INSECT PESTS OF SELECTED MEDICINAL PLANTS: BIONOMICS AND MANAGEMENT

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled **"Insect pests of selected medicinal plants: Bionomics and management"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

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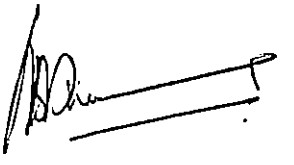
CERTIFICATE

Certified that the thesis entitled **"Insect pests of selected medicinal plants: Bionomics and management"** is a record of work done independently by **Sri. Rajan, V.P.** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.



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Introduction

INTRODUCTION

Man's relationship with medicinal plants is as old as man himself and the practice of using herbs as medicine also dates back to the earliest periods of human history. In the present trend of "back to nature and health for all", Ayurveda after years of neglect is in the path of resurgence. Advances in phytochemistry and identification of plant compounds effective against a wide spectrum of diseases have renewed the interest in herbal medicine especially during the last two or three decades. The health tourism is another area gaining momentum today where Ayurveda is increasingly being linked to tourism. The great potential of green remedies in human, veterinary and plant health stands well recognised at present. The green remedies have components acting additively or synergistically providing protective, preventive and curative roles.

The last three decades have seen revival of interest in plant-based drugs. There is a definite trend to adopt plant-based medicaments even in the western societies due to the cumulative derogatory and effects produced by the irrational use of synthetics and antibiotics. The availability of plant-based drugs is mainly from the natural resources like forests and wastelands. But due to ever increasing utilization of land for food crops, devastation of forests and concurrent indiscriminate destruction of these vegetation, their availability from the natural sources have declined. On the other hand the demand for these plants and their products both for domestic use and for export has been increasing, necessitating the production of these crops in a larger scale. This fact has been very strongly indicated in the reports of many UN agencies, advocating greater attention on these crops as a means of socio-economic uplift of the people of the developing nations.

India has a leading position in the production, world trade in plant drugs and intermediaries obtained from Opium poppy, Isabgol, Senna, Rauvolfia, Cinchona, Periwinkle, Gloriosa, Papaya (Papain) and Ipeae. Although no commercial survey has been made, the export earnings from this sector is reported to account for 1000 million

rupees annually. There are over 5000 small and medium scale manufacturing units for drug formulations based on raw materials of plants origin which together is estimated to be anywhere between 3000 to 5000 million rupees worth of raw materials.

Kerala is one of the few states in India which has very rich vegetation representing evergreen, semi-evergreen, deciduous, shrub and shola forests. The geographical location with salubrious climate is congenial for the cultivation of a majority of commercially important medicinal plants. In fact some of the plants like *Neelamari, Atapathiyan, Chethikoduveli, Thippali, Vallippala, Tulsi, Kacholam, Chakkarakkolli* are attempted to be under commercial cultivation in the state.

Among the various constraints in the successful production of medicinal plants, the injury caused by insect species is a serious one. Like other cultivated plants, almost all medicinal plants are susceptible to one or the other pest species. However, as these plants are newly domesticated ones, information on the insect pests of medicinal plants in general and their management, in India and Kerala are particular is meager. The practical feasibility and management practices are very much lacking. Stray information available on the control aspects advocate always indiscriminate spray of insecticides.

The diverse consumers of medicinal plants include traditional physicians, folk healers, pharmacies, cosmetic and beauty shops, households etc. The ever increasing demand for medicinal plants is met by collection from wild sources often adopting non-sustainable methods. Thereby, many of the medicinal plants have become endangered or even extinct. Considering the importance and diverse role of medicinal plants now, concerted efforts are now being taken in the popularisation of these plants. Domestication and cultivation of medicinal plants are quite different from that of the conventional agricultural crops in that the technology development integrates quality with quantity. Hence, development of suitable production technologies particularly pest and disease management of medicinal plants is indispensable in domestication and cultivation of medicinal plants.

It is in this background the research program entitled "Insect pests of selected medicinal plants: Bionomics and management" has been taken up covering ten different medicinal plants of commercial importance.

The main objective of the study include,

1) Collection and identification of pests on selected medicinal plants.
2) Studies on bionomics of key pests.
3) Management of key pests using botanicals.

Review of Literature

2. REVIEW OF LITERATURE

The available literature pertaining to various aspects of insect pests of important medicinal plants, their identification, bionomics and management using botanical insecticides is presented below.

2.1 INSECT PESTS OF MEDICINAL PLANTS

The literature so far has clearly revealed the absence of systematic studies on insect pests of medicinal plant. Boshart (1934) recorded different insect pests on 40 medicinal plants cultivated in Germany and neighboring countries. Ziarkiewicz (1951) gave a description of 31 insect pest species on medicinal plants of which 16 were noted for the first time in Poland. Maximum number of species were observed during July and August in those areas.

Fifty-two different species of insect pests attacking 57 medicinal and aromatic plants, both cultivated and wild conditions were recorded in Jammu and Kashmir (Mathur and Srivastava, 1967). About 72 insect species belonging to 16 families under Coleoptera and 38 species of Hemiptera were found to attack 84 species of medicinal plants in Bulgaria (Popov, 1972, 1973a). Seven insect pests attacking 13 medicinal plants including the economically important part of the plant and the season of attack were reported by Tiwari and Joshi (1974) from Uttar Pradesh. The association of 16 species of Heteroptera and 12 species of Homoptera was observed on 12 families of medicinal plants in London (Davis, 1983).

Injuriousness of 70 pests and 60 diseases of the medicinal crops were reported in the Moldavia region of North-Eastern Romania (Sapunaru, 1987). One hundred and fifteen species of phytophagous insects found on medicinal plants along with the season of their occurrence, frequency and degree of damage, in USSR (Kuznetsova and Nosyrev, 1989) had been documented.

2.1.1 Order: Orthoptera

2.1.1.1 Family: Acridiidae

The long horned grasshopper *Acrida conica* Fab. appeared in large numbers and caused damage to young trees of *Duboisia myoporoides* Brown and *D. leichhardtii* F. with loss of foliage (Smith, 1974).

Ali (1980) observed that *Solanum nigrum* Linn., *Datura stramonium* Linn., *Ricinus communis* Linn., *Achyranthus aspera* Linn. and *Abutilon indicum* Linn. were all attacked by Bombay locust *Nomadacris succincta* (Linn.) According to him, the seedlings were more prone to damage than mature plants.

2.1.1.2 Family: Pyrgomorphidae

The wingless grasshopper of millets, *Neorthacris simulans* (Boliv) was reported as a serious pest of *Rauvolfia serpentina* Benth. nibbling leaves from edges inward to the midrib (Singh, 1964). Both adults and nymphs of *O.simulans and Acrida exaltata* Walk. were found feeding on leaves of Periwinkle, *Catharathus roseus* L.Don (Reddy *et al.*,1981).

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2.1.2 Order: Hemiptera

2.1.2.1 Family: Aphididae

The *Aconitum* crop was infested by *Aphis nepelli* Schr. and *A. rumicis* Linn. Aphids were found to suck sap from leaves and stems of Papaver. They were also found attacking the Hemlock (Zacher, 1921).

Aphids were reported to cause twisting and distortion of tender and succulent parts of *D. myoporoides* and *D. leichhardtii* (Smith, 1974).

Bhagat (1987) recorded from Kashmir 16 species of medicinal plants attacked by 12 species of aphids. Seasonal occurrence of aphids, abundance and role of parasitoids as biocontrol agents were also studied.

Singh *et al.* (1986) studied the phenology and chemical control of *Myzus persicae* Sulzer on *Hyoscyamus niger* Linn. and *H. mutius* Linn. The appearance of this aphid on the plant was noticed during January. Their population increased with increase in temperature. Rainfall and relative humidity had no effect on aphid population.

Further, Singh (1999) reported *M. persicae* Sulzer on *Atropa belladona* and *Hyoscyamus* sp. during their vegetative phase i.e. in January-March. *Dioscorea floribunda*, *Plantago ovata* and *Withania somnifera* Linn. were reported to be infested during their flowering stage by *Aphis* sp. *A. craccivora* was infesting on *Pelargonium graveolens* during November-December, *Aphis* sp. on *Cymbopogon martini* from January-March and *Macrosiphum* sp. on *Rosa damacina* during March-May were come of his other observations.

2.1.2.2 Family: Cicadellidae

Muhle (1953) reported that leafhoppers of *Empoasca* spp. and *Eupterix* spp. cause serious damage to medicinal plants especially *Melissa officinalis* Linn.

White spots on the leaves were the first symptom of attack and plants eventually died due to loss of chlorophyll, as feeding continued.

Two species of leafhoppers *E. flavescens* Fab. and *E. pteridis* Dhlb. predominated on *Digitalis lanata* Ehrh. and *Valeriana officinalis* Linn. They were having two generations in a year on medicinal plants, the first in May and the second in July-August (Nowacka and Adamskawilczek, 1974).

They were also reported that leafhoppers, *Eupterix atropunctata* Goeze, *E. collina* Flor, *E. origani* Zkhv., *E. strachydearum* Hardy predominated on *Mentha piperita* Linn., *M. officinalis* and *Salvia officinalis* Linn. in USSR.

The pink edged leafhopper *Colgar paracuta* Mel.and Green leafhopper *Siphanta* spp were caused twisting and distortion of the young growth of *D. myoporoides* and *D. leichhardtii* (Smith, 1974).

Adults and nymphs of *Amrasca biguttula biguttula* (Ishida) were occasionally found to suck sap from *C. roseus* leaves (Reddy *et al.*, 1981).

2.1.2.3 Family: Coccidae

The nymphs of the scales *Saissetia nigra* Neitn were reported to feed on the under surface of leaves, the stem and branches of *R. serpentina* Benth (Singh, 1964).

Twigs of *D. myoporoides* and *D. leichhardtii* were infested with brown olive scale *Saissetia oleae* Bem. Heavily infested trees were covered with black sooty mould due to sugary secretion from scales (Smith, 1974).

Aonidiella auranti were seen infesting *Rosa damacina* during July-October (Singh, 1999).

2.1.2.4 Family: Coreidae

The lab lab pod bug, *Riptortus pedestris* Fab. had been considered as a minor pest of *R. serpentina* (Singh, 1964).

The gundhi bug, *Leptocorisa acuta* Thumb. a major pest of rice was found to overwinter on *Blumea lacera* Burni from November-February. They were found to feed during March-April on the new flushes of Mango, *Mangifera indica* Linn.(Lal and Mukharji, 1975).

2.1.2.5 Family: Ricaniidae

In an investigation of Fulgorid plant hoppers in the tea gardens of Hunan Province of China, out of the five species recorded for the first time as tea pests, *Ricania marginalis* and *R. sublimbata* were the major ones (Tan, 1995).

2.1.2.6 Family: Lygaeidae

The lygaeid bug, *Lygaeus militaris* Fab. were observed feeding on leaves, buds, flowers and developing pods of *C. procera* (Parihar, 1981). These bugs occurred in the beginning of July and thereafter its population increased gradually.

2.1.2.7 Family: Membracidae

Mohammad *et al.* (1996) reported about two new species of tree hoppers attacking medicinal plants. Particular reference to male and female genitalia and their cladistic relationships were also discussed.

2.1.2.8 Family: Plataspidae

The bug *Coptosoma duodecimpunctatum* Germ. was found to feed on berries of *R. serpentina.*

2.1.2.9 Family: Pentatomidae

Plautia viridicollis West. had been recorded as a major sucking pest of *R. serpentina* (Singh, 1964).

The green stink bug *Plautia affinis* Dall. and *Nezara viridula* Linn. occurred on *D. myoporoides* and *D. leichhardtii.* They were seen to suck the sap from young shoots but the damage was not significant (Smith, 1974).

Reddy *et al.* (1981) reported both adults and nymphs to suck the sap from tender shoots of *C. roseus.*

2.1.2.10 Family: Psyllidae

Extensive wilting and drying of Indian Indigo, *Indigofera tinctoria.* Linn. were reported due to the infestation by a psyllid, *Arytaina punctipennis* which was a new record of the pest from Southern India (Skaria *et al.*, 1996).

2.1.2.11 Family: Pyrrhocoridae

New report of *Dysdercus cingulatus* Fabricus as a pest on plants and seedlings of Karanj (*Pongamia pinnata*) was made by Meshram *et al.* (1988).

2.1.2.12 Family: Tingidae

The occurrence of lace bug *Monanthia globulifera* W. damaging Tulsi, *Ocimum sanctum Linn.* in South Andaman along with morphology and biology of this pest was studied by Chandra (1992).

2.1.3 Order: Thysanoptera

2.1.3.1 Family: Thripidae

Taeniothrips atratus Hal. was recorded on *A. belladonna, Centaurea jacea* Linn and *Datura innoxia. Thrips flavus* Schr. and *T. physapus* Linn. were the other

two thrips on *C. jacea, T. tabaci* Lind.and on *Matricaria inodora* Linn. (Popov, 1973b).

Thrips, *Frankliniella* sp. was reported to infest *A. annua* during April-May and on *C. martini* during October-December (Singh, 1999).

2.1.4 Order: Lepidoptera

2.1.4.1 Family: Arctiidae

Black headed hairy caterpillar *Spilosoma oblique* Walker has been found defoliating about a dozen species of medicinal plants, the important ones being *Ocimum* spp. and *W. somnifera* (Mathur, 1962b).

2.1.4.2 Family: Danaidae

The larvae of *Danais crysippus* Linn. were present on the shrubs of *C. procera* throughout the monsoon season from July to October with its peak population during August (Parihar, 1981).

Chaturvedi and Haribal (1992) studied Cannibalism in butterfly larvae and reported consumption of conspecific eggs by larvae of *Danaus genutia* Cramer.

Oshaki (1995) studied preferential predation of female butterflies and the evolution of Batesian mimicry. Differential predation of males and females of Papilionidae, Pieridae and Danaidae that show Batesian mimicry was discussed with particular reference to *Papilio polytes* Linn. a and *Pachliopta aistolochiae* Fab.

2.1.4.3 Family: Gelechiidae

The larvae of *Gelechia malvella* Hub. were found feeding on seeds of *Althea officinalis* Linn. (Zacher, 1921 and Belski, 1924).

2.1.4.5 Family: Papilionidae

2.1.4.4 Family: Noctuidae

Parfentjev (1921) observed that the leaves and flowers of *A. belladonna* were attacked by the larvae of *Barathra brassicae* Linn. and *Helicoverpa peltigera* Schiff. The leaves of *Papaver sp.* were also infested by the same larvae (Zacher, 1921). He also found that the larvae of *Agrotis baja* Fab. and *Gortyna flavago* Schill were attacking *Atropa* spp. and *Digitalis* sp. respectively.

Belski (1924) observed the semilooper of *Phytometra gamma* on *Salvia officinalis* Linn.

The cutworm *Agrotis ypsilon* Rott. was attacking the young plants of *A. belladonna* and caused damage up to 10 per cent (Mathur, 1962a).

Smith (1974) reported that cut worms attacked the seedlings of *D. myoporoides* and *D. leichhardtii.* and larvae of *Spodoptera litura* Fab. defoliate the same.

The larvae of *Anomis flava* Fab. were found to web the top shoots and feed on leaves, buds, flowers and tender parts of *C. roseus* (Reddy *et al.*, 1981).

Devasthali and Saran (1997) have concluded a study on pest complex of Okra during Kharif season in Malwa region of Madhya Pradesh. In the field experiment, to identify the pest infesting Okra, of the six insect pests, the noctuid *Earias vitella* (Fb.) were seen to infest the crop from the age of seven days till maturity.

Studies on fruit loss in okra due to the attack by *E. vitella* (Dubey and Ganguli, 1998) revealed avoidable losses.

2.1.4.5 Family: Papilionidae

Mathew (1998) mass reared selected butterflies for possible reintroduction in conservation programs. Based on the data gathered the common rose (*Pachliopta arislolochiae*) was selected for mass rearing.

The morphology, culture, structure and innervation of the spiracles of the instars and adults of Papilionids were examined (Schmitz and Wasserthal, 1999). In adults of *P. aristolochiae* all cuticular parts (bow, bar and lever) of the value were inervated by multipolar-dendrites.

Studies on the influence of semi-synthetic diet for *P. aristolochiae* by Ying *et al.* (1999) revealed no significant difference between the optimal diets and fresh foliage of *Aristolochia tagala* on the larval development and mean pupal weight of *Atrophaneura aristolochiae.*

2.1.4.6 Family: Pyralidae

Loxostege sticticalis Linn. was reported infesting numerous medicinal plants such as Matricaria, Peppermint, Thyme, Calendula, Poppy and Isabagal in USSR (Nosyrev, 1978).

Larvae of *Glyphodes vertumnalis* Guen. roll the leaves of *R. serpentia* and remain inside by feeding on the green matter (Sivagami and Narayanaswamy, 1962).

Diaphania nilgirica Hamm. has been reported as a pest of *R. serpentia* where the larvae were found feeding on leaves and flowers (Singh, 1964).

Euzophera perticella Rag. was reported to damage as a stem borer of *Solanum aviculare* Forst. Its incidence peaked during June-September, when more than 95 per cent of the plants were killed. Infested plants developed wilt symptoms and finally died due to severe damage to stem tissue. Large quantities of frass was found oozing out from holes near the nodes of the plants (Srivastava and Saxena, 1965).

Syngamia abruptalis walker was recorded as a serious pest of sweet basil, *O. basilium* in Thailand (Anont, 1990). Ten species of the family Labiatae were found to be food plants of which *O. sanctum* is one.

2.1.5 Order: Coleoptera

2.1.5.1 Family: Cetonidae

Cetonid beetle *Oxycetonia versicolor* was observed causing serious damage to brinjal at Tamil Nadu (Ambethyar, 2000).

2.1.5.2 Family: Chrysomelidae

The adult beetles of *Cassida viridis* Linn. and the grubs and adults of *Cryptocephalus ocellatus* Drap. were found to perforate the leaves of *M. officinalis* Linn. (Parfentjev, 1921).

Parfentjev (1921) again reported that flea beetles of *E. pubescens* Koch. nibble the leaves of *A. belladona* and oviposit during the summer in the ground. The larvae hatch in seven to eight days and remain in the soil where they pupate and adult emerge after six or seven days. These beetles were also observed on *Hyoscymnus* spp. (Zacher, 1921).

The leaf beetle, *Lema trilineata* Oliv. was found feeding on *D. stramonium* Linn., *Solanum*, *Physalis*, Henbane and *Belladona* in Columbia (Chittendev, 1924).

Jackson (1997) had made a study on the biology of the chrysomelid *Apthona nigritis*. Life history data were similar to other univaltine *Aphthona* sp. except that these had a female based sex ratio, greater male longevity and higher female oviposition.

Pest injuring the Linseed crop were monitored in South East England. Adult flea beetles *Aphthona euphorbiae* were reported to cause severe injury to seedlings (Furguson *et al.*, 1997).

Experiments were conducted on the life history, feeding and reproductive potential of *Colasposoma semicostatum* Jack. (Singh *et al.*, 1997). Only one alternate

host plant of *C. semicostatum* was recorded out of twenty forest tree species screened in the laboratory.

2.1.5.3 Family: Coccinellidae

Subcoccinella vigintiguatuorpunctata Linn. was found to feed on *Saponaria officinalis* Linn. (Belski, 1924).

Henosepilachna vigintioctopunctata Fab. has been reported as a defoliator of some solanaceous medicinal plants (Mathur and Srivastava, 1964). It was also recorded on *D. myoporoides* and *D. leichhardtii* (Smith, 1974).

2.1.5.4 Family: Curculionidae

Ramesh (1994) has reported the specificity of the weevil *Lixus truncatulus* Fab. to the weed *Polygonum glabrum* in no choice, single choice and multichoice test in cage experiments. The insect was not observed feeding in the wild on any plant other than *P. glabrum.*

2.2 MANAGEMENT USING BOTANICALS

A comprehensive review of work done on the plant products and there utilization as pest control agents by virtue of their antifeedant activity has been done.

2.2.1 Antifeedant action

Neem

The practical utility of neem as a pest control agent was first demonstrated by Pradhan *et al.* (1962).

Ketker listed 95 publications on insect repellency and antifeedancy of neem derivatives (1976). In 1990 Schmutter reported that Lepidopterans, in general are highly sensitive to neem derivatives in laboratory conditions. Singh (2000) also reported about 103 insect pest species in different orders which are sensitive to neem.

2.2.2 Neem leaf extract

In India the first detailed experiment employing neem leaf extract was conducted on the desert locust *Schistocerea gregoria* Forsk. by Chopra (1928). The neem leaf extract at 15 per cent gave 75.5 per cent protection against *S. litura* (Koshiya and Ghelani, 1993). Antifeedant effect against *Pericallia ricini* F. and *Selepa docilis* Bull. at 5 per cent was found out by Jacob and Sheila (1994). Ninety nine per cent protection of castor leaves against *Spilosoma obliqua* Walker was also obtained at 5 per cent leaf extract (Tripathi and Singh, 1994). Kumar *et al.* (1997) reported the antifeedant effect of terminal reddish flushes extracts of the neem leaves on *S. litura*. Sergent (1944) found that the extract of fresh or dry leaves either by maceration or by decoction was effective in preventing the feeding of desert locust *Schistocerca gregoria* Forsk.

Chari and Muraleedharan (1983) found 10 per cent extract of neem leaves to be an effective feeding deterrent against castor semilooper *Achoea janata* Linn. While Singh and Sharma (1986) observed strong repellent and antifeedant action of water extracts of neem leaves at 1 and 5 per cent concentration against aphid *Brevicornye brassicae* Linn. when applied at 15 days interval on cabbage and cauliflower in the pots and under field conditions.

2.2.3 Neem seed kernel suspension

Pradhan *et al.* (1962) observed that 0.5 per cent aqueous suspension of neem seed kernel gave absolute deterrence to *Locusta migratoria* (Linn.) and even at 0.01 per cent the feeding of *S. gregoria* F. was completely inhibited.

The repellent action of neem seed kernel suspension against *Euproctis lunata* Walk., *Prodenia litura* F., *Utethesia pulchella* L., *Acrida exaltaka* L. and *Aulacophora fovecollis* L. were reported by Mane as early as 1968. Pradhan and Jotwani (1971) reported the superiority of crude extracts of neem over refined products. Meisner *et al.* (1980) found that neem seed kernel suspension at 0.4 to 1 per cent showed significant feeding inhibition on *Spodoptera littoralis* (Boi) On Lurcerne.

Significant protection of Citrus against *Papilio demoleus* L. (Red Knap, 1980) and Tobacco nurseries against *S. litura* Ramprasad *et al.* (1987) were reported with neem seed kernel suspension.

2.2.4 Hyptis extracts

Leaf extract of Hyptis at 10 per cent were tested against pea aphid *Aphis craccivora* by Reghunath and Gokulapalan (1996) and the results showed it to be very effective.

2.2.5 Lantana extracts

Crude extract of *Lantana camara* was found to be effective even in diluted form against mustard saw fly *A. proxima* (Pandey *et al.*, 1977). Flower extract of *L. camara* was reported to be toxic to BPH. Water extract gave more than 30 per cent mortality against *S. litura* and *Lipaphis erysini* (Desai and Desai, 2000). Khan (1944) and Lal (1986) have reported that dry leaves *of Lantana camara* gave effective control against potato tuber moth under storage.

2.2.6 Yellow oleander extract

The effectiveness as well as ineffectiveness of thevatia powders and extracts against a variety of insect species were reported (Mc Indoo, 1945; Jacobson, 1958; Deshmukh and Borle, 1975). Gattefossae (1949) attributed the insecticidal activity of *Thevatia nerifolia* Juss. to the glycoside thevetin and to another unidentified material of even greater toxicity. In India extracts of *Thevatia* leaves were used in pedicilloid (Atal and Kapur, 1977).

Materials and Methods

3. MATERIALS AND METHODS

Field surveys were conducted in herbal gardens attached to the College of Horticulture, Vellanikkara; Thycaud Moos Arya Vydasala, Chuvannamannu and Kottakkal Arya Vydasala, Kottakkal during the period from February 2002 to January 2003. All the insect pest infesting the ten selected medicinal plants viz. Indian Indigo, *Indigofera tinctoria* Linn. (Neelamari); Chhirvel, *Holostemma adakodien* Schultes (Adapathiyan); Fire plant, *Plumbago rosea* Linn. (Chethikoduveli); Indian long pepper, *Piper longum* Linn. (Thippali); Emetic Swallowwory, *Tylophora indica* (Brum.f.) (Vallippala); Tulasi, *Ocimum sanctum* Linn.; Kacholam, *Kaempferia galanga* Linn.; Indian Birthwart, *Aristolochia indica* Linn. (Karalakom); Musk mallow, *Abelmoschus moschatus* Medikus (Kasturivenda) and Periploca of the woods *Gymnema sylvestre* (Retz.)R.Br. (Madhunashini) were carefully collected, preserved and got identified. The choice of medicinal plants was on the basis of their commercial importance and wide popularity in Kerala.

A detailed study on the biology of two key pests along with their management using botanicals was carried out. Besides, influence of weather parameters on the key pest distribution were also investigated.

3.1 SURVEY

The frequency of the field survey on insect pests occurring in the ten selected medicinal plants were such that, it was weekly once from the herbal gardens of College of Horticulture, Vellanikkara and fortnightly both from the gardens of Kottakkal Arya Vydasala, Kottakkal and Thycaud Moos Arya Vydasala, Chuvannamannu.

3.2 COLLECTION, PRESERVATION AND IDENTIFICATION OF INSECTS

Different infested plant parts along with the prevailing stages of insect pests as mature and immature forms collected from the fields were promptly recorded.

A thorough scruting for their natural enemies was also made simultaneously. Different techniques were adopted for the collection and preservation of different insects.

Care was taken to collect the thrips by tapping the pepper spikes over a white paper. These collected specimens were transferred to Petridishes containing a mixture of methanol (50%) and ethyl acetate (5%) for three minutes and so as to kill them and later preserved in 70 per cent alcohol.

Similar procedure was followed for psyllids and mealy bugs.

The adult insects belonging to the orders Coleoptera, Hemiptera, Diptera and Lepidoptera were killed using a killing bottle. The killed specimen were properly mounted and dried in an oven maintained at 40-45°C for 5 hours. The specimen were accurately identified, labelled and preserved for further references.

The identification of all specimens were got done by the specialized experts from the University of Agricultural Sciences, GKVK Campus, College of Agriculture, Vellayani and Kerala Forest Research Institute, Peechi.

3.3 STUDY ON BIOLOGY

Biology of Tylophora semilooper *Dichromia orosia* and Karalakom butterfly *Pachliopta aristolochiae* were carried out under laboratory conditions.

Mass culturing the different larval instars of both the above insects found infesting the host plants in the field were collected along with their food. For rearing them in the laboratory museum jars of (19.5 cm x 12 cm x 12 cm) were used. The freshness of the leaves served as food was maintained by swabbing the petiole with moistened cotton. Special care was taken for prompt feeding and cleaning. Immature forms were taken care of till attaining maturity.

3.3.1 Fecundity

Freshly emerged adults were sexed, paired and each pair of both the insects were confined in separate wooden cages. There were ten pairs for each insect. The

wooden cages used were (48 cm x 30 cm x 30 cm) with wire mesh on all sides except the bottom so as to supply ample ventilation. Cotton swabs soaked in diluted honey kept in petridishes were also provided as adult food so as to induce egg deposition. Observations were made at 24 hrs. Interval for consequent five days. Thereafter the adults were removed and a count of total egg deposited by each pair were recorded.

3.3.2 Incubation period

Petridishes having 9.5cm dia and 8.5cm dia were used for this study. Round blotting paper of 8cm dia were placed inside the petridishes. Eggs laid were collected along with its base also placed over these blotting papers. Care was taken to wet the blotting paper. Observations for the egg emergence were taken at 24 hrs. interval and the incubation period ascertained.

3.3.3 Larval duration

Duration of each instars after hatching for both the insects were recorded. For this purpose ten larvae from both insects were isolated and supplied with right type of food for its stage. Equisize petridishes (9.5 cm) kept in position by using two rubber bands cross wise were the containers used for the first two instar rearing. For later instars glass jar (19.5 cm x 12 cm x 12 cm) covered with muslin cloth were used. Close observation for the casted off skin / exuviae was made with the help of a hand lence for the early instars. The larval period for each instar was then determined.

3.3.4 Pupal duration

At the time of attaining prepupal stage the jars were cleaned using wet tissue paper and they were allowed to pupate in hygenic condition. The duration until attaining adult hood was recorded.

3.3.5 Adult longevity

Emerging adults were collected and five freshly emerged adults were kept singly in glass jars (19.5 cm x 12 cm x 12 cm) covered with muslin cloth. Adults were

provided with diluted honey swabbed in cotton. Date of mortality of adults was recorded and there by the adult longevity calculated.

3.4 CORRELATION OF KEY PEST WITH WEATHER PARAMETERS

Different weather parameters taken into consideration include maximum temperature, minimum temperature, relative humidity, rainfall, windspeed and sunshine hours. A record of all these weather parameters prevailing in Vellanikkara campus from 1st February 2002 to 31st January 2003 was made at the Meteorology Department of College of Horticulture, Vellanikkara. A count of the two key pests namely *D. orosia* and *P. aristolochiae* throughout the year was also observed and recorded.

3.5 MANAGEMENT STUDIES

Preliminary studies on the management of key pests using botanicals were conducted in the laboratory. Formulation selected for this study include Neem Kernal Suspension (NKS) (0.3%). Neem leaf extract (3%) and 10 per cent aqueous extract each of hyptis, lantana and yellow oleander. The antifeedancy will be assayed.

3.5.1 Preparation of botanicals

3.5.1.1 Preparation of Neem Kernal Suspension (NKS) (0.3%)

For preparing NKS (0.3%), 0.3 gram of powdered neem seed was required per 100 ml of water. The required quantity of the coarse seed powder was put in a small bag of muslin cloth and dipped in water contained in a beaker for 12 hrs. Thereafter the bag was squeezed separately after dipping in the fluid until the out flowing fluid turns light brown.

3.5.1.2 Preparation of Neem Leaf Extract (3%)

To prepare 3 per cent neem leaf extract 3 grams of fresh neem leaves were thoroughly ground in 50 ml water in a waring blender. Thereafter by adding rest 50 ml water it was made to 3 per cent extract.

3.5.1.3 Preparation of 10 per cent aqueous extract

For preparing 10 per cent aqueous extracts the collected leaves of *Hyptis*, lantana and yellow oleander were weighed to 10 gram each and ground well in a waring blender and dissolved separately in 100 ml of water.

3.5.2 Antifeedant activity

Area of the freshly collected leaves were measured using graph paper. Third instar larvae of laboratory bred *D. oroisea* and *P. aristolochiae* were used for the study. The larvae were transferred into equisize Petridishes (9.5cm). Such that there was only one larva in one plate. There were ten replications for both insects with all three extracts. The larvae were starved for 6 hrs. There after the measured leaves dipped in prepared aqueous extracts for just two seconds and air dried were provided as food. Care was taken to provide only one leaf per plate. A control was also run parallely for each treatment. On completion of 24 hrs the total feeding area was measured with graph paper.

Results

4. RESULTS

All the insect pests occurring on the ten selected medicinal plants observed in the three regions viz., herbal gardens of College of Horticulture, Vellanikkara, Thycaud Moos Arya Vydyasala, Chuvannamannu and Kottakkal Arya Vydyasala, Kottakkal are being listed. Morphological descriptions, feeding habits along with the extent of damage done on the plant are also presented. Based on the intensity of infestation they are being grouped as key, major and minor pests. Bionomics of two lepidopteran key pests along with their management using botanicals are reported in this chapter. All the natural enemies occurring along with the pests are also projected here. Interpretations drawn from the analysis of correlation of weather parameters on the above two key pest distributions are also included.

4.1 PEST SURVEY

4.1.1 Neelamari, *Indigofera tinctoria* Linn.

4.1.1.1 Major pests

4.1.1.1.1 Neelamari psyllid, *Arytaina punctipennis* Crawford (Hemiptera:Psyllidae)

All the tender parts of the plant were attacked by this psyllid. No preference was observed for the hardy portions and the roots. First appearance of psyllid could be detected by the presence of black spot like eggs which were neatly inserted along the mid rib region of the leaves on both upper and lower sides and the tender stem portions all in a line. In two weeks time the nymphs emerging out could be seen crawling. These nymphs were identified easily by their prominent wing pads. A peculiarity observed was, their tendency for aggregation. Both the nymphs and the adults could be seen in clusters on the tender portions desapping the plant. As a result, typical 'die back' symptoms could be observed (Plate 1a) which was followed by the leaf withering. The net result of infestation was the appearance of bare leaved twigs. Even at this stage the plant was capable of maintaining its life. As the attack by this pest subsided, the plant rejuvenated and normal growth was observed. Regarding the

Plate 1a

Plate 1b

Plate 1c

Plate 1a. Psyllid attack, Plate 1b. *Cheilomenes sexmaculata*, Plate 1c. *Adoxophyses* sp.

period of occurrence, they were found to occur in large numbers during November to January.

Other observations

Coccinellid

Common predatory coccinellid, *Cheilomenes sexmaculata* Fab. was seen to prey upon the Neelamari psyllids. Distribution of grubs and adults of the coccinellids (Plate 1b) coinciding with the emergence of psyllid nymphs was a typical biocontrol measure in nature.

Ants

Four different types of ants were found in association with the psyllids, feeding on the honeydew excretions.

Spiders

Two different types of small spiders in close association with the psyllids were observed. The spiders made webs and preyed on the psyllids.

4.1.1.2 Minor pests

4.1.1.2.1 Neelamari leaf webber, *Adoxophyses sp.* (Lepidoptera: Totricidae)

Adult moth was brown coloured. When at rest it mimics a bell. Both the fore and hind wings had dark brown markings uniformly in the coastal region. Besides, the forewings had wavy lines all throughout while it was totally absent in the hind wings. Apical margin of the forewing and the anal margin of hind wing were well lined with fine hairs (Plate 1c).

Larvae were medium sized, sparsely hairy with dull yellowish green colour. These larvae web the leaf and feed from within. The damaged leaves dry up and get suspended within the webbings. Pupation was within the leaf webs. Pupae were brown coloured.

4.1.1.2.2 Cetoniid beetles (Coleoptera:Cetonidae)

Four different types of cetoniid beetles infesting Neelamari include *Protaetia aurichalcea* F., *P. peregrina* Hbrt., *Clinteria klugi* (Hope) and *Oxycetonia versicolor* (F.). Adults were seen feeding both on the flowers and the leaves making round holes on them. *P. aurichalcea* has prominent brown colour with off white markings (Plate 1d), *P. peregrina* is a metallic blue beetle with white markings (Plate 1e). *C. klugi* is a medium sized beetle with reddish brown colour with white spots and wavy marking dorsally and its prothorax has two bracket-like white markings laterally (Plate 1f). *O. versicolor* is a red coloured beetle with prominent black spots on prothorax and elytra (Plate 1g).

4.1.1.2.3 Treehopper, *Anchon pilosum* W. (Hemiptera: Membracidae)

Adults and nymphs of this bug infest the tender shoots and suck sap from them. The affected shoots become weakened as a result of the attack (Plate 1h).

4.1.1.2.4 Pentatomid bugs

4.1.1.2.4.1 Tipulpara sp. (Hemiptera: Pentatomidae)

Bugs were brown coloured (Plate 1i). Both adults and nymphs desap the tender shoot.

4.1.1.2.4.2 Nezara antennata Scott. (Hemiptera: Pentatomidae)

Green coloured bigger pentatomids were found to desap tender foliage (Plate 1j).

Plate 1d

Plate 1e

Plate 1f

Plate 1g

Plate 1h

Plate 1i

Plte 1j

Plate 1k

Plate 1l

Plate 1d. *Protaetia aurichalcea* F., Plate 1e. *Protaetia peregrina* Hbrt.
Plate 1 f. *Clinteria klugi* (Hope), Plate 1g. *Oxycetonia versicolor* (F.)
Plate 1h. *Anchon pilosum* W., Plate 1i.*Tipulpara* sp., Plate 1j. *Nezara antennata* Scott.
Plate 1k. *Riptortus pedestris* Fb., Plate 1l. *Riptortus linearis* (L.)

Plate 2a

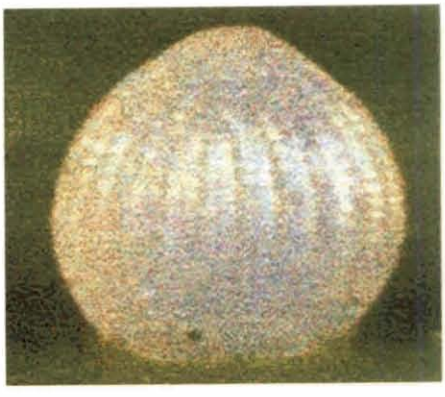

Plate 2b

Plate 2c

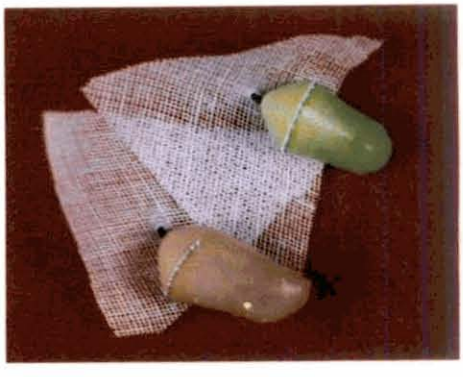

Plate 2d

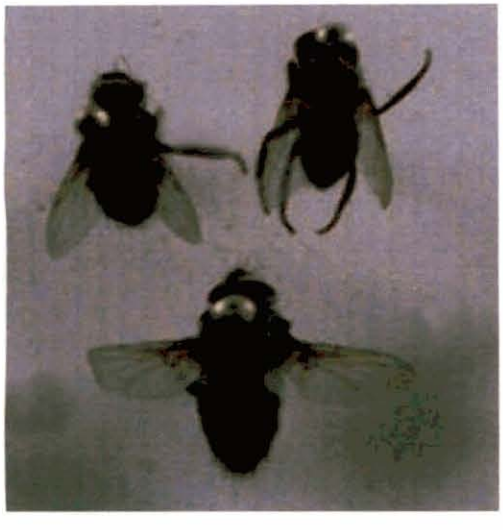

Plate 2e

Plate 2f

Different stages of *Danaus genutia* Cramer

Plate 2a. Adult, Plate 2b. Egg, Plate 2c. Larva, Plate 2d. Pupa

Plate 2e. Tachinid fly (Parasite of *Danaus*)
Plate 2f. *Platycorynus decemnotatus* Baly

Other relevant observations

An unidentified tachinid fly (Diptera: Tachinidae) was found parasitising *D. genutia* larva. Adults deposit eggs on the later instars of the caterpillar. Parasitised caterpillars became sluggish in two days, stopped feeding and mummified. Development of the fly maggot was within the mummified larvae, which was completed in 2 weeks. The adult fly was dark grey with grey hairs on the abdomen and legs (Plate 2e).

4.1.2.2 Minor pest

4.1.2.2.1 Adapathiyan chrysomelids, *Platycorynus decemnotatus* Baly. (Coleoptera: Chrysomelidae)

These chrysomelids are metallic blue with shiny red spots on the pronotum and elytra. Adults measured 0.8 cm in length and 0.5 cm in width. They fed on tender foliage (Plate 2f). Paired adults in the process of mating was a common sight on these plants.

4.1.3 Chethikoduveli, *Plumbago rosea* Linn.

4.1.3.1 Major pest

4.1.3.1.1 Citraka looper, *Anisephyra ocularia* (Fb) (Lepidoptera: Geometridae)

Moths had straw-coloured body and wings with a small black ring-like spot on each wing approximately towards the centre. They exhibited prominent sexual dimorphism. The females are with filiform antenna and stouter abdomen (Plate 3a). Males possessed bipectinate antenna and slender abdomen (Plate 3b).

Eggs were laid singly or in pairs on tender leaf axils. They hatch in three days. Larva was a looper with dark ash colour with yellowish shiny diamond shaped makings on the dorsal side (Plate 3c). Larvae fed from the sides of the leaves. Larval period lasted for 7-9 days.

Plate 3a

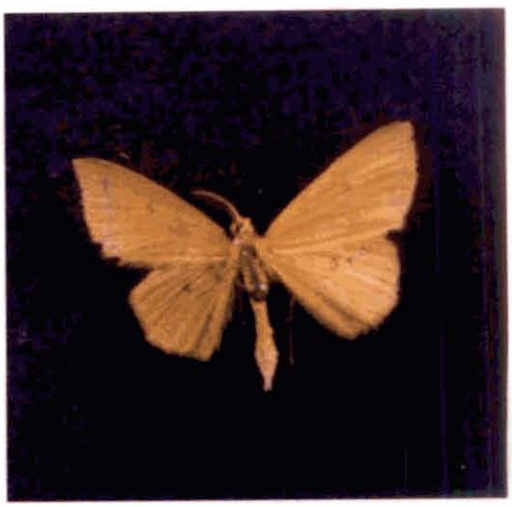

Plate 3b

Plate 3c

Plate 3d

Different stages of *Anisephyra ocularia* (Fb.)

Plate 3a. Adult female, Plate 3b. Adult male, Plate 3c. Larva, Plate 3d. Pupa

Pupation took place in leaf axils. Occasionally they were also seen to pupate on the under surface of leaf. The pupae were clothed with soft yellow webbing (Plate 3d). The pupal period lasted for 6-8 days.

4.1.4 Thippali , *Piper longum* Linn.

4.1.4.1 Major pest

4.1.4.1.1 Spike borer (unidentified) (Lepidoptera: Gracillaridae)

Adult was a grey coloured micro-lepidopteran. Body was slender. Both fore and hind wings were slender tapering towards the tips. Forewings had shiny silvery spot at middle of costal region. Though both pairs of wings had hairs throughout, the tuft of hairs in the anal region was more prominent on the hind wings (Plate 4a).

Eggs were laid on tender spike. Incubation period lasted for two days.

Freshly emerged larvae were pale brown and bored into the spike and fed on the inner content. Grown up larvae were brown with dark brown head (Plate 4b). Larval period lasted for 7-8 days.

In nature, the pupation took place within the soil in a very soft small brown pupal case. Pupal period lasted for 6-7 days.

Borer infested only the tender spikes resulting in discolouration at the point of attack. As the spikes grew the larvae feed within by tunneling inside. The affected spike turned yellow later and dropped down. When such spikes were cut opened, larvae along with excreta could be seen inside (Plate 4c).

4.1.4.2 Minor pests

4.1.4.2.1 Spike thrips (unidentified) (Thysanoptera: Thripidae)

Thrips attacked tender spikes preferentially. Such spikes showed discolouration and dropped prematurely. In rare cases when the thrips infested mature spikes, such spikes became distorted.

Plate 4a

Plate 4b

Plate 4c

Plate 4d

Thippali spike borer (Unidentified)

Plate 4a. Adult, Plate 4b. Larva, Plate 4c. Damage

Plate 4d. Thippali mealy bug

4.1.4.2.2 Thippali leafhoppers (Hemiptera: Cicadellidae)

Occurrence of three species of leafhoppers viz. *Kolla paulula* (Walker), *Tettigella iocosta* (Distant) and *Cofana lineata* (Distant) on the tender leaves were only as minor pests. *K. paulula* could be identified by its black colour while *T. iocosta* by its green and *C. lineata* by the white colour. Infested leaves showed brown spots.

4.1.4.2.3 Thippali mealy bugs (*Ferrisia virgata* Cockerell) (Homoptera: Pseudococcidae)

All parts of the plant attacked by the two tailed mealy bugs, *Ferrisia virgata* Cockerell (Plate 4d) resulted in slow drying of the plant. These mealy bugs covering the twigs and under surfaces of leaves desaped resulting in complete drying up of leaves.

4.1.5 Vallippala, *Tylophora indica* (Brum.f.)

4.1.5.1 Key pest

4.1.5.1.1 Vallippala semilooper, *Dichromia orosia* (Gram) (Lepidoptera: Noctuidae)

Adult was a stout bodied noctuid moth. Forewings were brownish while the hind wings were yellow coloured. A prominent 'V' shaped dark brown marking extending from the costal margin almost in the middle of the forewing was typical of this moth (Plate I). Besides, hind wings also had dark border in the apical region. Eggs were very small and yellow in colour. They were laid on the tender leaves or shoots.

Larvae were semiloopers. The neonate larvae were sparsely hairy and slender (Plate I). As they grew, they became stout with yellow colour bearing prominent black bands on the dorsal side.

Pupation took place within a brown coloured case attached to lower surface of the plant, usually on dried vine or yellow leaves.

4.1.5.2 Major pest

4.1.5.2.1 Glossy tiger, *Parantica aglea* (Stoll) (Lepidoptera: Danaidae)

Adults were black coloured with symmetrical transparent bluish white streaks and spots on both fore and hind wings and thorax (Plate 5a).

Creamy white eggs were laid singly (Plate 5b). The incubation period lasted for 3-4 days.

Larvae were chocolate brown coloured, stout, with prominent paired yellow spots dorsally on each of the segments. Appearance of white spots on the lateral region, mid dorsally and demarcating each body segment was another distinguishing character (Plate 5c). Presence of paired anterior longer filaments on segment 2 and shorter ones on segment 11 were the other prominent features.

Pupae were pale green with white and black spots (Plate 5d). Pupal period lasted for 7-8 days.

4.1.5.3 Minor pest

4.1.5.3.1 Tylophoran bug, *Spilostethus pandurus* (Scopoli) (Hemiptera: Lygaeidae)

Adults were red coloured bugs, resembling the red cotton bug (*Dysdercus cingulatus*) except for the white coloured bands on the ventral side of the abdomen and presence of ocelli (Plate 5e). They had head and legs black in colour. The apical portion of hemelytra was black with prominent white spot in the middle. The basal portion was uniformly red. When at rest it gives the appearance of inverted 'V' shaped marking on the abdomen. Presence of prominent black spot in the scutellum was another important character.

Eggs were red in colour (Plate 5f). Neonate nymphs were similar to adults except for the spots on the scutellum and the wings (Plate 5 g). They had a tendency to aggregate together and desap the tender leaves (Plate 5h) resulting in complete loss of chlorophyll. Later, the leaves became papery white.

Plate 5a

Plate 5b

Plate 5c

Plate 5d

Different stages of *Parantica aglea* (Stoll)

Plate 5a. Adult, Plate 5b. Egg, Plate 5c. Larva, Plate 5d. Pupa

Plate 5e

Plate 5f

Plate 5g

Plate 5h

Plate 5i

Different stages of *Spilostethus pandurus* (Scopoli)

Plate 5e. Adult, Plate 5f. Egg, Plate 5g. Nymph, Plate 5h. Aggregation of nymphs

Plate 5i. *Corynodes peregrinus* Herbst.

4.1.5.3.2 Asclepidian beetle, *Corynodes peregrinus* Herbst (Coleoptera: Chrysomelidae)

Adults were stout bodied metallic blue coloured with well-developed legs (Plate 5i). They defoliated the crop.

4.1.6 Tulasi, *Ocimum sanctum* Linn.

4.1.6.1 Major pest

4.1.6.1.1 Tulasi lacewing bug, *Cochlochila bullitia* Horv. (Hemiptera: Tingidae)

Adult was black with hyaline wings. Its thorax had dorsally hollow globular out growths, trelliced in design and curved inwards as hollow globules from the outer margin of the thorax.

Eggs were thrust within the veins or edges of the leaves on the under surface. The nymphs were flat, black and spinous. All stages of the bug were seen on the leaves sucking sap from them. The infested leaves curled up, withered and dried up.

4.1.6.2 Minor pests

4.1.6.2.1 Tulasi leaf webber, *Syngamia abruptalis* Walker (Lepidoptera: Pyralidae)

Adult was a yellow coloured pyralid moth with prominent pink markings on both fore and hind wings (Plate 6a). Caterpillar folded and fed the leaf by remaining within the fold. Pupation also took place within leaf fold.

4.1.6.2.2 Tulasi grasshopper, *Cyrtocanthacris tatarica.* (Orthoptera: Acrididae)

Adults were stout brown coloured grasshoppers with dark brown markings on forewings and hind tibia (Plate 6b). They fed on tender foliage and made irregular holes.

Plate 6a

Plate 6b

Plate 6c

Plate 6d

Plate 6e

Plate 6f

Plate 6g

Plate 6a. *Syngamia abruptalis* Walker
Plate 6b. *Cyrtocanthacris tatarica*, Plate 6c. *Myllocerus viridanus* Fab.
Plate 6d. *Nezara antennata* Scott., Plate 6e. *Nezara* sp.
Plate 6f. *Agonoscelis nubilla* Fab., Plate 6g. *Riptortus linearis* (L.)

4.1.6.2.3 Ash weevil, *Myllocerus viridanus* Fab.
(Coleoptera: Curculionidae)

These were medium sized greenish weevils with grey tinge. (Plate 6c). Adults fed from margin inwards.

4.1.6.2.4 Tulasi sap feeders

4.1.6.2.4.1 Pentatomid bugs

4.1.6.2.4.1.1 *Nezara antennata* Scott.
(Hemiptera: Pentatomidae)

Adults were bigger green coloured bugs (Plate 6d). They suck sap from the tender shoots and panicle.

4.1.6.2.4.2 *Nezara sp.*
(Hemiptera: Pentatomidae)

Comparitively smaller than *N. antennata*. They also desap tender shoots and panicles (Plate 6e).

4.1.6.2.4.3 *Agonoscelis nubilla* Fabricius
(Hemiptera: Pentatomidae)

Bugs were medium sized, yellowish brown with a Y shaped marking dorsally (Plate 6f). The hemelytra had dark brown wavy lines. They suck sap from the tender shoots and panicles.

4.1.6.2.5 Alydid bug, *Riptortus linearis* Fab.
(Hemiptera: Alydidae)

Both adults and nymphs suck sap from the tender portions (Plate 6g).

4.1.7 Kacholam, *Kaempferia galanga* Linn.

4.1.7.1 Minor pests

4.1.7.1.1 Leaf beetle, *Lema sp.*
(Coleoptera: Chrysomelidae)

Adult was a small criocerine beetle about 6 mm long (Plate 7a). They laid eggs on the tender leaves. The eggs were yellow and cylindrical. The emerging grub began to feed on surface tissues of the leaf. The grub had a dull white body with

Plate 7a

Plate 7b

Plate 7c

Plate 7d

Plate 7e

Plate 7f

Plate 7a. *Lema* sp., Plate 7b. *Lema* grub

Plate 7c. Estigmene perotetti, Plate 7d. Black hairy caterpillar

Plate 7e. *Spodoptera litura* Fabricius, Plate 7f. Swarming caterpillar

Eggs were pale orange and laid singly (Plate II). Larvae were black with red coloured tubercles (Plate II). Larva defoliated the plant completely. Pupation was within pale brown pupal case (Plate II).

4.1.8.2 Minor pest

4.1.8.2.1 Flea beetle, *Aphthona azuriae* Jacoby (Coleoptera : Chrysomelidae)

The adult was a small shiny, metallic blue beetle with prominent hind legs. It feeds on the lower surface of the plant scraping the green tissues resulting in papery thin leaves, which gradually dry up.

4.1.9 Kasthurivenda, *Abelmoschus moschatus* Medikus

4.1.9.1 Major pest

4.1.9.1.1 Shoot and fruit borer, *Earias vitella* (Fb.) (Lepidoptera: Noctuidae)

Medium sized moths. The forewings were white with wedge-shaped pea green band running medially from base to outer margin on each wing (Plate 8a). Eggs were laid singly or in twos and threes on the tender plant parts. Newly hatched larva bored into the terminal shoot or into fruits. Full grown larvae were in brownish with a white median longitudinal streak dorsally and pale yellow/green streak ventrally. Pupation was in a dirty white boat shaped cocoon of tough silk. Damaged shoot drooped, withered and dried up (Plate 8b).

4.1.9.1.2 Leaf roller, *Sylepta derogata* Fb. (Lepidoptera: Pyralidae)

Moth was medium-sized. Wings were yellowish with wavy brown markings. Eggs were laid singly on the under surface of leaves. The emerging caterpillar rolls the leaf and feeds from within and becomes full grown in 2-3 weeks. The full-grown caterpillar was green in colour. Pupation took place within the leaf roll. In severe cases of infestation, almost the entire leaf lamina was seen to be cut and made into rolls.

Other observations

A predatory spider (unidentified) had been seen along with the leaf roller caterpillar. The spiders preferentially fed on the early instars of the caterpillar.

4.1.9.2 Minor pests

4.1.9.2.1 Semilooper caterpillar, *Acontia groellsi* Fsth. (Lepidoptera: Noctuidae)

Medium sized moth. It had yellowish forewings with brown patches along the outer margins and curved lines. The hind wings were uniformly yellow (Plate 8c). The caterpillar was a semilooper which when was full-grown was green with a pair of black marks on each segment (Plate 8d). The caterpillar was found to feed on the leaves.

4.1.9.2.2 Red bug, *Dysdercus koenigii* (F.) (Hemiptera: Pyrrhocoridae)

Adult was a red and black bug. The ventral side was red with white transverse stripes (Plate 8e). Eggs were laid in loose soil. Both adults and nymphs sucked sap from leaves and shoots. All stages of the insect were seen on plants bearing mature pods.

4.1.9.2.3 *Leaf beetles*

4.1.9.2.3.1 *Lema sp.* (Coleoptera: Chrysomelidae)

The adult was peculiar with head, pronotum antenna and legs being orange while the elytra was bright metallic blue coloured (Plate 8f). The adult damages the tender foliage by feeding on them.

4.1.9.2.3.2 *Colasposoma sp.* (Coleoptera: Chrysomelidae)

Adult beetle was oval with an attractive metallic blue colour on both the pronotum and elytra (Plate 8g). These beetles feed by scraping the green matter from the upper side leading to gradual appearance of circular holes on it.

4.1.9.2.3.3 Unidentified
(Coleoptera: Chrysomelidae)

Adult was medium sized having orange colour on the pronotum and elytra. Appearance of a triangular metallic blue coloured patch dorsally was another identifying character (Plate 8h). They feed by scraping the green matter from the upper side leading to appearance of circular holes.

4.1.9.2.4 *Epilachna spp.*
(Coleopteran: Coccinellidae)

Adults and grubs of the beetle were observed to feed on and destroy the leaves (Plate 8i).

4.1.9.2.5 *Tortoise beetle*

4.1.9.2.5.1 *Aspidiomorpha sp.*
(Coleoptera: Chrysomelidae)

Adult beetle was medium-sized, orangish with black markings dorsally. Adults feed on the surface tissues of the leaves (Plate 8j).

4.1.9.2.5.2 Unidentified
(Coleoptera: Chrysomelidae)

Small sized adults having prominent black marks dorsally and an orange boarder all around was the typical character. Adults feed scrapping the leaves and the damage was not extensive (Plate 8k).

4.1.9.2.6 Flower petal feeder (unidentified)
(Coleoptera: Curculionidae)

Small sized stout bodied beetle, which were black in colour. They were found to feed on both the yellow and dark coloured portions of the flower petal by scraping on it (Plate 8l). Normally they were seen to prefer the upperside of the petals.

Plate 8a

Plate 8b

Plate 8c

Plate 8d

Plate 8e

Plate 8f

Plate 8g

Plate 8h

Plate 8i

Plate 8j

Plate 8k

Plate 8l

Plate 8m

Plate 8n

Plate 8a. *Earias vitella* (Fb.), Plate 8b. Damage on shoot, Plate 8c. *Acontia graellsi* Fsth., Plate 8d. Semilooper larva
Plate 8e. *Dysdercus koenigii* (F.), Plate 8f. *Lema* sp., Plate 8g. *Colasposoma* sp., Plate 8h. Leaf beetle (Unidentified)
Plate 8i. *Epilachna* sp., Plate 8j. *Aspidiomorpha* sp., Plate 8k. Tortoise beetle (Unidentified), Plate 8l. Flower petal feeder
Plate 8m. *Lixus truncatulus* F., Plate 8n. *Myllocerus viridanus*

4.1.9.2.7 Kasthurivenda weevil, *Lixus truncatulus* F. (Coleoptera: Curculionidae)

Adult was a medium sized brownish black weevil (Plate 8m). They cause damage by scrapping and chewing tender portions of the leaf petioles resulting in slow withering of the leaf.

4.1.9.2.8 Ash weevil, *M. viridanus* Fab. (Coleoptera: Curculionidae)

Adult beetles were medium sized, greenish with a grey tinge (Plate 8n). Adults feed by making holes on the leaves.

4.1.10 Madhunashini, *Gymnema sylvestre* (Retz.)R.Br.

4.1.10.1 Minor pest

4.1.10.1.1 Madhunashini defoliator, *Micronia aculeata* Guenee (Lepidiptera: Uraniidae)

Adult was a milky white coloured moth with greyish wavy markings both on fore and hind wings. The wings mimic the wings of looper caterpillar adults. A differentiating character was the presence of a small tail like projection at the baso-apical region of the hind wings along with a prominent black spot very near to it (Plate 9a).

Minute eggs were laid singly on tender foliage. Emerging larvae were green coloured. They feed on the lower leaf surface and defoliate. The larva had a very flat ventral side and the dorsal part was beautifully dome-shaped (Plate 9b). As the larva grew they became pink. Pupation took place within soil.

Other observations

The last instar larvae were parasitised by hymenopterans belonging to the family Braconidae. The adult wasp laid eggs within the larvae. Emerging larva was seen to feed upon the defoliator larvae (Plate 9c). Seven to eight larvae were seen to

Plate 9a

Plate 9b

Plate 9c

Plate 9d

Madhunashini defoliator, *Micronia aculeata* Guenee

Plate 9a. Adult, Plate 9b. *Micronia* larva
Plate 9c. Braconid parasite, Plate 9d. Braconid pupa

emerge out from a single parasitised defoliator larva. The parasitised larvae pupated in a silken cocoon. Each such pupal case had 7-8 pupal cells (Plate 9d).

4.1.10.1.2 Aphids (unidentified)

This bright yellow aphid was a minor pest. The adults and nymphs sucked sap from the under surface of tender leaves and growing tips. The infested portions became yellow and the growth was greatly retarded. The aphids were abundant during December to March.

4.1.10.1.3 Leafhopper, *T. iocosta* (Distant)
(Homoptera: Cicadellidae)

This was a uniformly pale green cicadellid, which infests tender and semi mature leaves. Their distribution was sparse. As a result of feeding, yellow spots on the leaves appear which eventually fell.

4.1.10.1.4 Moth bugs

4.1.10.1.4.1 *Flata ocellata* Fb.
(Homoptera: Flatidae)

This was a pale green moth like bug with minute red spots on the forewings (Plate 9e). The nymphs were long and white with two green bordered yellow lines dorsally and two long white caudal filaments. Adults and nymphs suck sap from the terminal shoots.

4.1.10.1.4.2 *Ricania sp.*
(Hemiptera: Ricaniidae)

Adult was brownish, moth-like and with hyaline patches on the forewings (Plate 9f). Nymphs were pale green with white wax on body and long caudal filaments held like a fan over the body. The oviposition punctures made by the adults resulted in withering of the shoots. The adults and nymphs sucked sap from the leaves and terminal portions.

Plate 9e

Plate 9f

Plate 9g

Plate 9h

Plate 9i

Plate 9j

Moth bugs

Plate 9e. *Flata ocellata* Fb., Plate 9f. *Ricania* sp.

Plate 9g. Unidentified

Passive visitors

Plate 9h. *Syngamia floridalis* (Zell.), Plate 9i. *Hymenia recurvalis* (Fab.),
Plate 9j. *Bocchoris onychinalis*

4.1.10.1.5 Alydid bugs

4.1.10.1.5.1 *R. pedestris*
(Hemiptera: Alydidae)

Adult was a brown bug measuring 15 mm long. Damage was caused by the nymphs and adults sucking sap from tender plant parts, which later did not develop.

4.1.10.1.5.2 Coreid bug
(Hemiptera: Coreidae)

This bug was stouter and bigger when compared with the former pod bug. Colour was also darker (Plate 9g). Both nymphs and adults sucked sap from tender plant parts resulting in stopping of further growth.

4.1.10.1.6 Passive visitors

4.1.10.1.6.1 *Syngamia floridalis* (Zell.)
(Lepidoptera: Pyralidae)

A small slender pyralid moth with brown wings having prominent orange marks both on fore and hind wings (Plate 9h).

4.1.10.1.6.2 *Hymenia recurvalis* (Fab.)
(Lepidoptera: Pyralidae)

Adult was a black moth with white wavy markings on wings (Plate 9i).

4.1.10.1.6.3 *Bocchoris onychinalis*
(Lepidoptera: Pyralidae)

Soft bodied slender brownish moth with white wavy markings all throughout the fore and hind wings (Plate 9j).

4.2 BIONOMICS OF KEY PESTS

Bionomics of two key pests were studied in detail. The choice of the two pests was made on the basis of intensity of infestation and extend of damage caused by them. Detailed description on the biology of Vallippala semilooper *D. orosia* and

Karalakom butterfly *P. aristolochiae* were presented here. Besides, report on the influence of weather parameters on the pest distribution was also included.

4.2.1 Biology of key pests

4.2.1.1 Biology of Vallippala semilooper (Plate I)

Eggs were laid on the tender leaves or shoots. They were laid in batches of 3 or 4. Eggs were round and light yellow in colour. A female moth laid 142-154 eggs in 4-5 days. Eggs were found to hatch in 3 days.

The freshly hatched larvae started feeding by scraping the green matter of the leaves. The first instar larvae were sparsely hairy, slender and brown. They remained in this style just for two days. On molting as it attains the second instar, the duration of which also was two days (Table 1) had a yellow colour with light brown coloured spots on each of the segment. The arrangement of these spots gives the look of a band. From these spots presence of sparse white hairs also could be located. On attaining third instar the caterpillars were stouter. The black marking takes up the appearance of small ridges. The duration of this instar was three days. The fourth instar larvae, which had duration of three days, were still stouter and the black ridge like appearance were more prominent. Remarkable observation was that maximum intake of food was in third and fourth instars. As it takes up the fifth instar, which had a span of just two days, the black ridge totally disappears and instead, on each segment a pair of black spot made prominent by the green halo could be identified. The consumption of food during this instar was comparatively lesser.

The prepupal stage was for a day where the caterpillar enters into a transparent pupal covering. The pupal period was on an average 6.4 ± 0.1956 days. The pupa was dark brown in colour 12.5 mm in length and 4 mm in breadth. A peculiarity observed in pupation was that it makes a cell out of the excreta and exuvia within which will be pupation.

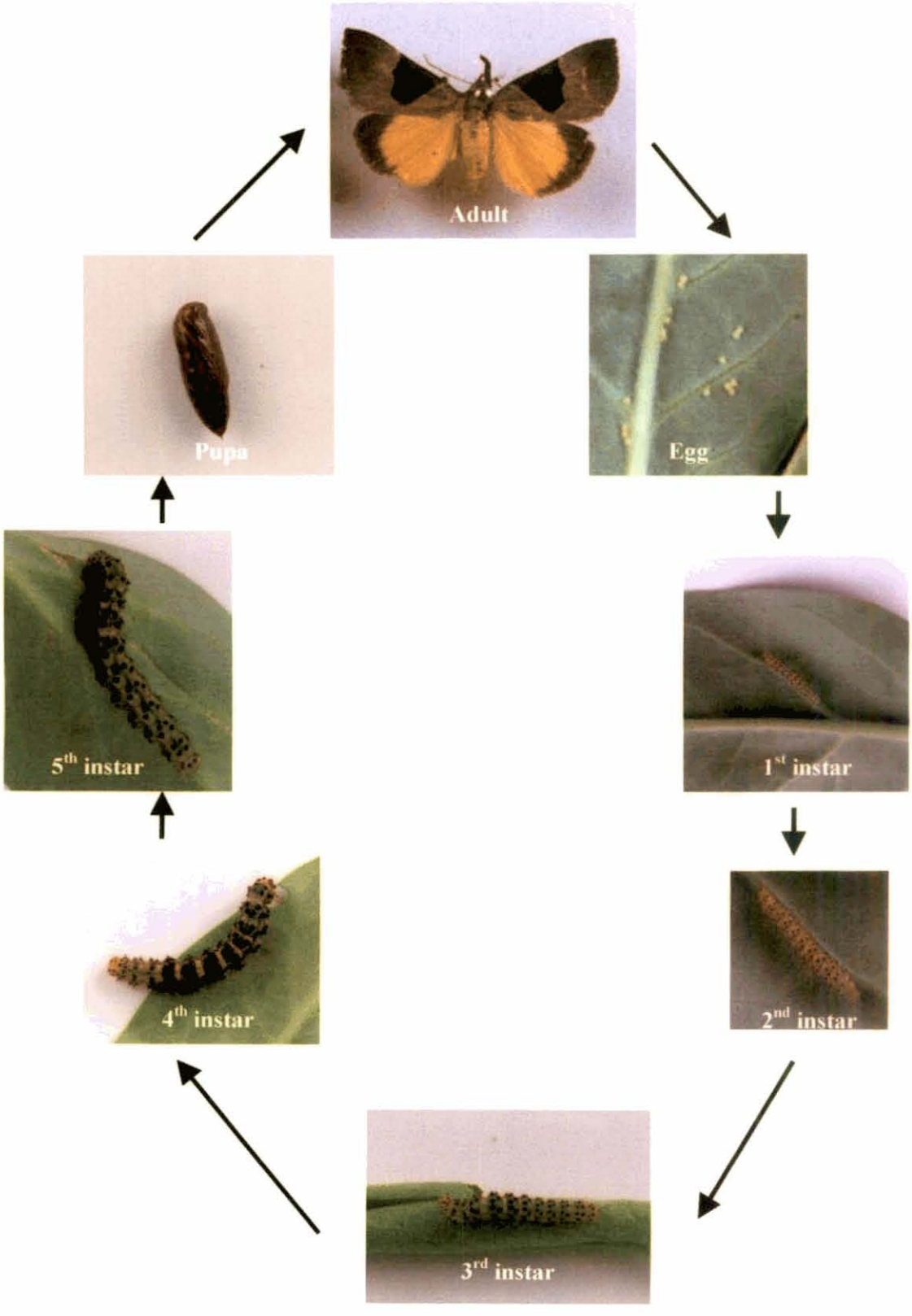

Plate I. Life cycle of Vallippala semilooper, *Dichromia orosia* (Gram)

The total life cycle from egg to adult occupies 22.1 ± 0.1956 days. When fed the adult lives for about 8-10 days.

4.2.1.2 Biology of Karalakom butterfly, *Pachliopta aristolochiae* (Plate II)

Eggs were laid singly on leaves, tender plant portions, flower stalks and leaf petioles. They were pale orange coloured. Egg hatch in 8.2 ± 0.1405 days (Table 2). A single female laid 32-44 eggs.

The larva grows feeding on the leaves. It had varying colouration of black with red during its different stages. First instar larva had uniform black colour with fleshy dorsal tubercles. Osmetrium were prominently orange. The presence of lateral tubercles could be detected on a close observation. Segments 7-8 had a pair of spot like white marking. It remains in the first instar for 7.7 ± 0.1768 days. As it moults and attains the second instar, the duration of which was 7.8 ± 0.1749 days (Table 2), the larva were still more stouter and the head takes up more of black colour. The white spot, which was seen in the first instar appears as a stretched marking. The food consumption in this stage was remarkably high as was observed in the case of third instar. In appearance the third instar caterpillar was of not much of difference from the second but for the size. The duration of this instar was 9 days. Full grown fourth instar larva which had a span of 7.9 ± 0.2422 days was prominently stout and comparatively sluggish. The lateral tubercles in this instar were much more prominent when compared with second or third instar. The rate of food consumption was seen to be very much reduced.

It pupates on the plant, chrysalis being attached to the plant at its head and thoracic region and held with silken girdle. The abdomen tip also had a binding with the plant. Pupal period lasts for 14.8 ± 0.1749 days.

Total life cycle was 56.1 ± 0.5248 days. When fed the adults lives for about 8-9 days.

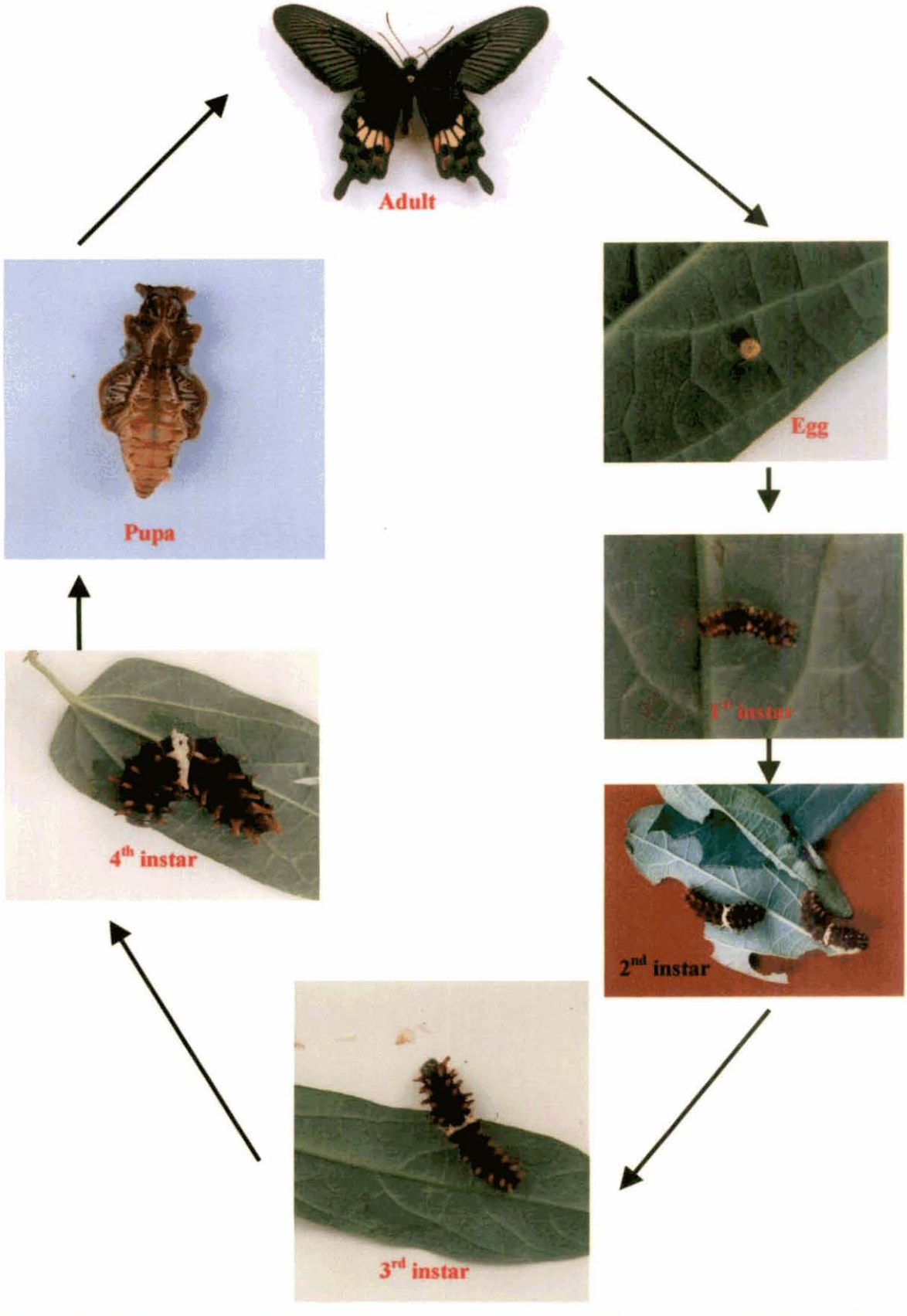

Plate II. Life cycle of Karalakom butterfly, *Pachliopta aristolochiae* Fab.

Table 1. Developmental period of Vallippala semilooper, *Dichromia orosia* (Gram)

Sl. No.	Duration In days								
	Egg	1st instar	2nd instar	3rd instar	4th instar	5th instar	Prepupa	Pupa	Total life cycle
1	3	2	2	3	3	2	1	6	22
2	3	2	2	3	3	2	1	7	23
3	3	2	*						
4	3	2	2	3	3	2	1	6	22
5	3	2	2	*					
6	3	2	2	3	3	2	1	7	23
7	3	2	2	3	3	2	1	6	22
8	3	2	2	3	3	2	1	6	22
9	3	2	2	3	3	2	1	7	23
10	3	2	2	3	3	2	1	6	22
Mean	3	2	2	3	3	2	1	6.4 ± 0.1956	22.4 ± 0.1956

Table 2. Developmental period of Karalakom butterfly, *Pachliopta aristolochiae* Fab.

Sl. No.	Duration In days							
	Egg	1st instar	2nd instar	3rd instar	4th instar	Prepupa	Pupa	Total life cycle
1	8	8	7	9	8	1	15	56
2	8	7	8	9	7	1	14	54
3	8	8	8	9	8	1	15	57
4	9	8	*					
5	8	7	7	9	9	1	15	56
6	8	7	8	9	8	1	15	56
7	9	8	8	9	8	1	14	57
8	8	8	8	9	8	1	15	57
9	8	*						
10	8	8	8	9	7	1	15	56
Mean	8.2 ± 0.1405	7.7 ± 0.1768	7.8 ± 0.1749	9	7.9 ± 0.2422	1	14.8 ± 0.1749	56.1 ± 0.5248

* Larva died

4.3 INFLUENCE OF WEATHER PARAMETERS ON KEY PESTS

Findings of the study relating to the influence of different weather parameters on the two key pests distribution are presented here.

4.3.1 Influence of weather parameters on Vallippala semilooper (Table 3)

4.3.1.1 Influence of temperature

A non significant positive correlation between the pest and maximum temperature had been observed. But with minimum temperature it was negatively correlated.

4.3.1.2 Influence of relative humidity

A significant negative correlation between the pest distribution and relative humidity was the result of analysis.

4.3.1.3 Influence of rainfall

A non significant negative correlation was observed between rainfall and semilooper spread.

4.3.1.4 Influence of wind speed

There was a significant positive correlation between pest and wind speed.

4.3.1.5 Influence of sunshine hours

Spread of sunshine was non significantly correlated with the occurrence of semilooper.

4.3.2 Influence of weather parameters on Karalakom butterfly (Table 4)

4.3.2.1 Influence of temperature

There was no significant correlation between the *Pachliopta* population and minimum and maximum temperature. Positive correlation was observed between pest and maximum temperature but only a negative correlation with minimum temperature.

Table 3. Influence of weather parameters on Key Pests

Pest	Correlation between pest and maximum temperature	Correlation between Pest and minimum temperature	Correlation between pest and relative humidity	Correlation between pest and rainfall	Correlation between pest and wind speed	Correlation between pest and sunshine hours
Dichromia orosia	0.063^{NS}	-0.068^{NS}	-0.159^{*}	-0.120^{NS}	0.145^{*}	0.094^{NS}
Pachliopta aristolochiae	0.001^{NS}	-0.018^{NS}	0.005^{NS}	-0.006^{NS}	0.006^{NS}	-0.016^{NS}

* Correlation significant at the 0.01 level (2-tailed)
NS - non significant.

4.3.2.2 Influence of relative humidity

Relative humidity was positively correlated with pest population.

4.3.2.3 Influence of rainfall

There was a non -significant negative correlation between pest and rainfall.

4.3.2.4 Influence of wind speed

Wind speed was positively correlated with pest but there was no significant correlation.

4.3.2.5 Influence of sunshine hours

There was a non-significant negative correlation between the pests and sunshine.

4.4 MANAGEMENT OF KEY PESTS USING BOTANICALS

Results of the study on the effect of botanicals on the key pests were presented here.

4.4.1 Management of Vallippala semilooper, *Dichromia orosia*

Results of the preliminary studies conducted in the laboratory for the management of semilooper pest on Vallippala using botanicals revealed the following observations.

Neem kernel suspension (0.3%) was the best treatment showing high antifeedant activity (Table 4) followed by neem leaf extract (3%). Other treatments were inferior and showed percentage feeding that ranged from 16 to 28.

4.4.2 Management of Karalakom butterfly

Treatment using Neem kernel suspension (0.3%) was the best showing total antifeedant activity closely followed by treatment using Neem leaf extract (3%). Other treatments showed inferior antifeedancy with the percentage of feeding which ranged from 19 to 27 (Table 5).

Table 4. Evaluation of antifeedancy using botanical insecticides against *Dichromia orosia* (Gram)

Treatment	Mean feeding (%)	SE
10% Aqueous extract of		
T_1 (Hyptis)	16.038	2.75
T_2 (Lantana)	24.609	2.75
T_3 (Yellow oleandar)	28.670	2.75
T_4 (Neem leaf extract 3%)	3.558	2.75
T_5 (NKS 0.3%)	No feeding	-
Control	100	100
Total within	18.221	2.03

CD value for comparing the means of the treatments - 5.09

Table 5. Evaluation of antifeedancy using botanical insecticides against *Pachliopta aristolochiae* Fab.

Treatment	Mean feeding (%)	SE
10% Aqueous extract of		
T_1 (Hyptis)	25.738	3.10
T_2 (Lantana)	27.366	3.10
T_3 (Yellow oleandar)	19.938	3.10
T_4 (Neem leaf extract 3%)	4.056	3.47
T_5 (NKS 0.3%)	No feeding	-
Control	100	100
Total within	20.075	2.10

CD for comparing the means of the treatments T_1, T_2, T_3 - 5.76
CD for comparing treatments T_1, T_2, T_3 with T_4 - 6.03

5. DISCUSSION

Survey conducted for insect pests occurring on ten selected medicinal plants revealed 57 species of insects. Based on the intensity of attack, the pests were ranked as key, major and minor pests. Of the 57 different species of insects found attacking the ten types of selected medicinal plants, 44 species are new reports in India. Observations on the natural enemies found on these insect pests are also recorded.

5.1 PEST SURVEY

5.1.1 Neelamari, *Indigofera tinctoria* Linn.

The rate of infestation was only to the level of major pest as far as neelamari psyllid, *Arytaina punctipennis* were concerned. Five species of insects were recorded as minor pests.

Indication of the appearance of psyllid on Neelamari was the presence of spot like eggs, which were neatly inserted along the midrib of the leaves in a line. Both the nymphs and adults could be seen in clusters on the tender portions desapping the plant. The typical 'die back' symptoms observed were in concurrence with the findings of Skaria *et al.* (1996).

The other observations were the co existence of ants, predatory coccinellids and spiders with the psyllids. All four different types of ants fed on the honey excretions of psyllids. Distribution of grubs and adults of the predatory coccinellids, *Cheilomenes sexmaculata* coinciding with the appearance of the psyllids is a typical example of balance of life in nature. The spiders, in addition to being predatory upon psyllids, were found to prey on the coccinellids which inturn were psyllid predators. No earlier reports are there to support this finding.

Occurrence of the leaf webber, *Adoxophysis* sp., flower beetles, treehoppers, pentatomid and alydid bugs as pests on Neelamari are only to a very low level. But this report of their distribution on Neelamari is first of its kind.

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Discussion

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Indication of the appearance of psyllid on Neelamari was the presence of spot like eggs, which were neatly inserted along the midrib of the leaves in a line. Both the nymphs and adults could be seen in clusters on the tender portions desapping the plant. The typical 'die back' symptoms observed were in concurrence with the findings of Skaria *et al.* (1996).

The other observations were the co existence of ants, predatory coccinellids and spiders with the psyllids. All four different types of ants fed on the honey excretions of psyllids. Distribution of grubs and adults of the predatory coccinellids, *Cheilomenes sexmaculata* coinciding with the appearance of the psyllids is a typical example of balance of life in nature. The spiders, in addition to being predatory upon psyllids, were found to prey on the coccinellids which inturn were psyllid predators. No earlier reports are there to support this finding.

Occurrence of the leaf webber, *Adoxophysis* sp., flower beetles, treehoppers, pentatomid and alydid bugs as pests on Neelamari are only to a very low level. But this report of their distribution on Neelamari is first of its kind.

5.1.2 Adapathiyan, *Holostemma adakodien* Schultes

Only one pest that is Plain/common tiger *Danaus genutia* has been observed as a major pest on Adapathiyan. While investigating the character and nature of attack, all the observations had great similarity with the findings of Mathew (1998). But a new finding with regard to this pest is that a fly belonging to the family Tachinidae which could not be identified was parasitising the larvae. The infested caterpillars became sluggish in two days followed by cessation of feeding and ending up in death.

Chrysomelids, *Platycorynus decemnotatus* appearing as defoliators could be ranked only as a minor pest. Their preference for the tender foliage and distribution with a unique style of pairing are the other new reports.

5.1.3 Chethikoduveli, *Plumbago rosea* Linn.

Citraka looper, *Anisephyra occularia* was considered as a major pest of this plant. Prominent sexual dimorphism observed in this pest needs a special mention. Larvae defoliated the terminal plant portions.

5.1.4 Thippali, *Piper longum* Linn.

Though several attempts were made to get identified the grey coloured microlepidopteran occurring as a major pest on Thippali, all were in vain. But special care was taken to study the morphological characters and the nature of damage caused by this minute lepidopteran. The larvae boring the tender spikes showed slight discolouration initially, which later, with the growth of the spike could be located by the presence of tunnels. If yellow coloured spikes, which fall down were cut opened, the larva with their excreta could be located inside. Generally this pest was appearing as a major one in all Thippali grown areas.

Three minor pests were also collected during the survey. First one in it was the spike thrips which had a preference for tender spikes. Earlier reports of thrips

infesting medicinal plants were there (Popov, 1973b and Singh, 1999). But distribution of thrips on Thippali are not recorded earlier. Three species of leaf hoppers observed include *Kolla paulula, Tettigella iocosta* and *Cofana lineata*. All these are new records on Thippali. Typical hopper burn symptoms exhibited by these pest infestations were only to a low level. Again, the appearance of two tailed mealy bugs *Ferrisia virgata* is a new report.

5.1.5 Vallippala, *Tylophora indica* (Brum.f.)

As the level of infestation by Vallippala semilooper, *Dichromia oroisea* was so high, this could be considered as a key pest. Besides the Glossy tiger, *Parantica aglea* which appeared with their damage to a considerable level could be ranked as a major pest. Other two pests namely the Tylophoran bug *Spilostethus pandurus* and the Asclepedian beetle *Corynodes perigrinus* could only be considered as minor pests.

Appearance of the semilooper, *D. oroisea* on Vallippala is reported for the first time. The stout bodied noctuid moths were seen to appear in large numbers. Caterpillars emerging out from small yellow eggs were seen to be sparsely hairy in the early instars. As they take up their later instars, they were to become very stout with a high rate of feeding. This pest was observed commonly in all the three surveyed areas.

Glossy tiger *P. aglea* recorded as a major pest was earlier reported by Mathew (1998). Chocolate brown coloured larvae with prominent yellow spots on the lateral region, and the presence of paired anterior longer tentacles on segment two and shorter ones on segment 11 were all in concurrence with the findings of Mathew (1998).

Other two pests observed as minor ones are new records on Vallippala. The Tylophoran bug mimicking red cotton bugs had a special tendency to aggregate together and desap the tender leaves making it papery white.

5.1.6 Tulasi, *Ocimum sanctum* Linn.

Lacewing bug, *Cochlochila bullitia* occurring as a major pest on Tulasi was earlier reported by Chandra (1992). Morphology and biology of this pest was also studied by him. The rate of infestation in all the three regions were to a major level. The results of their desapping were curling, withering and drying up of leaves.

Leaf webers, grasshoppers, ash weevils, sap feeders including alydid bugs were all seen occurring as minor pests. Though the leaf weber, *Syngamia abruptalis* was observed as a minor pest here, Anont (1990) had recorded this as a serious pest on sweet basil *O. basilium* in Thailand.

First report of grasshopper, *Cyrtocanthacris tatarica* occurring as a minor pest was found to feed on the tender foliage making holes on them. Reports of grass hoppers infesting medicinal plants were there (Singh, 1965, Reddy *et al.*, 1981 and Smith, 1974). But Ali (1980) had observed a preference for the seedlings by Bombay locusts.

Ash weevil, *Myllocerus viridanus* attacking as a minor pest made holes on the leaves. Appearance of *M. viridanus* on Tulasi is being reported for the first time.

Sap feeders, *Nezara antennata, Nezara* sp., *Agonoscelis nubilla* belonging to Pentatomidae were seen to suck sap from tender shoots and panicle. All these three are reported for the first time. But Smith (1974) had recorded the green stinkbug to suck sap from young shoots of *Duboisia myoporoides* and *D. leichhardtii.* According to him also the damage was not severe.

Alydid bugs, *Riptortus linearis* were found to occur as new minor pest on Tulasi. *R. pedestris* had earlier been considered as a minor pest of *Rauolfia serpentina* by Singh in 1964.

5.1.7 Kacholam, *Kaempferia galanga* Linn.

No pest has been found to attack Kacholam to a major level. Leaf beetle, black hairy caterpillar and swarming caterpillar were occurring as minor pests on

Kacholam. All these three minor pests were not reported earlier and hence first reports.

Leaf beetle, *Lema* sp. were small criocerine beetles. They feed on tender foliage both during the grub and adult stage. As early as 1924 Chittendev had recorded the feeding by leaf beetle on *Datura stramonium, Solanum, Physalis*, Henbane and Belladona in Columbia.

The black hairy caterpillar, *Estigmene perotetti* larvae were found to feed on the green tissues in the early stages and completely devouring the leaf in their later instars. Though this is the first report on Kacholam, distribution of black hairy caterpillars as defoliators on a dozen species of medicinal plants was reported by Mathur (1962b).

The swarming caterpillar, *Spodoptera litura* was observed to feed on the leaf blades from their margins to a minor level. Larvae of *S. litura* were earlier reported to defoliate *D. myoporoides* and *D. leichhardtii* trees (Smith, 1974).

5.1.8 Karalakom, Aristolochia *indica* Linn

Karalakom butterfly, *Pachliopta aristolochiae* was found to infest to an extensive level and so rated as key pest. This pest had earlier been reported by Mathew (1998). Larvae were observed to defoliate the plant completely. Studies on the influence of semi-synthetic diet for *P. artistolochiae* by Ying *et al.* (1999) revealed no significant difference between the optimal diets and fresh foliage on the larval development and mean pupal weight.

The flea beetle, *Aphthona azuriae* occurring on Karalakom as a minor pest had not been reported on any of the medicinal plants earlier and hence is the first report. As a result of its feeding, the leaves turned papery thin which gradually dried up. A study on the biology of *A. nigritis* (Jakson, 1997) revealed that they had a female based sex ratio, greater male longevity and a higher female oviposition.

5.1.9 Kasthurivenda, *Abelmoschus moschatus* Medikus

There were two major pests and six minor pests occurring on Kasthurivenda. Of the major pests, the shoot and fruit borer, *Earias vitella* which were reported as the most important pest on Bhindi is recorded for the first time on Kasthurivenda. Larvae boring into the terminal portions resulted in drooping, withering and drying up of shoots and fruits. Though this pest had not been recorded on Kasthurivenda, detailed study on host preference, age and mating behaviour (Thamhankar, 1994) and identification of it as one of the major pests of Bhindi (Devasthali and Saran, 1997) was made earlier.

The leaf roller, *Sylepta derogata* occurring as major pest was the first report. The caterpillar emerging out, was observed to roll the leaf and feed within. In severe cases of infestation the entire leaf lamina were seen to be cut and made into rolls hanging on the plants. Another noteworthy observation in this regard was predation on it by a spider, which could not be got identified. This again was a typical example of natural control. A preference for the early instars of the caterpillar by the spider had also been observed.

Semilooper caterpillar, *Acontia groellsi*, red bugs, *Dysdercus koenigii*, leaf beetles, *Lema* sp. and *Colasposoma* sp., another unidentified species of leaf beetle, ladybird beetle, *Epilachna* sp., tortoise beetles, flower petal feeders and weevils were all observed as minor pests and all these are first reports. Semilooper caterpillar, *A. graellsi* feeding on the leaves were not recorded on any other medicinal plants but Belsky (1924) had recorded another species i.e., *A. rumicis* on *Rheum palmatum*. Red bugs, *D. cingulatus* were reported as pest on plants and seedlings of Karanj by Meshram *et al.* during 1988 and thus the report as minor pest of Kasthurivenda is a new one.

Different leaf beetles include *Lema* sp. *Colasposoma* sp. and another one of the same family which was unidentified. The leaf beetle *Lema* sp. occurring as minor pest on Kasthurivenda is not reported earlier but their occurrence on Kacholam was

identified in the contemporary studies. Though the leaf beetle, *Colasposoma* sp. observed to be feeding by scrapping the green matter from the upper side, leading to gradual appearance of circular holes on Kasthurivenda was a first record of this pest on medicinal plants, a similar pest *C. semicostatum* was reported as a pest on one of the forest trees out of 20 species screened in the laboratory (Singh *et al.*, 1997).

The third unidentified species of leaf beetles were found to feed by scrapping the green matter from the upper side leading to appearance of circular holes. This is also a first report.

The *Epilachna* sp. destroying the leaves of Kasthurivenda had not been reported earlier. But similar pests defoliating solanaceous medicinal plants were recorded by Smith during 1974.

The chrysomelids, the tortoise beetles (unidentified) and another unidentified species were also found to scrape the leaves. But the extent of damage was not extensive. Occurrence of both these on Kasthurivenda are first reports. The tortoise beetles, *Cassida viridis* were reported to perforate the leaves of *Melissa officinalis* as early as 1921 (Parfenjev, 1921).

Flower petal feeder which are seen to have a preference for the upper side of the petals was again a new report of the pest on this crop.

Weevils, *Lixus trancatulus* and *M. viridanus,* observed to be feeding by scrapping and chewing the tender portions of the leaf petioles, resulting in withering were not reported earlier on any of the medicinal plants.

5.1.10 Madhunashini, *Gymnema sylvestre* (Retz.)R.Br.

None of the insects recorded were of major importance. But the defoliators, aphids, leaf hoppers, moth bugs, coreid bugs and unidentified pod bugs were all observed infesting to a minor level. These observations are all new records.

The report about the defoliation by *Micronia aculeata* belonging to Uraniidae is of its first kind in Madhunashini. Larvae defoliating the plant were seen to have a preference for the lower leaf surfaces. Another observation which needs a mention was the parasitism by a hymenopteran which is also a first record.

Reports on the aphids infesting medicinal plants causing twisting were made by Zacher (1921). In the present study both adults and nymphs of aphids were seen to suck sap from the under surfaces of tender leaves and growing tips. Another speciality, which deserves a special mention, was that their distribution on Madhunashini was more in the months of December to March.

Leafhoppers, *T. iocosta* whose distribution were sparse on Madhunashini was a new record. Typical hopper burn symptoms exhibited by this pest infestation was only to a lower level. Appearance of the pest on Thippali too was made with the present study.

Moth bugs, *Flata ocellata* and *Ricania* sp. occurring on Madhunashini were new reports. Adults and nymphs feeding on the terminal shoots and leaves were not recorded on any of the medicinal plants earlier.

Pod bug, *R. pedestris* and another unidentified pod bug seen on Madhunashini were not reported earlier. Both the nymphs and adults desap tender plant parts resulting in cessation of growth.

Syngamia floridalis, Hymenia recurvalis and *Bochoris onychinalis* all belonging to Pyralidae, and were observed as passive visitors on Madhunashini were not reported on any of the medicinal plants earlier.

5.2 BIONOMICS OF KEY PESTS

5.2.1 Biology of key pests

5.2.1.1 Biology of Vallippala semilooper, *D. oroisea*

Study on the biology of *D. orosia* had not been made earlier. A complete description on the morphology highlighting the identifying characters had been

presented which would definitely help in detecting the presence of the pest on the crop. Evaluation of fecundity and incubation period revealed the possibility for the spread of the pest. Identification features of the different larval stages clearly presented had also revealed that maximum intake of food was in the third and fourth instars. This again will be a helping tool for adopting any control measures. Another noteworthy observation which needs mention was that, the pupation was within a cell made of its own excreta and exuvia.

5.2.1.2 Biology of Karalakom butterfly, *P. aristolochiae*

No detailed study on the biology had been made earlier.

Attempts made to describe the morphological characters, revealed complete description for easy identification of the pest. Details regarding the fecundity, incubation period, different larval duration and pupation along with the complete identifying characters presented, would definitely help for detecting the existence of the pest and adopting timely control measures.

5.3 INFLUENCE OF WEATHER PARAMETERS ON KEY PESTS

Temperature, both maximum and minimum, relative humidity, rainfall, wind speed and prevailing sunshine hours were the different parameters taken into account while surveying the influence of weather on key pest distribution. By making a record of the total count of both these pests all throughout the year, a correlation report on these two insect pests with the weather parameters were easily drawn.

A complete scan through for revewing the available literature on earlier work carried out in this line ie inflence of weather parameters on medicinal plant pest distribution indicated it to be none. Hence this line of research is the first one of its kind.

5.3.1 Influence of weather parameters on Key pests

5.3.1.1 Influence of temperature

Both the key pests Vallippala semilooper, *D. oroisea* and Karalakom butterfly, *P. aristolochiae* revealed a non-significant positive correlation between the

pests and maximum temperature. With a rise in temperature there was a flare-up in population. This finding, which is a new report, could not be supported by any earlier observations, as no study was made in this regard. But precautionary measures could be adopted wherever an increase in temperature is felt.

5.3.1.2 Influence of relative humidity

Vallippala semilooper showed a negative correlation between population and relative humidity. With an increase in relative humidity there was a decrease in the pest population. But with regard to Karalakom butterfly it was contrary wherein there was an increase in the pest spread with an increase in relative humidity. As there are no earlier reports to substantiate these findings, no conclusions could be drawn.

5.3.1.3 Influence of rainfall

Rainfall had a non-significant negative correlation with the both the pests distribution. With an increase in rainfall the spread of the pests were diminishing. This finding could not be compared with any earlier reports as no research were taken up in this line.

5.3.1.4 Influence of wind speed

A significant positive correlation between the pests and wind speed were observed. There was an increase in both the pests population with an increase in wind speed. This is a useful information for adopting necessary preventive measures against the spread of the pests.

5.3.1.5 Influence of sunshine hours

While studying the effect of total sunshine hours in a day on the spread of the pest, it was evident that with an increase in the sunshine hours there was an increase in Vallippala semilooper distribution whereas the count was reduced in Karalakom butterfly population. There were no earlier reports to supplement these

findings. But this piece of information would definitely help in adopting precautionary control measures.

5.4 MANAGEMENT OF KEY PEST USING BOTANICALS

Formulations of botanicals selected for the preliminary studies to identify their effects on key pest management included Neem Kernal Suspension (0.3%), neem leaf extract (3%) and 10 per cent aqueous extracts each of hyptis, lantana and yellow oleander.

5.4.1 Management of Vallippala semilooper

Results of the analysis of data revealed no variation in the effects of yellow oleander and lantana. The rate of food consumed by both these treatments were significantly lesser when compared with control indicating that both these treatments had an antifeedant effect. Treatment using NKS (0.3%) was found to be the best as there was total antifeedancy. The repellent action of NKS against lepidoptran pests had been earlier reported (Mane, 1978, Meisner *et al.*, 1980, Redknap, 1980 and Ramprasad *et al.*, 1987). Neem leaf extract was also seen to have antifeedancy though not to the same level as NKS. Supporting data by Jacob and Sheila (1994) and Tripathi and Singh (1994) on other lepidopteran pests helps to ensure neem leaf extract as a good repellent against Vallippala semilooper. Further, reports of Kumar *et al.* (1997), Chari and Muraleedharan (1983) also support the findings of this research. Aqueous extracts of hyptis indicated antifeedancy. Though the rate of food consumed was more than that with the treatment using neem leaf extract, it was significantly lesser than treatments using yellow oleander and lantana. Hence hyptis could also be listed as an antifeedant against Vallippala semilooper. There were no reports indicating hyptis extracts as an antifeedant against lepidopteran pests earlier. But extracts tested against pea aphid showed it to be an effective antifeedant (Gokulapalan, 1996).

While rating the five botanicals tested against Vallippala semilooper as an antifeedant, neem kernal suspension ranks first followed by neem leaf extract, hyptis

extract, yellow oleander and lantana. The last two extracts i.e., those with yellow oleander and lantana had no significant difference between them and they were on par. But the rate of food consumed was significantly lesser when compared with control.

5.4.2 Management of Karalakom butterfly

Analysis revealed the treatment using neem kernel suspension (0.3%) to be the best as an antifeedant. This finding was in agreement with the findings of Mane (1978), Meisner *et al.* (1980), Redknap (1980) and Ramprasad *et al.* (1987). Neem leaf extract (3%) used for testing its antifeedancy against Karalakom butterfly also showed antifeedancy. The rate of antifeedancy here was not as much as that with NKS. But could be used as a repellent and this finding agrees with the reports of Jacob and Sheila (1994), Tripathi and Singh (1994), Kumar *et al.* (1997) and Chari and Muraleedharan (1983). Yellow oleander was found to have the next best antifeedant effect. The effects of hyptis and lantana were identical. Both hyptis and lantana extracts which on analysis were found to be on par had showed significantly lesser food consumption when compared with the control.

Neem kernal suspension (0.3%) followed by neem leaf extract (3.0%) and acqueous extracts of yellow oleander followed by aqueous extracts of hyptis and lantana were the series of order in the rate of antifeedancy against Karalakom butterfly.

These findings are new records for controlling pests on medicinal plants. These are ecofriendly approaches that could be adopted in all localities without any hesitation.

Summary

6. SUMMARY

Commercially important medicinal plants cultivated in Kerala is now facing a serious constraint, which is nothing other than injury by insect pests. A thorough survey conducted in three different localities had resulted in alarming informations. Survey was done just on ten economically important medicinal plants viz., *Neelamari, Adapathiyan, Chethikoduveli, Thippali, Vallippala, Thulsi, Kacholam, Karalakom, Kasthurivenda* and *Madhumashini*. All the insect specimens collected were grouped as key, major and minor pests based on the intensity of infestation. A record of natural enemies existing with these pests was also made. After presenting the identifying characters, detailed biology of two key pests along with the influence of weather parameters on these pest distributions were also investigated. Management using the botanicals insecticides was the next aspect dealt with.

Complete survey of selected ten medicinal plants indicated the presence of 57 different species of insect pests. Of this 57, 44 species are new reports.

No insect could be ranked as key pest in Neelamari. The rate of infestation by psyllids was to a major level. Typical symptom of attack was the "die back". The five minor species include webbers, flower beetles, treehoppers, pentatomid and alydid bugs. A speciality with the spiders was that they prey upon the coccinellids which inturn were psyllid predators.

Occurrence of plain tiger on Adapathiyan was to a major level. These larvae defoliate the plant. The chrysomelids appearing as defoliators were to a minor level. An unidentified fly belonging to the family Tachinidae parasitising the butterfly larvae was another new report.

Chethikoduveli were infested by the citraka looper to a major level, which again was a new report. The larvae were found to defoliate the terminal plant portions.

A microlepidopteran (unidentified) infesting the spike appeared as major pests in all Thippalli grown areas. Infested spike when cut and opened showed the

presence of larva within the tunnels along with their excreta. Spike thrips, three species of leafhoppers and the two tailed mealy bugs appearing on Thippalli were all new reports. But the level of attack was to a minor one.

Vallippala semilooper a key pest was studied in detail with regard to its biology, influence of weather parameters on its distributions and its management using botanicals. Report of this semilooper on Vallippala was first of its kind. The semilooper devours the plant completely. Appearance of Glossy tigeron Vallippala was to a major level. The other pests observed as minor ones include the Tylophoran bug and the Asclepidian beetle. Appearance of these insects as pests on Vallippala were all reported for the first time.

Lacewing bug occurring as a major pest on Tulasi were found to desap resulting in curling, withering and drying up of leaves. Leaf webers, grasshoppers, ash weevils and five different sap feeders were seen occurring as minor pests. Their attack on Tulasi except for the leaf weber were all new reports.

No pest has been found to attack Kacholam to a major level. Leaf beetle, black hairy caterpillar and swarming caterpillar were occurring as minor pests and all were new reports.

Karalakom butterfly occurring on Karalakom were found to defoliate the plant completely. Hence this was considered as key pest. Biology along with influence of weather parameters on its distribution and management using botanicals were studied. The flea beetle occurring on Karalakom as a minor pest was reported for the first time.

Of the two major and six minor pests on Kasthurivenda, the shoot and fruit borer and leaf roller ranked as major ones were recorded for the first time. The larvae of shoot and fruit borer were found to bore into terminal shoots and fruits resulting in drooping withering and drying up. Because of leaf roller attack, entire leaf lamina were seen to be cut made into rolls and hung on the plant. Predation of this larva by a spider (unidentified) was also a new report. Semilooper caterpillar, red bugs, leaf

beetles, epilachna beetles, tortoise beetles, flower petal feeders, Kasthurivenda weevil and ash weevil were all observed as minor pests and all these were first reports.

No pests were observed to be major on Madhunashini. Defoliators, aphids, leafhoppers, moth bugs, alydid bugs and coreid bugs were observed infesting to a minor level. The larvae of defoliators were parasitised by a Braconid. Three passive visitors all belonging to lepidopteran order was another finding. These observations were all new records.

As the influences of weather parameters on the distribution pattern of key pests were studied, it was observed that with a rise in temperature there was a flare up on Vallippala semilooper and Karalakom butterfly population. With a decrease in temperature the reduction in pest population was common for both the insects.

When the relative humidity was taken into consideration it was evident that with an increase in relative humidity there was a decrease in the population of Vallippala semiloopers while with Karalakom butterfly it was an increase. With regard to rainfall it was observed that with an increase in rain intensity the spread of both the pests were diminishing.

When the influence of wind speed was taken into consideration it was found that wind speed had no direct influence on Vallippala semilooper distribution. But with regard to Karalakom butterfly the spread was more with an increased wind speed. While studying the effects of total sunshine hours in a day on the pest spread, it was clear that there was an increase in Vallippala semilooper distribution and a reduction in Karalakom butterfly population with increased sunshine hours.

Management of the key pests using botanical pesticides resulted in Neem Kernel Suspension (0.3%) to be the best as an antifeedant for both the test insects followed by neem leaf extracts (3%). In the case of Vallippala semilooper aqueous extracts of hyptis ranked as the next best while it was yellow oleander for Karalakom butterfly. These eco-friendly approaches are new records, which needs further investigations.

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INSECT PESTS OF SELECTED MEDICINAL PLANTS: BIONOMICS AND MANAGEMENT

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ABSTRACT OF THE THESIS

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ABSTRACT

The availability of Medicinal plants is mainly from the natural resources like forests and waste lands. Today farmers of Kerala are taking up cultivation of medicinal plants in an organised manner. A thorough survey conducted in three different localities such as herbal gardens of College of Horticulture, Vellanikkara, Thycaud Moos Arya Vydyasala, Chuvannamannu and Kottakkal Arya Vydyasala Kottakkal being listed had resulted in alarming informations. Survey was done just on ten economically important medicinal plants, viz., *Neelamari, Adapathiyan, Chethikoduveli, Thippali, Vallippala, Thulsi, Kacholam, Karalakom, Kasthurivenda* and *Madhunashini.*

Complete survey of selected ten medicinal plants indicated the presence of 57 different species of insect pests of which, 44 species are new reports.

In *Neelamari* rate of infestation by psyllids was to a major level. Typical symptoms of 'die back' had been observed. The five minor species include webbers, flower beetles, treehoppers, pentatomids and alydids. The predatory coccinellids, ants and spiders associated with the psyllids were the other new reports. Spiders were observed to prey upon the coccinellids which inturn were psyllid predators. Occurrence of milkweed butterfly on adapathiyan was to a major level. Tachinid flies were found to parasitise the butterfly larvae. Chethikoduveli heavily infested by citraka looper was a major one. A microlepidopteran belonging to the family Grassillaridae was found infesting on Thippali spikes. Spike thrips, thippali mealy bugs were the other minor pests. Vallippala semilooper, a key pest was ranked as a completely defoliating one. Its biology studied reveals that egg period to be three days, larval instars as first, second, third, fourth and fifth, prepupal and pupal duration of 2, 2, 3, 3, 2, 1, 6.4 ± 0.1956 days respectively. Total life cycle was found to be 22.4 ± 0.1956 days. Tylophoran bug and Asclepidian beetle which were first reports. Glossy tiger in Vallippala was found on a major level. Lacewing bug were found to be major one in Tulasi. But there were numerous minor pests as Tulasi leaf webber, grasshopper, ash weevil, Pentatomid bugs and Coried bugs. Kacholam were infested

by *Lema* beetle, black hairy caterpillar and swarming caterpillar which were the minor ones. Karalakom butterfly were ranked as key pest. Its biology and management using botanical pesticides were studied. The egg, larval duration of first, second, third and fourth instars prepupal and pupal stages had a duration of 8.2 ± 0.1405, 7.7 ± 0.1768, 7.8 ± 0.1749, 9, 7.9 ± 0.2422, 1, 14.8 ± 0.1749 days respectively. Total life cycle was found to be that 56.1 ± 0.5248 days. Flea beetles were found to make the leaf papery thin. In Kasthuri venda there were two major and 11 minor pests. The major ones were found to be the pests of okra too. Major ones are shoot and fruit borer and leaf roller. Defoliator in Madhunasini were parasitised by a Hymenopteran belonging to the family Braconidae. Moth bugs and three types of passive visitors observed were also new reports.

As the influence of weather parameters on the distribution of key pests were studied, it was observed that with a rise in temperature there was a flare up on Vallippala semilooper and Karalakom butterfly population. With decrease in temperature the reduction in pest population was common for both the pests. When the relative humidity was taken into account, it was evident that decrease in Vallippala semilooper population was indirectly proportional to the relative humidity but it was directly proportional to the spread of Karalakom butterfly. When the influence of wind speed was taken into consideration it was found that wind speed had no direct influence on Vallippala semilooper distribution but with regard to Karalakom butterfly the spread was more with an increased wind speed. While studying the effects of total sunshine hours in a day on the pest spread, it was clear that there was an increase in Vallippala semilooper distribution and a reduction in Karalakom butterfly population with increased sunshine hours.

The evaluation of botanical pesticides revealed a maximum antifeedancy with Neem Kernel Suspension (NKS) followed by neem leaf extracts. In the case of Vallippala semilooper hyptis ranked as the next best. While it was yellow oleander for Karalakom butterfly. These eco-friendly approaches are new records.