THE PEST COMPLEX INFESTING CASHEW INFLORESCENCE

BY

B. BALA SUBRAHMANYAM

THESIS

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Faculty of Agriculture

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DECLARATION

I hereby declare that this thesis entitled "The pest complex infesting cashew inflorescence" is a bonafide record of work done by me during the course of research work and 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.

B Bala Subrahmanyam

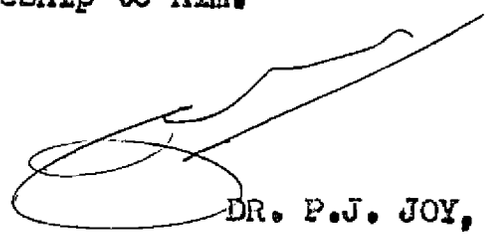
(B. BALA SUBRAHMANYAM)

Vellanikkara,

31 --8---1981.

CERTIFICATE

Certified that this thesis entitled "The pest complex infesting cashew inflorescence" is a record of research work done independently by Sri. B. Bala Subrahmanyam under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.



Vellanikkara,
31 -- 8--1981.

DR. P.J. JOY,
Chairman,
Advisory Committee
Associate Professor of Entomology
AICRP on Biological Control of Crop Pests
College of Horticulture

CERTIFICATE

We, the undersigned members of the Advisory Committee of Sri. B. Bala Subrahmanyam, a candidate for the degree of Master of Science in Agriculture with major in Agricultural Entomology, agree that the thesis entitled "The pest complex infesting cashew inflorescence" may be submitted by Sri. B. Bala Subrahmanyam in partial fulfilment of the requirements for the degree.

Dr. P.J. JOY,
Chairman,
Advisory Committee.

Dr. C.C. ABRAHAM,
(Member)

Dr. T.S. VENKITESAN,
(Member)

Dr. C.K. PEETHAMBHARAN,
(Member)

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INTRODUCTION

INTRODUCTION

Cashew (Anacardium occidentale Linn.) is one of the important dollar earning crops of India. The major cashew growing areas in India are Maharastra, Bombay, Goa, Kerala, Tamilnadu, Karnataka, Andhra Pradesh, Orissa and West Bengal. The total production of raw cashewnuts in India during 1979-80 has been estimated at 1.31 lakh metric tonnes. The production has been on an increasing trend till 1976-77 when the country had a record production of 1.82 lakh tonnes. Since then the production has decreased to 1.43 lakh tonnes in 1977-78 which further dropped to 1.31 lakh tonnes in 1978-79.

To conserve the foreign exchange reserves of the country and for ensuring profitable functioning of the cashew processing industries, it is of utmost importance to bring about substantial increase in the yield of raw nuts.

The factors responsible for the low level of cashewnut production are many. Pest complex associated with cashew is the most important one. By adopting proper plant protection measures alone, the production of cashewnuts can be increased considerably.

The yield reduction due to infestation of the inflorescence by pests is quite substantial being about 30-50%. For the effective management of the different pests attacking cashew inflorescence information on the pest complex, their seasonal history and nature of damage are of great value and hence studies are carried out.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The cashew tree is infested by as many as sixty species of insect pests. These pests damage different parts of the plant including the inflorescence. Insect pest infestation is reported to cause 30 to 50% reduction in yield due to inflorescence blight and damage to nuts. T.V. Ramakrishna Ayyar was pioneer in studying the cashew pests in South India. The vast literature on cashew pests has been reviewed by Abraham, (1958), Beccari and Gerini, (1968), Pillai *et al.*, (1976) and Ohler, (1977). The work already done on the pest complex associated with cashew inflorescence is discussed below.

Tea mosquito : *Helopeltis antonii* Signoret
(Miridae: Hemiptera)

The tea mosquito bug *H. antonii* is one of the most important pests of cashew in Kerala causing severe economic losses to the crop. Pillai *et al.*, (1976) have reviewed the work done in India on the bioecology and control of *H. antonii*. Ambika and Abraham, (1979) studied in detail the biology and the effect of different levels of constant temperature on the oviposition and egg hatching in *H. antonii*.

The adult bug is reddish brown with a black head,

red thorax and a black and white abdomen. A knobbed process arises from the dorsal aspect of the thorax. The bug lays eggs singly deep inside the tissues of tender shoots and inflorescence axis and also in nuts. A pair of thread like chorionic processes projecting outside indicate the presence of eggs inside the tissues. The incubation period ranges from 5 to 9 days. The nymphs pass through five instars to attain adult hood. The duration of the first nymphal instar is 3 to 3.5 days and the second instar lasts for 2.4 days. The third instar moults in about 2 to 4 days. The fourth instar lasts for 3 to 4 days. The last instar nymphs moult in 2 to 5 days. Pre-oviposition period is 4 to 5 days while the oviposition and post-oviposition periods are 16 and 2 days respectively. The fecundity is found to vary from 10 to 60. The adult longivity varies from 4 to 14 days for males and 4 to 24 days for females. The total life cycle occupied 22 to 35 days (Abraham, 1958; Sudhakar, 1975; Pillai et al., 1976; Ambika and Abraham, 1979).

Nymphs and adults suck sap from the tender tissues of the plant by inserting the proboscis deep into the tissues up to the vascular region. The fifth instar nymph causes relatively greater damage.

On the shoots elongate streaks and brownish patches develop around the feeding punctures and these regions dry up eventually. A resinous substance exudes from the feeding punctures on the shoots and the exudate dries up and hardens on exposure to air. The shoot apices eventually dry up. On the inflorescence, feeding is usually restricted to the main axis. Secondary floral branches are also attacked. Irregular, elongate, shiny, rusty-brown lesions are caused due to feeding. On immature nuts and apples, scabby spots are produced due to feeding (Sathiamma, 1977; Ambika and Abraham, 1979).

The average damage to tender shoots was about 25% and tender nuts 15% (Abraham, 1958). The loss due to inflorescence blight accounts for about 30% (Anon., 1966). Out of 80.6% cashew fruits shed at various stages of immaturity 20.2% are damaged by H. antonii. Remaining 60.4% fruit fall ranged from nutritional imbalance to faulty metabolism (Pillai et al., 1975).

A final instar nymph produces 114 lesions (range 78 to 235), a female bug 97 lesions (range 16 to 238) and a male 25 lesions (range 11 to 59) during 24 hours, (Sathiamma, 1977).

The pest population build up in Kerala commences from October with the emergence of new vegetative flushes. The population reaches its peak during the blossom period in January. H. antonii populations are not recorded during the monsoon period (Pillai and Abraham, 1975). However, on young trees, the pest populations are observed throughout the year since the pattern of flushing in these trees is some what continuous (Sathiamma, 1977).

The host range of the insect include tea, cinchona, cocoa, neem, guava, mahogony, mango and redplum in addition to cashew (Rao, 1915; Fletcher, 1914 and 1920; Puttarudriah and Appanna, 1975; Puttarudriah, 1958; Singh, 1964; Abraham and Padmanabhan, 1967; Sathiamma, 1976; Abraham and Remamony, 1979).

Three species of Helopeltis are associated with cashew in different cashew growing tracts of the world (Swaine, 1959; Northwood and Kayumbo, 1970). Of these H. schoutedeni Reuter (=H. bergrothi) is the most wide spread species occurring in Africa, extending from Tago and Nigeria to Tanzania and Mozambique, while H. anacardii Miller is essentially confined to the coastal cashew regions of Africa. H. antonii on the other hand, is distributed in India and neighbouring countries, Brazil,etc.

Two species of Helopeltis are associated with cashew in Kerala (Ambika and Abraham, 1979). They are H. antonii and H. theivora.

Pachypeltis maesarum Kirkaldy (Heteroptera; Miridae)

Remamony and Abraham, (1977) observed P. maesarum in company with H. antonii. The percentage of P. maesarum in the mixed populations ranged from 22 to 52 as revealed from random samples. Under confinement in cages, the adults and nymphs are found to infest tender stems, young leaves and inflorescences. The affected leaves curl up and shows necrotic lesions around the feeding punctures. The infested twigs and inflorescences dry up rapidly.

Brown aphid: Toxoptera odinae Vander Goot
(Aphididae: Hemiptera)

Abraham, (1959) and Pillai et al., (1976) recorded this on cashew. The brownish aphid infests in colonies the tender shoots and inflorescence and causes shedding of flowers.

Mondal, Basu and Raychaudhuri,(1976) studied the biology, food plants, distribution and keys to the alate and apterous viviparous females. This brown plumy aphid is polyphagous and gregarious. Large colonies could be found on rachis of the young leaves and some

times also on the moderately old leaves. Colonies are mostly found along the mid ribs. The food plants include Berberis sp., Cassia fistula, Cassia sp., Datura fustuosa, Duranta repens, Fagopyrum sp., Gardenia florida, Hamiltonia suaveolens, Hibiscus esculentus, Leea, sp., Magnolia sp., Mangifera indica, Pyrus communis, Rhus sp., Stercula sp., Symplocos spicata, Tagetes patula, Thea sinensis, Zanthosylum ornatum, Erythrina indica, Momordica charantia, Rhus semialata, Citrus aurantium, and Maesa chisea.

Toxoptera aurantii B.de Fons

Aphis spiraecola Patch.

(Aphididae: Hemiptera)

These aphids infests in colonies on the tender parts of the plant (Anon., 1973).

Ferrisia virgata Cockerell

(Pseudococcidae: Hemiptera)

The incidence of the mealy bug on cashew has been recorded in Africa (Beccari and Gerini, 1968; Bohlen, 1973; Brown, 1968) and in India (Abraham, 1958).

Rawat and Modi, (1968) studied the biology of E. virgata in Madhya Pradesh, India, Reproduction

is both sexual and parthenogenetic, more commonly parthenogenetic. The egg stage lasts 0.25-4 hours and males and females moult four and three times, respectively. Post embryonic development takes 19.8 to 59.5 days for males and 18.9 to 47.0 days for females. Oviposition begin 10 to 75 days after the final moult and is continued for 6 to 32 days and the females are survived for upto 20 days afterwards. From 33 to 447 eggs are laid by a female. The mealy bug is most active in the field during August to November and March to April. Adult female predominated during December to January and May to June.

Mohammad Ali, (1962) studied the nature of damage in India and reported that the infested plants are sometimes killed as a result of the sap loss.

Betrem, (1936) studied the ecology and epidemology of F. virgata. The course of infestation on coffee by the mealy bug is usually ascertained by counting the infested trees. The size of the population present at the beginning of the dry season determines the rate of multiplication. The most important ecological factor is atmospheric humidity, which exercises an indirect effect through its influence on parasitic fungi. Windy areas are very susceptible to attack, hill tops being

more infested than valleys. Infestation is greater in lightly shaded coffee and during the dry east monsoon. The influence of temperature on populations in Java is evident only in certain cases, but all plantations below an altitude of 300 ft. are probably too warm for infestation. Parasites and Predators are of little importance as they are scarce at the beginning of an out break.

F. virgata is dispersed by wind and also by rain, which washes them from their food plants to distance (Betrem, 1934 and 1936).

The host range of insect includes cocoa, cotton, coffee, lamtoro, mango, papaya, lantana, brinjal. (De Fluiter, 1936; Beccari and Gerini, 1968; Otanes, 1935; Esaki, 1937; Betrem, 1936; Carter, 1956; Hambleton, 1952; Beeson, 1940; Dozier, 1932).

Ceroplastes floridensis comst.
Lecanium latioperculum Gr.
Aspidiotus orientalis Newst.

(Coccidae: Hemiptera)

Ramachandran and Ramakrishna Ayyar, (1934) reported these scale insects as pest of cashew. These infests different plant parts including the inflorescence and tender nuts.

Flatids: (i) Flata sp.
(ii) Ketumala sp.

(Flatidae: Hemiptera)

Pillai et al., (1976) reported this on cashew feeding on the inflorescence.

Selenothrips rubrocinctus (Giard)

(Thripidae: Thysanoptera)

The thrips, Selenothrips rubrocinctus Giard has recently been to recorded from Kerala (Ananthakrishnan and Muraleedharan, 1976). It is a dark brown thrips infesting the leaves, flowers and nuts. It completes its life cycle in about 25 days. The second instar larva is greenish yellow and has red cross bands across the first, second and last abdomenal segments. The thrips feed by lacerating the surface tissues of the plant parts and suck the exuding sap. As a result of feeding the leaves will be crinkled and discoloured. When the thrips feed on the flower stalks the flowers drop. When the panicle stalks are attacked they become stunted and do not bear full complement of flowers. Malformation of nuts and immature fruit drop takes place.

Fennah, (1962) observed the nutritional factors associated with seasonal population increase of S. rubrocinctus Giard on cashew tree in Trinidad, West Indies.

On trees observed for three years, populations regularly increases during dry season, from a low level in December and January to a peak in April or May and then rapidly declines during the wet season. Even when thrips are most abundant, some trees are free from attack and this could not be attributed to protective morphological features or to specific repellent substances in the leaf, or to chance. S. rubrocinctus feed on leaves that are subjected to water stress and breed only on debilitated trees, the evidence suggests that the adequacy of its supply of nutrients depends on the induction of suitable metabolic conditions within the leaf by water-stress. The ability of the thrips to establish themselves and breed on leaves of a particular tree in dry season and their failure to do so on leaves of the same tree in the wet season conforms with the greater or less amino acid concentration occuring in the leaf at these respective times.

Bigger, (1960) studied the relationship between S. rubrocinctus and the floral biology of cashew in Tanganyika. Inflorescence counts shows that the trees attacked are producing more flowers than those unattacked, but it is later found that the yields are

lower on attacked trees. The trees flower in July-December, reaching a maximum in mid September from which time to the beginningof the December 90 per cent of the yield is produced. Attack by the thrips result in a loss of 259 lbs. nuts per acre, the infested trees producing 378 lbs. and the uninfested 637 lbs. per acre. Infestation do not seriously alter the time of development of the inflorescence, and though the number of male flowers are drastically remained reduced, the perfect flowers at about the same level. However, pollination seems to be affected, as the set nuts are reduced from 10.2 per cent of the perfect flowers to 3.8 per cent and the percentage of panicles producing mature nuts from 93 to 71.

Boboye, (1968) studied the seasonal fluctuation of S. rubrocinctus at Okigwi in Eastern Nigeria. Field observations on seasonal population fluctuation on 12 year old trees shows that the number of thrips are higher in the dry season than in the rainy season, with a peak occurring some time between December and March.

S. rubrocintus has a wide host range including cocoa, mango, guava, Eugenia jambos, avocado, groundnut, rose and Terminalia catappa (Ananthakrishnan and Muraleedharan, 1974; Castro, Z.B.De, 1975; Souto Lima Filho, 1969).

Rhynchothrips raoensis Ramakrishna

(Phlaeothripidae: Thysanoptera)

This has been reported by Abraham, (1958) attacking cashew inflorescence. The rasping and feeding injury made by the thrips result in scabs on floral branches, apples and nuts. Infestation on the developing nuts results in the formation of corky layers on the affected parts, malformation of nuts and even immature fruit drop.

Rhipiphorothrips cruentatus Hood

(Thripidae: Thysanoptera)

This has been reported by Abraham, (1958) and Lakshminarayana et al., (1961) attacking cashew. The female thrips are dark brown with legs and antennae yellow, male thrips has yellow abdomen. The thrips infests underside of the tender leaves which become discoloured and crinkled. It completes its life-cycle in 11 to 25 days. It may cause injury to the nuts also. The oviposition and feeding punctures at the bases of the ovaries lead to reduction in size of nuts and malformation.

Idolothrips halidayi Newm.

Phlaeothrips anacardii Newm.

(Phlaeothripidae: Thysanoptera)

These are reported by Lefroy, (1909) feeding on the

tender parts of the plant.

Flower beetle: Popillia complanata Newm.

(Rutelidae: Coleoptera)

Sreeramulu et al., (1975) recorded this on cashew. The adult is a metallic blue beetle and measures ten mm long and six mm wide. It lays eggs in soil. Eggs hatch in 10 to 12 days. The full grown grub is 20 to 25 mm long. Larval period lasts for 40 to 50 days. Pupation is in soil for a period of 12 days. Injury is caused by the beetle feeding on the flowers and flower buds.

Amblyrhinus poricollis Schoenherr

(Curculionidae: Coleoptera)

Abraham, (1958) and Brown, (1968) recorded this on cashew, feeding on the tender foliage. Issac, (1934) recorded it on the new growth of mango leaves.

Shoot tip and Inflorescence caterpillar:
Hypatima (=Chelaria) haligramma Meyrick

(Gelechidae: Lepidoptera)

The tiny yellowish or greenish brown caterpillars of the moth H. haligramma M. damage the shoot tips and inflorescences. It occasionally bores through the

tender shoot tip to a depth of about 20-25 mm causing stunting and drying up of growing shoot tips. Gummy exudation oozes out of the infested tips. As a result no panicle develop. Upto 60% damage has been recorded in severe cases of infestation (Abraham, 1958 and 1959). Pillai et al., (1976) reported heavy incidence of this pest in some parts of Kerala State in 1975.

Euproctis scintillans Walker

(Lymantriidae: Lepidoptera)

Abraham, (1958); Brown, (1958) and Pillai et al., (1976) recorded this insect on cashew and studied the biology. The adult lays eggs in batches either on leaves or on inflorescence. The larva is brown with tuft of fine hairs with a broad, dorsal yellow stripe. It pupates in the leaf fold. The caterpillar feeds on leaves and inflorescences and also scrape green tissue of the apples and the shell of the green nuts.

The alterative hosts includes mango, various species of Hibiscus, sunnhemp, linseed, castor, Cassia fistula, Eugenia cumini, tea, Cajanus cajan (indicus), Acacia decurrens, Zizyphus jujube. (Andrews, 1980; Pandy, 1969; Pillai, 1921; Ananthanarayan and Venugopal, 1954; Sevastopula, 1943; Puttarudraiah, 1947; Teotia

and Chaudhuri, 1966; Rutherford, 1913 and Kushwaha and Bhardwat, 1967).

Leaf and Flower looper: Pingasa ruginaria Gu.

(Geometridae: Lepidoptera)

Sreeramulu et al., (1975) recorded this on cashew. The adult is a medium sized white moth bearing smoky band along apical wing margins. The caterpillar feeds on foliage and inflorescence and grows to length of 50 to 60 mm. It is black with white transverse bands.

Thalassodes quadraria Guen.

(Geometridae: Lepidoptera)

Rao et al., (1977) studied the biology of this leaf caterpillar on cashew at Guntur and Prakasam districts of Andhra Pradesh. The life cycle from egg to adult is completed in 22-35 days. Egg period 3-5 days, larval period 13-20 days and pupal period 6-10 days. The caterpillar feeds on tender foliage.

The host plants includes mango (Pillai, 1921) and Eugenia jambos (Padmanabha Ayyar, 1943).

Leaf and Blossom Webber: Lamida (=Macalla) moncusalis Walker

(Pyralidae: Lepidoptera)

The leaf and blossom webber Lamida (=Macalla)

moncusalis Walker is a major pest of cashew in recent years in the East Coast tracts, particularly in the coastal districts of Andhra Pradesh (Ayyanna, Narayan and Rao, 1977). L. moncusalis causes serious damage to crop by feeding on the tender leaves and shoots at new flush and the flowers at blossom (Abraham, 1958).

Krishna Murthy et al., (1974) studied in detail the biology of L. moncusalis. Adult is a medium sized moth with dark brown fore wings having wavy markings and dirty white hind wings with brownish margin. The female possess two posteriorly horn like projections on the dorsal side of the head while the male has only one such fairly large process which when disturbed formed into a brush with innumerable thread like structures. Eggs are laid singly or in groups of three to four on the twigs, leaves and inflorescence stalks. The freshly emerged larva is pale white in colour with dirty white hairs distributed on the body. The full grown caterpillar turns to reddish brown with yellow lateral longitudinal bands and pinkish dorsal lines. It measures 26 mm in length and 2.5 to 3.0 mm in width. Pupation takes place within the webbed leaves in silken cocoon. The pupa when formed is light yellow in colour with greenish tinge at the thoracic region and

later turns to dark reddish brown. Each female lays 60 to 90 eggs. The egg, larval, prepupal, pupal and adult stages lasted for 5 to 6, 16 to 21, 1 to 2, 8 to 11 and 3 to 6 days respectively. There are four larval instars.

Oligonychus coffeae Neitner

(Acarina: Tetranychidae)

It is a pest of cashew in Africa (Rodrigues, 1967). This is a dark red mite that colonises on the upper side of the leaf, though it infest inflorescence as well. As a result of infestation inter veinal tissues appear bright red and later show large number of silvery blotches.

Arruda and Aquino, (1970) discovered a mite, which they supposed to belong to the genus Aceria (Eriophyidae), attacking cashew flowers in the state of Pernambuco, Brazil. Shortly afterwards, Leao and Arruda, (1971) identified this mite as Calacarus citrofolii. Apparently healthy flowers can harbour colonies of these mites on the underside of the sepals. The attacked tissue first become chlorotic and then necrotic. When the necrosis become visible the mites are no longer present on the flowers.

MATERIALS AND METHODS

MATERIALS AND METHODS

To study the pest complex infesting the cashew inflorescence in the state, a detailed survey was conducted in different locations during November, 1980 to April, 1981. For the survey, the state has been divided into six zones. From each zone one representative area is selected for conducting the survey work and the observations are taken approximately at monthly intervals.

Details of the zones selected for survey work are given below:

Sl. no.	Zones	Locality selected for survey work	Remarks
1.	Quilon district	Kottarakara	
2.	Ernakulam district	Kalady	
3.	Trichur district	Madakkathara	
4.	Malappuram district	Anakkayam	
5.	Calicut district	Calicut University Campus	
6.	Cannanore district	Kasaragod	

Collection of samples

Ten trees are selected randomly from a farm in the locality. Fifteen panicles are collected

randomly from every one of the selected trees. For collection of the panicle samples, the tree is divided into four equal segments and from each segment three panicles are collected and from the top conical portion three more panicles are collected. Polythene bags of the size 30 x 26 cm are used for the collection of the panicles. The panicle is first caged in polythene bags and then cut at the base. In the same manner one hundred and fifty panicles are collected from each station and brought to the lab to count the population density of variety of insects.

Rating the trees for natural field damage intensities

To ascertain the intensity of damage under field conditions, the feeding injuries on the floral branches are recorded based on random samples. The intensity of damage to floral branches is scored on 0-5 scale on the basis of necrotic lesions developing on the plant tissues as a result of feeding by the insects. The norms for recording damage ratings are as follows:

0 - No lesions/streaks

1 - Upto 3 necrotic lesions/streaks

2 - 4 to 6 lesions

3 - 7 to 9 lesions

4 - 10 to 12 lesions

5 - Above 12 lesions which tend to be confluent

Ten trees in each station are scored for natural field infestation. For this, the canopy of each tree is divided into four equal segments. Three panicles are collected randomly from each segment and the other three panicles are collected from the top conical portion of the trees. Total of fifteen panicles are collected and the intensity of infestation is recorded as already indicated.

Estimation of insect population

(a) Tea mosquito

A handnet of 30 cm diameter has been used for estimating the population density of tea mosquito. Ten sweeps are taken randomly from each tree and at the end of each sweep the number of nymphs and adults caught are counted. During the process, population counts of jassids present, if any, are also taken.

(b) Other insect pests

Flowers are opened with the help of a fine needle and counts are taken of the various insects present on the inflorescence. The immature stages collected during counting are sorted out based on morphological characters and kept under observation for studying the biology and nature of damage of the pests.

Studies on the nature of damage

The nature of damage of beetles, thrips, jassids etc., have been studied in specimen tubes of size 10 x 2.5 cms. A small piece of the inflorescence is wrapped in moist cotton at its basal portion and inserted into the tube containing the adults and nymphs of the test insects. The mouth of the tube is closed with muslin cloth and observed under a sterio microscope. The nature of damage of lepidopterans, have been studied during their breeding work for taxonomical and biological studies.

Biology studies

Glass troughs of 20 x 13 cm size are used for rearing caterpillar pests. Freshly cut inflorescence

is then placed in the trough. Cut end of the inflorescence is inserted into vials containing water and the mouth of the vial is closed by using moist cotton. The freshly emerged adult moths are then released into the troughs in equal proportions of males and females. Honey (50%) is smeared on the inflorescence branches as food for adults. The eggs are allowed to hatch in the same trough and the emerged caterpillars are transferred to plastic containers containing fresh inflorescence with the help of a camels hair brush. Fresh inflorescence is given on alternate days. When pupated, they are transferred to specimen tubes with cotton plug for adult emergence.

Morphological studies.

Morphological features are studied by observing the insects under a binocular microscope.

Measurements of minute insects mounted on glass slides are made by using an ocular micrometer fitted to a microscope. Larger specimens are measured using a calibrated scale or by stretching them on a

graph paper and then by taking counts of the number of columns occupied by the insect.

Statistical analysis

For comparing the density of population in different stations, the analysis of variance technique as described by Snedecor and Cochran (1967) is made use of. The data relating to the field population fluctuations of different insects at monthly intervals in different localities are analysed by two-way classification with multiple observations per cell after transforming the data into $\sqrt{x + 1}$ values except for Helopeltis antonii where the infestation rate is ascertained by two-way classification with multiple observations per cell without transforming the data.

RESULTS

RESULTS

During November 1980 to April, 1981 a survey of the pest complex associated with cashew inflorescence has been conducted in various districts of Kerala. Observations on the nature of damage and population density have been made during the survey. Studies on biology and morphology of the selected species are also attempted. The results obtained are given below and the insects collected are listed in Appendix XI.

1 Tea mosquito: Helopeltis antonii Signoret

(Miridae: Hemiptera)

Adults blackish brown. Dorsal surface of thorax reddish in both male and female. Adult female 8 mm long (Fig. 1A) and adult male 6 mm long (Fig. 1B). Scutellar horn reddish brown and funnel shaped. Antennae four segmented. Dorsum of abdominal segments one to eight dull creamy white. Fore wings overlap the entire body. Tarsi three segmented. Legs deep brown. Tarsus blackish in males and females.

Nymphs (Fig.1C) reddish brown. Antennae four segmented. Antennae and legs deeply pigmented than the abdomen. Thorax reddish purple. Scutellar

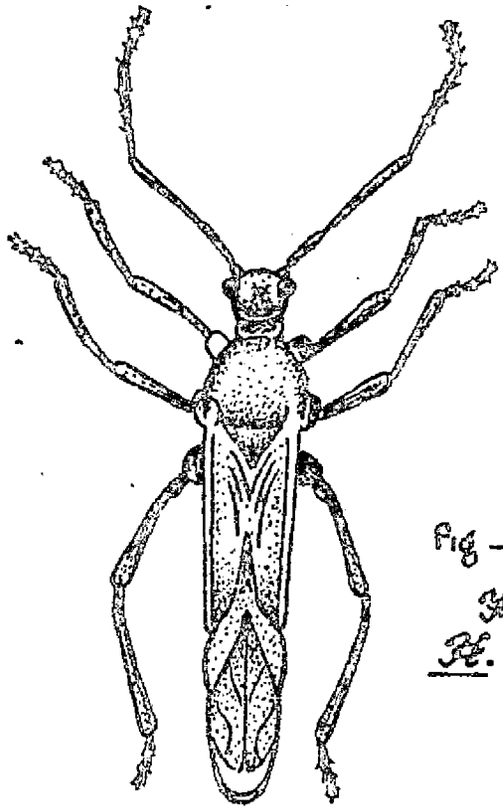

Fig - 1 A

Female

H. antonii

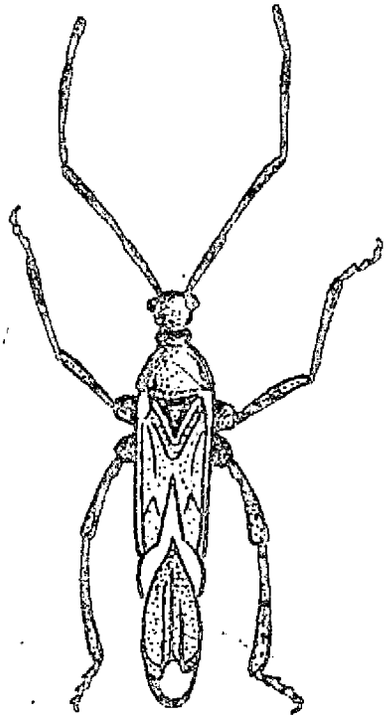

Fig - 1 B.

Male

H. antonii

TRIETIC

Fig-1 C.

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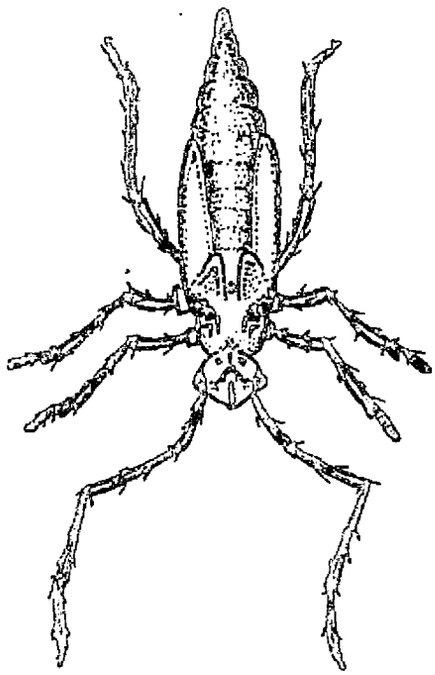


I

horn well developed. Wing pads present. Tarsi two segmented.

Both nymphs and adults cause damage by sucking sap from tender shoots, leaves, floral branches, developing nuts and apples. On the leaves and shoots brownish lesions are formed surrounding the feeding punctures due to necrosis of tissues. On the shoots a resinous substance exudes from the feeding punctures. In severe cases the brownish lesions coalesce and the shoot tip dries up. On inflorescence lesions are noticed on the main axis. It also feeds on the secondary floral branches. In severe cases the inflorescence completely dries up. The immature nuts and apples develops scabby spots by the attack.

1.1 Seasonal occurrence of H. antonii in different stations.

Tea mosquito population starts building up by the end of the September during the emergence of new flushes. By early November the first instar nymphs are found dominating. Towards the end of November and early December the fourth and fifth instar nymphs are noted more prevalent. On a single inflorescence a maximum of 5-6 nymphs are noted at Vellanikkara.

Table I A. Seasonal fluctuation of H. antonii at different stations (out of 10 sweeps)

Stations	Mean number of insects/tree (Transformed)	Mean number of insects/tree (Original)
S_1	1.91	2.65
S_2	1.99	2.96
S_3	1.96	2.84
S_4	1.74	2.03
S_5	1.83	2.35
S_6	1.54	1.37
CD (.05)	0.20	

S_6 S_4 S_5 S_1 S_3 S_2

Table I B.

Months	Mean number of insects/tree (Transformed)	Mean number of insects/tree (Original)
P_1	2.22	3.93
P_2	1.93	2.72
P_3	1.33	0.77
CD (.05)	0.123	

P_3 P_2 P_1

Table I C.

Interaction	Mean number of insects/tree (Transformed)	Mean number of insects/tree (Original)
S_1P_1	2.217	3.92
S_1P_2	2.109	3.35
S_1P_3	1.392	0.94
S_2P_1	2.618	5.85
S_2P_2	1.968	2.87
S_2P_3	1.392	0.94
S_3P_1	2.394	4.73
S_3P_2	2.022	3.09
S_3P_3	1.451	1.11
S_4P_1	2.091	3.37
S_4P_2	1.911	2.65
S_4P_3	1.205	0.45
S_5P_1	2.155	3.64
S_5P_2	1.938	2.76
S_5P_3	1.392	0.94
S_6P_1	1.845	2.40
S_6P_2	1.621	1.63
S_6P_3	1.164	0.35
CD (.05)	NS	

NS .. Statistics not significant

S_1 .. Calicut S_4 .. Kottarakara P_1 .. January

S_2 .. Madakkathara S_5 .. Anakkayam P_2 .. February

S_3 .. Kalady S_6 .. Kasaragod P_3 .. March

The lowest population (1.37/tree) is recorded at Kasaragod. It is significantly lower than that at Kottarakara (2.03/tree), Anakkayam (2.35/tree), Calicut (2.65/tree), Kalady (2.84/tree) and Madakkathara (2.96/tree)(Table IA). The population at Madakkathara is significantly more than other stations except Kalady, Calicut and Anakkayam with which it is on par. The population at Kottarakara, Anakkayam and Calicut is higher than at Kasaragod but lower than at Kalady and Madakkathara.

The lowest density is noted during March (0.77/tree) followed by February (2.72/tree) and January (3.93/tree)(Table IB). The differences are statistically significant.

Analysis reveals no significant differences between months within a station and between stations within a month (Table IC). The analysis of variance table is presented in Appendix I.

The pest population almost disappeared by April.

1.2 Damage intensity by H. antonii at different stations during the survey period.

Field damage inflicted to the floral branches

Table II A. Mean score values indicating the degree of natural field infestation of floral branches by H. antonii at different localities during different periods.

Stations	Mean number of lesions/tree (Original)
S_1	1.54
S_2	2.33
S_3	1.62
S_4	1.72
S_5	1.87
S_6	1.22
CD (.05)	0.18

S_6 $\overline{S_1 \quad S_3}$ $\underline{S_4 \quad S_5}$ S_2

Table II B.

Months	Mean number of lesions/tree (Original)
P_1	2.25
P_2	2.14
P_3	0.93
CD (.05)	0.139

P_3 $\overline{P_2 \quad P_1}$

Table II C.

Interaction	Mean number of lesions/tree (Original)
S_1P_1	1.456
S_1P_2	2.337
S_1P_3	0.818
S_2P_1	3.636
S_2P_2	2.216
S_2P_3	1.141
S_3P_1	2.391
S_3P_2	1.211
S_3P_3	1.271
S_4P_1	2.186
S_4P_2	2.378
S_4P_3	0.590
S_5P_1	2.542
S_5P_2	2.099
S_5P_3	0.971
S_6P_1	1.277
S_6P_2	1.577
S_6P_3	0.803
CD (.05)	NS

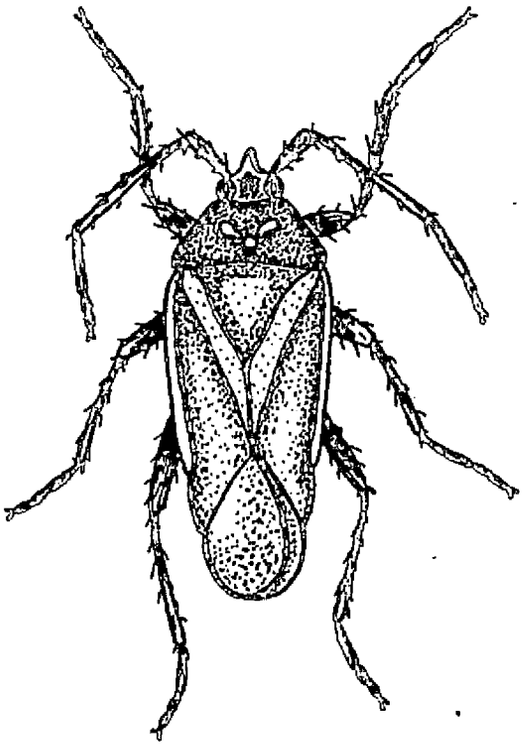
is scored on 0-5 scale as already explained. The lowest infestation (1.22/tree) is noticed at Kasaragod. The infestation is significantly lower than Calicut (1.54/tree), Kalady (1.62/tree), Kottarakara (1.72/tree), Anakkayam (1.87/tree) and Madakkathara (2.33/tree)(Table IIA). The highest infestation is recorded at Madakkathara. Significant difference in infestation is not noted among Calicut, Kalady, Kottarakara and Anakkayam.

Lowest infestation is noticed during March (0.93/tree) followed by February (2.14/tree) and January (2.25/tree)(Table IIB). Highest infestation is observed during January.

Analysis reveals no significant difference between the months within the station and between the stations in a month (Table IIC). The analysis of variance table is presented in Appendix II.

2 Ragmus sp. (Miridae: Hemiptera)

Nymphs and adults small, active, greenish bugs (Fig. 2). Head as long as broad. Eyes globular of moderate size and reddish purple. Antennal segments dissimilar, the second joint more than three



I

Ragmus sp.

Fig-2

times longer than first segment. Legs of moderate length, antennae, femora and tibiae covered with spines. Length 2.5 mm, width 1.5 mm.

Both nymphs and adults suck sap from petals and sepals. As a result, the tissues surrounding the feeding punctures, become necrotic and brownish spots develop on the floral parts.

2.1 Seasonal fluctuation of Ragmus sp. at different stations.

The incidence of this pest is noticed from November to March. They are practically absent by April. The pest is uniformly distributed in all stations.

Population level of Ragmus at Kotterakara (3.75/tree) has been significantly lower than other stations (Table IIIA). The population at Calicut (8.67/tree) has been significantly higher than other stations except Madakkathara (7.01/tree) with which it is on par.

The lowest population has been noted during March (1.37/tree) followed by February (6.40/tree) and January (13.06/tree)(Table IIIB). The differences are found to be statistically significant.

Lowest population has been observed in March followed by February and January in all stations except

Table III A. Seasonal fluctuation of Ragmus sp. at different stations.

Stations	Mean number of insects/tree (Transformed)	Mean number of insects/tree (Original)
S_1	3.11	8.67
S_2	2.83	7.01
S_3	2.66	6.08
S_4	2.18	3.75
S_5	2.70	6.29
S_6	2.53	5.40
CD (.05)	0.33	

S_4 S_6 S_3 S_5 S_2 S_1

Table III B.

Months	Mean number of insects/tree (Transformed)	Mean number of insects/tree (Original)
P_1	3.75	13.06
P_2	2.72	6.40
P_3	1.54	1.37
CD (.05)	0.27	

P_3 P_2 P_1

Table III C.

Interaction	Mean number of insects/tree (Transformed)	Mean number of insects/tree (Original)
S_1P_1	4.212	16.74
S_1P_2	3.432	10.78
S_1P_3	1.697	1.88
S_2P_1	4.031	15.25
S_2P_2	3.043	8.19
S_2P_3	1.424	1.03
S_3P_1	3.539	11.52
S_3P_2	2.802	6.85
S_3P_3	1.633	1.67
S_4P_1	3.166	9.02
S_4P_2	1.551	1.41
S_4P_3	1.815	2.29
S_5P_1	3.736	12.96
S_5P_2	2.982	7.89
S_5P_3	1.378	0.90
S_6P_1	3.786	13.33
S_6P_2	2.527	5.39
S_6P_3	1.269	0.61
CD (.05)	0.63	

S_1	P_3	P_2	P_1			
S_1	P_3	P_2	P_1			
S_2	P_3	P_2	P_1			
S_3	P_3	P_2	P_1			
S_4	P_2	P_3	P_1			
S_5	P_3	P_2	P_1			
S_6	P_3	P_2	P_1			
P_1	S_4	S_3	S_5	S_6	S_2	S_1
P_2	S_4	S_6	S_3	S_5	S_2	S_1
P_3	S_6	S_5	S_2	S_3	S_1	S_4

Kottarakara. Significant difference has been obtained between months within a station except Kottarakara.

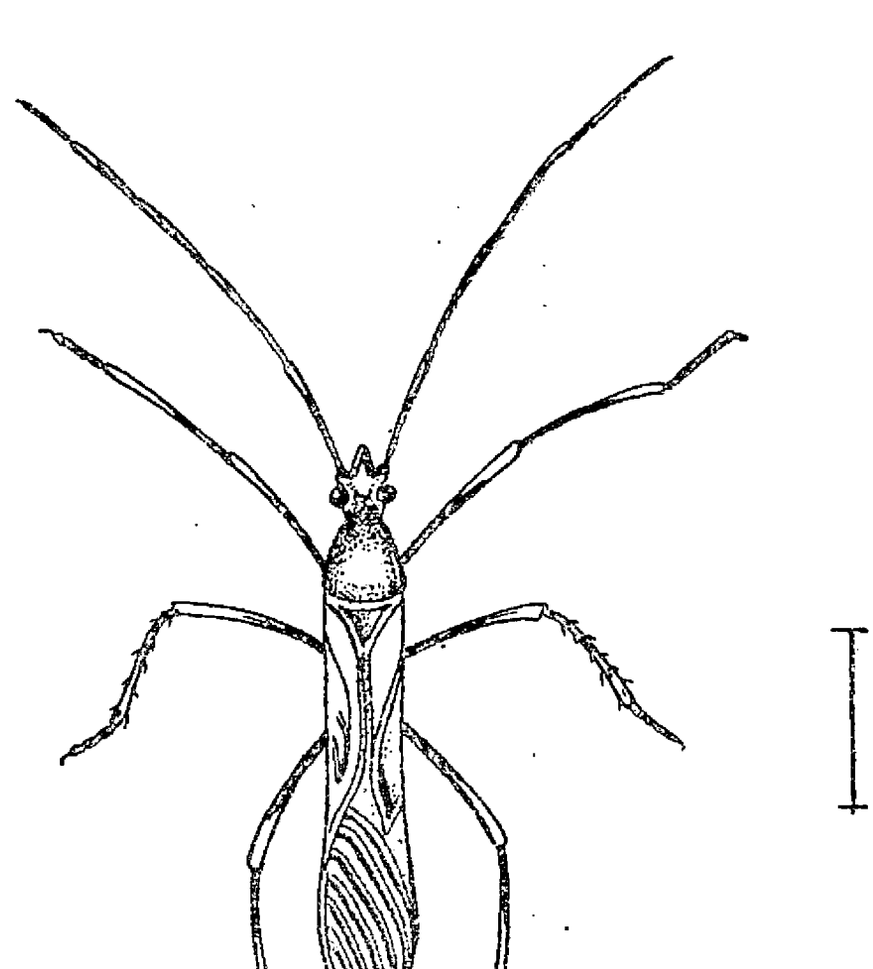
Calicut and Madakkathara record higher levels of population during January and February where-as the population is low at Kottarakara during the same period (Table IIIC). There is no significant difference between the stations with regards to average abundance of insects during March. The analysis of variance table is presented in Appendix III.

3 Leptocorisa sp. (Coreidae: Hemiptera)

Adult bug elongated, slender, measuring 18 mm long and 4 mm breadth (Fig. 3). Dorsal surface of abdomen pale and greenish on the ventral surface. Head much narrower than pronotum. Antennae black, basal joint reddish yellow. Legs long and light yellowish.

They suck sap from floral parts and inflorescence axis. As a result necrotic lesions are formed around the feeding punctures.

These insects, in few number, are noted at Vellanikkara and Madakkathara during December-January and during January at Kalady.



Leptocorisa sp.

Fig - 3

4 Coptosoma sp. (Plataspididae: Heteroptera)

Body broadly ovate, moderately convex, very slightly convex beneath (Fig. 4). Head usually small. Eyes moderately prominent. Ocelli nearer to the eyes than to each other. Scutellum covering almost the entire abdomen. Hemielytra long and bent beneath scutellum. Tarsi two segmented. Length 2 to 3 mm, width 2.5 mm.

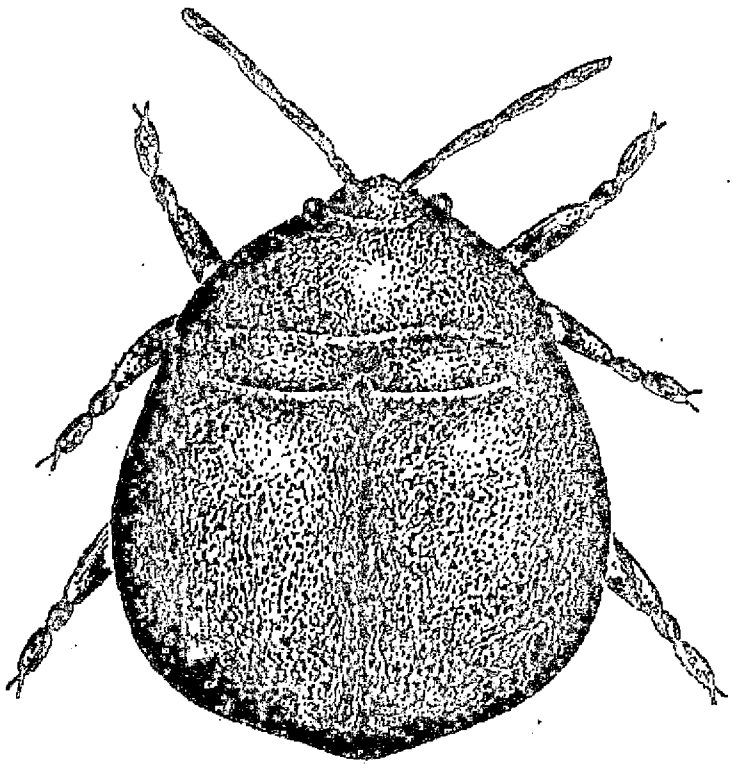
Adults suck sap from the floral parts and inflorescence branches.

The insects are noted at Kalady during January-February.

5 Tettigoniella? ceylonica Melich. (Cicadellidae: Hemiptera)

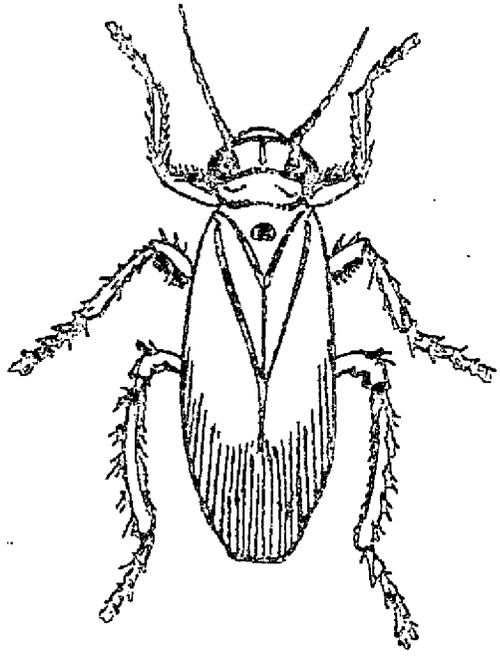
Whole body above and beneath pale yellowish (Fig. 5). Eyes brown. Tegmina hyaline, pale yellowish, with tender yellowish veins. Terminal marginal vein brown to black, membrane hyaline. Legs pale yellowish. Dorsum commonly orange yellowish. Length 5 to 5.25 mm for both males and females.

Nymphs and adults suck sap from tender leaves and inflorescence causing yellowing and leaf curling.



Coptosoma sp.

Fig - 4



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Tettigoniella ? ceylonica

Fig - 8

6 Batracomorphus linnavuorii Kameswara Rao and Ramakrishnan (Cicadellidae: Hemiptera)

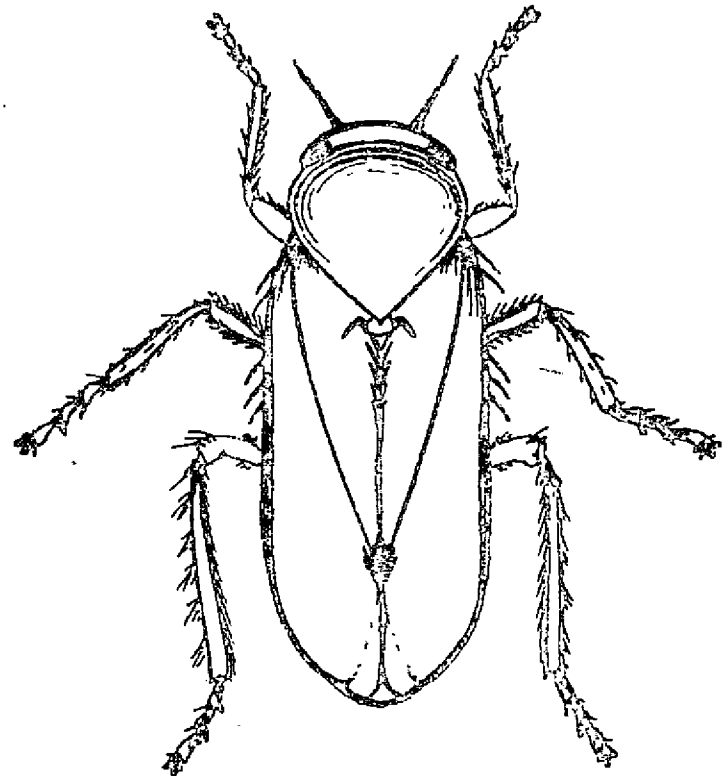
Whole body greenish. Broad and robust, frog like (Fig. 6). One and half times longer and 2 to 3 times broader than Tettigoniella. Head short, bluntly rounded. Ocelli large and placed far apart from each other. Antennae short. Tegmina moderately long, membranous, tapering towards the tip. Length 7.5 mm.

Both nymphs and adults feed by sucking sap from tender leaves and inflorescence and causes yellowing and curling.

Both the species of jassids, though in few number, are observed at Kalady, Vellanikkara and Anakkayam during January and at Calicut, Anakkayam and Kasaragod during February.

7 Toxoptera odinae Vander Goot (Aphididae: Hemiptera)

Apterous female:- Body pale coloured, 2.5 mm long and 1.5 mm wide (Fig. 7A). Antennae six segmented. Head brownish. Cornicles on the fifth segment. Rostrum extends upto hind coxae. Dorsal surface of abdomen pale with some discontinuous brownish



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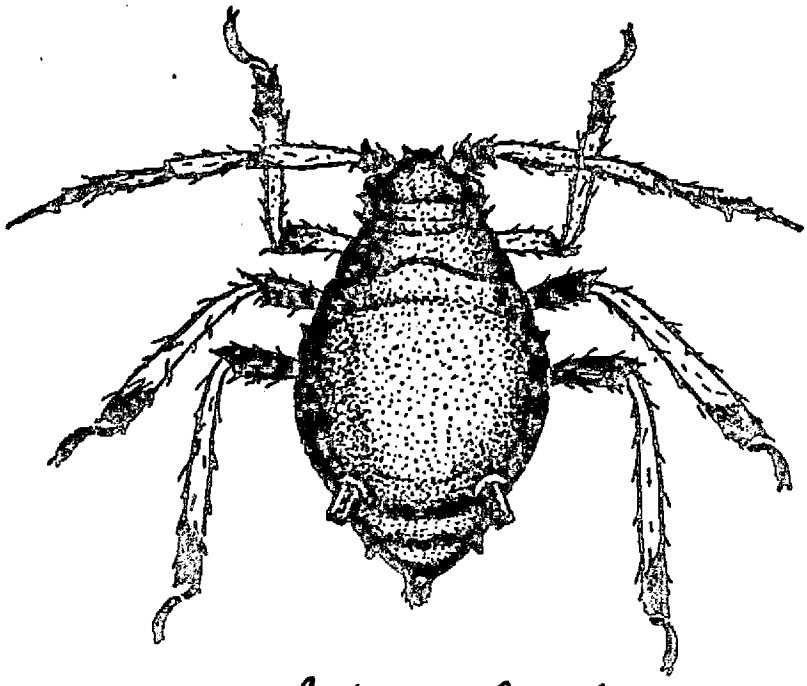
Baltracomorphus linnavuorii

Fig-6



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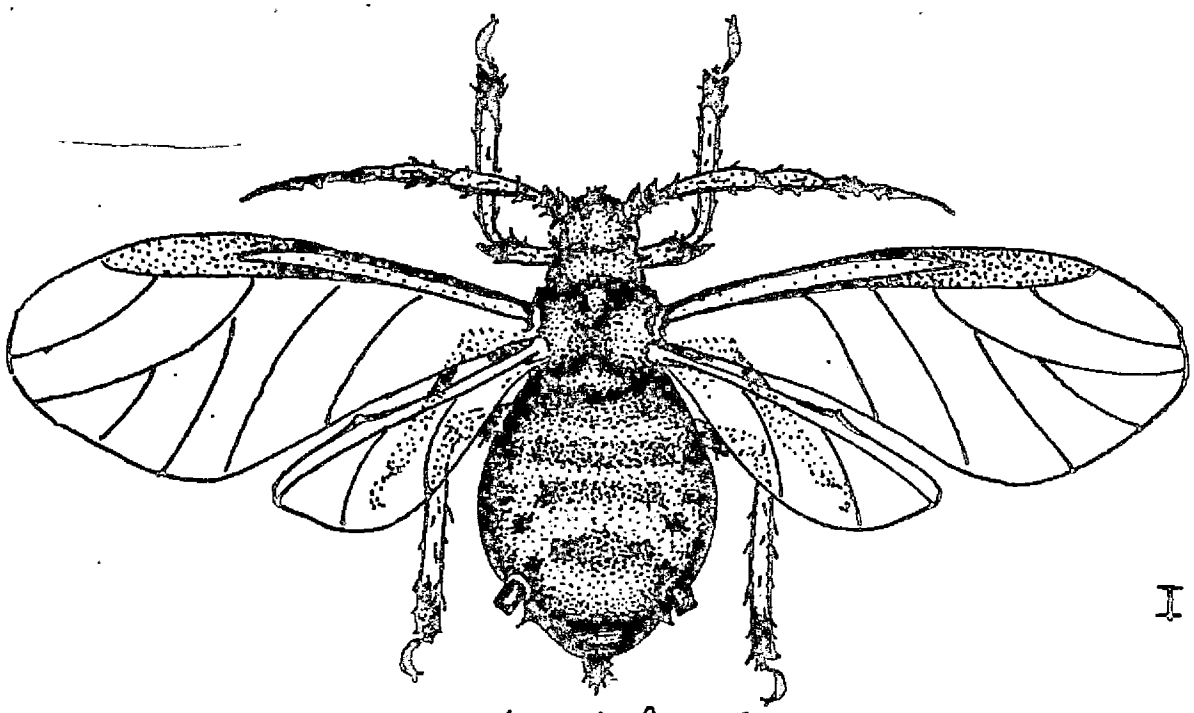
Aptetous female. Fig-7 A



I

Winged female

Fig-7 B

Yoxoptera odinae.

patches on segments 7 and 8. Cauda dark. Basal portion of femora and tibiae pale and the rest brownish pigmented.

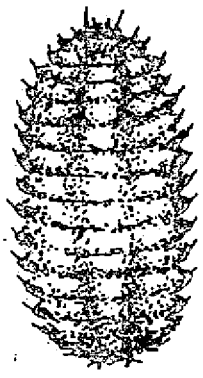
Alate female:- Length 2.5 mm and width 1 mm. Abdomen pale with a continuous dark band on segments 6 to 8. Cauda elongated, dark brown with a slight constriction near the middle. Basal portion of the femora and tibiae brownish and the rest pale to pale brown (Fig. 7B).

Both nymphs and adults congregate in clusters around the flower stalk of cashew and suck sap from the inflorescence and tender nuts.

The incidence is noticed at Madakkathara during the end of March.

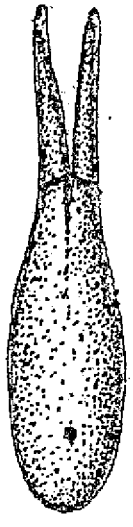
8 Ferrisia virgata Cockerell (Pseudococcidae:Homoptera)

Small, oval shaped, soft bodied insects with distinct segmentation (Fig. 8B). Legs well developed. It has the usual habit of encircling itself by secreting thin glossy threads of wax especially when the population of the mealy bug is low and scattered (Fig. 8A). Paired, caudal filaments are characteristic of the species which may be about half the length of the body. Adult about 3 mm in length and 2 mm in width.



a- usual habit of encircling.

Fig-8 A



b- with characteristic caudal filaments.

Fig-8 B

Yerrisia virgata

Both nymphs and adults cluster on inflorescence stalks, on fruits and tender nuts and suck sap.

8.1 Seasonal fluctuation of *E. virgata* at different stations.

Observed from end of December upto April. Distributed in all stations. Analysis reveals no significant difference between the stations with regard to population density (Table IVA). The highest density of population is observed during February (2.03/tree)(Table IVB) and it is significantly higher than January (1.04/tree) and March (0.66/tree). Significant difference is not observed between March and January.

In all the stations highest population density is observed during February except at Anakkayam and Kasaragod (Table IVC).

The lowest population density is observed during January at Kottarakara. This is significantly lower than that at Kalady, Calicut, Madakkathara, Kasaragod and Anakkayam. The population density at Kottarakara, Kalady and Calicut is significantly lower than that at Madakkathara, Kasaragod and Anakkayam.

Table IV A. Seasonal fluctuation of F. virgata at different stations.

Stations	Mean number of insects/tree (Transformed)	Mean number of insects/tree (Original)
S_1	1.54	1.37
S_2	1.58	1.50
S_3	1.34	0.80
S_4	1.37	0.88
S_5	1.70	1.89
S_6	1.39	0.93
CD (.05)	NS	

Table IV B.

Months	Mean number of insects/tree (Transformed)	Mean number of insects/tree (Original)
P_1	1.43	1.04
P_2	1.74	2.03
P_3	1.29	0.66
CD (.05)	0.20	

$\overline{P_3 \quad P_1}$ P_2

Table IV C.

Interaction	Mean number of insects/tree (Transformed)	Mean number of insects/tree (Original)
S_1P_1	1.237	0.88
S_1P_2	1.736	2.01
S_1P_3	1.650	1.72
S_2P_1	1.440	1.07
S_2P_2	1.863	2.47
S_2P_3	1.451	1.11
S_3P_1	1.164	0.35
S_3P_2	1.788	2.20
S_3P_3	1.082	0.17
S_4P_1	1.000	0.00
S_4P_2	1.896	2.59
S_4P_3	1.205	0.45
S_5P_1	2.070	3.28
S_5P_2	1.656	1.74
S_5P_3	1.371	0.88
S_6P_1	1.673	1.80
S_6P_2	1.501	1.25
S_6P_3	1.000	0.00
CD (.05)	0.43	

S_1 ------- P_1 P_3 P_2

S_2 ------- P_1 P_3 P_2

S_3 ------- P_3 P_1 P_2

S_4 ------- P_1 P_3 P_2

S_5 ------- P_3 P_2 P_1

S_6 ------- P_3 P_2 P_1

P_1 ------- S_4 S_3 S_1 S_2 S_6 S_5

P_2 ------- S_6 S_5 S_1 S_3 S_2 S_4

P_3 ------- S_6 S_3 S_4 S_5 S_2 S_1

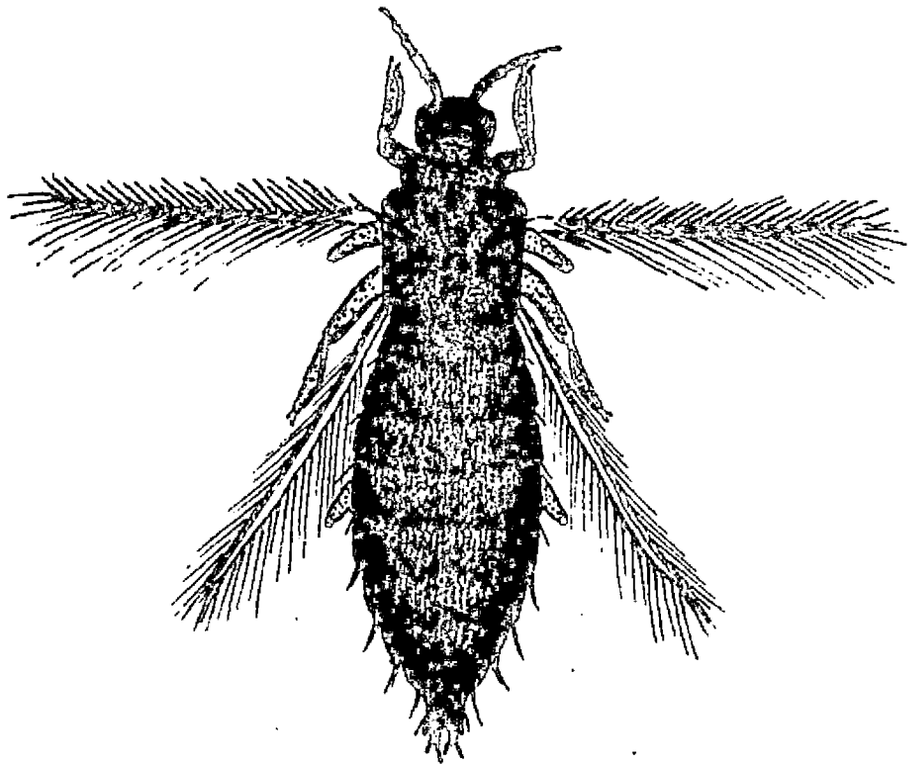
Significant difference in population density is not observed during February in all the stations.

The population density during March at Kasaragod, Kalady, Kottarakara and Anakkayam are significantly lower than at Madakkathara and Calicut. The analysis of variance table is presented in Appendix IV.

9 Haplothrips ganglbaueri Schmutz (Phlaeothripidae: Thysanoptera)

Small, dark brown slender bodied insects. Antennae six to nine segmented (Fig. 9). Head with a pair of small prominent compound eyes. Prothorax free and distinct and meso and meta thorax completely united. Wings membranous, very narrow and fringed with long setae. The abdomen long tapering posteriorly and composed of 11 segments. Length 2 mm.

Both nymphs and adults feed by lacerating the surface tissues of the inflorescence including the male and bisexual flowers. The injured tissues are stimulated to form scabby out growth on the floral branches. As a result the flowers, fade and drop prematurely.



Haplothrips ganglbaueri

Fig-9

9.1 Seasonal fluctuation of H. ganglbaueri at different stations.

The incidence of this pest is noticed from November to April. It is uniformly distributed in all stations.

The population density at Kasaragod (1.46/tree) is significantly lower than at Anakkayam (2.76/tree), Calicut (2.80/tree), Madakkathara (4.43/tree), Kotterakara (4.76/tree) and Kalady (7.01/tree) (Table VA). The number of insects in the sample collected from Kalady is significantly higher than other stations.

Highest population density is noticed during March (7.24/tree)(Table VB) and the lowest (1.82/tree), during January. The differences are statistically significant.

Significant difference in population density between months within the station is observed at Kalady, Kotterakara and Anakkayam (Table VC). Lowest population density is observed during January except at Anakkayam where it is in February. In all the stations the population density is highest during March except at Madakkathara where it is during February.

Table V A. Seasonal fluctuation of H. ganglbaueri at different stations.

Stations	Mean number of insects/tree (Transformed)	Mean number of insects/tree (Original)
S_1	1.95	2.80
S_2	2.33	4.43
S_3	2.83	7.01
S_4	2.40	4.76
S_5	1.94	2.76
S_6	1.57	1.46
CD (.05)	0.20	

S_6 $\underline{S_5}$ S_1 $\underline{S_2}$ $\underline{S_4}$ S_3

Table V B.

Months	Mean number of insects/tree (Transformed)	Mean number of insects/tree (Original)
P_1	1.68	1.82
P_2	1.95	2.80
P_3	2.87	7.24
CD (.05)	0.14	

P_1 P_2 P_3

Table V C.

Interaction	Mean number of insects/tree (Transformed)	Mean number of insects/tree (Original)
S_1P_1	1.879	2.53
S_1P_2	1.718	1.95
S_1P_3	2.258	4.10
S_2P_1	2.341	4.48
S_2P_2	2.476	5.13
S_2P_3	2.176	3.73
S_3P_1	1.413	1.00
S_3P_2	2.523	5.37
S_3P_3	4.546	19.67
S_4P_1	1.310	0.72
S_4P_2	2.289	4.24
S_4P_3	3.592	11.90
S_5P_1	1.809	2.27
S_5P_2	1.242	0.54
S_5P_3	2.774	6.70
S_6P_1	1.360	0.85
S_6P_2	1.471	1.16
S_6P_3	1.873	2.51
CD (.05)	0.33	

S_1 -------	P_2	P_1	P_3		
S_2 -------	P_3	P_1	P_2		
S_3 -------	P_1	P_2	P_3		
S_4 -------	P_1	P_2	P_3		
S_5 -------	P_2	P_1	P_3		
S_6 -------	P_1	P_2	P_3		
P_1 -------	S_4	S_6	S_3	S_5	S_1 S_2
P_2 -------	S_5	S_6	S_1	S_4	S_2 S_3
P_3 -------	S_6	S_2	S_1	S_5	S_4 S_3

Highest population density is observed at Madakkathara during January. The population density is significantly higher than that at Calicut, Anakkayam, Kalady, Kasaragod and Kottarakara. Kottarakara, Kasaragod and Kalady recorded lower number of insects than that at Anakkayam, Calicut and Madakkathara. The lowest population density is observed at Anakkayam during February. The population density of insects at Anakkayam is significantly lower than other stations except Kasaragod. The number of insects in the sample collected from Kasaragod is significantly lower than all other stations except Anakkayam. The analysis of variance table is presented in Appendix V.

10 Beetles:

The following three species of beetles are found together feeding in flowers.

(i) Silvanolomus denticollis Rtt. (Silvanidae: Coleoptera)

Small, brown, flattened beetles. Antennae clubbed. Forewings horney elytra which almost always meet to form a straight mid-dorsal suture (Fig. 10A). Hindwings membranous, folded beneath the

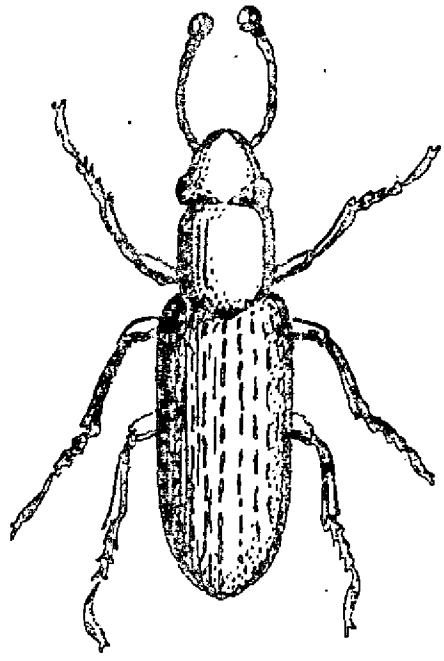
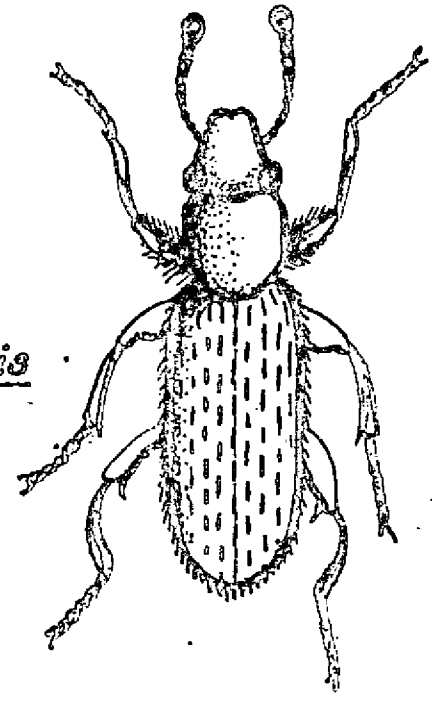


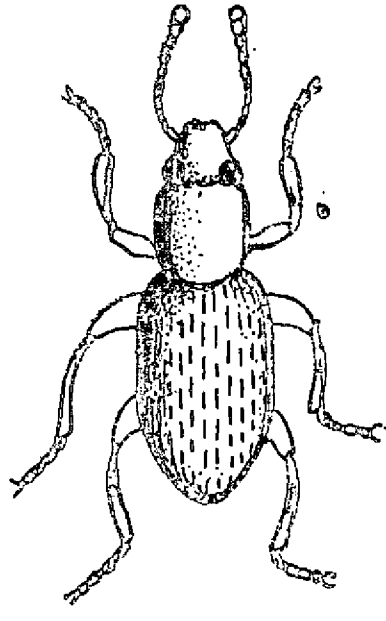
Fig-10 C

Beginus maindroni



Silvanolomus denticollis

Fig-10 A



Melanophthalma Sp.

Fig-10 B

elytra. Prothorax large and mobile. Mesothorax much reduced. Tarsi five segmented. Third tarsal segment is lobed beneath, fourth shorter than the first. Length 2.5 mm.

(ii) Melanophthalma sp. (Lathrididae: Coleoptera)

Small, brown, flattened beetles. Antennae with a club formed of one, two or three joints. Ventral abdominal segments five, free, the first longest. Tarsi three segmented (Fig. 10B). Length 2.5 mm.

(iii) Berginus maindroni Grouv. (Mycetophagidae:Coleoptera)

Adults are small beetles, dull in colour. Antennae four to five segmented and club like. Tarsi four segmented in female. The anterior tarsi three segmented in males. Length 2 mm (Fig. 10C).

The above three species of beetles are found together feeding on pollen grains.

10.1 Seasonal fluctuation of the three species of beetles.

The highest level of population density of the three species is together observed at Madakkathara (6.40/tree) (Table VIA). The population density is significantly

Table VI A. Seasonal fluctuation of Beetles at different stations.

Stations	Mean number of insects/tree (Transformed)	Mean number of insects/tree (Original)
S_1	2.21	3.88
S_2	2.72	6.40
S_3	2.24	4.02
S_4	2.04	3.16
S_5	2.37	4.62
S_6	1.93	2.72
CD (.05)	0.33	

S_6 S_4 S_1 S_3 S_5 S_2

Table VI B.

Months	Mean number of insects/tree (Transformed)	Mean number of insects/tree (Original)
P_1	2.66	6.08
P_2	2.44	4.95
P_3	1.66	1.76
CD (.05)		

P_3 P_2 P_1

Table VI C.

Interaction	Mean number of insects/tree (Transformed)	Mean number of insects/tree (Original)
S_1P_1	2.546	5.48
S_1P_2	2.547	5.49
S_1P_3	1.547	1.39
S_2P_1	3.512	11.33
S_2P_2	2.396	4.74
S_2P_3	2.244	4.04
S_3P_1	2.767	6.66
S_3P_2	2.753	6.47
S_3P_3	1.205	0.45
S_4P_1	1.987	2.95
S_4P_2	2.641	5.97
S_4P_3	1.483	1.20
S_5P_1	3.022	8.13
S_5P_2	2.039	3.16
S_5P_3	2.054	3.22
S_6P_1	2.111	3.46
S_6P_2	2.256	4.09
S_6P_3	1.424	1.03
CD (.05)	0.59	

S_1 ----- P_3 P_1 P_2

S_2 ----- P_3 P_2 P_1

S_3 ----- P_3 P_2 P_1

S_4 ----- P_3 P_1 P_2

S_5 ----- P_2 P_3 P_1

S_6 ----- P_3 P_1 P_2

P_1 ----- S_4 S_6 S_2 S_1 S_3 S_5

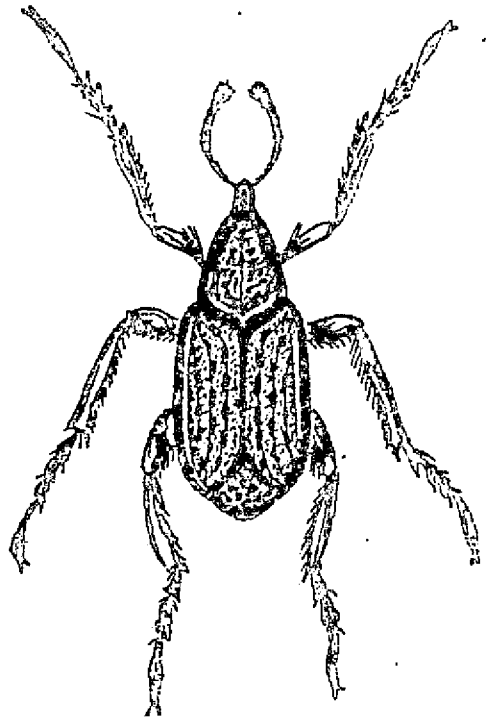
P_2 ----- S_5 S_6 S_2 S_1 S_4 S_3

P_3 ----- S_3 S_6 S_4 S_1 S_5 S_2

higher than that at Anakkayam (4.62/tree), Kalady (4.02/tree), Calicut (3.88/tree), Kottarakara (3.16/tree) and Kasaragod (2.72/tree). Kasaragod, Kottarakara, Calicut and Kalady are having significantly lower number of insects than that at Anakkayam and Madakkathara.

The lowest level of population is noticed during March (1.76/tree) followed by February (4.95/tree) and January (6.08/tree)(Table VIB). The number of insects observed during February and January are significantly higher than that during March.

The highest population density is noticed during January at Anakkayam. It is significantly higher than that at Kalady, Calicut, Madakkathara, Kasaragod and Kottarakara. The population density at Kottarakara, Kasaragod, Madakkathara and Calicut are significantly lower than that at Kalady and Anakkayam. The lowest density of population is recorded at Anakkayam, followed by Kasaragod, Madakkathara, Calicut, Kottarakara and Kalady during February. The lowest density of population is noticed at Madakkathara during March. The number of insects found at Madakkathara and Anakkayam are significantly higher than that of other stations (Table VIC). The analysis of variance table is presented in Appendix VI.



Amblyrhinus poricollis

Fig - 11

11 Amblyrhinus poricollis Schonh. (Curculionidae: Coleoptera)

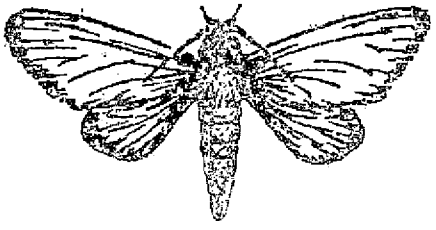
A small brown weevil with lighter markings (Fig. 11). Head with a broad pinkish central stripe. Scutellum whitish. Antennae geniculate. Prothorax little longer than broad and longer than the head. Elytra ovate. Legs slender, the femora strongly clavate. Tibiae straight and simple. Total length 5 mm and width 2 mm.

They feed on the leaves and flowers by cutting small holes on them. They are found at Kalady and Calicut during January.

12 Hypatima (=Chelaria) heligramma Meyrick (Gelechiidae: Lepidoptera)

Adult small, dark brown moth with a wing length of 5 mm and width of 1.5 mm. Body length of 4 mm (Fig. 12A). Head and thorax dark grey. Forewings narrow and oblong and covered with black dots.

Young caterpillar pale white to pale yellow in colour, actively moving and the fully grown caterpillar pale green with a prominent black head. The full grown caterpillar is 12 mm long and 1.5 mm wide (Fig. 12B).



Adult Fig-1R A

Larva

Fig-1R B

pupa

Fig-1R C

Hypatima haligramma

Pupa naked, found inside the bore holes made on the shoot top or floral branches. It is yellowish red and is 5 mm long 2.5 mm wide (Fig. 12C).

The caterpillar feeds on different plant parts depending upon its seasonal occurrence. Very tender leaves are damaged often at bud stage. Emerging leaves are folded and the caterpillar feeds on the leaf margin from within. The caterpillar bores into the fresh shoot tip and inflorescence and a gummy exudation oozes out of the infested tips. Due to the boring, the growing shoot becomes stunted, and withers and dries up. No panicle development takes place. It also bores into the unopened buds and eats away the internal contents, preventing the fruit set. On a single inflorescence about as many as 15 caterpillars have been noted feeding.

12.1 Seasonal fluctuation of H. haligramma at different stations.

The incidence of this pest is noticed from September onwards feeding on the new flushes and from November to March it is found feeding on the inflorescence. The population has declined considerably during April. The pest is found distributed all over the areas surveyed, though there is

significant difference in the population level among the different stations.

The lowest population density is noticed at Kasaragod (0.59/tree)(Table VIIA). The number of insects found at Kasaragod is significantly lower than other stations. Significant difference is not found between Madakkathara (1.46/tree) and Kalady (3.13/tree). The population density recorded at Madakkathara and Kalady are significantly higher than Kasaragod and lower than the other stations.

Fewer insects are found during March (1.04/tree) followed by January (2.10/tree) and February (2.42/tree). Significant difference in population is not found between the month of January and February (Table VIIB).

Population density is low during March at Calicut followed by January and February. Significant difference is not observed between population at Madakkathara and Kasaragod. Lowest population density is observed during January at Kalady. The lowest population is noticed during March at Kottarakara and Anakkayam but January and March are on par in Kottarakara whereas March and February in Anakkayam. The highest population density is observed during February at Calicut, Kalady and Kottarakara and during January at Madakkathara, Anakkayam and Kasaragod.

Table VII A. Seasonal fluctuation of H. haligramme at different stations.

Stations	Mean number of insects/tree (Transformed)	Mean number of insects/tree (Original)
S_1	1.80	2.24
S_2	1.57	1.46
S_3	1.77	3.13
S_4	1.79	2.20
S_5	1.89	2.57
S_6	1.26	0.59
CD (.05)	0.232	

S_6 $\underline{S_2 \quad S_3}$ S_4 S_1 S_5

Table VII B.

Months	Mean number of insects/tree (Transformed)	Mean number of insects/tree (Original)
P_1	1.76	2.10
P_2	1.85	2.42
P_3	1.43	1.04
CD (.05)	0.16	

P_3 $\overline{P_2 \quad P_1}$

Table VII C.

Interaction	Mean number of insects/tree (Transformed)	Mean number of insects/tree (Original)
S_1P_1	1.897	2.60
S_1P_2	2.277	4.18
S_1P_3	1.237	0.53
S_2P_1	1.670	1.79
S_2P_2	1.615	1.61
S_2P_3	1.410	0.99
S_3P_1	1.524	1.32
S_3P_2	1.934	2.74
S_3P_3	1.861	2.46
S_4P_1	1.697	1.88
S_4P_2	2.312	4.35
S_4P_3	1.351	0.83
S_5P_1	2.345	4.50
S_5P_2	1.774	2.15
S_5P_3	1.583	1.51
S_6P_1	1.456	1.12
S_6P_2	1.164	0.35
S_6P_3	1.164	0.35
CD (.05)	0.39	

S_1 ------ P_3 P_1 P_2

S_2 ------ P_3 P_2 P_1

S_3 ------ P_1 P_3 P_2

S_4 ------ P_3 P_1 P_2

S_5 ------ P_3 P_2 P_1

S_6 ------ P_2 P_3 P_1

P_1 ------ S_6 S_3 S_2 S_4 S_1 S_5

P_2 ------ S_6 S_2 S_5 S_3 S_1 S_4

P_3 ------ S_6 S_1 S_4 S_2 S_5 S_3

The highest rate of population is observed at Anakkayam during January. This is significantly higher than that at Calicut, Kottarakara, Madakkathara, Kalady and Kasaragod. Significant difference is not found among Kasaragod, Kalady, Madakkathara and Kottarakara. The highest level of population is noticed during February at Kottarakara. Significant difference is not found among Madakkathara, Anakkayam and Kalady and among Kalady, Calicut and Kottarakara.

The lowest level of population is noticed at Kalady during March. Significant difference is not noticed among Kasaragod, Calicut, Kottarakara, Madakkathara and between Anakkayam and Kalady (Table VIIC). The analysis of variance table is presented in Appendix VII.

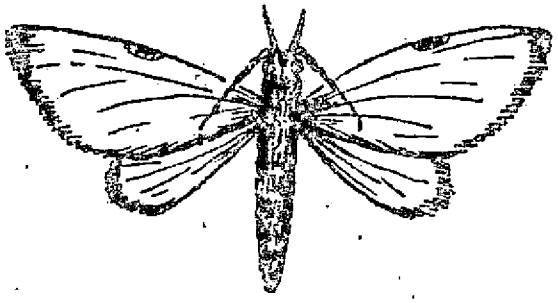
13 Unidentified Gelechidae. (Gelechiidae: Lepidopetera)

Tiny moths, 4 mm in length with the head pale grey and thorax dark grey. Forewings grey, length of 4 mm and width 1.5 mm and dusted with blackish brown and with a few blackish brown spots along the costa and a big spot in the middle. Hindwings grey in colour (Fig. 13A).

Young caterpillar yellowish brown, cylindrical, gradually tapering posteriorly. Head pale brown. Body covered with numerous minute hairs arising singly. Thoracic legs and prolegs dark brown. Colour changes to pinkish in grown up caterpillars and the head then becomes dark brown. Fully grown caterpillar measures 8 to 9 mm in length and 1 mm in width. Body colour reddish pink on the dorsal side and pale reddish on the ventral side (Fig. 13B). Head rather small and flattened. Pupa naked. Pupation both inside and outside the flower. Pupa dark brown and measures 5 mm long and 2 mm wide (Fig. 13C). Pupal period 7 days.

Larva feeds on leaves and inflorescence. It webs two tender leaves with fine silken threads and feed from inside by making irregular holes. It webs the inflorescence too and feed on it. The caterpillar bores into the opened and unopened flowers and feed on the ovary. Sometimes it bores into the shoot also.

Caterpillars are observed feeding on the leaves during October-November at Vellanikkara and at Madakkathara from November to April. From November onwards the population starts building up and



Adult

Fig-13 A

Larva

Fig-13 B

pupa

Fig-13 C

Unidentified Gelechidae

reaches its peak during January and by the end of January the population declines. The population is reduced to zero during March-April.

Paralitomastix varicornis, an encyrtid parasite has been reared from the larva of this pest.

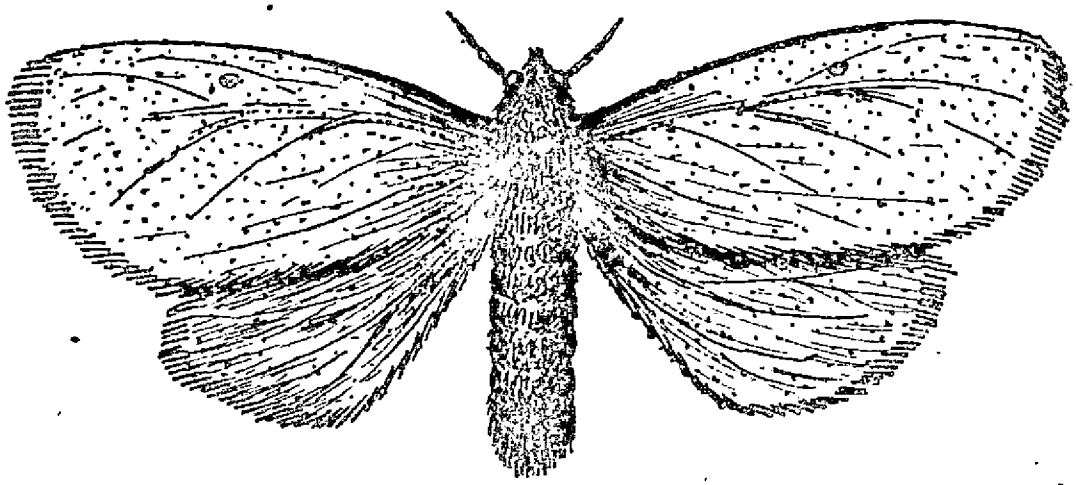
14 Euproctis sp. (Lymantriidae: Lepidoptera)

Head, thorax and forewings bright orange yellow (Fig. 14A). Abdomen straw coloured. Body length 19 mm, wing expanse 45 mm. A tuft of orange hairs at the anal end. Forewings with prominent black spot at the middle. Antennae bipectinate. Ocelli absent. Mid tibiae with one pair of long spurs and hind tibiae with two pairs.

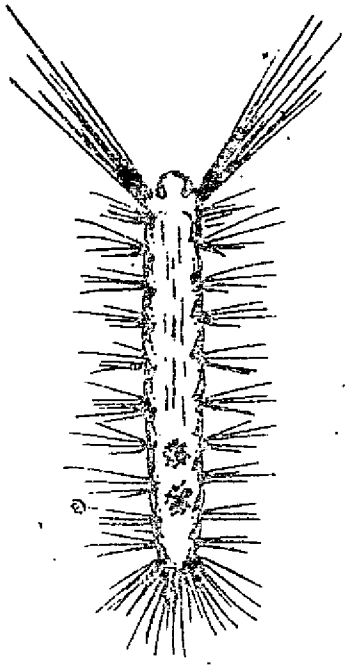
Caterpillars dark brown. A long tuft of black hairs on the first segment. Tufts of white hairs on the other segments. Black spots on the dorsal surface of the 9th and 10th segment. Eleventh segment with a black tuft of hairs. The fully grown caterpillar is 20 mm long and 4 mm wide (Fig. 14B).

Pupation in a cocoon made up of body hairs. Pupa reddish brown.

The caterpillars are noticed during September feeding on the leaves at Vellanikkara and Madakkathara and on inflorescence during December-January at Calicut and Kalady.



Adult Fig-14 A



Larva Fig-14 B

Euproctis Sp.

15 Porthesia xanthorrhoea Kollar (Lymantriidae: Lepidoptera)

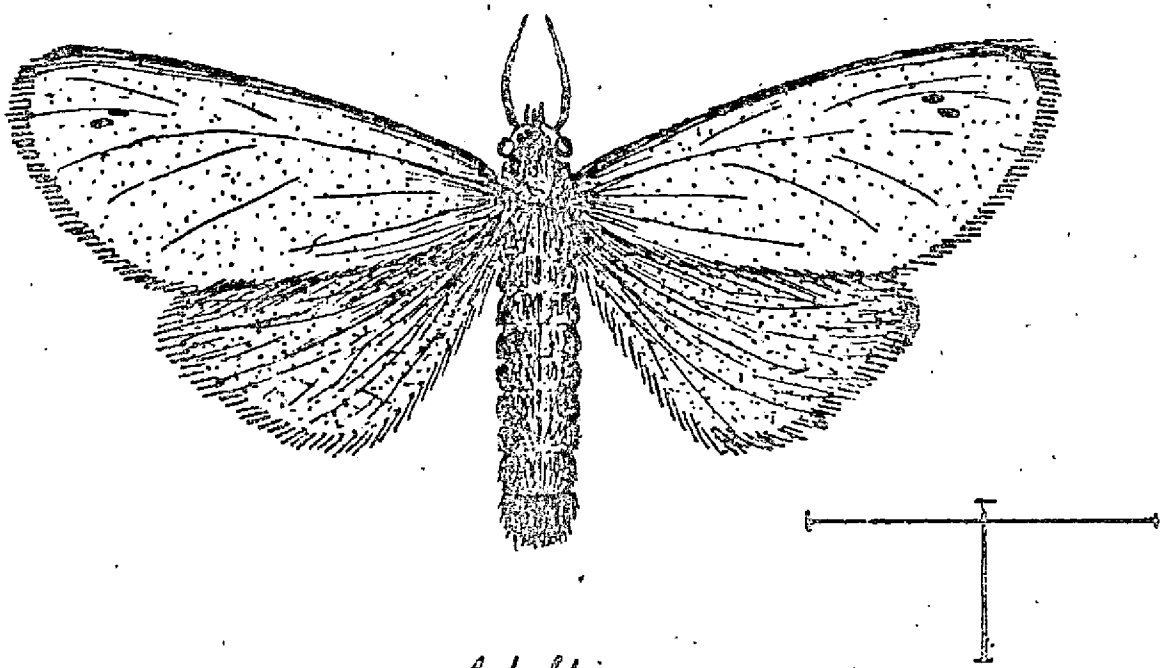
Adult white (Fig. 15A). Antennae brownish. Tuft of orange hairs at the anal end. Apical and outer parts of hindwings and the underside of both the wings with minute dots. Body length 18 mm, wing expanse 42 mm.

Caterpillar black. Head stripped with white band. A crimson line through the 2nd, 3rd and 6th to 10th segments. First segment with long forwardly projecting tuft of black hairs and the other segments with shorter tuft of hairs. The full grown caterpillar is 20mm long and 4 mm wide (Fig. 15B).

Pupation in a cocoon made up of body hairs. Pupa light red in colour.

The caterpillars feed on both the leaves and inflorescence, as a result the leaves are skeletonized and brownish lesions develop on the inflorescence due to scraping of the green tissues. The flowers are completely eaten up by the larvae.

They are found on inflorescence during December-January at Vellanikkara and Madakkathara.



Adult

Fig - 15 A

Larva Fig - 15 B

Porthesia xanthorrhoea

16 Thalassodes sp. (Geometridae: Lepidoptera)

Adult medium sized moth. Body length 13 mm. Apple green in colour with an oblique line running across the fore and hindwings (Fig. 16A). Wing expanse 29 to 31 mm. They have the habit of resting with fully opened wings tightly pressed against the surface. Antennae of the male bipectinate to two-third length.

Eggs laid singly four days after emergence. They are oval and smooth (Fig. 16B). Incubation period 4 to 6 days. Freshly emerged larva light yellow in colour and measures 1 to 1.5 mm in length. The looper caterpillar grow by feeding on the flowers. Fully grown caterpillar measures 20 to 31 mm long and 1.6 to 1.8 mm wide. Larva elongate, naked and slender. It is green with prominent dark spots on the dorsal side in a row from head to tail. It has two pairs of prolegs. It mimics a tiny twig. Larval period 12 to 21 days (Fig. 16C). Pupa naked and light brown. It is 12 mm long and 3 mm wide (Fig. 16D) and attached to the inflorescence by its anterior portion. Pupal period 7 to 8 days. The life cycle completes in 23 to 35 days. Adults live for 8 days on 50% honey.

Adult Fig-16 A

Egg

Fig-16 B

Larva

Fig-16 C

pupa

Fig-16 D

Life Cycle of <u>Thalassodes</u> sp.

Table VIII A. Seasonal fluctuation of Thalassodes sp. at different stations.

Stations	Mean number of insects/tree (Transformed)	Mean number of insects/tree (Original)
S_1	1.53	0.77
S_2	1.50	1.25
S_3	1.72	1.96
S_4	1.44	1.07
S_5	1.55	1.40
S_6	1.47	1.16
CD (.05)	NS	

Table VIII B.

Months	Mean number of insects/tree (Transformed)	Mean number of insects/tree (Original)
P_1	1.50	1.25
P_2	1.18	0.39
P_3	1.60	1.56
CD (.05)	NS	

Table VIII C.

Interaction	Mean number of insects/tree (Transformed)	Mean number of insects/tree (Original)
S_1P_1	1.296	0.68
S_1P_2	1.361	0.85
S_1P_3	1.337	0.78
S_2P_1	1.547	1.39
S_2P_2	1.328	0.76
S_2P_3	1.629	1.65
S_3P_1	1.886	2.56
S_3P_2	1.709	1.92
S_3P_3	1.556	1.42
S_4P_1	1.319	0.74
S_4P_2	1.319	0.74
S_4P_3	1.688	1.85
S_5P_1	1.547	1.39
S_5P_2	1.319	0.74
S_5P_3	1.774	2.15
S_6P_1	1.392	0.94
S_6P_2	1.392	0.94
S_6P_3	1.615	1.61
CD (.05)	NS	

The caterpillar feeds on opened and unopened flowers, and on the leaves by making holes on them. Both the young and mature caterpillars scrape the green tissue from the panicle stalk. A maximum of four caterpillars are noted on a single inflorescence.

16.1 Seasonal fluctuation of Thalassodes sp. at different stations.

The incidence of this pest is noticed during October onwards feeding on the tender leaves and from November to March it is found feeding on the inflorescence. The pest is distributed all over the areas surveyed. The population has declined considerably during April.

Analysis revealed no significant difference with regard to population density between stations (Table VIIIA), months (Table VIIIB) and also months within a station and stations within a month (Table VIIIC). The analysis of variance table is presented in Appendix VIII.

17 ? Eucrostes sp. (Geometridae: Lepidoptera).

Bright yellow green with a wing length of 10 mm

Adult Fig-17 A

Larva Fig-17 B

? *Eucosteа* sp.

and width 6 mm. Body length 8 mm (Fig. 17A). Male antennae bipectinate for two thirds its length. Both wings with reddish brown spot at the end of the cell. Hind tibia with one pair of spurs in both sexes.

Caterpillar greenish brown. Dorsal side covered with dried sepals and the ventral surface naked (Fig. 17B). Mature larva measures 13 mm long and 3 mm wide. Before pupation the larva shed the dried sepals and construct a cocoon with it. Pupa light brown in colour and measures 8 mm long and 2.5 mm wide. Adults emerged 7 days after pupation.

The caterpillar feeds on both opened and unopened flowers and scrape the green tissues from inflorescence stalk.

17.1 Seasonal fluctuation of ? Eucrostes sp. at different stations.

The incidence of this insect is noticed only from February onwards upto April. The population density at Kasaragod (0.04/tree) is significantly lower than all other stations (Madakkathara (0.40/tree), Kottarakara (0.56/tree), Anakkayam (0.68/tree) and Kalady (0.92/tree) except Calicut (0.26/tree). The

Table IX A. Seasonal fluctuation of *Eucrostes* sp. at different stations.

Stations	Mean number of insects/tree (Transformed)	Mean number of insects/tree (Original)
S_1	1.123	0.26
S_2	1.185	0.40
S_3	1.387	0.92
S_4	1.248	0.56
S_5	1.298	0.68
S_6	1.020	0.04
CD (.05)	0.11	

S_6 S_1 S_2 S_4 S_5 S_3

Table IX B.

Months	Mean number of insects/tree (Transformed)	Mean number of insects/tree (Original)
P_2	1.177	0.39
P_3	1.244	0.55
CD (.05)	NS	

Table IX G.

Interaction	Mean number of insects/tree (Transformed)	Mean number of insects/tree (Original)
S_1P_2	1.123	0.26
S_1P_3	1.123	0.26
S_2P_2	1.082	0.17
S_2P_3	1.287	0.66
S_3P_2	1.287	0.66
S_3P_3	1.497	0.24
S_4P_2	1.374	0.89
S_4P_3	1.123	0.26
S_5P_2	1.164	0.35
S_5P_3	1.433	1.05
S_6P_2	1.041	0.08
S_6P_3	1.000	0.00
CD (.05)	0.138	

S_1 ------ $\overline{P_2 \quad P_3}$

S_2 ------ $P_2 \quad P_3$

S_3 ------ $P_2 \quad P_3$

S_4 ------ $P_3 \quad P_2$

S_5 ------ $P_2 \quad P_3$

S_6 ------ $\overline{P_3 \quad P_2}$

P_2 ------ $\overline{S_6 \quad S_2 \quad S_1} \quad \underline{S_5 \quad S_3 \quad S_4}$

P_3 ------ $\overline{S_6 \quad S_1 \quad S_4} \quad \underline{S_2 \quad S_5 \quad S_3}$

number of insects in the sample collected from Calicut is significantly lower than that all other stations except Kasaragod (Table IXA). The population density at Kalady is significantly higher than other stations except Anakkayam, with which it is on par.

Analysis reveals no significant difference among the months with regard to the population density (Table IXB).

Significant difference is not observed between months within the station on population density at Calicut and Kasaragod (Table IXC). In all the other four stations significantly higher number of insects are recorded during March compared to February.

Significant difference is not observed in population density of insects during February. During March the population density is significantly lower at Kasaragod, Calicut and Kottarakara as compared to Madakkathara, Anakkayam and Kalady. Analysis of variance table is presented in Appendix IX.

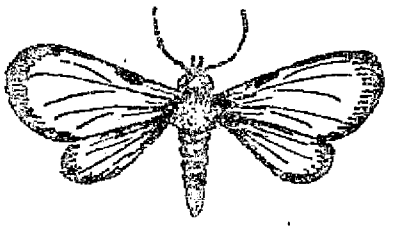
18 Selepa sp. (Noctuidae: Lepidoptera)

Adult moth small with a wing length of 10 mm and width 5 mm. Body length 8 mm. Antennae heavily

ciliated in male. Forewings greyish brown with a purplish and grey tinge. Hindwings whitish with dark colour towards outer margin. Head, thorax pale brown. Abdomen fuscous (Fig. 18A).

Eggs laid two days after the emergence in batches of 3 to 11. They are pyrdmidal in shape with ridges all round and pale yellow in colour (Fig. 18B). Egg period 4 to 5 days.

Freshly hatched larva transferant with ridges all round the body and measures 1 mm in length. Caterpillars feed in clusters for a few days after emergence. Mature larva light green on the sides with reddish 'V' shaped bands on the dorsal surface. Long hairs present on the lateral side on each segment. Dorsal surface of the 2nd and 3rd thoracic segments and the 2nd and 9th abdominal segments black. The head pale creamy (Fig. 18C). Full grown caterpillar measures 17 mm long and 4 mm wide. Larval period lasts 13 to 15 days. A day before pupation, the caterpillar stops feeding and becomes inactive. Pupation in a boat shaped dirty white cocoon which measures about 12 mm long and 5 mm wide (Fig. 18D). Pupa 9 mm long and 3 mm wide (Fig. 18 E). Pupal period 10 to 12 days.



Adult Fig-18 A

Egg

Fig-18 B

Larva

Fig-18 C

pupa with cocoon

Fig-18 D

pupa without cocoon

Fig-18 E

Life Cycle of Selepa sp.

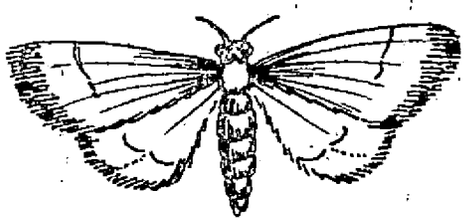
Caterpillar feeds voraciously on leaves and inflorescences. The flower is completely eaten up except the ovary and stamen. A maximum of five caterpillars are noted on a single inflorescence.

This insect is noticed at Vellanikkara, Madakkathara and Calicut only. This is first found during November at Vellanikkara and Madakkathara. During December the population starts increasing and by February the population declines. The pest has not been observed in the other stations.

19 Unidentified Noctuidae (Noctuidae: Lepidoptera)

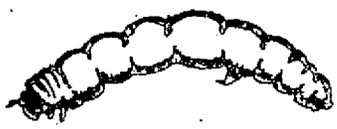
Moth pale red brown with a wing length of 8 mm and 6 mm width. Body length 7 mm. Wings grey with a dark zig zag line. Forewings with a pale patch at its apex. Underside of both the wings covered with reddish and blackish hairs (Fig. 19A).

Larva reddish brown, with black streaks on the dorsal side (Fig. 19B). Yellow transverse stripe is present on lateral side. The semilooper larva has two pairs of abdominal legs. Minute hairs all over the body. Fully grown caterpillar measures 15 mm long and 2 mm wide. It pupates in a silken cocoon. Pupa brown in colour and measures 9 mm long and 3 mm wide.



Adult

Fig - 19 A



larva

Fig - 19 B

Unidentified Noctuidae

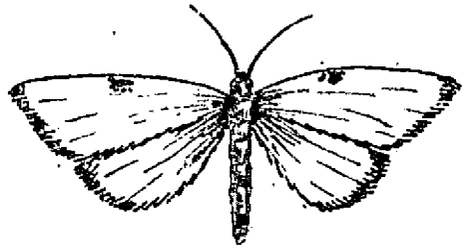
The caterpillar feeds on the sepals and petals of flowers. Collected from Vellanikkara during January.

20 Spatulipalpia nr. erythrina Hampson (Phycitidae: Lepidoptera)

Small reddish brown moth with a wing expanse of 14 mm. Body length 7 mm. Forewing narrow and elongated, fringed with reddish brown hairs (Fig. 20A). Wing margins are slightly darker. Hindwing pale brownish in colour, border fringed with shiny brownish hairs. Tuft of blackish scales on mesothoracic sterna towards the base of mesothoracic coxa. Male antennae fringed with short hair like structures. Anal tuft composed of short hairs.

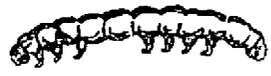
The young caterpillar pinkish, slender and cylindrical (Fig. 20B). Grown-up caterpillars greenish brown with reddish brown head. A light brown shield like structure on prothorax, and measures 17 mm long and 2 mm wide. A day before pupation the larva stops feeding. Pupation in a silken cocoon.

The larva webs the inflorescence with fine silken threads and feeds inside by eating away the flowers.



Adult

Fig - 20 A



Larva

Fig - 20 B

Spatulipalpia nr. *erythrina*

20.1 Seasonal fluctuation of S. nr. erythrina at different stations.

The incidence of this insect is noticed from February to March in all stations. The number of insects in the sample collected from Kottarakara (0.17/tree) is significantly lower than all other stations except Kasaragod. The population density at Kalady (0.68/tree) is significantly higher than other stations except Madakkathara (0.48/tree) with which it is on par (Table XA).

Analysis reveals no significant difference between months with regard to the density of population (Table XB).

Significant difference in population density is not observed between months within the station at Calicut, Anakkayam and Kasaragod (Table XC). Madakkathara and Kottarakara recorded significantly higher number of insects during March compared to February and in Kalady during February compared to March.

The lowest population density is observed in February at Kasaragod. It is significantly lower than that at Kottarakara, Anakkayam, Calicut, Kalady and Madakkathara. Madakkathara recorded maximum number of

Table X A. Seasonal fluctuation of S. nr. erythrina at different stations.

Stations	Mean number of insects/tree (Transformed)	Mean number of insects/tree (Original)
S_1	1.205	0.45
S_2	1.218	0.48
S_3	1.298	0.68
S_4	1.082	0.17
S_5	1.123	0.26
S_6	1.000	0.00
CD (.05)	0.088	

$\underline{S_6 \quad S_4} \quad \underline{S_5 \quad S_1} \quad \underline{S_2 \quad S_3}$

Table X B.

Months	Mean number of insects/tree (Transformed)	Mean number of insects/tree (Original)
P_2	2.182	0.40
P_3	1.13	0.28
CD (.05)	NS	

Table X C.

Interaction	Mean number of insects/tree (Transformed)	Mean number of insects/tree (Original)
S_1P_2	1.205	0.45
S_1P_3	1.205	0.45
S_2P_2	1.355	0.84
S_2P_3	1.082	0.17
S_3P_2	1.205	0.45
S_3P_3	1.392	0.94
S_4P_2	1.164	0.35
S_4P_3	1.000	0.00
S_5P_2	1.164	0.35
S_5P_3	1.082	0.17
S_6P_2	1.000	0.00
S_6P_3	1.000	0.00
CD (.05)	0.113	

S_1 ------- $\overline{P_2 \quad P_3}$

S_2 ------- $P_3 \quad P_2$

S_3 ------- $P_2 \quad P_3$

S_4 ------- $P_3 \quad P_2$

S_5 ------- $\overline{P_3 \quad P_2}$

S_6 ------- $\overline{P_3 \quad P_2}$

P_2 ------- $S_6 \quad \overline{S_4 \quad S_5 \quad S_1 \quad S_3} \quad S_2$

P_3 ------- $\overline{S_4 \quad S_6 \quad S_2 \quad S_5} \quad S_1 \quad S_3$

insects. The population density at Kottarakara, Anakkayam, Calicut and Kalady are significantly higher than at Kasaragod but lower than at Madakkathara. The population density at Kottarakara, Kasaragod, Madakkathara and Anakkayam are significantly lower than that at Calicut and Kalady during March. Analysis of variance table is presented in Appendix X.

The following insects are not recorded during the present survey although they are known as pests of cashew in other areas:

Leaf and blossom webber:- Lamida (=Macalla) moncusalis W
(Pyralidae: Lepidoptera)

Though it is a major pest in the coastal districts of Andhra Pradesh, this is not observed feeding on inflorescence in Kerala.

Flower beetle: Popillia complanata Newm.
(Rutelidae: Coleoptera)

Thrips: Selenothrips rubrocinctus Giard
(Thripidae: Thysanoptera)

Leaf and flower looper: Pingasa ruginaria Gu.
(Geometridae: Lepidoptera)

Soft scales : Ceroplastes floridensis C.

Lecanium latioperculum Gr.

(Coccidae: Hemiptera)

Mealy bug : Planococcus lilacinus Ckll.

(Pseudococcidae: Hemiptera)

Mites : Oligonychus coffeae Neitner

(Tetranychidae: Acarina)

DISCUSSION

DISCUSSION

Survey of the pest complex infesting cashew inflorescence has been conducted in different parts of Kerala during November, 1980 to April, 1981. Various pests are noted infesting cashew inflorescence in different localities. Studies on biology and seasonal fluctuations of the pest complex are also attempted during the present study. The results obtained are discussed below.

1 Helopeltis antonii

Noted in all the areas surveyed. Studies at Vellanikkara and Madakkathara reveal that the first instar nymphal population out-numbers the adults in November while both the nymphs and adults are noticed in equal proportions during late November and early December. In late November the fourth and fifth instar nymphs have the majority over other nymphal stages. The pest population density level has been relatively high at Vellanikkara than at Madakkathara.

Significant difference is noted in population density and damage intensity between stations and also in months. The population levels and damage intensity

are significantly lower at Kasaragod (1.37 and 1.22/tree respectively) and higher at Madakkathara (2.96 and 2.33/tree respectively) (Table 1 A, II A). The population level is low during March (0.77/tree) and high during January (3.93/tree) (Table I B, II B). By April the pest disappears. The fast rate of multiplication of the pest during November to April may be due to the availability of succulent leaves and floral parts and favourable climatic factors. Differences in population level between localities can be due to climatic factors, genetic factors and biotic factors like the activities of the predatory complex.

Pillai and Abraham, (1975) reported that the pest population build up in Kerala commences from October and reaches its peak during January. The present studies agree with their observations.

From the data (Table IA, IB, IIA, IIB), it is observed that there is a positive relationship between the population density and damage intensity.

2 Ragmus sp.

Both nymphs and adults of this species suck sap from floral parts. Gopalan, (1975 and 1976) reported R. importunitas feeding on the leaves of Crotalaria

juncea. It is likely that the species of Ragmus reported on cashew may feed on leaves too.

Two species of Ragmus are recorded from South India by Ballard, (1921). They are R. monosus on cotton, Crotalaria juncea, Andropogan sorghum and Sesamum indicum and R. flavomaculatus on Andropogan sorghum. These are predatory on thrips, aphids and mites. However, the Ragmus on cashew is phytophagous and not predatory.

Significant difference is noticed in population between staticns and also in months. The population has been significantly lower at Kottarakara (3.75/tree) and higher at Calicut (7.01/tree) (Table IIIA). The population is significantly low during March (1.37/tree) and high during January (13.06/tree) (Table IIIB).

Ragmus sp. is reported here for the first time feeding on cashew.

3 Leptocorisa sp.

During the present survey these insects are noted at Vellanikkara and Madakkathara during December-January and during January at Kalady. At Madakkathara and Kalady, several alternate hosts

of Leptocorisa are noted and this may be the reason that some of those Leptocorisa have migrated on cashew.

Report of Leptocorisa is another new record on cashew.

4 Coptosoma sp.

The adults are noticed feeding on cashew at Kalady during January-February. It seems that the pest has very limited distribution.

It is a notorious pest on other crops like pulses (Subramania Ayyer, 1922). It is also reported on avenue trees like Pongamia glabra and medicinal plants like Rauwolfia serpentina (Esaki, 1926; Pratap singh, 1964). Record of Coptosoma on cashew is reported for the first time here.

Two species of jassids are noted on cashew. They are:

5. Tettigoniella ? ceylonica

6. Batracomorphus linnavuorii

Both the species are noted at Kalady, Vellanikkara and Anakkayam during January and at Calicut, Anakkayam and Kasaragod during February. These jassids appear to be casual feeder on cashew and their

population has been extremely low for affecting any appreciable damage on the crop by feeding on leaves and inflorescence. However these are new records on cashew.

7 Toxoptera odinae

The incidence is observed only at Madakkathara during March. Both nymphs and adults congregate in clusters around the flower stalks of cashew and suck sap from inflorescence and tender nuts. Abraham, (1959) also made similar observations. Earlier records of aphids on cashew include T. auranti (B.d.F) and Aphis spiraecola Patch. (Anon., 1973). But during the present survey these aphids are not found attacking cashew inflorescence.

8 Ferrisia virgata

The population of this pest is found significantly higher in February (2.03/tree)(Table IVB). According to Rawat and Modi, (1968) this pest is more active during August to November and March to April in Madhya Pradesh. The climatic dissimilarities between the states may explain for the differences in

population level between the places.

Significant difference is also observed between months within a station and between stations within a month. In all the stations the highest population is observed during February except at Anakkayam and Kasaragod where it is during January. The population is significantly lower at Kottarakara during January than other stations. But during February significant difference is not observed at all the stations. The population during March at Kasaragod, Kalady, Kottarakara and Anakkayam is significantly lower than at Madakkathara and Calicut (Table IVC). These differences in pest population may be due to climatic variations in different seasons and in different localities. This has been proved by the studies of Betrem, (1936), who worked out the ecology and epidemology of F. virgata on coffee. He found that the most important factor in population regulation of F. virgata is the atmospheric humidity, which exercises an indirect effect through its influence on parasitic fungi.

Flata sp. and Ketumala sp. are two hemipterans reported by Pillai et al.,(1976), feeding on the cashew inflorescence but are not observed during the present study.

9 Haplothrips ganglbaueri

The incidence is noted from November onwards. The population is significantly low at Kasaragod (1.46/tree) and high at Kalady (7.01/tree)(Table VA).

Boboye, (1968) studied the seasonal fluctuation of thrips at Okigwi in Eastern Nigeria, and reported that the population is higher in the dry season than in the rainy season with a peak during December and March. The results of the present study agree with his observations and high incidence of thrips on cashew in Kerala is found in the dry months of March-April (Table VB).

Record of H. ganglbaueri on cashew is reported for the first time here.

Three species of beetles are found feeding on pollen grains of cashew inflorescence. They are:

10 Silvanolomus denticollis

11 Melanophthalma sp.

12 Berginus maindroni

Detailed information on the biology and habits of S. denticollis and Melanophthalma sp. are not available.

However, a species of Melanophthalma (M. gibbosa) is reported on potato foliage in summer transmitting the virus disease (Cottier, 1931 and 1937). Imms and Chatterjee, (1915) observed that B. maindroni feeding on Tachardia lacca devouring both the lac and scales in the United and Central Provinces. However, no records are available of this insect feeding on pollen grains on cashew inflorescence.

Significant difference is observed in the population of the three species of beetles together between stations and between months. The population density is high at Madakkathara (6.40/tree) and low at Kasaragod (2.72/tree)(Table VIA) and high during January (6.08/tree) followed by February (4.95/tree)(Table VIB.)

Significant difference is also observed between the months within a station and also between the stations within a month. The higher number of insects are noticed during January at Madakkathara, Kalady and Anakkayam followed by February and March at Madakkathara and Kalady and March and February at Anakkayam (Table VIC).

13 Amblyrhinus poricollis

During the present survey these weevils are noticed at Kalady and Calicut during January.

According to Abraham, (1958) and Brown, (1968), this is found feeding on the tender foliage of cashew. It is also recorded on the new growth of mango leaves (Issac, 1934). However, during the present study it is found feeding not only on leaves but also on flowers by cutting small holes on them.

Previous record of beetles on cashew inflorescence include the pest, Popillia complanata Newm. (Rutelidae: coleoptera). This beetle is known to attack cocoa, rose etc., in Kerala. Any how they are not observed on cashew during the present survey.

14 Hypatima haligramma

It is present all over the areas surveyed, though there is a significant difference in its population among the different stations and months. Low population density is noted at Kasaragod (0.59/tree) and high at Madakkathara (1.46/tree) and Kalady (3.13/tree) (Table VIIA) and it is significant. Low population density is noted during March (1.04/tree) and high during January (2.10/tree) and February (2.42/tree)(Table VIIB).

The population level significantly varies between months within a station and between stations within a month. Lowest population is observed during January at Kalady and during March at Calicut. Highest population is observed during February at Calicut, Kalady and Kottarakara and during January at Madakkathara, Anakkayam and Kasaragod (Table VIIC).

In addition to H. haligramma, another Gelechid pest has been observed on cashew in limited numbers from November to February at Vellanikkara and Madakkathara. However their identify could not be established for want of sufficient specimens. The larva of this species is found feeding on the leaves and inflorescence by webbing together and feeding from inside. An encyrtid parasite, Paralitomastix varicornis has been reared from the larva of this pest. It is not known whether similar records have been made earlier for want of establishing its identify.

15 Euproctis sp.

The caterpillars are observed during September at Vellanikkara and Madakkathara and during December-January at Calicut and Kalady.

The caterpillars of E. scientillans feed on leaves and inflorescences and also scrape the green tissues of apples and the shell of the green nuts. (Abraham, 1958; Brown, 1968 and Pillai et al., 1976). During the present study somewhat similar nature of damage has been observed by Euproctis sp.

16 Porthesia xanthorrhoea

It is recorded during December-January at Vellanikkara and Madakkathara. This pest is another new record on cashew.

17 Thalassodes sp.

Rao et al., (1977) studied the biology of Thalassodes quadraria. The total life cycle lasts for 22-35 days being the egg, larval and pupal periods as 3 to 5, 13 to 20 and 6 to 10 days respectively. The results of the biology studies at Vellanikkara agree with the above study. According to present studies, the total life cycle of Thalassodes sp. lasts 23 to 35 days. Egg period 4 to 6 days, larval period 12 to 21 days and pupal period 7 to 8 days.

Rao et al., (1977) reported that the caterpillar

feeds on leaves. During present study, it is observed that the caterpillar feeds both on leaves and inflorescence. The pest incidence is noted from October to March.

Significant difference in population is not observed between stations and among the months (Table VIIIA,B). It is found that the pest has uniform distribution in all the areas as well as in months.

18 Eucrostes sp.

Noted during February and March only. The population at Kasaragod (0.04/tree) and Calicut (0.26/tree) are significantly lower than other stations and the highest population is noticed at Kalady (0.92/tree) and Anakkayam (0.68/tree) (Table IXA). Differences in population between months are not significant (Table IXB). Somewhat uniform distribution of population is noted during February in all the stations. But during March the population density is found significantly low at Kasaragod, Calicut and Kottarakara compared to Madakkathara, Anakkayam and Kalady (Table IXC).

There is no previous record of Eucrostes sp. on cashew.

19 Selepa sp.

Noted at Vellanikkara, Madakkathara and Calicut from November to February. The egg, larval and pupal stages of Selepa sp. last\$ 3,7 to 10 and 7 to 11 days respectively. The caterpillar feeds on cashew flowers.

The insect is reported for the first time on cashew.

In addition to this another noctuid pest has been noted feeding on cashew flowers at Vellanikkara but its identify could not be established yet.

20 Spatulipalpia nr. erythrina

This is noted during February-March in all the areas surveyed. Significant variation is observed between the stations and the population density is significantly low at Kottarakara (0.17/tree) and high at Kalady (0.68/tree) and Madakkathara (0.48/tree)(Table XA).

This insect is not recorded earlier as a pest of cashew.

Previous records of lepidopterans on cashew inflorescence include Pingasa ruginaria as reported by Sreeramulu et al.,(1975) and Lamida (=Macalla) moncusalis (Abraham, 1958). However, both the insects are not observed during the present study, though the latter pest is notorious on cashew especially in Andhra Pradesh (Ayyanna, Narayana and Rao, 1977).

Rodrigues, (1967) reported a dark red mite, Oligonychus coffeae, on cashew feeding on leaf and inflorescence. This mite too is not observed during the present study.

SUMMARY

SUMMARY

Pests infesting cashew inflorescence in different localities in Kerala, their seasonal fluctuations and nature of damage are briefly discussed below.

1 Hemipteran pests

1.1 Helopeltis antonii

Noted in all the areas surveyed. The population level and damage intensity are low at Kasaragod (1.37/tree and 1.22/tree respectively) and high at Madakkathara (2.96/tree and 2.33/tree respectively). The population level is low during March (0.77/tree) and high during January (3.93/tree). Both the nymphs and adults suck sap from tender leaves, shoots, floral branches, developing nuts and apples resulting in brownish lesions, die-back, inflorescence blight and scabby spots respectively.

2.2 Ragmus sp.

The population level is high at Calicut (8.67/tree) and Madakkathara (7.01/tree) and low at Kottarakara (3.75/tree). The lowest population density is recorded during March (1.37/tree) and the highest during January (13.06/tree). Both nymphs and adults

suck sap from floral parts resulting in the formation of brownish spots on the tissues.

1.3 *Leptocorisa* sp.

Noted at Vellanikkara, Kalady and Madakkathara during December-January. They suck sap from floral parts and inflorescence axis.

1.4 *Coptosoma* sp.

They are collected from Kalady during January-February. Adults suck sap from floral parts and inflorescence branches.

1.5 *Tettigoniella* ? *ceylonica*

1.6 *Batracomorphus linnavuorii*

Both these species are noted at Kalady, Vellanikkara, Anakkayam, Calicut and Kasaragod during January-February. Nymphs and adults suck sap from tender leaves and inflorescence causing yellowing and leaf curling.

1.7 *Toxoptera odinae*

The incidence is noted only at Madakkathara. Both nymphs and adults congregate in clusters around

the flower stalk and suck sap from the inflorescence and tender nuts.

1.8 Ferrisia virgata

Highest population density is recorded during February (2.03/tree) followed by January (1.04/tree) and March (0.66/tree). Both nymphs and adults cluster on the stalk of the inflorescence, on the fruit and tender nuts and suck sap.

2 Thysanopteran pests

2.1 Haplothrips ganglbaueri

The density is low at Kasaragod (1.46/tree) and high at Kalady (7.01/tree). The population level is high in March (7.24/tree) and low in January (1.82/tree). Both nymphs and adults feed by lacerating the surface tissues of the inflorescence.

3 Coleopteran pests

3.1 Silvanolomus denticollis

3.2 Melanophthalma sp.

3.3 Berginus maindroni

Population density of the three species of beetles together are high at Madakkathara (6.40/tree) and low at Kasaragod (2.72/tree). High in January (6.08/tree) followed by February (4.95/tree) and March (1.76/tree). They are found feeding on the pollen

grains of cashew inflorescence.

3.4 *Amblyrhinus poricollis*

Noted at Kalady and Calicut during January. Adults feed on leaves and flowers by cutting small holes on them.

4 Lepidopteran pests

4.1 *Hypatima haligramma*

Population density is low at Kasaragod (0.59/tree) and high at Madakkathara (1.46/tree) and Kalady (3.13/tree). The population level is low during March (1.04/tree) and high during February (2.42/tree) and January (2.10/tree). Caterpillar feeds on tender leaves and also bores into the fresh shoot tip, inflorescence and opened and unopened flowers.

4.2 Unidentified Gelechidae

Observed during October-November at Vellanikkara and from November to April at Madakkathara. The larva webs the leaves and inflorescence and feeds within.

4.3 *Euproctis* sp.

Noted during September at Vellanikkara and Madakkathara and during December-January at Calicut and Kalady. Caterpillars feed on both the leaves and inflorescence.

4.4 Porthesia xanthorrhoea

Noticed during December-January at Vellanikkara and Madakkathara. Caterpillars feed on both the leaves and inflorescence.

4.5 Thalassodes sp.

The incidence is noticed from October to April. Caterpillars feed on leaves, opened and unopened flowers and scrape green tissues from the inflorescence stalk.

4.6 Eucrostes sp.

The lowest density is noticed at Kasaragod (0.04/tree) and Calicut (0.26/tree) and the highest density at Kalady (0.92/tree) and Anakkayam (0.68/tree). Caterpillars feed on both opened and unopened flowers.

4.7 Selepa sp.

Noted at Vellanikkara and Madakkathara during November to February. Caterpillars feed on leaves and inflorescence.

4.8 Unidentified Noctuidae.

Noticed from Vellanikkara during January. Caterpillars feed on floral parts.

4.9 Spatulipalpia nr. erythrina

The lowest population density is noticed at

Kotterakara (0.17/tree) and the highest level at Kalady (0.68/tree) and Madakkathara (0.48/tree). Noticed from February to March. Larva webs the inflorescence with fine silken threads and feed inside by eating away the flowers.

Out of 20 species of insects recorded on the cashew inflorescence, the following are reported for the first time, Ragmus sp. (Miridae: Hemiptera), Leptocorisa sp. (Coreidae:Hemiptera), Coptosoma sp. (Plataspididae:Hemiptera), Tettigoniella? ceylonica Melich. (Cicadellidae: Hemiptera), Batracomorphus linnavuorii Kameswara Rao and Ramakrishnan (Cicadellidae:Hemiptera), Haplothrips ganglbaueri Schmutz (Phlaeothripidae: Thysanoptera), Silvanolomus denticollis Rtt. (Silvanidae: Coleoptera), Melanophthalma sp. (Lathridiidae: Coleoptera), Berginus maindroni Grouv. (Mycetophagidae: Coleoptera), Porthesia xanthorrhoea Koller (Lymantriidae: Lepidoptera) Eucrostes sp. (Geometridae: Lepidoptera), Selepa sp. (Noctuidae: Lepidoptera), Spatulipalpia nr. erythrina Hampson (Phycitidae: Lepidoptera).

REFERENCES

REFERENCES

Abraham, E.V. 1958. Pests of cashew (Anacardium occidentale L.) in South India. Indian J. agric. Sci. 28: 531-543.

*Abraham, E.V. 1959. Killer insects of cashew. Indian Fmg. 9 (3): 14-15

Abraham, E.V. and Padmanabhan, M.D. 1967. Pests that damage cocoa in Madras. Ind. Hort. 11 (3): 11-12.

Abraham, C.C. and Remamony, K.S. 1979. Pests that damage cocoa plants in Kerala. Indian Arecanut, Spices and Cocoa Journal. 11 (3): 77-81.

Ambika, B. and Abraham, C.C. 1979. Bio-ecology of Helopeltis antonii Sign. (Miridae: Hemiptera) infesting cashew trees. Entomon 4 (4): 335-342.

*Ananthakrishnan, T.N. and Muraleedharan, N. 1974. On the incidence and effects of infestation of Selenothrips rubrocinctus (Giard)(Thysanoptera: Heliothripinae) on the free aminoacids of some susceptible host plants. Current Science 43(7): 216-218.

Ananthanarayanan, K.P. and Venugopal, S. 1954. Pests of Eugenia jambolana in Coimbatore (South India). S. Indian Hort. 1 (4): 137-140.

*Andrews, E.A. 1918. Notes on insect pests of Green manures and shade trees. Qtrly. Jl. Scient. Dept., Indian Tea Assoc. 29-34.

*Anonymous, 1966. Annual Progress Report of the Central Cashew Research Station, Ullal, 1968-69.

Arjunarao, P., Edwin Dharmaraju and Ayyanna, T. 1979. Studies on the biology and bionomics of Thalassodes sp. a serious pest on cashew. Andhra agric. J. 24: 182.

Atwal, A.S. 1976. Agricultural Pests of India and South East Asia. Kalyani Publishers, Delhi, India. 502 PP.

Ayyanna, R., Subbaratnam, G.V. and Rao, B.H.K. 1977. Insect pests of cashew in Andhra Pradesh and their control. Tech. Bull. No.7. Andhra Pradesh Agricultural University, Rajendra Nagar, Hyderabad. 29 pp.

*Ayyar, T.V.R. 1932. Annotated list of insects affecting the important cultivated plants in South India. Agric. Dept. Madras Bull. No. 27.

*Ayyar, T.V.R. 1941. Insects associated with cashew plants in South India. Proc. 28th Indian Science Cong. III. 208 pp.

*Ayyar, T.V.R. 1942. Insects enemies of the cashewnut plant (Anacardium occidentale) in South India. Madras agric. J. 30: 223-226.

Ayyar, T.V.R. 1949. Hand book of Economic Entomology for South India. Govt. Press, Madras. 528 pp.

*Ballard, E. 1921. Two new species of Ragmus from South India. Records Ind. Mus. Calcutta. 22 (26):509-510.

Basheer, M. and Jayaraj, S. 1964. Cashewnut pests. In Entomology in India. Silver Jubilee number. Entomological Society of India, New Delhi. 261-266.

*Beccari, P. and Gerini, V. 1968. Contributes all a conoseeuza dell "Entomofauna dell" Anacardium occidentale L. Tanzania enct mosds. Riv. Agric. Subtrop. Trop. 62 (46): 129-134.

Beeson, C.F.C. 1941. The Ecology and control of the Forest Insects of India and the Neighbouring countries. Govt. of India Press, New Delhi. 767pp.

*Betrem, J.G. 1934. Witte Luis en Klimaat (Mealy bugs and climate). Bergcultures 8 (34): 797-804.

*Betrem, J.G. 1936. De oecologic en epidemiologic Vande Wittee Luizen. (The Ecology and Epidomology of white mealy bugs). Arch. Koffiecult Ned. Ind. 10(2): 87-186.

*Bigger, M. 1960. Selenothrips rubrocinctus (Giard) and the floral biology of cashew in Tanganyika. East African agric. J. 25: 229-234.

*Boboye, S.O. 1968. Studies on biology and chemical control of red banded thrips, Selenothrips rubrocinctus Giard (Thysanoptera: Thripidae) infesting cashew at Okigwi, Eastern Nigeria. Niger. Ent. Mag. 1 (5): 77-81.

*Bohlen, E. 1973. Cashew-crop pests in Tanzania and their control. Verlag plant Derev, Berlia. 62 pp.

*Brown, F.C. 1968. Pests and Diseases of Forest Plantation Trees. An annotated list of the principal species occurring in the British Common Wealth. Clarendon Press, Oxford. 122pp.

*Carter (Walter) 1956. Notes on some mealy bugs (Coccidae) of economic importance in Ceylon. FAO Plant. Prot. Bull. 4 (4): 49-52.

*Castro, Z.B. De., Cavalcante, M.L.S. and Calvalcante, R.D. 1974. Ocorrencia de Selenothrips rubrocinctus (Giard). Comopraga no Estade de Ceara. Fitossanidade 1 (3): 71-72.

*Cottier, W. 1931. The transmission of virus diseases of the Potato by insects. N.Z.J. Sci. Tech. 13(2): 85-95.

*Cottier, W. 1932. An insect survey of potato foliage in Newzealand. N.Z.J. Sci. Tech. 13 (3): 125-139.

*De Fluiter, H.J. 1935. Investigations and observations regarding mealy bugs. Bergcultures 10: 25 & 27.

*Esaki, T. 1936. Verzeichniss der Hemiptera-Heteroptera der Insel Formosa. (List of the Heteroptera of Formosa). Ann. List. nat. Mus. natnl. hung. 24: 136-189.

Fennah, R.G. 1962. Nutritional factors associated with seasonal population increase in cocoa thrips Selenothrips rubrocinctus Giard (Thysanoptera) on cashew Anacardium occidentale. Bull. Ent. Res. 53: 681-715.

Fletcher, T.D. 1914. Some South Indian Insects. Government Press, Madras. 565pp.

*Gopalan, M. 1975. Studies on the feeding behaviour of Ragmus importunitas Distant (Hemiptera: Miridae) and estimation of its feeding rates. Labdev Journal of Science and Technology 13: 38-43.

*Imms, A.D. and Chatterjee, N.C. 1915. On the structure and biology of Tachardia lacca, Kerr, with observations on certain insects predacious or parasitic upon it. Indian Forest. Mem., Forest Zool: Ser. 2 (1).

*Issac, P.V. 1933. Report of the Imperial Entomologist. Sci. Rep. Inst. agric. Res. Pusa. 168-174.

Kushwaha, K.S. and Bhardwaj, S.C. 1967. Biology and external morphology of forage posts. Tussock caterpillar, Euproctis sp. (Lymantriidae: Lepidoptera). Indian J. agric. Sci. 37 (2): 93-107.

Lefroy, H.M. 1909. Indian Insect Life. Government of India. 544pp.

Mohammad Ali, S. 1962. Some new host plants of Ferrisiana virgata Ckll. in Bihar, India (Pseudococcidae: Hemiptera). Indian J. Ent. 23 (3): 236-238.

Mondal, P.K., Basu, R.C. and Raychaudhuri, D.N. 1976. Studies on the aphids (Homoptera: Aphididae) from eastern India. Oriental insects 10 (4): 533-540.

Murthy, M.M.K., Sayi, I.V., Rao, S.V. and Rao, B.H.K. 1974. Note on the biology of shoot and blossom webber Macalla moncusalis Walker (Lepidoptera: Pyralidae) of cashew. Indian J. Ent. 36 (1): 76-77.

Ohler, J.G. 1979. Cashew. Koninklijik Instituut voor de Tropen, Amsterdam. 168-201.

*Otanes, F.Q. and Butac, F.L. 1935. A preliminary study of the insect pests of cotton in Philippines with suggestions for their control. Philipp. J. agric. 6 (2): 147-174.

*Padmanabha Ayyar, K.S. 1943. Notes on two major Caterpillar pests of Eugenia jambos (Rose Apple). J. Bombay nat. Hist. Soc. 43 (4): 673-675.

Pandey, S.N. 1969. Observations on the biology of castor hairy caterpillar Euproctis lunata Walker (Lepidoptera: Lymantriidae). Indian J. Ent. 30 (4): 263-265.

Pillai, R.M. 1921. Short notes on the insect pests of crops in Travancore. Travancore Dept. agric. 53pp.

Pillai, G.B. and Abraham, V.A. 1975. In. C.P.C.R.I. Annual Report for 1974. Kasaragod, India. 132-133.

Pillai, G.B. and Abraham, V.A. 1975. Tea mosquito, a serious menace to cashew. Indian cashew Journal 10 (1): 5-7.

Pillai, P.K.T. and Pillai, G.B. 1975. Note on the shedding of immature fruits in cashew. Indian Journal of Agricultural Sciences 45 (5): 233-234.

Pillai, G.B., Dubey, O.P. and Vijay Singh. 1976. Pests of cashew and their control in India - a review of current status. J. of plant crops 4 (2): 37-50.

*Pratap Singh. 1964. Studies on the pests of Rauwolfia serpentina Benth exkurz. Indian For. 90 (12): 839-842.

Puttarudraiah, M. 1947. Some observations on the biology and habits of red gram flower bud borer (Euproctis scintillans W). Mysore agric. J. 26 (2): 20-24.

Puttarudraiah, M. and Appnna, M. 1965. Two new hosts of Helopeltis antonii Sign. in Mysore. Indian J. Ent. 17: 391-392.

Ramakrishna Ayyar, T.V. 1929. The economic status of Indian Thysanoptera. Bull. Ent. Res. 77-79.

*Ramakrishna Ayyar, T.V. 1932. Bionomics of some thrips injurious to cultivated plants in South India. Agric. Live Stk, Ind. 391-403.

Rawat, R.R. and Modi, B.N. 1968. Studies on biology of Ferrisia virgata Ckll. (Pseudococcidae: Homoptera) in Madhya Pradesh. Indian Journal of Agricultural Science 39 (3): 274-281.

Rao, Y.R. 1915. Helopeltis antonii as a pest of neem trees. Agric. J India 10: 412-416.

Remamony, K.S. and Abraham, C.C. 1977. New record of Pachypeltis maesarum Kirkaldy (Miridae:Hemiptera) as a pest of cashew in Kerala. Sci. and Cult. 43: 533.

Rutherford, A. 1913. Report of the Entomologist. Rept. Ceylon Dept. Agric. from July 1, 1912 to December 31, pp 9-12.

Sathiamma, B. 1976. In C.P.C.R.I. Annual Report for 1975. Kasaragod, India. 132-133.

Sathiamma, B. 1977. Nature and extent of damage by Helopeltis antonii S. the tea mosquito on cashew J. of Plant Crops 5 (1): 58-59.

Sathiamma, B. 1978. Occurrence of insect pests on cashew. Cashew Bull. 15 (4): 9-10.

*Sevastopulo, D.G. 1943. Pests of tea. J. Bengal nat. Hist. Soc. 18 (1): 20-21.

Sreeramulu, C., Premakumar, T., Mariamma Daniel and Sathiamma, B. 1975. Record of new pests of cashew, Popillia complanata Newm., Pingasa ruginaria Gn., and Estigmone lactinea C. Journal of Plantation Crops 3 (1): 38.

*Subramania Ayyer, T.V. 1922. Notes on the more important insect pests of crops in the Mysore State. III. Diptera-IV. Rhynchota. Jl. Mysore Agric & exptl. union 1: 18-24.

Sudhakar, A.M. 1975. Role of Helopeltis antonii Sign. (Hemiptera: Miridae) in causing scabs on guava fruits, its biology and control. Mysore J. agric. Sci. 9 (1): 205- 206.

Swaine, G. 1959. Preliminary note on Helopeltis sp. damaging cashew in Tanganyika Territory. Bull. Ent. Res. 50: 181-197.

*Teotia, T.P.S. and Chaudhuri, S. 1966. Some observations on the life history of Euproctis fraterna Moore (Lepidoptera: Lymantriidae) on cashew. Labdev J. Sci. Technol. 4 (1): 45-47.

* Originals not seen

APPENDIX

Analysis of variance table for the seasonal fluctuation of H. antonii at different stations.

Appendix I

Source	df	SS	MS	F
Total	179	47.20		
Station	5	4.17	0.83	7.55**
Month	2	24.54	12.27	111.55**
Interaction	10	1.41	0.14	1.27
Error	162	17.08	0.11	

** Significant at one per cent level of significance.

Analysis of variance table for the mean score values indicating the degree of natural field infestation of floral branches by H. antonii at different localities during different periods.

Appendix II

Source	df	SS	MS	F
Total	179	129.11		
Station	5	21.63	4.33	30.93**
Month	2	63.76	31.88	227.7 **
Interaction	10	21.77	0.22	1.57
Error	162	21.95	0.14	

** Significant at one per cent level of significance.

Analysis of variance table for seasonal fluctuation of Ragmus sp. at different stations.

Appendix III

Source	df	SS	MS	F
Total	179	254.06		
Station	5	14.63	2.92	6.08**
Month	2	146.66	73.33	152.77**
Interaction	10	15.30	1.53	3.19**
Error	162	77.48	0.48	

** Significant at one per cent level of significance.

Analysis of variance table for seasonal fluctuation of *F. virgata* at different stations.

Appendix IV

Source	df	SS	MS	F
Total	179	63.14		
Station	5	3.03	0.61	2.44
Month	2	6.28	3.14	12.56**
Interaction	10	3.61	0.86	3.44**
Error	162	40.22	0.25	

** Significant at one per cent level of significance.

Analysis of variance table for the seasonal fluctuation of H. ganglbaueri in different stations.

Appendix V

Source	df	SS	MS	F
Total	179	143.44		
Station	5	29.15	5.83	41.64**
Month	2	46.30	23.15	165.34**
Interaction	10	45.83	4.58	32.71**
Error	162	22.16	0.14	

** Significant at one per cent level of significance.

Analysis of variance table for seasonal fluctuation of Beetles at different stations.

Appendix VI

Source	df	SS	MS	F
Total	179	134.43		
Station	5	11.47	2.29	5.08**
Month	2	32.95	16.47	36.6 **
Interaction	10	16.26	1.63	3.62**
Error	162	73.75	0.45	

** Significant at one per cent level of significance.

Analysis of variance table for seasonal fluctuation of *H. haligramma* at different stations.

Appendix VII

Source	df	SS	MS	F
Total	179	57.17		
Station	5	8.18	1.636	7.81**
Month	2	5.71	2.85	13.57**
Interaction	10	9.29	0.93	4.43**
Error	162	33.99	0.21	

** Significant at one per cent level of significance.

Analysis of variance table for seasonal fluctuation of Thalassodes sp. at different stations.

Appendix VIII

Source	df	SS	MS	F
Total	179	427.64		
Station	5	2.47	0.49	0.19
Month	2	1.14	0.57	0.22
Interaction	10	2.18	0.22	0.08
Error	162	421.85	2.60	

Analysis of variance table for the seasonal fluctuation of Eucrostes sp. at different stations.

Appendix IX

Source	df	SS	MS	F
Total	119	7.61		
Station	5	1.70	0.34	11.33**
Month	1	0.14	0.14	4.67
Interaction	5	2.93	0.59	19.67**
Error	108	2.84	0.03	

** Significant at one per cent level of significance.

Analysis of variance table for the seasonal fluctuation of S. nr. erythrina at different stations.

Appendix X

Source	df	SS	MS	F
Total	119	6.62		
Station	5	1.15	0.23	11.50**
Month	1	0.10	0.10	5.00
Interaction	5	3.50	0.70	35.00**
Error	108	1.87	0.02	

** Significant at one per cent level of significance.

Appendix XI

List of insects collected from cashew inflorescence in Kerala.

Common name	Scientific name	Family	Order
Tea mosquito	Helopeltis antonii Signoret	Miridae	Hemiptera
Mirid bug	Ragmus sp.	Miridae	Hemiptera
Coreid bug	Leptocorisa sp.	Coreidae	Hemiptera
Plataspid bug	Coptosoma sp.	Plataspidae	Hemiptera
Jassids	Tettigoniella ? ceylonica Melich.	Cicadellidae	Hemiptera
	Batracomorphus linnavuorii Kameswara Rao and Ramakrishnan	Cicadellidae	Hemiptera
Brown aphid	Toxoptera odinae vander Goot	Aphididae	Hemiptera
Mealy bug	Ferrisia virgata Cockerell	Pseudococcidae	Hemiptera
Thrips	Haplothrips ganglbaueri Schmutz	Phlaeothripidae	Thysanoptera
Beetles	Silvanolomus denticollis Rtt.	Silvanidae	Coleoptera
	Melanophthalma sp.	Lathridiidae	Coleoptera
	Berginus maindromi Grouv.	Mycetophagidae	Coleoptera
Weevil	Amblyrhinus poricollis Schonh.	Curculionidae	Coleoptera
Shoot tip and inflorescence caterpillar	Hypatima haligramma Meyrick	Gelechiidae	Lepidoptera

(Contd....)

(Appendix XI contd...)

Common name	Scientific name	Family	Order
	Unidentified Gelechiidae	Gelechiidae	Lepidoptera
Tussock caterpillars	Euproctis sp.	Lymantriidae	Lepidoptera
	Porthesia xanthorrhoea Kollar	Lymantriidae	Lepidoptera
Looper caterpillars	Thalassodes sp.	Geometridae	Lepidoptera
	Eucrostes sp.	Geometridae	Lepidoptera
Noctuid caterpillars	Selepa sp.	Noctuidae	Lepidoptera
	Unidentified Noctuidae	Noctuidae	Lepidoptera
Phycitid caterpillars	Spatulipalpia nr. erythrina Hampson	Phycitidae	Lepidoptera

THE PEST COMPLEX INFESTING CASHEW INFLORESCENCE

BY

B. BALA SUBRAHMANYAM

ABSTRACT OF THE THESIS

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ABSTRACT

To study the pest complex infesting cashew inflorescence in Kerala, a detailed survey has been conducted in different parts during the period from November 1980 to April 1981. Various pests infesting cashew inflorescence in different localities, their seasonal fluctuations and nature of damage are summerised below.

1 Hemipteran pests

1.1 Helopeltis antonii

Population level and damage intensity are lower at Kasaragod and higher at Madakkathara. Lower during March and higher during January. Nymphs and adults suck sap from tender leaves, floral branches, developing nuts and apples.

1.2 Ragmus sp.

Population level is highest at Calicut and Madakkathara and lowest at Kottarakkara. Lower during March and higher during January. Both nymphs and adults suck sap from floral parts.

1.3 Leptocorisa sp.

Noted at Vellanikkara, Kalady and Madakkathara during December-January. Adults suck sap from floral parts and inflorescence axis.

1.4 Coptosoma sp.

Noted at Kalady during January-February. Adults suck sap from floral parts and inflorescence branches.

1.5 Tettigoniella? ceylonica

1.6 Batracomorphus linnavuorii

Both the species are noted at Kalady, Vellanikkara, Anakkayam, Calicut and Kasaragod during January-February. Both nymphs and adults suck sap from tender leaves and inflorescence.

1.7 Toxoptera odinae

Noted only at Madakkathara. Both nymphs and adults congregate in clusters around the flower stalk and tender nutsand suck sap.

1.8 Ferrisia virgata

Population level is highest during February. Both nymphs and adults cluster on the inflorescence stalk, on fruit and tender nuts and suck sap.

2 Thysanopteran pests

2.1 Haplothrips ganglbaueri

Population level is lowest at Kasaragod and highest at Kalady. Lower during January and higher during March. Both nymphs and adults feed by lacerating the surface tissues of the inflorescence.

3 Coleopteran pests

3.1 Silvanolomus denticollis

3.2 Melanophthalma sp.

3.3 Berginus maindroni

Population density of the three species of beetles together are higher during February. Adults feed on pollen grains.

3.4 Amblyrhinus poricollis

Noted at Kalady and Calicut during January. Adults feed on the leaves and flowers by cutting small holes.

4 Lepidopteren pests

4.1 Hypatima haligramma

Population level is lowest at Kasaragod and highest at Madakkathara and Kalady. Lower during March and higher during January and February. Caterpillars feed on leaves and bores into shoot tip and inflorescence.

4.2 Euproctis sp.

Noted at Vellanikkara and Madakkathara in September and at Calicut and Kalady during December-January. Caterpillars feed on leaves and inflorescence.

4.3 Porthesia xanthorrhoea

Noted at Vellanikkara and Madakkathara during December-January. Caterpillars feed on leaves and inflorescence.

4.4 Thalassodes sp.

This is having uniform distribution in all the

areas and during all the months. Caterpillars feed on the leaves and inflorescence.

4.5 Eucrostes sp.

Population density is lower at Kasaragod and Calicut and higher at Kalady and Anakkayam. Noticed from February to March. Caterpillars feed on buds and flowers.

4.6 Selepa sp.

Noted at Vellanikkara and Madakkathara during November to February. Caterpillars feed on leaves and inflorescence.

4.7 Spatulipalpia nr. erythrina

Population level is lowest at Kasaragod and Kottarakara and highest at Kalady and Madakkathara. Noticed from February to March. Larva web the inflorescence, with fine silken threads and feed inside.

Out of 20 species of insects recorded on the cashew inflorescence, the following are reported for the first time, Ragmus sp. (Miridae:Hemiptera), Leptocorisa sp. (Coreidae:Hemiptera), Coptosoma sp. (Plataspididae:Hemiptera), Tettigoniella? ceylonica Melich. (Cicadellidae:Hemiptera), Batracomorphus linnavuorii Kameswara Rao and Ramakrishnan (Cicadellidae:Hemiptera), Haplothrips ganglbaueri

Schmutz (Phlaeothripidae: Thysanoptera), Silvanolomus denticollis Rtt. (Silvanidae: Coleoptera), Melanophthalma sp. (Lathridiidae: Coleoptera), Berginus maindroni Grouv (Mycetophagidae: Coleoptera), Porthesia xanthorrhoea Kollar (Lymantriidae: Lepidoptera), Eucrostes sp. (Geometridae: Lepidoptera), Selepa sp. (Noctuidae: Lepidoptera), Spatulipalpia nr. erythrina Hampson (Phycitidae: Lepidoptera).