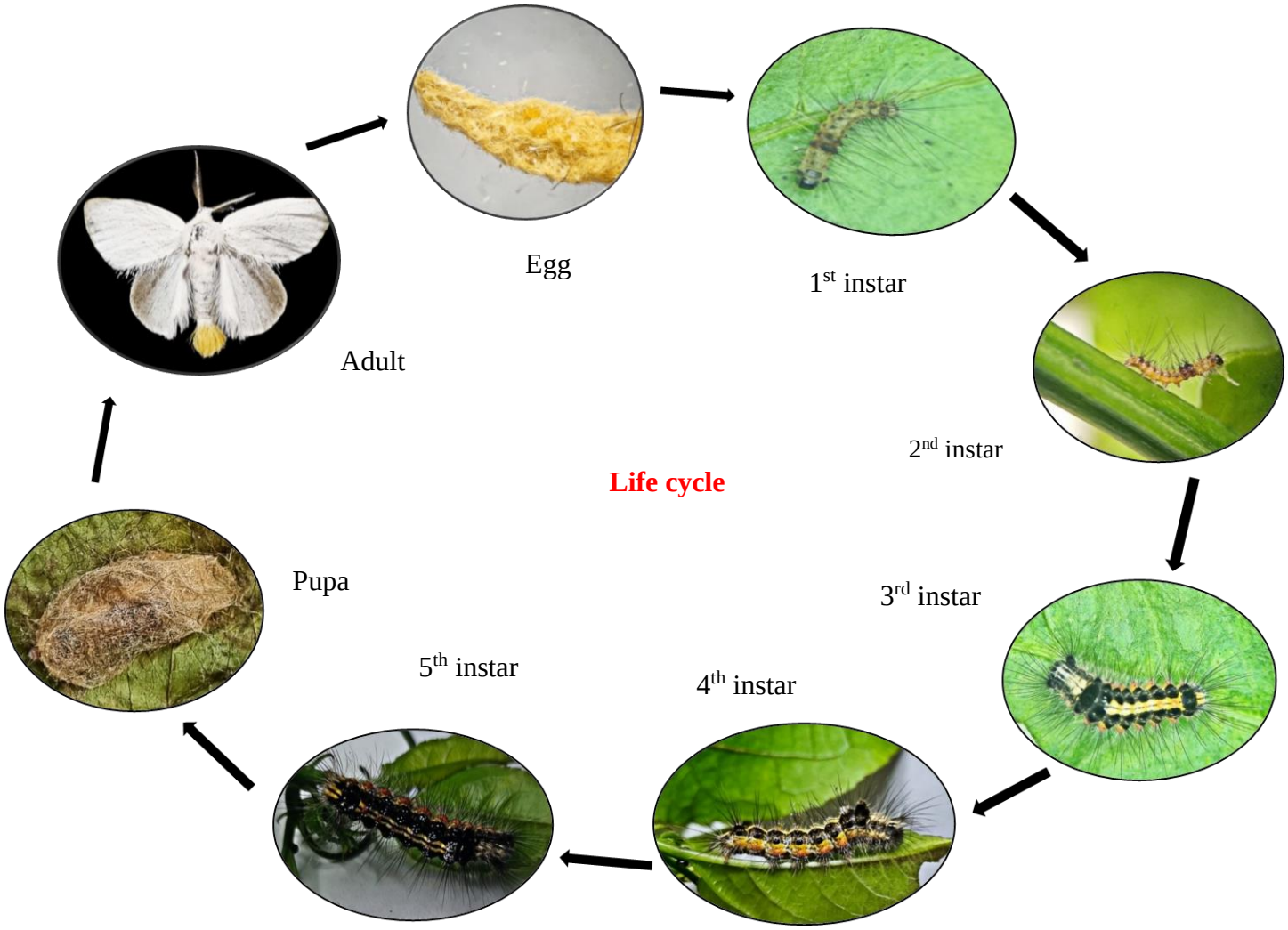



Plate 50. Biology of *Sphrageidus xanthorrhoea* on *Passiflora edulis*

## 4.3 DOCUMENTATION OF NATURAL ENEMIES OF PESTS OF EXOTIC FRUIT CROPS

Spiders were observed to be the predominant predators associated with the pests of exotic fruit crops followed by insect predators of various orders. The comprehensive survey identified 15 different spider species in exotic fruit crops. In addition, six insect predators were also documented belonging to order Mantodea (3), Coleoptera (1), Lepidoptera (1) and Hemiptera (1). Along with predators, different parasitoids were also observed. In the present investigation, three different parasitoids belonging to family Trichogrammatidae, Euplemidae and Aphelinidae were found associated with the pests of exotic fruits.

### 4.3.1 Spiders

The spiders documented from the exotic fruit crops during the study period are presented in Table 10. A total of 15 spider species, spanning 12 genera, distributed across 5 families were observed in association with pests of exotic fruit crops (Plate 51). The predominant spiders observed belonged to the family Salticidae featuring 6 species, followed by Thomisidae and Oxyopidae, each with 3 species. The other spider families observed were Areneidae and Uloboridae. Among the spiders, three distinct feeding guilds were identified, with stalkers being the prevalent feeding guild, followed by orb weavers and ambushers. These spiders were actively preying on larvae of *S. litura* on dragon fruit, as well as *E. abrupta* on rambutan, along with other soft-bodied insects.

Table 10: Spiders associated with the pests of exotic fruits

| Sl No | Common Name | Scientific name | Family | Ecological guild |
|---|---|---|---|---|
| 1 | Crab spider | *Thomisus pugilis* Stoliczka | Thomisidae | Ambusher |
| 2 | Crab spider | *Camaricus formosus* Thorell | Thomisidae | Ambusher |
| 3 | Flower crab spider | *Thomisus lobosus* Tikader | Thomisidae | Ambusher |
| 4 | Lynx spider | *Hamataliwa* sp. | Oxyopidae | Stalker |
| 5 | White lynx spider | *Oxyopes shweta* Tikader | Oxyopidae | Stalker |
| 6 | Lynx spider | *Oxyopes javanus* Thorell | Oxyopidae | Stalker |
| 7 | Jumping spider | *Epeus indicus* Koch | Salticidae | Stalker |
| 8 | Black and white jumper | *Carrhotus viduus* Koch | Salticidae | Stalker |
| 9 | Semi-coppered heavy jumper | *Hyllus semicupreus* Simon | Salticidae | Stalker |
| 10 | Jumping spider | *Chrysilla volupe* Karsch | Salticidae | Stalker |
| 11 | Jumping spider | *Indopadilla insularis* Malamel | Salticidae | Stalker |
| 12 | Jumping spider | *Epeus tener* Simon | Salticidae | Stalker |
| 13 | Orb weaving spider | *Neoscona mukerjei* Tikader | Araneidae | Orb weaver |
| 14 | Marble Anepsion | *Anepsion maritatum* Pickard | Araneidae | Orb weaver |
| 15 | Humped spider | *Zosis geniculata* Olivier | Uloboridae | Orb weaver |

*Hyllus semicupreus*

*Oxyopes javanus*

*Thomisus pugilis*

*Carrhotus viduus*

*Oxyopes shweta*

*Epeus indicus*

*Thomisus lobosus*

*Hamata liwa*sp.

*Camaricus formosus*

*Indopadilla insularis*

*Anepsion maritatum*

*Epeus tener*

*Neoscona mukerjei*

*Chrysilla volupe*

*Zosis geniculata*

Plate 51.Spiders documented from exotic fruit crops

### 4.3.2 Insect Predators

A total of 6 insect predators belonging to 6 genera, included in 5 families of 4 different orders were documented from exotic fruit crops (Table 11). The dominant order observed was Mantodea that includes 3 species of praying mantis belonging to family Hymenopodidae (2) and Mantidae (1) (Plate 52). One predator each from order Coleoptera, Lepidoptera and Hemiptera were also observed in the study. The Lepidopteran, Coleopteran, and Hemipteran predators belonged to families Lycanidae (Apefly) (Plate 53), Coccinellidae and Reduvidae (Plate 54) respectively.

Table 11: Predators associated with the pests of exotic fruit crops

| Sl. No | Predators | Scientific name | Family | Host | Crop |
|---|---|---|---|---|---|
| 1 | Coccinellid beetle | *Cheilomenes sexmaculata* Fabricius | Coccinellidae | Mealy bug | Rambutan |
| 2 | Apefly | *Spalgis epius* Westwood | Lycanidae | Mealy bug | Rambutan |
| 3 | Giant Asian mantis | *Hierodula* sp. | Mantidae | General predator | Rambutan |
| 4 | Ant mimic mantis | *Odontomantis pulchra* Olivier | Hymenopodidae | General predator | Rambutan |
| 5 | Flower mantis | *Creobroter gemmatus* Saussure | Hymenopodidae | General predator | Rambutan |
| 6 | Murder bugs | *Nagusta* sp. | Reduviidae | General predator | Rambutan |

### 4.3.3 Parasitoids

The parasitoids documented from pests infesting exotic fruits are presented in Table12 and Plate 55.

Three hymenopteran parasitoids were observed predominantly in the exotic fruit crops. Egg parasitoids belonging to the family Trichogrammatidae were observed on the eggs of the warty leaf beetle *E. salemensis*, in rambutan. The pupal parasitoid belonging to the family Eupelmidae were recorded from the pupa of the bark borer affecting rambutan. These parasitoids were small in size, yellowish-orange in coloration, and possessed a sharp ovipositor. *Encarsia guadeloupae* (Viggiani) belonging to Aphelinidae was collected from the colony of the spiraling white fly. They are obligate endoparasitoids of white fly *Aleurodicus rugioperculatus* nymph.

Table 12: Parasitoid associated with the pests of exotic fruit crops

| Sl. No | Parasitoid | Scientific name | Family | Host | Crop |
|---|---|---|---|---|---|
| 1 | Egg parasitoid | Unidentified | Trichogrammatidae | Leaf beetle | Rambutan |
| 2 | Aphelinid parasitoid | *Encarsia guadeloupae* | Aphelinidae | Spiralling white fly | Passion fruit |
| 3 | Eupelmid parasitoid | *Eupelmus* sp. | Eupelmidae | Bark borer | Rambutan |

*Hierodula* sp.

*Odontomantis pulchara*

*Creobroter gemmatus*

Plate 52. Praying mantids documented from exotic fruit crops

*Spalgisepius* – Dorsalview

*Spalgisepius* – Ventral view

Plate 53. Life stages of lepidopteran predator, *Spalgis epius*

*Cheilomenes sexmaculata*

*Nagusta* sp.

Plate 54. Coccinellid beetle and assassin bug documented from exotic fruit crops

Unidentified

Parasitoid emerged egg case of wartv leaf beetle

*Eupelmus sp.*

*Encarsia guadeloupae*

Plate 55. Prasitoids documented from exotic fruit crops

## 4.4 DOCUMENTATION OF POLLINATORS IN EXOTIC FRUIT CROPS

A total of 14 insect pollinators were recorded in rambutan (10) and passion fruit (4). The floral visiting time of the pollinators was also recorded in both the crops.

### 4.4.1 Pollinators of Rambutan

The insect pollinators recorded in rambutan belonged to the order Hymenoptera, Lepidoptera, and Diptera (Table 13). The Hymenopteran members belonged to the families Apidae, Leucospidae, Tiphiidae, and Halictidae whereas two species of *Syriphids* (Syrphidae) were recorded from the order Diptera. The lepidopteran pollinators included members from the families Scythrididae and Nymphalidae (Plate 56 & 57).

Foraging pattern of insect pollinators in rambutan during 0600 to 1800 h are presented in Table 14.

Hymenopterans pollinators belonging to the family Apidae were predominant in rambutan followed by Tiphiidae, Leucospidae, and Halictidae. The hymenopteran pollinators recorded an average population of 8.49/5 inflorescence/5 min followed by Lepidoptera (1.06 /5 inflorescence/5 min) and Diptera (0.03/5 inflorescence/5 min). The Apis groups recorded on rambutan were *Apis cerana indica*, *Tetragonula travancorica* and *Nomada* sp. whereas the non Apis groups were *Leucospis* sp., *Myzinum* sp. and *Halictus* sp. The frequency and abundance of the Apis groups (8.020/5 inflorescence/5 min) pollinating the rambutan was higher compared to the non Apis groups (0.478 /5 inflorescence/5 min). It was observed that *T. travancorica* was the most frequent visitor from morning 0060 h to evening 1800 h and recorded a mean population of 6.41 /5 inflorescence/5 min. The mean population of *T. travancorica* was seen highest during 1100 to 1200 h (10.80/5 inflorescence /5min) followed by 1000 to 1100h (10.50 /5 inflorescence/5min).

In the order Lepidoptera, *Eretmocera impactella* was recorded as the frequent pollinator, followed by *Ypthima* sp. The mean population of *E. impactella* reached its peak during two-time intervals, specifically between 1100 to 1200 h and 1300 to 1400 h

(2.450 /5 inflorescence/5 min). Within the Diptera order, *Ischidon* sp. was the primary flower visitor, followed by *Stomorhina* sp. The population of *Ischidon* sp. visiting rambutan inflorescences peaked at 1500 to 1600 h, with a mean population of 0.10 /5 inflorescences/ 5 min. The mean number of *Stomorhina* sp. visiting rambutan inflorescences reached its peak (0.05 /5 inflorescences/ 5 min) during two time periods 1000 to 1100 h and 1300 to 1400 h.

Table 13: Insect pollinators documented from rambutan flowers

| Sl. No | Common name | Pollinators | Family |
|---|---|---|---|
| ORDER: HYMENOPTERA | | | |
| 1 | Indian honey bee | *Apis cerana indica* Fabricius | Apidae |
| 2 | Stingless bee | *Tetragonula travancorica* Shanas and Faseeh | Apidae |
| 3 | Nomad bee | *Nomada* sp. | Apidae |
| 4 | Leucospid wasp | *Leucospis* sp. | Leucospidae |
| 5 | Thinnid wasp | *Myzinum* sp. | Tiphiidae |
| 6 | Sweat bee | *Halictus* sp. | Halictidae |
| ORDER: LEPIDOPTERA | | | |
| 7 | Common five ring | *Ypthima* sp. | Nymphalidae |
| 8 | Spurs-legged moth | *Eretmocera impactella* Walker | Scythrididae |
| ORDER: DIPTERA | | | |
| 9 | Snout fly | *Stomorhina* sp. | Muscidae |
| 10 | Hover fly | *Ischidon* sp. | Muscidae |

*Myzinum* sp.

*Tetragonula travancorica*

*Leucospis* sp.

*Apis cerana indica*

*Nomada* sp.

*Halictus* sp.

Plate 56. Pollinators documented from *Nephelium lappaceum*

*Eretmocera impactella*

*Ypthima* sp.

*Ischidon* sp.

*Stomorhina* sp.

Plate 57. Pollinators documented from *Nephelium lappaceum*

Table 14: Foraging pattern of insect pollinators in rambutan

| **Mean population /5 inflorescences/5min*** | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species / time of day | 0600-0700 | 0700-0800 | 0800-0900 | 0900-1000 | 1000-1100 | 1100-1200 | 1200-1300 | 1300-1400 | 1400-1500 | 1500-1600 | 1600-1700 | 1700-1800 | Mean |
| *A. cerana indica* | 0.55 | 1.20 | 1.80 | 2.25 | 2.30 | 2.40 | 2.05 | 1.70 | 1.25 | 1.50 | 1.00 | 0.50 | 1.54 |
| *T. travancorica* | 5.00 | 6.70 | 7.00 | 8.60 | 10.50 | 10.80 | 7.80 | 7.65 | 4.00 | 3.80 | 3.05 | 2.10 | 6.41 |
| *Nomada* sp. | 0.00 | 0.00 | 0.00 | 0.00 | 0.40 | 0.00 | 0.05 | 0.20 | 0.10 | 0.10 | 0.00 | 0.00 | 0.07 |
| **Apis Hymenopterans** | **5.55** | **7.90** | **8.80** | **10.85** | **13.20** | **13.20** | **9.92** | **9.55** | **5.35** | **5.40** | **4.49** | **2.60** | **8.02** |
| *Leucospis* sp. | 0.00 | 0.00 | 0.30 | 0.20 | 0.36 | 0.05 | 0.45 | 0.30 | 0.30 | 0.10 | 0.00 | 0.00 | 0.17 |
| *Myzinum* sp. | 0.00 | 0.00 | 0.10 | 0.00 | 0.80 | 0.60 | 0.60 | 0.40 | 0.40 | 0.10 | 0.00 | 0.00 | 0.25 |
| *Halictus* sp. | 0.00 | 0.00 | 0.00 | 0.05 | 0.05 | 0.30 | 0.10 | 0.00 | 0.20 | 0.00 | 0.00 | 0.00 | 0.06 |
| **Non Apis Hymenopterans** | **0.00** | **0.00** | **0.40** | **0.25** | **1.21** | **0.95** | **1.15** | **0.70** | **0.90** | **0.20** | **0.00** | **0.00** | **0.48** |
| *Stomorhina* sp. | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.00 | 0.00 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| *Ischidon* sp. | 0.00 | 0.00 | 0.00 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 | 0.00 | 0.00 | 0.01 |
| **Dipterans** | **0.00** | **0.00** | **0.00** | **0.05** | **0.05** | **0.00** | **0.00** | **0.05** | **0.00** | **0.10** | **0.00** | **0.00** | **0.03** |
| *E. impactella* | 0.00 | 0.35 | 0.35 | 0.75 | 1.46 | 2.45 | 2.35 | 2.45 | 1.47 | 0.50 | 0.25 | 0.25 | 1.05 |
| *Ypthima* sp. | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.05 | 0.00 | 0.05 | 0.00 | 0.05 | 0.00 | 0.00 | 0.01 |
| **Lepidopterans** | **0.00** | **0.35** | **0.35** | **0.75** | **1.51** | **2.50** | **2.35** | **2.50** | **1.47** | **0.55** | **0.25** | **0.25** | **1.06** |

### 4.4.2 Pollinators of Passion Fruit

Four insect species, belonging to Hymenoptera and Diptera, were documented from passion fruit flowers during 1200h to 1800h of a day (Table 15). The recorded hymenopteran pollinators were from family Apidae, while the dipteran pollinator was from the family Muscidae (Plate 57).

Table 15: Insect pollinators documented from passion fruit flowers

| Sl. No | Common name | Pollinators | Family |
|---|---|---|---|
| ORDER: HYMENOPTERA | | | |
| 1 | Indian Honey bee | *Apis cerana indica* Fabricius | Apidae |
| 2 | Carpenter bee | *Xylocopa* sp. | Apidae |
| 3 | Stingless bee | *Tetragonula travancorica* Shanas and Faseeh | Apidae |
| ORDER: DIPTERA | | | |
| 4 | Hover fly | *Ischidon* sp. | Muscidae |

Foraging pattern of insect pollinators in passion fruit during 1200 to 1800 h is presented in Table 16.

*Xylocopa* sp. was the most prevalent pollinator (0.33 /5 flowers /5 min) followed by *T. travancorica* (0.11/5 flowers /5 min) *A. cerana indica* ( 0.07 /5 flowers /5 min). Population of *Xylocopa* sp. was maximum 1500 to 1600 h (0.71/ 5 flowers/5 min).

*Ischidon* sp.

*Apis cerana indica*

*Tetragonula travancorica*

*Xylocopa* sp.

Plate 58. Pollinators documented from *Passiflora edulis*

Table 16: Foraging pattern of insect pollinators in passion fruit

| **Mean population /5 flowers/5min*** | | | | | | | |
|---|---|---|---|---|---|---|---|
| Species / time of day | 1200-1300 | 1300-1400 | 1400-1500 | 1500-1600 | 1600-1700 | 1700-1800 | Mean |
| *Xylocopa* sp. | 0.10 | 0.25 | 0.45 | 0.71 | 0.45 | 0.10 | 0.33 |
| *T. travancorica* | 0.10 | 0.05 | 0.15 | 0.20 | 0.10 | 0.05 | 0.11 |
| *A. cerana indica* | 0.05 | 0.10 | 0.20 | 0.05 | 0.025 | 0.00 | 0.07 |
| **Apis Hymenopterans** | **0.25** | **0.40** | **0.80** | **0.96** | **0.57** | **0.15** | **0.52** |
| *Ischidon* sp. | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| **Dipterans** | **0.00** | **0.03** | **0.00** | **0.00** | **0.00** | **0.00** | **0.01** |

*Mean of 4 observations

## 4.5 SEASONAL INCIDENCE OF PESTS

Seasonal incidence of pests infesting rambutan was recorded for one year from November 2022 to November 2023. Monthly population of pests of rambutan is presented in Table 17. The pest infestation in rambutan was highest during March to May, covering the flowering to fruit-setting season. During this period, the insect pest noticed on rambutan were *Monolepta* sp., *Popillia* sp., *E. salemensis*, *O. oneratulus, R. pedestris*, *P. chlora*, *H. tritonaria*, and an unidentified flower webber. It was observed that the infestation of hemipteran bug *R. pedestris* was there on the trees up to the month of September feeding the flowers and young fruits. There was no pest infestation on rambutan trees from October to February.

Correlation between pest population of rambutan and weather parameters are presented in Table 18. The pest population had a negative correlation with both rainfall and average relative humidity, while a positive correlation was observed with temperature, wind velocity and sunshine hours. All the documented pests showed a significant positive correlation with temperature. *R. pedestris* exhibited a significant positive correlation with wind velocity. On the other hand, the populations of *Popillia* sp., *H. tritonaria*, and *P. chlora* displayed a significant negative correlation with average relative humidity.

Table 17: Seasonal incidence of pests of rambutan from Nov.22- Nov.23

| Month (22-23) | **Mean population per plant*** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *Monolepta* sp. | *Popillia* sp. | *E. Salemensis* | *R. pedestris* | *O. oneratulus* | *H. tritonaria* | Flower webber | *P. chlora* |
| November | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| December | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| January | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| February | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| March | 1.00 | 1.40 | 0.00 | 0.00 | 1.80 | 0.90 | 0.00 | 0.30 |
| April | 1.80 | 1.30 | 1.40 | 1.80 | 1.40 | 1.20 | 2.10 | 0.40 |
| May | 2.20 | 0.00 | 1.80 | 1.50 | 2.10 | 0.40 | 1.70 | 0.00 |
| June | 0.00 | 0.00 | 1.30 | 0.30 | 1.40 | 0.00 | 0.00 | 0.00 |
| July | 0.00 | 0.00 | 0.40 | 0.90 | 0.40 | 0.00 | 0.00 | 0.00 |
| August | 0.30 | 0.00 | 0.00 | 1.30 | 0.30 | 0.00 | 0.00 | 0.00 |
| September | 0.00 | 0.00 | 0.00 | 0.30 | 0.00 | 0.00 | 0.00 | 0.00 |
| October | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Table 18: Correlation between pest population of Rambutan and weather parameters

| Sl no | Pests | Temperature (°C) | Average Relative Humidity (%) | Total rainfall (mm) | Wind velocity (km/h) | Sunshine (Hours) |
|---|---|---|---|---|---|---|
| 1 | *Monolepta* sp. | 0.867* | -0.503 | -0.296 | 0.446 | 0.464 |
| 2 | *Popillia* sp. | 0.689* | -0.693* | -0.396 | 0.534 | 0.507 |
| 3 | *E. Salemensis* | 0.686* | -0.128 | -0.143 | 0.352 | 0.209 |
| *4* | *R. pedestris* | 0.612* | -0.181 | -0.215 | 0.688* | 0.528 |
| 5 | *O. oneratulus* | 0.871* | -0.505 | -0.322 | 0.511 | 0.446 |
| 6 | *H. tritonaria* | 0.811* | -0.646* | -0.352 | 0.480 | 0.435 |
| 7 | Flower webber | 0.739* | -0.303 | -0.196 | 0.348 | 0.301 |
| 8 | *P. chlora* | 0.685* | -0.621* | -0.340 | 0.460 | 0.391 |

*significant

# *Discussion*

# 5. DISCUSSION

Exotic fruits such as rambutan, dragon fruit, mangosteen, and passion fruit hold significant importance in the food culture of the present day health conscious generation. These fruits bring a unique set of flavors, textures, and nutritional profiles that contribute to the dietary diversity of the population. As consumer preferences evolve towards healthier and more diverse food choices, the demand for exotic fruits has been on the rise, providing farmers with the potential for increased income. Overall, the cultivation and consumption of exotic fruits play a crucial role in fostering agricultural diversity, economic growth, and cultural richness in India.

As the cultivation of exotic fruits continues to gain significance in agriculture, it becomes crucial to document pests, natural enemies, and their seasonal patterns for the development of effective integrated pest management programs. Additionally, the documentation of floral visitors is essential for implementing measures to enhance crop yields. The findings from this study are now deliberated upon.

## 5.1 DOCUMENTATION OF PESTS OF EXOTIC FRUITS

The findings of the present investigation recorded 60 pests, 24 natural enemies, and 14 pollinators in exotic fruit cultivated in Kerala. Among the pests documented, 27 were from the order Hemiptera, 21 from Lepidoptera, six from Coleoptera, 4 from Hymenoptera, and 2 from Diptera. Thirty-two pests were documented from rambutan which includes members from order Lepidoptera (14), Hemiptera (11), Coleoptera (5) and Hymenoptera (2) (Fig.1). Dragon fruit faced challenges from five pests in the order Hemiptera and one each in Lepidoptera, Diptera, and Hymenoptera. Three pests each from the orders Hemiptera and Lepidoptera were recorded in mangosteen along with a pest from the order Hymenoptera. Passion fruit pests included two members from Hemiptera, one each from Lepidoptera, and Diptera. A total of ten pests belonging to the order Hemiptera (6), Lepidoptera (3), and Coleoptera (1) were documented from other minor exotic fruits (Fig. 5).

### 5.1.1 Pests of Rambutan

The findings of this study indicate that a total of 32 pests were identified in rambutan. The study conducted by Mala *et al*. during 2015 in India, documented mealy bugs *P. citri*, red borers *Zeuzera* sp., bostrichid beetles *Sinoxylon* sp., as well as fruit flies *B. dorsalis* and *B. caryeaea*. Yunus and Ho (1980) documented a total of 127 insects associated with rambutan. Later Khoo *et al*. (1991) provided a description of 15 insects infesting rambutan in Malaysia. In a survey conducted by Waterhouse (1993), 28 pests of rambutan in Southeast Asia were identified.

During the current study, 11 species of sucking pests *viz., P. lilacinus, C. hirsutus, F. virgata, P. citri, C. floridensis, Icerya* sp., *R. pedestris, O. oneratulus, Gargara* sp., *Ricania* sp. and *Flatormenis* sp. were documented. Among these pests *F. virgata, C. floridensis, Icerya* sp., *R. pedestris, O. oneratulus, Gargara* sp., *Ricania* sp. and *Flatormenis* sp. were documented for the first time in rambutan in India. *P. lilacinus* and *P. citri* were reported from rambutan growing tracts of Philippines (Tripathi, 2021). Muhammed *et al*. (2016) documented two sucking pests viz., *P. citri* and an unidentified species of armoured scale on rambutan trees from Kerala. Villatoro-Moreno *et al*. (2016) recorded the presence of *F. virgata* in the rambutan orchards of Mexico.

Apart from the sucking pests, inflorescence feeders (15) were also documented in rambutan. Among them, 10 were lepidopteran caterpillars like *P. chlora, R. manea, H. tritonaria, S. scintillans, O. mendosa, C. cassidara, A. lycaenina, E. abrupta, E. versicolor* and an unidentified flower webber. Flower feeding beetles like *Popillia* sp., *E. salemensis, Monolepta* sp., *O. versicolor* and one unidentified flower beetle from the family Bruchidae were also documented from rambutan. *P. chlora., R. manea, H. ritonaria, S. scintillans, O. mendosa, C. cassidara, A. lycaenina, E. abrupta, E. versicolor,* flower webber, *Popillia* sp., *E. salemensis, Monolepta* sp., *O. versicolor* and an unidentified beetle of Bruchidae were documented for the first time as the pest of rambutan from India. The above-mentioned lepidopteran pests fed on the inflorescence of rambutan. The adult and grubs of the warty leaf beetle, *E. salemensis* were found to feed

on the inflorescence. While adult beetles were destructive in other cases where they feed on inflorescence.

The leaf feeders observed on rambutan were *A. discolor* and two unidentified species of bagworms. *A. discolor* is documented for the first time as the pest of rambutan in India. Lepidopteran caterpillars like lobster caterpillar *Neostauropus alternus* and leaf folder *Thalassodes quadraria* were the other leaf eating caterpillars recorded from the rambutan and earlier recorded by Muhammed *et al*. (2016) in rambutan growing tracts of Kerala.

Two unidentified bark borers belonging to the family Lecithoceridae and Xylorictidae were recorded from rambutan. Infestation was evident by the presence of tunnels on the bark and was sealed with excreta. Mala *et al*. (2015) reported the red twig borer *Zeuzera* sp. on rambutan from south India.

### 5.1.2 Pests of Dragon Fruit

The findings of this study recorded 8 pests on dragon fruit, belonging to the order Hemiptera (5), Lepidoptera (1), Diptera (1), and Hymenoptera (1) (Fig.2). In the present investigation lower pest infestation was noticed on dragon fruit compared to other exotic fruits studied. Occurrence of pests such as ants, scale insects, and mealy bugs was wide spread in Indian dragon fruit cultivation (Wakchuare *et al*., 2020).

A total of five sucking pests were documented from dragon fruit and it includes *H. picus*, plant hoppers like *Eurybrachis* sp., *Ricania* sp. and *Flatormenis* sp. and *F. virgata*. All these insect pests were sap feeders. The above-mentioned pests were documented for the first time on dragon fruit in India. In the present investigation on biology of the stink bug *H. picus*, it required 5.2 $\pm$ 0.20, 46.8 ± 2.53 days as egg and nymphal period respectively. Both nymphs and adults suck sap from the soft stems of dragon fruit and the characteristic feeding symptoms can be seen as white scars on stem. Sartiami *et al*. (2020) noted sucking pests like mealy bugs viz., *F. virgata*, *Planococcus minor* (Maskell),

*Phenacoccus solenopsis* (Tinsley) and *Pseudococcus jackbeardsleyi* (Gimpel and Miller) on dragon fruits in Mexico.

Caterpillars of *S. litura* were found feeding on the stem of young seedlings of dragon fruit**.** Prathapan and Santhoshkumar (2022) reported the incidence of *S. litura* for the first time in dragon fruit at an orchard in Thiruvananthapuram, Kerala. The early instar larvae fed by boring in to soft succulent stem, results in the exudation of viscous sap. Later instars hide in the soil during day time and at night time they voraciously feed on the soft stems. Duncan *et al.* (2021) noted the presence of *Spodoptera exigua* (Hubner) throughout the year in South Florida.

In the present investigation the oriental fruit fly *B. dorsalis* were recorded for the first time in dragon fruit from India. The adult females laid their eggs just beneath the mature fruit skin, and the maggots fed the internal contents of the fruit. Studies on biology of these pests showed an average of 1.6± 0.40, 8.0 ± 0.40, and 8.0 ± 0.31 days as egg, larval and pupal period respectively. The total life cycle (egg to adult) was longer for females with 28.4 ± 1.32 days whereas the males had 25.4 ± 1.28 days. Dragon fruits were found to be infested with the fruit flies *B. cucurbitae* and *B. dorsalis* in Japan (Iwaizumi *et al*., 1995).

The destructive trailing ant, *T. destructor* were observed foraging on fruits, flowers, and stems. The fruit fly *B. dorsalis* and the ant *T. destructor* was documented for the first time as the pest of dragon fruit from India. Parween *et al*. (2018) reported the ants *viz., Atta* sp. and *Solenopsis* sp. on dragon fruit.

### 5.1.3 Pests of Mangosteen

A total of seven pests were identified on mangosteen, belonging to the order Hemiptera (3), Lepidoptera (3), and Hymenoptera (1) (Fig.3). Three species of sucking pests observed were *C. hesperidum, C. hirsutus* and *P. citri.* These were documented for the first time as the pests of mangosteen from India. *Dysmicoccus lepelleyi* (Betrem) is a quarantine pest on mangosteen in Australia. Adults and nymphs of this mealy bug were

found feeding on the fruits of mangosteen (Syauqi *et al*., 2021). *Scirtothrips dorsalis* (Hood) and *Selenothrips rubrocintus* (Giard) are the other two sucking pests which feed on the fruits of Mangosteen (Emilda, 2009).

The lepidopteran caterpillars like *A. flavobasalis*, *Stictoptera* sp. and *Homona* sp. were documented in mangosteen. Nagao (2004) reported the lepidopteran caterpillar pests *S. cuculioides* responsible for the damage of young leaves of mangosteen in Hawaii.

### 5.1.4 Pests of Passion Fruit

Among the major exotic fruits studied in the present investigation, lowest pest infestation was observed in case of passion fruit. A total of four pests were documented belonging to the order Hemiptera (2), Lepidoptera (1) and Diptera (1) (Fig. 4).

*A. rugioperculatus* and *C. cirripediformis* were the two sucking pests documented on passion fruit. Adults and crawlers of whitefly were found to feed from the lower surface of leaves. *A. rugioperculatus* was documented for the first time as the pest of passion fruit in India. Nymphs and adults of *C. cirripediformis* were found to feed on the leaves and stems. *A. rugioperculatus* was originally described from Belize and has been recently reported from India, especially from Tamil Nadu, Karnataka, Kerala and Andhra Pradesh. Coconut, and banana were the common and preferred hosts and smaller infestations were observed on guava, citrus, mango, sapota, bhendi, custard apple, jatropha, nutmug, tapioca, neem, black pepper, brinjal, cotton, maize, bajra and hibiscus (Elango, 2019) The invasive soft scale, *C. cirripediformis* was recorded for the first time from India in a study conducted during 2020 in connection with the wilting of passion fruit. They attack wide host plants like citrus, mango, jackfruit and ficus (Joshi *et al*., 2021)

Apart from the sucking pests, a total of two leaf feeders were documented from passion fruit viz., *S. xanthorrhoea* and an unidentified leaf miner from the order Diptera and the two pests were documented for the first time as the pest of passion fruit from India. The hairy caterpillars of *S. xanthorrhoea* were defoliators and found to feed on the

foliages. Studies on biology of these pest showed that an average of 6.8 ± 0.37, 25.6 ± 1.20 and 6.6 ± 0.37 days were required as egg, larval and pupal period respectively. The total life cycle (egg to adult) was longer for females with 35.4 ± 0.50 days whereas the males had 33.8 ± 0.37days. Maggots of unidentified leaf miner were yellow coloured and were found mining on the young leaves creating a distinctive pattern on the foliage. *I alcumena*, *S. cosmioides* and *S. eridania* are the lepidopteran defoliators of passion fruit reported from Brazil (Ferreira *et al*., 2019). The lepidopteran pests of passion fruit recorded from Venezuela were *D. juno*, *A. vanilla*, and *E. isabella* (Dominquez- Gil and McPheron, 1992). The caterpillar *Azamora penicillana* (Walker) were found to feed on the passion fruit leaves in Brazil (Soares *et al*., 2021)

### 5.1.5 Pests of Minor Exotic Fruits

In the present study, a total of ten pests were documented on other minor exotic fruits, belonging to the order Hemiptera (6), Lepidoptera (3) and Coleoptera (1) (Fig.5). Sucking pests documented were *P. lilacinus* on miracle fruit, *P. citri* on pulasan, *S. coffeae* on abiu, *C. floridensis* on litchi, *D. expansum* on soursop and *Ceroplastes destructor* on longan. Apart from the sucking pests, four leaf feeders were also documented, belonging to the order Lepidoptera (3) and coleopteran (1). Leaf feeders documented were *Brunia antica* on velvet apple, *Statherotis* sp., *R. amor* and *Monolepta* sp. on longan.

India is one of the major litchi growing country in the world especially in eastern India and Bihar, the major pests of litchi are litchi fruit borer *C. cramerella*, bark eating caterpillar *Indarbela tetraonis* (Moore) and *I. quadrinotata* (Walker), leaf roller *Platypeplus aprobola* (Meyrick) and litchi mite *Aceria litchi* (Keifer) red weevil *Apoderus blandus* (Faust), looper *Perixera illepidaria* (Guenee), leaf roller *Dudua aprobola* (Meyrick) and bagworm *Eumeta crameri* (Westwood) (Kumar *et al*., 2014; Srivastava *et al*., 2016).

The major pest of longan is stink bug *Tessaratoma javanica* (Thunberg). The adult bug fed on the panicles and young fruits of newly developed shoots of longan, causing the desiccation of the infested part of the tree (Prasad *et al*., 2017). *Eriophyes dimocarpi* (Kuang) (Acari: Eriophyidae), *C. punctiferalis* (Lepidoptera: Crambidae), *Conopomorpha sinensis* (Bradley) (Lepidoptera: Gracillariidae), *Conopomorpha litchiella* (Bradley) (Lepidoptera: Gracillariidae), *Tessaratoma papillosa* (Drury) (Hemiptera: Tessaratomidae), *Eudocima phalonia* (Linnaeus) (Lepidoptera: Erebidae), oriental fruit fly *B. dorsalis* (Diptera: Tephretidae), *P. lilacinus* (Hemiptera: Pseudococcidae), *Drepanococcus chiton* (Green) (Hemiptera: Coccidae), and *Cornegenapsylla sinica* (Yang & Li) (Hemiptera: Psyllidae) were the pests of longan reported from Vietnam (Tran *et al*., 2019).

## 5.2 NATURAL ENEMIES OF PEST OF EXOTIC FRUITS

It was observed that in addition to various insect pests, a large number of natural enemies were also associated with exotic fruits. A comprehensive survey identified 15 different spider species in exotic fruit crops. In addition, six insect predators were also documented belonging to order Mantodea (3), Coleoptera (1), Lepidoptera (1) and Hemiptera (1) (Fig.6). A total of 15 spider species, spanning 12 genera, distributed across 5 families were observed in association with pests of exotic fruit crops. The spiders observed belonged to the family Salticidae featuring 6 species.

Among the spiders, three distinct feeding guilds were identified, with stalkers being the prevalent feeding guild, followed by orb weavers and ambushers. *Thomisus pugilis*, *Hamataliwa* sp., *Hyllus semicupreus, Camaricus formosus, Thomisus lobosus, Carrhotus viduus, Epeus indicus, Oxyopes shweta, Zosis geniculata, Oxyopes javanus, Anepsion maritatum, Neoscona mukerjei, Epeus tener, Indopadilla insularis* and *Chrysilla volupe* were the prominent spiders observed on the exotic fruits. It was observed that spiders were actively preying on larvae of *S. litura* in dragon fruit, as well as *E. abrupta* in rambutan and also other soft-bodied insects.

Spiders belonging to the Araneidae, Heteropididae, Lycosidae, Oxyopidae, and Salticidae families are general predators. Their significance is not fully comprehended, but it was noted that they are non-selective feeders, targeting various insects, both beneficial and harmful. Literatures were scanty on insect predators of exotic fruit ecosystem. Astridge, (2021) recorded a predatory mite *Phtoseiulus persimilis* (Athias-Henriot) in connection with two-spotted mite on rambutan fruit.

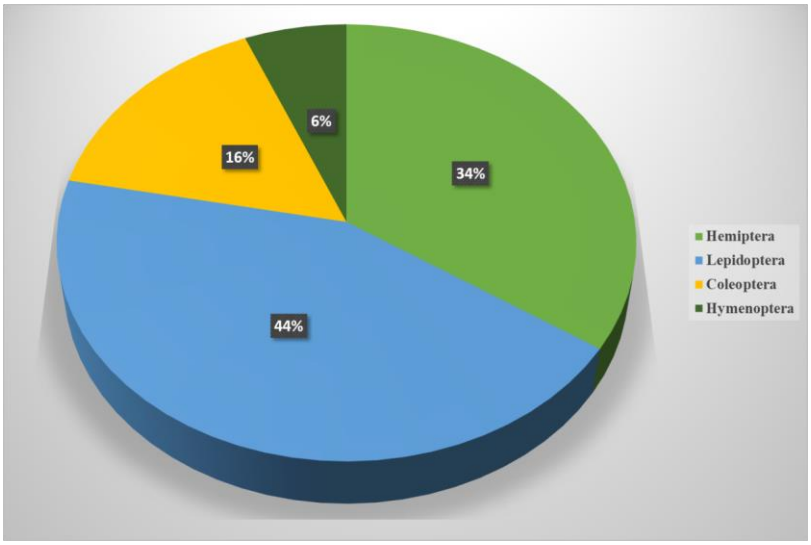



Fig. 1. Distribution of insect pests on rambutan

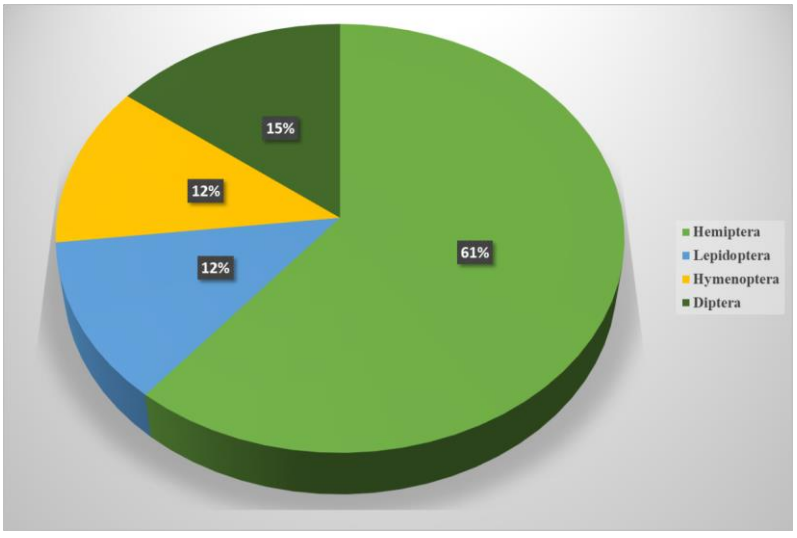



Fig. 2. Distribution of insect pests on dragon fruit

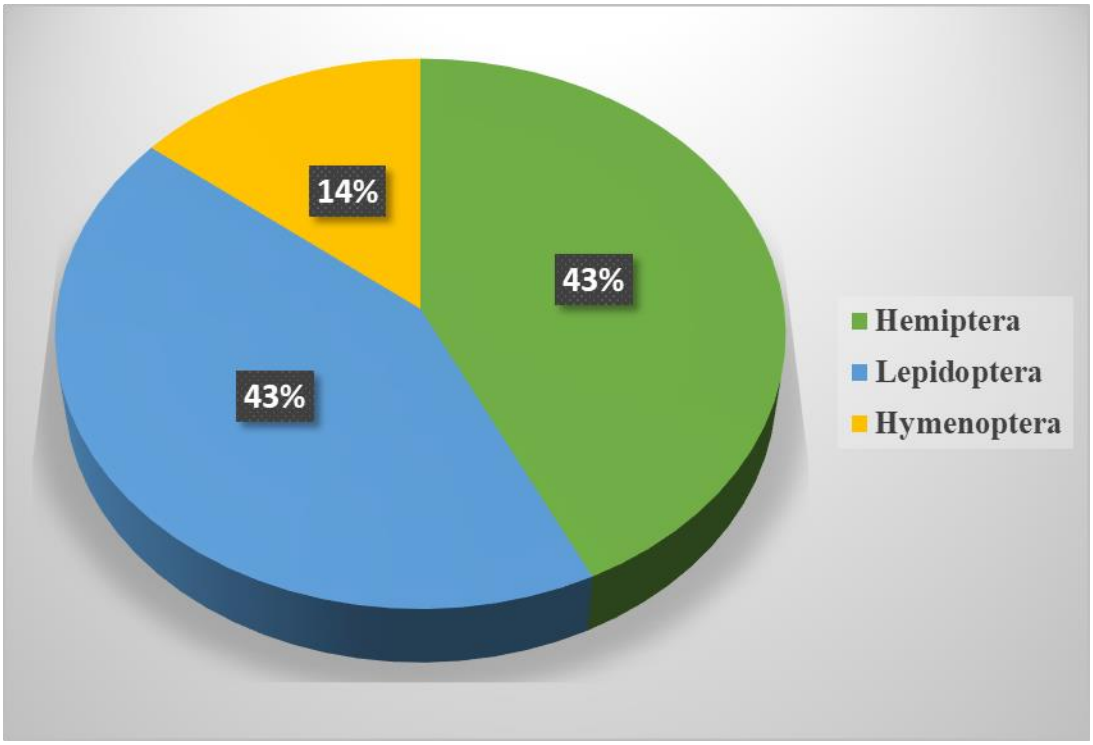



Fig. 3. Distribution of insect pests on mangosteen

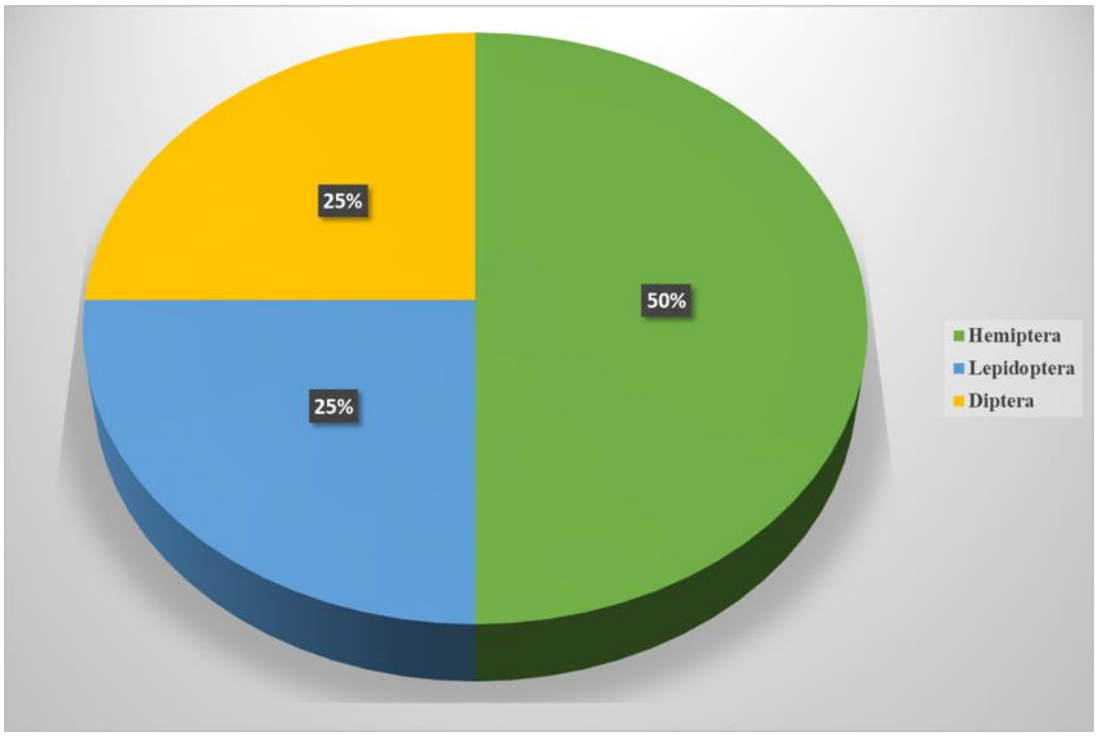



Fig. 4. Distribution of insect pests on passion fruit

## 5.3 POLLINATORS OF EXOTIC FRUITS

About ten pollinators were recorded on the inflorescence of rambutan and four pollinators on the flowers of passion fruit. Pollinators of rambutan include *A. cerana indica, T. travancorica, Nomada sp., Leucospis sp., Myzinum* sp., *Halictus* sp., *Stomorhina* sp., *Ischidon* sp., *Ypthima* sp and *E. impactella.* Among the observed pollinators, the Hymenopteran pollinators were abundant and recorded an average of 8.49 / 5 inflorescence/ 5 min followed by Lepidoptera (1.06 / 5 inflorescence/ 5 min) and Diptera (0.03 / 5 inflorescence/ 5 min) (Fig.7). These findings provide valuable insights into the diverse dynamics of pollinators within the Hymenoptera order, highlighting the significant roles played by *T. travancorica, A. cerana indica*, and other species in the pollinating rambutan.

Shivaramu *et al*. (2012) documented that the stingless bee (*Trigona iridipennis*) and the Indian honeybee (*Apis cerana*) were the most predominant pollinators of rambutan. Stingless bee species *Scaptotrigona* and *Tetragonisc*a in open pollination treatments and within cages showed that fruit production increased nearly 10 fold in rambutan (Rincon-Rabanales *et al*., 2015).

Pollinators of passion fruit include *A. cerana indica*, *Xylocopa* sp., *T. travancorica* and *Ischidon* sp. (Fig.8). *Xylocopa* sp. was the most prevalent pollinator (0.33/ 5 flowers/ 5 min) followed by *T. travancorica* (0.11/ 5 flowers/ 5 min) and *A. cerana indica* (0.070/ 5 flowers/ 5 min). Population of *Xylocopa* sp. was maximum during 1500 to 1600 h (0.71/ 5 flowers/5 min). Asiatic honey bees *Apis cerana* (Fabricius), stingless bees *Tetragonula laeviceps* (Smith), and carpenter bees *Xylocopa latipes* (Drury) were the major pollinators of the passion fruit flowers (Putra *et al*., 2023). Das *et al*. (2013) reported that honey bees *Apis mellifera* (Linnaeus), bumblebees and carpenter bee *Xylocopa sonorina* (Smith) were the major pollinators of passion fruit.

## 5.4 SEASONAL OCCURRENCE OF PESTS IN EXOTIC FRUITS

The peak period of pest infestation in rambutan occurred from March to May, encompassing the flowering to fruit-setting phase. During this period, the insect pest observed on rambutan were *Monolepta* sp., *Popillia* sp., *E. salemensis*, *O. oneratulus*, *R. pedestris*, *P. chlora*, *H. tritonaria*, and an unidentified flower webber. The observations revealed that rambutan trees were devoid of pests from October to February (Fig.9).

In North Queensland, yellow peach fruit piercing moths were found during December to March in rambutan .The fruit piercing moth adults fed on the fruit juices of maturing fruit by damaging the skin allowed the entry of secondary pathogens causing rots on fruits. These pests were most active from February to April (Astridge, 2001). Pests like fruit fly *B. dorsalis*, and the moths *C. punctiferalis* and *Cryptophlebia ombrodelta* were considered as major pests of rambutan in Vietnam during the fruit setting period (Orwa *et al*., 2009).

Pest infection on dragon fruit was noted throughout the year in South Florida and the pests reported were leaf-footed bugs, aphids, scales and mealy bugs (Duncan *et al*., 2021). Aphids on passion fruit in Kenya showed seasonal high and low during the months from June to July and from December to February respectively (Kilalo *et al*., 2013). The red banded thrips of mangosteen in North Queensland were found only during the flowering and fruit season (Astridge, 2001).

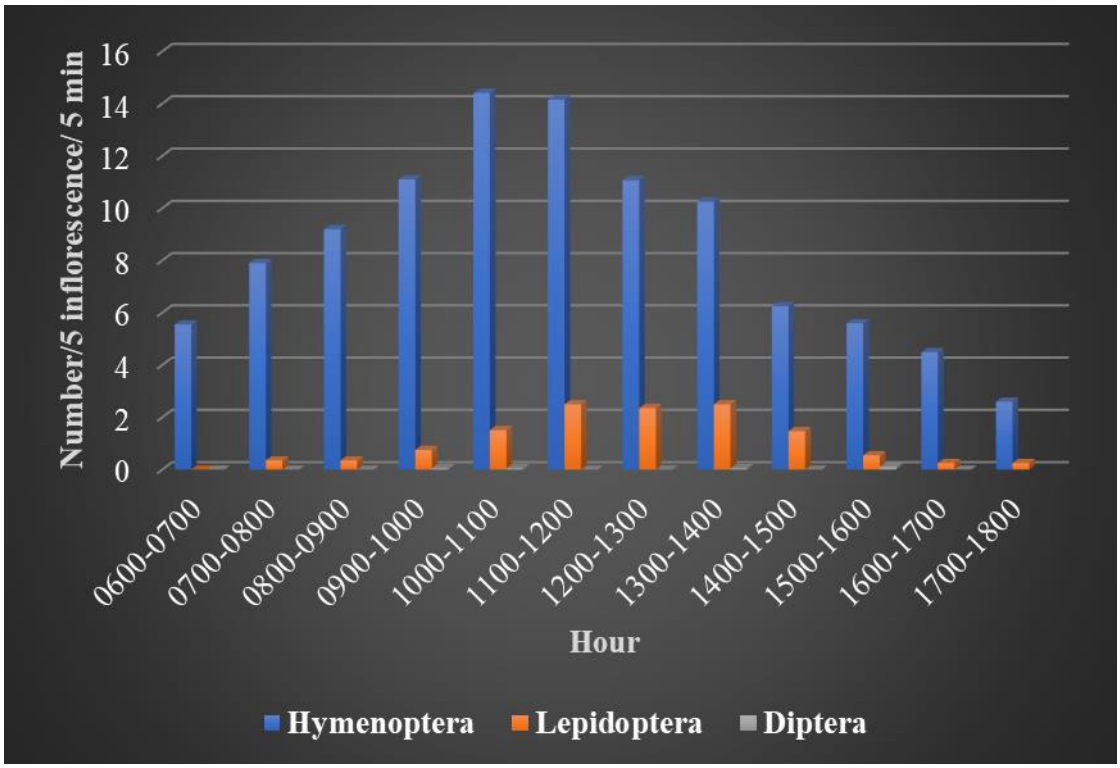



Fig. 7. Mean population of pollinators documented on rambutan at hourly intervals

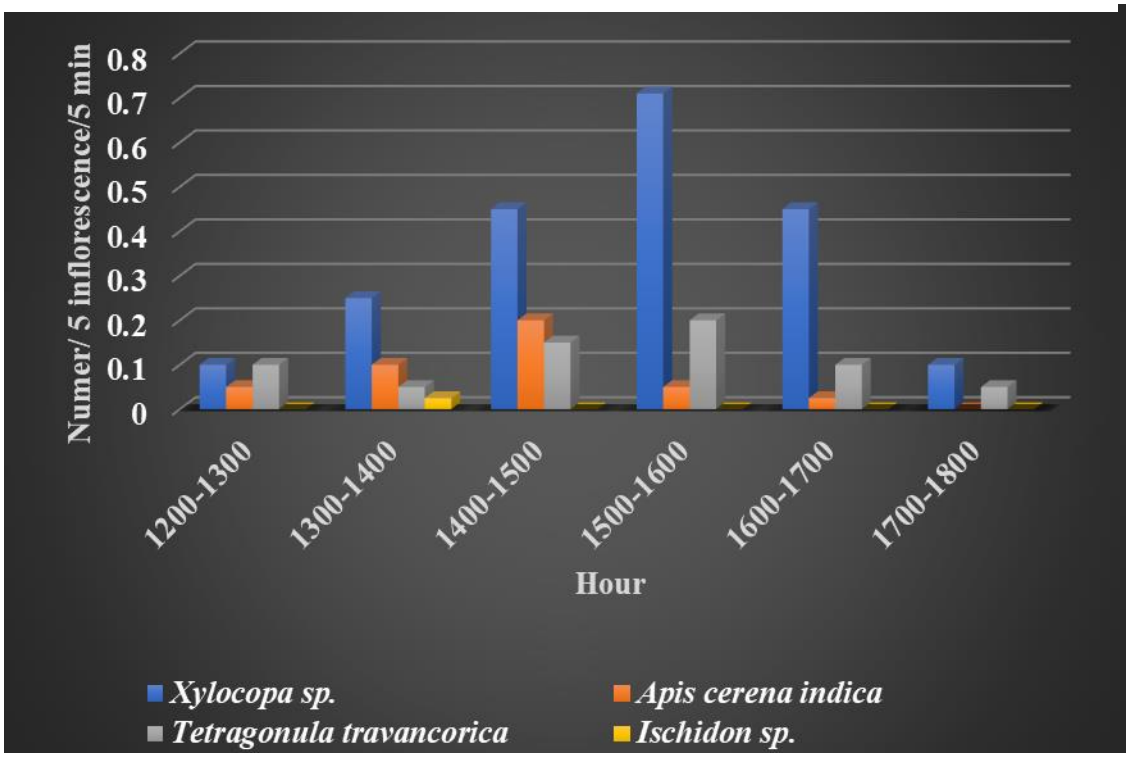



Fig. 8. Mean population of pollinators documented on passion fruit at hourly intervals

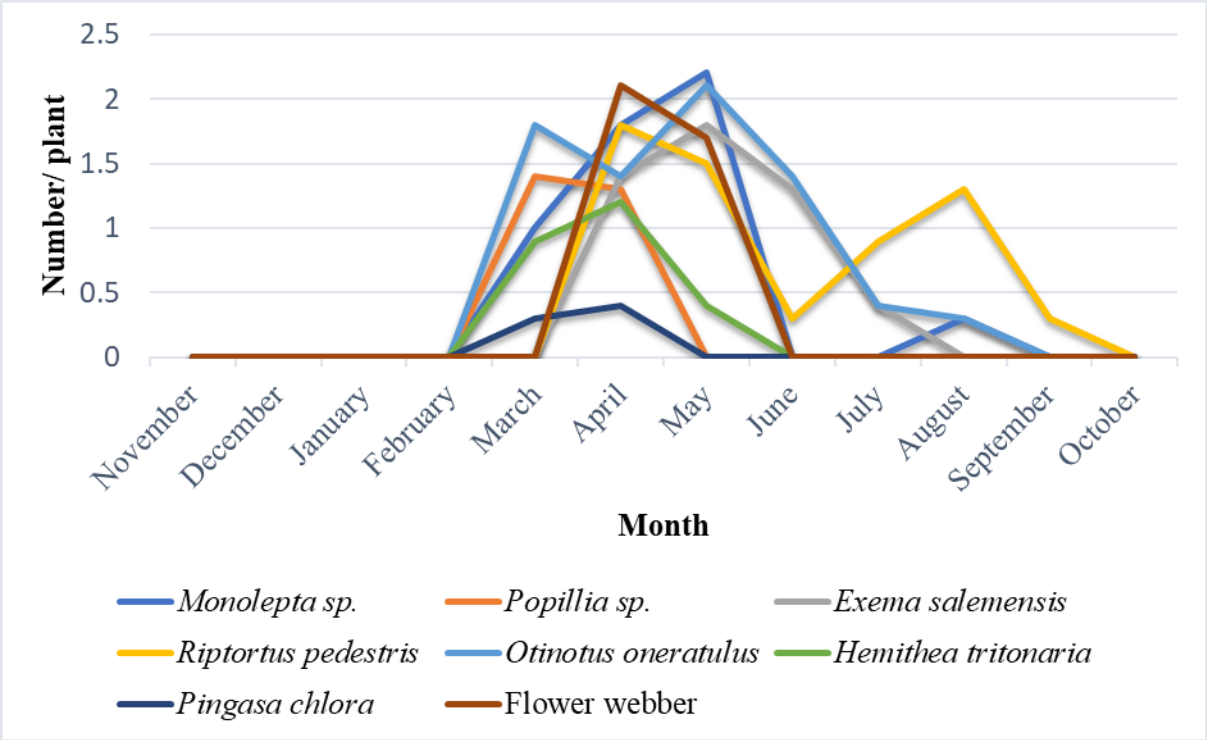



Fig. 9. Seasonal incidence of insect pests on rambutan

# *Summary*

## 6. SUMMARY.

The documentation conducted at Instructional Farm Vellayani, College of Agriculture, Vellanikkara and farmers field in Thiruvananthapuram, Kollam, Kottayam and Malappuram recorded a total of 60 pests, 24 natural enemies and 14 pollinators. 32 pests were documented from rambutan, 8 from dragon fruit, 7 from mangosteen, 4 from passion fruit and 10 from other minor exotic fruit crops like miracle fruit *S. dulcificum*, pulasan *Nephelium mutabile***,** abiu *Pouteria caimito,* soursop *Annona muricata*, litchi *Litchi chinensis*, velvet apple *Diospyros discolor* and longan *Dimocarpus longan.*

Mealybug *Planococcus lilacinus, Crisicoccus hirsutus, Ferrisia virgata*, scales *Ceroplastis floridensis, Icerya* sp., bean bug *Riptortus pedestris*, cow bug *Otinotus oneratulus,* tree hopper *Gargara* sp., black plant hopper *Ricania* sp. and flatid plant hopper *Flatormenis* sp. were the sucking pests documented from rambutan. Leaf and inflorescence caterpillars were also predominant in rambutan, which include white looper moth *Pingasa chlora*, slate flash *Rapala manea,* emerald moth *Hemithea tritonaria,* yellow-tail tussock moth *Somena scintillans*, tussock caterpillar *Olene mendosa*, looper *Comibaena cassidara,* pointed ciliate blue *Anthene lycaenina*, owl moth *Avatha discolor*. The inflorescence feeding beetles documented were scarab beetle *Popillia* sp. warty leaf beetle *Exema salemensis,* leaf beetle *Monolepta* sp. and flower beetle *Oxycetonia versicolor*. Apart from these pests two unidentified bark borers were also documented from the micro lepidopteran family Lecithoceridae and another from the family Xylorictide.

A total of five sap feeders were documented from the dragon fruit *viz.*, brown stink bug *Halyomorpha picus*, plant hopper (*Eurybrachis* sp., *Ricania* sp. and *Flatormenis* sp.) and striped mealybug *Ferrisia virgata*. Apart from this, other pests documented on dragon fruit were the oriental fruit fly *Bactrocera dorsalis,* Tobacco cutworm *Spodoptera litura* and a destructive trailing ant *Trichomyrmex destructor*. The fruit fly and destructive trailing ant were found feeding on the fruits.

Pest infestation was lower in mangosteen and passion fruit. The brown soft scale *Coccus hesperidum*, mealybug *C. hirsutus,* leaf eating caterpillar *Agrotera flavobasalis* and flower feeding caterpillar *Homona* sp. were documented on mangosteen. The rugose spiraling whitefly *Aleurodicus rugioperculatus,* gold tail moth *Sphrageidus xanthorrhoea*, Barnacle scale *Ceroplastes cirripediformis* and unidentified a leaf miner species were documented on passion fruit.

Along with the pests of major exotic fruit crops some pests were also documented on minor exotic fruit crops. *P. lilacinus* on miracle fruit, *P. citri* on pulasan, *Saissetia coffeae* on abiu, *C. floridensis* on litchi, *Discochiton expansum* on soursop, *C. destructor* on longan, *Brunia antica* on velvet apple, *Statherotis* sp., *Rathinda amor* and *Monolepta* sp. on longan were the pests documented on minor exotic fruits.

Biology of *B. dorsalis, H. picus* and *S. xanthorrhoea* were carried out under laboratory condition. The egg, larval, and pupal periods of *B. dorsalis* took an average of 1.6 ± 0.40, 8.0 ± 0.40 and 8.0 ± 0.31days respectively. The adult female had a longevity of 9.6 ± 0.5 days and 6.4 ± 0.50 days in males. The egg and nymphal periods for *H. picus* were 5.2 ± 0.20 and 46.8 ± 2.53 days, respectively. The egg, larval and pupal period of *S. xanthorrhoea* were 5.2 $\pm$ 0.20, 25.6 ± 1.20, 6.6 ± 0.37 days respectively.

Spiders were the predominant natural enemies associated with the pests of exotic fruits followed by insect predators. 15 species of spiders, 6 insect predators and 3 parasitoid species were the natural enemies documented on exotic fruits. The major spiders documented were from the genera *Thomisus, Hamataliwa, Hyllus, Camaricus, Carrhotus, Epeus, Oxyopes, Zosis, Anepsion, Neoscona, Indopadilla* and *Chrysilla.* Apart from spiders, six insect predators, including praying mantis *Odontomantis pulchra* (Olivier), *Creobroter gemmatus* (Saussure) and *Hierodula* sp. (Mantodea), coccinellid beetle *Cheilomenes sexmaculata* (Fabricius) (Coleoptera), reduviid bug *Nagusta* sp. (Hemiptera) and ape fly *Spalgis epius* (Westwood)(Lepidoptera) were also documented. Along with predators, three parasitoids belonging to the family Trichogrammatidae, Eupelmidae and Aphelinidae were also documented.

From the present investigation14 pollinators were documented on rambutan (10) and passion fruit (4). The floral visitors were monitored through visual observations. Pollinators visiting the inflorescence were recorded for 5 min between 0600 to 1800 hours. *Apis cerana indica*, *Tetragonula travancorica*, *Nomada sp., Leucospis sp.*, *Myzinum* sp., *Halictus* sp., *Ypthima* sp., *Eretmocera impactella*, *Stomorhina* sp. and *Ischidon* sp. were the pollinators documented on the inflorescence of rambutan. hymenopteran pollinators dominated other groups, with their abundance at rate of 8.49 /5 inflorescence/ 5 min. This was followed by lepidoptera (1.06/ 5 inflorescence / 5min) and Diptera (0.03 /5 inflorescence /5 min). *T. travancorica* was the most abundant pollinator with mean population of 6.41 /5 inflorescence /5 min followed by *A. cerana indica* (1.54 /5 inflorescence /5 min). *A. cerana indica*, *T. travancorica, Xylocopa* sp. and *Ischidon* sp. were the pollinators documented on the flowers of passionfruit. *Xylocopa* sp. was the most dominant pollinator (0.33/5 flowers /5 min) in passion fruit followed by *T. travancorica* (0.11 /5 flowers /5 min) and *A. cerana indica* (0.07 /5 flowers /5 min).

The seasonal incidence study revealed that the pest infestation in rambutan was maximum during March to May (flowering to fruit-setting season) and the insect pest noticed on rambutan were *Monolepta* sp., *Popillia* sp., *E. salemensis*, *O. oneratulus*, *R. pedestris*, *P. chlora*, *H. tritonaria*, and an unidentified flower webber. There was no pest infestation on rambutan trees from October to February. The pest population of rambutan shows a positive correlation with temperature, wind velocity and sunshine hours while a negative correlation was observed with both rainfall and average relative humidity.

From the present study a total of 60 pests, 24 natural enemies, and 14 pollinators were documented from exotic fruits in the state of Kerala. Among the identified pests 27 pests were recorded from the order Hemiptera, 21 from Lepidoptera, 6 from Coleoptera, 4 from Hymenoptera and 2 from Diptera. Among the total pests, 32 pests were documented on rambutan, 8 on dragonfruit, 7 on mangosteen, 4 on passionfruit and 10 on minor exotic fruit crops. Spiders emerged as the predominant predators followed by insect predators. hymenopteran pollinators were the abundant contributors to pollination where stingless bee (*T. travancorica*) was the most abundant and frequent visitor of rambutan

infloresence and carpenter bee (*Xylocopa* sp.) was the frequent visitor of passion fruit flowers. The pest incidence in rambutan showed a positive correlation with temperature, wind velocity and sunshine hours and negative correlation with both rainfall and relative humidity.

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# *Appendices*

## APPENDIX I

**Weather parameters during November 2022 – October 2023**

| Month | Temperature (℃) | Average Relative Humidity (%) | Total rainfall (mm) | Wind velocity (km/h) | Sunshine (Hours) |
|---|---|---|---|---|---|
| November | 30.92 | 84.30 | 5.10 | 0.57 | 4.90 |
| December | 31.25 | 84.46 | 3.30 | 0.30 | 3.60 |
| January | 31.56 | 80.00 | 0.50 | 1.30 | 6.20 |
| February | 32.00 | 80.00 | 0.40 | 2.70 | 7.90 |
| March | 33.43 | 75.00 | 0.60 | 5.00 | 8.30 |
| April | 34.01 | 78.98 | 1.40 | 5.80 | 7.92 |
| May | 33.76 | 81.61 | 3.50 | 3.90 | 7.40 |
| June | 32.41 | 84.75 | 4.00 | 3.70 | 5.90 |
| July | 31.22 | 86.29 | 5.20 | 5.30 | 5.90 |
| August | 32.37 | 81.33 | 0.90 | 6.60 | 10.20 |
| September | 30.52 | 88.61 | 11.30 | 2.00 | 3.90 |
| October | 30.28 | 93.00 | 12.60 | 3.50 | 3.90 |

# PESTS OF EXOTIC FRUIT CROPS IN KERALA

*by*

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**ABSTRACT**

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## ABSTRACT

The study entitled “Pests of exotic fruit crops in Kerala.” was conducted at the Department of Entomology, College of Agriculture, Vellayani from 2021 to 2023 with the objective of documenting the pests of exotic fruits, its natural enemies and pollinators in Kerala.

The documentation was carried out at the orchard of Instructional Farm, Vellayani and in farmer’s field in Thiruvananthapuram, Kollam, Kottayam and Malappuram districts of Kerala through multiple field visits. A total of 60 different pests were documented from different exotic fruit crops. Among them, 32 pests were documented from rambutan *Nephelium lappaceum* (L.), 8 from dragon fruit *Selenicereus undatus* (Haw.) D. R. Hunt, 7 from mangosteen *Garcinia mangostana* (L.), 4 from passion fruit *Passiflora edulis* (Sim.), and 10 from other minor exotic fruit crops like miracle fruit *Synsepalum dulcificum* (Schumach. and Thonn.), pulasan ***N****ephelium mutabile* (Blume.)**,** abiu *Pouteria caimito* (Radik.), soursop *Annona muricata* (L.), litchi *Litchi chinensis* (Sonn.), velvet apple *Diospyros discolor* (Willd.) and longan *Dimocarpus longan* (Lour.).

Leaf and inflorescence caterpillars were predominant in rambutan followed by sucking pests and beetles. The sucking pests include, mealybug *Planococcus lilacinus* (Cockerel), *Crisicoccus hirsutus* (Newstead), *Ferrisia virgata* (Cockerell), scale *Ceroplastis floridensis* (Comstock), *Icerya* sp., bean bug *Riptortus pedestris* (Fabricius), cow bug *Otinotus oneratulus* (Walker), tree hopper *Gargara* sp., black plant hopper *Ricania* sp., flatid plant hopper *Flatormenis* sp. The lepidopterans recorded in rambutan were white looper moth *Pingasa chlora* (Stoll), slate flash *Rapala manea* (Hewitson), emerald moth *Hemithea tritonaria* (Walker), yellow-tail tussock moth *Somena scintillans* (Walker), tussock caterpillar *Olene mendosa* (Huebner), looper *Comibaena cassidara* (Guenee), pointed ciliate blue *Anthene lycaenina* (Felder), owl moth *Avatha discolor* (Fabricius) and a bark borer which is an unidentified micro lepidopteran. Scarab beetle *Popillia* sp., warty leaf beetle *Exema salemensis* (Bhasin), leaf beetle *Monolepta* sp. and

flower beetle *Oxycetonia versicolor* (Fabricius) were the coleopteran pests documented on rambutan. Rambutan was identified as the host for the above-mentioned pests for the first time in India.

In dragon fruit, the oriental fruit fly *Bactrocera dorsalis* (Hendel) was reported for the first time in India. The sucking pests like the brown stink bug *Halyomorpha picus* (Fabricius), plant hopper *Eurybrachis* sp., *Ricania* sp. and *Flatormenis* sp., striped mealybug *Ferrisia virgata* (Cockerell), and a destructive trailing ant *Trichomyrmex destructor* (Jerdon) were also reported for the first time as insect pests of dragon fruit from India.

Pest infestation was comparatively lower in mangosteen and passion fruit. The brown soft scale *Coccus hesperidum* (Linnaeus), mealybug *C. hirsutus*, leaf eating caterpillar *Agrotera flavobasalis* (Inoue) and flower feeding caterpillar *Homona* sp. were reported for the first time in mangosteen from India. The rugose spiralling whitefly *Aleurodicus rugioperculatus* (Martin) and gold tail moth *Sphrageidus xanthorrhoea* (Kollar) were reported for the first time in passion fruit from India.

Biology of *B. dorsalis, H. picus* and *S. xanthorrhoea* were studied under laboratory condition. The egg, larval, pupal and adult period of male, female *B. dorsalis* in dragon fruit were 1.6± 0.40, 8.0 ± 0.40, 8.0 ± 0.31, 6.4 ± 0.50 and 9.6 ± 0.5 days respectively. The egg, larval and pupal period of *S. xanthorrhoea* 5.2 $\pm$ 0.20, 25.6 ± 1.20, 6.6 ± 0.37 days respectievely. Adult period of male and female were 4.4 ± 0.24 and 6 ± 0.44 days respectively. The egg and nymphal periods for *H. picus were* 5.2 ± 0.20 and 46.8 ± 2.53 days, respectively.

Spiders were the dominant predators of the pests of exotic fruits. A total of 24 natural enemies were documented from exotic fruit crops, which include spiders (15), hymenopteran parasitoids (3) and insect predators (6) belonging to Coleoptera (1), Lepidoptera (1), Mantodea (3) and Hemiptera (1). The hymenopteran parasitoids documented were from the family Eupelmidae, Aphelinidae and Trichogrammatidae.

For the documentation of pollinators, a study was conducted during the flowering season of rambutan and passion fruit at Instructional Farm Vellayani. For documentation of pollinators of rambutan, five inflorescences each were selected randomly from five different trees. Population of pollinators was recorded by visual observation once in a week from 0600 to 1800 h for a period of four weeks. For documentation of pollinators of passion fruit, the same methodology was adopted for plant selection and pollinators were recorded once in four weeks from 1200 to 1800 h for a period of four weeks. Ten pollinators were recorded from rambutan and four were from passion fruit. The pollinators documented belong to Hymenoptera (9) Diptera (3) and Lepidoptera (2). Stingless bee *Tetragonula travancorica* (Shanas and Faseeh) was the most abundant and frequent flower visitor of rambutan and carpenter bee (*Xylocopa* sp.) was the frequent visitor of passion fruit flowers.

Seasonal incidence of pests infesting rambutan was carried out for one year from November 2022 to November 2023. The presence of pests in rambutan was noted specifically from March to July, encompassing the flowering to fruit-setting season. The peak pest infestation had a positive correlation with the temperature in rambutan.

In the course of the current investigation, a comprehensive catalogue of 60 pests, 24 natural enemies, and 14 pollinators were documented from exotic fruits in Kerala. Among the identified pests 27 pests were recorded from the order Hemiptera, 21 from Lepidoptera, 6 from Coleoptera, 4 from Hymenoptera and 2 from Diptera. Rambutan has been documented to have 14 pests from the order Lepidoptera, 11 from Hemiptera, 5 from Coleoptera, and 2 from Hymenoptera. Dragon fruit pests include 5 from Hemiptera, 1 from Lepidoptera, 1 from Diptera, and 1 from Hymenoptera. Mangosteen pests belong to the order Hemiptera (3), Lepidoptera (3), and Hymenoptera (1). Passion fruit pests include 2 from Hemiptera, 1 from Lepidoptera, and 1 from Diptera. Minor exotic fruits have pests from Hemiptera (6), Lepidoptera (3), and Coleoptera (1).Spiders emerged as the predominant predators associated with the exotic fruit pests. Hymenopteran pollinators stood out as the most abundant contributors to pollination where stingless bee

(*T. travancorica*) was the most abundant and frequent flower visitor of rambutan and carpenter bee (*Xylocopa* sp.) was the frequent visitor of passion fruit flowers. The pest incidence in rambutan showed a positive correlation with temperature, and negative correlation with both rainfall and relative humidity.

# സംഗ്രഹം

"കേരളത്തിലെ വിദേശ ഫലവിളകളുടെ കീടങ്ങൾ" എന്ന ഗവേഷണം 2021 മുതൽ 2023 വരെ വെള്ളായണിയിലെ അഗ്രികൾച്ചർ കോളേജിലെ എന്റോമോളജി വിഭാഗത്തിൽ, കേരളത്തിലെ വിദേശ പഴങ്ങളുടെ കീടങ്ങളെയും അവയുടെ പ്രകൃതി ശത്രുക്കളെയും പരാഗണത്തെ കുറിച്ചും രേഖപ്പെടുത്തുക എന്ന ലക്ഷ്യത്തോടെയാണ് ഇത് നടത്തിയത്.

വെള്ളായണിയിലെ ഇൻസ്ട്രക്ഷണൽ ഫാമിന്റെ തോട്ടത്തിലും കേരളത്തിലുടനീളമുള്ള കർഷകരുടെ വയലിലും ഒന്നിലധികം ഫീൽഡ് സന്ദർശനങ്ങളിലൂടെ ഡോക്യുമെന്റേഷൻ നടത്തി. വിവിധ വിദേശ ഫലവിളകളിൽ നിന്ന് മൊത്തം 60 വ്യത്യസ്ത കീടങ്ങളെ രേഖപ്പെടുത്തി. അവയിൽ, 32 കീടങ്ങളെ റംബുട്ടാൻ (നെഫെലിയം ലാപ്പാസിയം ലിന്നേയസ്), 8 ഡ്രാഗൺ ഫ്രൂട്ട് (സെലിനിസെറിയസ് അണ്ടറ്റസ് ഹാവോർത്ത്), 7 മാംഗോസ്റ്റീൻ (ഗാർസീനിയ മാംഗോസ്റ്റാന ലിനേയസ്), 4 പാഷൻ ഫ്രൂട്ട് (മറ്റ് മൈനറിൽ പാസിഫ്ലോറ എഡ്യൂലിസ് സിംസ്), കൂടാതെ 10 കീടങ്ങളെ മിറാക്കിൾ ഫ്രൂട്ട് (സിൻസെപാലം ഡൽസിഫിക്കം ഡാനിയൽ), പുലാസൻ (നെഫെലിയം മ്യൂട്ടാബൈൽ ബ്ലൂം), അബിയു (പൗട്ടേരിയ കൈമിറ്റോ റാഡിക്), സോഴ്സോപ്പ് (അന്നോണ മുരിക്കാറ്റ എൽ.), ലിച്ചി (ലിച്ചി ചിനൻസിസ് സൺ.), വെൽവെറ്റ് ആപ്പിൾ, ഡിസോർ വിൽപൈഡ്), ലോംഗൻ (ഡിമോകാർപസ് ലോംഗൻ ലൂർ.)തുടങ്ങിയ ഫലവിളകളിൽ നിന്നും രേഖപ്പെടുത്തിയിട്ടുണ്ട്.

ഇലകളെയും പൂങ്കുലകളെയും ബാധിക്കുന്ന കാറ്റർപില്ലറുകൾ റംബുട്ടാനിൽ പ്രബലമായിരുന്നു, തുടർന്ന് നീരുറ്റിക്കുടിക്കുന്ന കീടങ്ങളും വണ്ടുകളും ഉൾപ്പെടുന്നു, മെലിബഗ് (പ്ലാനോകോക്കസ് ലിലാസിനസ് കോക്കറൽ, ക്രിസ്റ്റിക്കോക്കസ് ഹിർസ്യൂട്ടസ് ന്യൂസ്റ്റെഡ്, ഫെറിസിയ വിർഗാറ്റ കോക്കറെൽ), സ്കെയിൽ (സെറോപ്ലാസ്റ്റിസ് ഫ്ലോറിഡെൻസിസ് കോംസ്റ്റോക്ക്, ഐസെരിയ എസ്പി.), ബീൻ ബഗ് (റിപ്റ്റോർട്ടസ് പെഡെസ്ട്രിസ്), ബ്രേബ്രിസിയൂസ് ട്രീ), ഗാർഗാര എസ്പി.), ബ്ലാക്ക് പ്ലാന്റ് ഹോപ്പർ (റിക്കാനിയ എസ്പി.), ഫ്ലാറ്റിഡ് പ്ലാന്റ് ഹോപ്പർ (ഫ്ലാറ്റർമെനിസ് എസ്പി.). വൈറ്റ് ലൂപ്പർ മോത്ത് (പിംഗസ ക്ലോറ സ്റ്റോൾ), സ്ലേറ്റ് ഫ്ലാഷ് (റാപാല മാനിയ ഹെവിറ്റ്സൺ), എമറാൾഡ് മോത്ത് (ഹെമിതിയ ട്രൈറ്റൊനാരിയ

വാക്കർ), യെല്ലോ-ടെയിൽ ട്യൂസോക്ക് നിശാശലഭം (സോമേന സിന്റിലൻസ് വാക്കർ), ടസ്സോക്ക് കാറ്റർപില്ലർ (ഒലെനെബ്ലെർ), ലൂപ്പർ (കോമിബേന കാസിഡാര ഗുനീ), കൂർത്ത സിലിയേറ്റ് ബ്ലൂ (ആന്റീൻ ലൈകെനീന ഫെൽഡർ), മൂങ്ങ പുഴു (അവത ഡിസ്കോളർ ഫാബ്രിഷ്യസ്), ഒരു അജ്ഞാത മൈക്രോ ലെപിഡോപ്റ്റെറൻ ആയ പുറംതൊലി തുരപ്പൻ. എന്നിവയാണ് റംബൂട്ടാനിൽ രേഖപ്പെടുത്തിയിരിക്കുന്ന ലെപിഡോപ്റ്റെറൻസ്. സ്കൂരാബ് വണ്ട് (പോപ്പിലിയ എസ്പി.), വാർട്ടി ലീഫ് വണ്ട് (എക്സെമ സെലെമെൻസിസ് ഭാസിൻ), ലീഫ് വണ്ട് (മോണോലെപ്റ്റ എസ്പി.), ഫ്ലവർ വണ്ട് (ഓക്സിസെറ്റോണിയ വെർസികളർ ഫാബ്രിഷ്യസ്) എന്നിവ റംബുട്ടാനിൽ രേഖപ്പെടുത്തിയിരിക്കുന്ന കോലിയോപ്റ്റെറൻ കീടങ്ങളാണ്. ഇന്ത്യയിൽ ആദ്യമായി മുകളിൽ പറഞ്ഞ കീടങ്ങളെ റംബുട്ടാനിൽ രേഖപ്പെടുത്തി .

ഡ്രാഗൺ ഫ്രൂട്ടിൽ, ഓറിയന്റൽ ഫ്രൂട്ട് ഈച്ച (ബാക്ട്രോസെറ ഡോർസാലിസ് ഹെൻഡൽ) ഇന്ത്യയിൽ ആദ്യമായി റിപ്പോർട്ട് ചെയ്യപ്പെട്ടു. ബ്രൗൺ സ്റ്റിങ്ക് ബഗ് (ഹാലിയോമോർഫ പിക്കസ് ഫാബ്രിസിയസ്), പ്ലാന്റ് ഹോപ്പർ (യൂറിബ്രാച്ചിസ് എസ്പി., റിക്കാനിയ എസ്പി, ഫ്ലാറ്റോമെനിസ് എസ്പി.), വരയുള്ള മെലിബഗ് (ഫെറിസിയ വിർഗറ്റ കോക്കറെൽ), വിനാശകാരിയായ ട്രൈലിംഗ് ഉറുമ്പ് (ട്രൈക്കോമിയോർഡെക്സ്) എന്നീ കീടങ്ങളെ ഇന്ത്യയിൽ നിന്ന് ഡ്രാഗൺ ഫ്രൂട്ടിൽ ആദ്യമായി റിപ്പോർട്ട് ചെയ്തു.

മാംഗോസ്റ്റിൻ, പാഷൻ ഫ്രൂട്ട് എന്നിവയിൽ കീടബാധ താരതമ്യേന കുറവായിരുന്നു. ബ്രൗൺ സോഫ്റ്റ് സ്കെയിൽ (കോക്കസ് ഹെസ്പെരിഡം), മീലിബഗ് (സി. ഹിർസ്യൂട്ടസ്), ഇല തിന്നുന്ന കാറ്റർപില്ലർ (അഗ്രോട്ടെറ ഫ്ലാവബസാലിസ് ഇനോ), പൂക്കൾ തിന്നുന്ന കാറ്റർപില്ലർ (ഹോമോണ എസ്പി.) എന്നിവ ഇന്ത്യയിൽ നിന്ന് മാംഗോസ്റ്റീനിൽ ആദ്യമായി റിപ്പോർട്ട് ചെയ്യപ്പെട്ടു. റുഗോസ് സ്പൈലിംഗ് വൈറ്റ്ഫ്ലൈ (അലൂറോഡിക്കസ് റുഗിയോ പെർകുലാറ്റസ് മാർട്ടിൻ), ഗോൾഡ് ടെയിൽ മോത്ത് (സ്ഫ്രാഗെയ്ഡസ് സാന്തോറിയ കൊല്ലാർ) എന്നിവ ഇന്ത്യയിൽ നിന്ന് പാഷൻ ഫ്രൂട്ടിൽ ആദ്യമായി റിപ്പോർട്ട് ചെയ്യപ്പെട്ടു.

ലബോറട്ടറി അവസ്ഥയിൽ ഡ്രാഗൺ ഫ്രൂട്ടിലെ ആൺ, പെൺ ബി . ഡോർസാലിസിന്റെ മുട്ട, ലാർവ, പ്യൂപ്പൽ, മുതിർന്നവർക്കുള്ള കാലഘട്ടം യഥാക്രമം 1.6± 0.40, 8.0 ± 0.40, 8.0 ± 0.31, 6.4 ± 0.50, 9.6 ± 0.5 ദിവസങ്ങളാണ്. ആൺ

പെൺ എന്നിവയുടെ മുതിർന്ന കാലഘട്ടം യഥാക്രമം 4.4 ± 0.24 ഉം 6 ± 0.44 ദിവസവുമാണ്. എച്ച്. പിക്കസിന്റെ മുട്ട നിംഫൽ കാലഘട്ടം യഥാക്രമം 5.2 ± 0.20 ഉം 46.8 ± 2.53 ദിവസവുമായിരുന്നു.

വിദേശ പഴങ്ങളുടെ കീടങ്ങളുടെ പ്രധാന പ്രേഡേറ്റർ ആയിരുന്നു ചിലന്തികൾ. വിദേശ ഫലവിളകളിൽ നിന്ന് മൊത്തം 24 പ്രകൃതി ശത്രുക്കളെ രേഖപ്പെടുത്തിയിട്ടുണ്ട്, അതിൽ ചിലന്തികൾ (15), ഹൈമനോപ്റ്റെറൻ പാരാസിറ്റോയിഡുകൾ (3), ഇൻസ്ക്ട് പ്രേഡേറ്റർസ് (6) എന്നിവ കോലിയോപ്റ്റെറ (1), ലെപിഡോപ്റ്റെറ (1), മാന്റോഡിയ (3), ഹെമിപ്റ്റെറ എന്നിവ ഉൾപ്പെടുന്നു. യൂപൽമിഡേ, അഫെലിനിഡേ, ട്രൈക്കോഗ്രാംമാറ്റിഡേ എന്നീ കുടുംബങ്ങളിൽ നിന്നുമാണ് ഹൈമനോപ്റ്റെറൻ പാരാസൈറ്റോയിഡുകൾ രേഖപ്പെടുത്തിയിരിക്കുന്നത്.

പോളിനേറ്ററുകളുടെ ഡോക്യുമെന്റേഷനായി, ഇൻസ്ട്രക്ഷണൽ ഫാം വെള്ളായണിയിൽ റംബൂട്ടാൻ, പാഷൻ ഫ്രൂട്ട് എന്നിവയുടെ പൂക്കാലത്തു ഒരു പഠനം നടത്തി. റംബുട്ടാനിലെ പരാഗണത്തെക്കുറിച്ചുള്ള ഡോക്യുമെന്റേഷനായി, അഞ്ച് വ്യത്യസ്ത മരങ്ങളിൽ നിന്ന് ക്രമരഹിതമായി അഞ്ച് പൂങ്കുലകൾ വീതം തിരഞ്ഞെടുത്തു. 0600 മുതൽ 1800 മണിക്കൂർ വരെ ആഴ്ചയിലൊരിക്കൽ നാലാഴ്ചയ്ക്കുള്ള ദൃശ്യ നിരീക്ഷണത്തിലൂടെ പരാഗണകാരികളുടെ എണ്ണം രേഖപ്പെടുത്തി. പാഷൻ ഫ്രൂട്ടിന്റെ പരാഗണത്തെക്കുറിച്ചുള്ള ഡോക്യുമെന്റേഷനായി, സസ്യങ്ങൾ തിരഞ്ഞെടുക്കുന്നതിനും ഇതേ രീതി അവലംബിക്കുകയും നാലാഴ്ചയിലൊരിക്കൽ 1200 മുതൽ 1800 മണിക്കൂർ വരെ നാലാഴ്ചത്തേക്ക് പരാഗണത്തെ രേഖപ്പെടുത്തുകയും ചെയ്തു. റംബൂട്ടാനിൽ നിന്ന് പത്ത് പരാഗണകാരികളെ രേഖപ്പെടുത്തി, നാലെണ്ണം പാഷൻ ഫ്രൂട്ടിൽ നിന്നാണ്. രേഖപ്പെടുത്തിയിരിക്കുന്നത്. റംബുട്ടാനിലെ ഏറ്റവും സമൃദ്ധവും പതിവുള്ളതുമായ പുഷ്പ സന്ദർശകനായിരുന്നു സ്റ്റിംഗ്ലെസ് തേനീച്ച (ടെട്രാഗോണുല ട്രാവൻകോറിക്ക), പാഷൻ ഫ്രൂട്ട് പൂക്കളുടെ പതിവ് സന്ദർശകനായിരുന്നു ആശാരി തേനീച്ച (സൈലോകോപ്പ എസ്പി.).

2022 നവംബർ മുതൽ 2023 നവംബർ വരെയുള്ള ഒരു വർഷത്തേക്ക് റംബുട്ടാൻ കീടങ്ങളെ ബാധിക്കുന്ന സീസണൽ രോഗബാധയുണ്ടായി. മാർച്ച്

മുതൽ ജൂലൈ വരെ റംബുട്ടാനിലെ കീടങ്ങളുടെ സാന്നിധ്യം പ്രത്യേകമായി ശ്രദ്ധിക്കപ്പെട്ടു, പൂവിടുമ്പോൾ മുതൽ ഫലങ്ങൾ വളരുന്ന കാലം വരെയാണ് റംബുട്ടാനിലെ കീടങ്ങളെ കണ്ടു വന്നിരുന്നത്.

നിലവിലെ അന്വേഷണത്തിൽ, കേരളത്തിലെ വിദേശ പഴങ്ങളിൽ നിന്ന് 60 കീടങ്ങൾ, 24 പ്രകൃതി ശത്രുക്കൾ, 14 പരാഗണകാരികൾ എന്നിവയുടെ സമഗ്രമായ കാറ്റലോഗ് രേഖപ്പെടുത്തി. തിരിച്ചറിഞ്ഞ കീടങ്ങളിൽ 27 കീടങ്ങളെ ഹെമിപ്റ്റെറയിൽ നിന്നും 21, ലെപിഡോപ്റ്റെറയിൽ നിന്ന് 6, കോലിയോപ്റ്റെറയിൽ നിന്ന് 6, ഹൈമനോപ്റ്റെറയിൽ നിന്ന് 4, ഡിപ്റ്റെറയിൽ നിന്ന് 2 കീടങ്ങളും രേഖപ്പെടുത്തിയിട്ടുണ്ട്. ലെപിഡോപ്റ്റെറ (14), ഹെമിപ്റ്റെറ (11), കോലിയോപ്റ്റെറ (5), ഹൈമനോപ്റ്റെറ (2) എന്നീ കീടങ്ങളെ റംബുട്ടാനിൽ നിന്ന് രേഖപ്പെടുത്തിയിട്ടുണ്ട്. ഹെമിപ്റ്റെറ (5), ലെപിഡോപ്റ്റെറ (1), ഡിപ്റ്റെറ (1), ഹൈമനോപ്റ്റെറ (1) എന്നിവയിൽ പെട്ട കീടങ്ങളെ ഡ്രാഗൺ ഫ്രൂട്ടിൽ രേഖപ്പെടുത്തിയിട്ടുണ്ട്. ഹെമിപ്റ്റെറ(3), ലേപിടൊപ്റ്ററെ (3), ഹൈമേനോപ്റ്ററെ (1) എന്നീ ക്രമത്തിൽ പെടുന്ന മാംഗോസ്റ്റീൻ കീടങ്ങളെ രേഖപ്പെടുത്തിയിട്ടുണ്ട് . ഹെമിപ്റ്റെറ (2), ലെപിഡോപ്റ്റെറ (1), ഡിപ്റ്റെറ (1) എന്നീ ക്രമത്തിൽ പെടുന്ന പാഷൻ ഫ്രൂട്ട് കീടങ്ങളെയും ഹെമിപ്റ്റെറ (6) ലെപിഡോപ്റ്റെറ (3), കോലിയോപ്റ്റെറ (1) എന്നീ ക്രമത്തിൽ ഉൾപ്പെടുന്ന കീടങ്ങളെ ചെറിയ വിദേശ പഴങ്ങളിൽ നിന്നും രേഖപ്പെടുത്തിയിട്ടുണ്ട്. വിദേശ പഴ കീടങ്ങളുമായി ബന്ധപ്പെട്ട പ്രധാന പ്രേഡേറ്റർ ആയി ചിലന്തികളെ രേഖപ്പെടുത്തി. ഹൈമനോപ്റ്റെറൻ പോളിനേറ്ററുകൾ പരാഗണത്തിന് ഏറ്റവും കൂടുതൽ സംഭാവന നൽകുന്നവയാണ്, അവിടെ സ്റ്റിംഗ്ലെസ് തേനീച്ച ട്രി. ട്രാവൻകോറിക്ക) റംബൂട്ടാനിലെ ഏറ്റവും സമൃദ്ധവും പതിവ് പുഷ്പ സന്ദർശകരും ആയിരുന്നു. റംബുട്ടാനിലെ കീടബാധ താപനിലയുമായി പോസിറ്റീവ് ബന്ധവും മഴയും ആപേക്ഷിക ആർദ്രതയുമായി നെഗറ്റീവ് ബന്ധവും കാണിക്കുന്നു.