BIOLOGY AND MANAGEMENT OF ORCHID PESTS

By
SAJITHA KUMARI

THESIS

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Department of Agricultural Entomology
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DECLARATION

I hereby declare that the thesis entitled `**Biology and management of orchid pests'** 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.

Vellanikkara
1- 6 -1998

SAJITHA KUMARI

CERTIFICATE

Certified that the thesis entitled `**Biology and management of orchid pests**' is a record of research work done independently by **Ms.Sajitha Kumari**, 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 her.

DR.K.R. LYLA
Chairperson, Advisory Committee
Associate Professor

Vellanikkara
1-6-1998

CERTIFICATE

We, the undersigned members of the Advisory Committee of **Ms.Sajitha Kumari,** a candidate for the degree of **Master of Science in Agriculture** with major in **Agricultural Entomology**, agree that the thesis entitled '**Biology and management of orchid pests'** may be submitted by Ms.Sajitha Kumari in partial fulfilment of the requirement for the degree.

Dr.K.R.Lyla
Associate Professor
Department of Agricultural Entomology
College of Horticulture, Vellanikkara
(Chairperson)

Dr.Jim Thomas
Associate Professor and Head
Department of Agricultural Entomology
College of Horticulture, Vellanikkara
(Member)

Dr.P.J.Joy
Professor
Regional Agricultural Research Station
Kumarakom
(Member)

Dr.P.K. Rajeevan
Associate Professor and Head
Department of Pomology & Floriculture
College of Horticulture, Vellanikkara
(Member)

Approved

EXTERNAL EXAMINER

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Introduction

INTRODUCTION

Orchids are well known throughout the world for their beautiful, myriad shaped, multicoloured and long lasting quality flowers. It has turned out to be an international trade industry elsewhere in the world and cultivation of orchids has become a very profitable occupation. India is blessed with an abundance of orchid flora and about 1300 species are reported to be existing in this country (Rao, 1979). There is tremendous scope for improvement and development of the floricultural industries based on these wonderful plants. Systematic cultivation of these plants at farm level constitutes a promising industry with attractive remuneration for the unemployed and the under employed in Kerala.

In recent years due to change in the aesthetic values of the society and the awareness of the export potentiality of the flowers, a radical change has taken place in the cultivation of orchids as an enterprise by most of the farmers and industrialists. Production and supply of quality flowers has become an ultimate goal of any commercial grower in order to derive maximum market value. But the main constraints in the production of quality flowers are pests and diseases.

In addition to the pests that find orchids as a favourite host, there are some insects in every locality that may feed incidently on orchids. Hence, a close watch of the plants is needed frequently to detect any type of infestation at early stages so that its control becomes easier. A review of literature reveals that orchids get infested with various kinds of pests like scale insects, thrips, springtails, aphids, beetles, ants, wasps, cockroaches, caterpillars, snails, slugs, mites, millipedes and nematodes (Pritchard, 1959; Batchelor, 1982; Newton, 1982; Hegde, 1984; Hamon, 1986 and Leong, 1989).

In Kerala, most of the orchid growers are not conventional agriculturists and are mostly unaware of the pest problems and their management. So far, in Kerala, no systematic work has been carried out on orchid pests. Thus investigations have been undertaken to study in detail the various aspects of the different pest species associated with orchids. The study included:

1. A survey on the pests of orchids in Kerala
2. Nature of damage caused by pests
3. Biology and morphology of the key pests
4. Preliminary management studies of the key pests

Review of Literature

REVIEW OF LITERATURE

2.1 Pests infesting orchids

Several species of insects infest orchids, causing considerable damage to plants. The information available on the type of insect pests affecting orchids, their biology, nature and extent of damage caused and also management of pests are briefly reviewed here.

2.1.1 Order : Hemiptera
Sub order : Heteroptera
Family : Miridae

Schumacher (1919) reported a capsid bug, *Mertila malayensis* Dist. as an orchid pest from Java. Capco (1941) made a detailed study on the biology of *M. malayensis*. According to him, the female deposits about hundred eggs in three weeks. He pointed out that the egg and nymphal stages lasted 15-16 and 18-21 days, respectively, and the adults lived for up to 38 days. He also reported that the injury of the orchid *Phalaenopsis amabilis* by *M. malayensis* is due to the feeding punctures of the nymphs and adults in the leaves, peduncles and roots.

Lima (1942) recorded the adults of *Neofurius carvalhoi* L., and *Neoneela zikani* L., infesting orchids in Brazil.

Sasscer (1917) observed *Tenthecoris bicolor* Scott. feeding on the orchids at Colombia and Venezuela. This bug was also found in the orchid packing from Venezuela (Smyth, 1919). Gimingham (1928) found *T. bicolor* on orchids from

Brazil causing serious damage to the young leaves and shoots of the orchid plants. Lepage (1942) reported that, the adults of *T. bicolor* lives for 4-6 months and are very voracious.

Tempel (1929) reported that nicotene sprays are effective against *T. bicolor* on orchids. Spraying with 0.02 per cent parathion also destroys this insect (Abraham and Vatsala, 1981).

Figueiredo (1951) found *T. figueiredoi* Carvalho feeding on *Dendrobium* and *Oncidium* spp. in Sao Paulo and resulting in chlorosis and sometimes the death of the plants.

According to Lepage (1942) orchid plants infested with the capsid bugs should be dipped completely except for the roots in to a solution of 3 ounce nicotene sulphate and 3 pounds soap in 10 gallons water.

Sub order : Homoptera

Family : Aleyrodidae

Prathapan (1996) reported for the first time the spiralling whitefly, *Aleurodicus dispersus* Russell infesting *Spathoglottis* spp. in India.

Family : Aphididae

Look and Afee (1944) recorded *Aphis gossypii* Glov., feeding on *Cattleya* spp. in Hawaii.

Maskew (1916) found *Cerataphis lataniae* Boisd., feeding on orchids at Central America. Ehrhorn (1917) observed the orchids in Guatemala infested with the same pest. Fonesco (1934) described the nature of injury caused by *C. lataniae* on orchids in South Paulo. Wolcott (1922) reported orchids as an alternate host of *Cerataphis* spp.

Bates (1931) noted *Macrosiphum luteum* Buckt. on an orchid in Guatemala.

Jensen (1954) reported that the aphid *Myzus circumflexus* Buckt., feeds on the undersides of the younger buds of orchids at Formosa, causing dwarfing and distortion of the sepals.

Family : Coccidae

Weiss (1916a) reported *Coccus hesperidum* Linnaeus on orchids from New Jersey. *C. pseudohesperidum* Ckll. was observed on orchids in New York (Ehrhorn, 1925 and Whitney, 1927).

Green (1917) described *Pulvinaria floccifera* westw. as a common and most widely distributed coccid on orchids in London. Steinweden (1946) recorded the same pest on orchids in California and New York.

Ordogh and Jakacs (1983) found *Saissetia coffeae* Wlk, attacking *Cymbidium* spp. in Hungary. They also suggested pyrotox against the larvae of this pest.

Maskew (1917) found *S. hemispherica* Targioni, feeding on orchids at New York. *S. oleae* Bern. was observed on orchids at Philippines (Strong, 1921).

Family : Conchaspididae

Harmon (1979) noted *Conchaspis angraeci* Cockerell infesting the stems and leaves of the orchid *Angraecum eburneum* in North America. Holttum (1964) recommended the use of the root extract of *Derris* to control this pest.

Family : Diaspididae

Cockerell (1922) recorded *Aonidia pseudoaspidiotus* Lind. on stems of *Vanda* spp. in Colarado.

Kuwana and Muramatsu (1931) reported *Aspidiotus australiensis* and *Aspidiotus biprominens* Kuw. on orchids from Hongkong and Java. Sasaki (1937) found *A. biprominens* from Netherlands on orchids. According to Tanaka (1939) the attack of *A. chinensis* Kuw. on *Cymbidium* spp. causes the leaves to wither. Ehrhorn (1916b) observed *A. cyanophylli* Sign. on orchids in New Jersey. The same pest on orchids was reported by Strong (1922) from England and New York. Maskew (1919) reported *A. hederae* Vall., on orchids from Rhode Island.

Bodkin (1915) recorded *Asterolecanium pustulans* Ckll on orchids at British Guiana. Maskew (1920) found *Aulacaspis boisduvalii* feeding on orchids in Australia.

Maskew (1915b) noted *Chrysomphalus biformis* Ckll feeding on orchids from Canal zone. Sasscer (1915) collected *C. biformis* from orchids at Venezuela

and Colombia. Bodkin (1915) and Dash (1916) noted the same pest on orchids at British Guiana and Barbados respectively. Essig (1916) found *C. dictyospermi* Morg. on orchids at Berkeley. Moznette (1921) reported orchids as an alternative host of *C. dictyospermi* in Florida. The same pest was recorded on orchids at Colarado and Florida by Cockerell and Howard (1922).

Cory (1945) recommended a mixture of 20 parts of DDT dissolved in 60 parts xylol to which 20 parts Triton (emulsifier) added and dispersed in water against *C. dictyospermi*.

According to Sasscer (1916) *C. perseae* Comst. is a serious pest of orchids in Venezuela. Maskew (1917) reported the same pest on orchids from Guatemala.

Frogatt (1914) recorded *Diaspis boisduvalii* Sign. from orchids in South America. *D. boisduvalii* was also reported by Weiss (1914) and Rutherford (1915) from England and Ceylon respectively. Maskew (1915a) reported *D. boisduvalii* on orchids from Canal zone. Maskew (1915b) also reported the same from Java. Takahashi (1934) observed the pest on an orchid *Rhynchostylis retusa* in Florida.

Howard (1925) reported that fumigation with hydrocyanic acid gas against *Furcaspis biformis* Cockerell feeding on orchids in California has not proved successful.

Schumacher (1919) reported that a scale, *Gymnaspis aechmeae* Newst has become firmly established in the orchid houses in Berlin.

Kuwana (1925) recorded *Lepidosaphes cymbidicola* Kuw., on *Cymbidum* sp. from Japan. *L. tuberculatus* Malen. was observed on the same host from England (Green, 1921).

Mckenzie (1944) described *Melanaspis tenax* on *Cattleya* sp. from Colombia and on pseudobulbs of *Odontoglossum rosii* from Guatemala.

Sasaki (1937) found *Parlatoria mangiferae* Marl. feeding on orchids at Malaya. Maskew (1919) reported *P. pseudoaspidiotus* Lindinger as a pest of orchids in Pennsylvania. Mackiew (1944) noted *Pseudoparlatoria parlatorioides* Comst. on orchids in U.S.A.

Family : Pseudococcidae

Hensill (1947) noted heavy infestation of *Pseudococcus adonidum* L. on *Phalaenopsis sp.* at New Jersey. He also reported that vapo-diffusion method using hexa ethyl tetraphosphate has given satisfactory control of the pest by three fumigations.

Camporese and Scaltriti (1991) reported for the first time the occurrence of *P. microcirculus* Mckenzie, on the roots of orchids belonging to the genera *Ansellia, Cattleya* and *Oncidium* in Northern Italy.

Ehrhorn (1915) noted *P. virgatus* on orchids from Singapore. *Pseudococcus* sp. was recorded as injuring *Phalaenopsis amabilis* in Java (Franseen, 1937).

Pritchard (1959) reported that mealybugs found on orchids can be controlled by spraying with 0.02% parathion.

Family : Psyllidae

Bordage (1914) found a psyllid, *Trioza litseae* Gd on orchids whose pod it desroys in Reunion.

2.1.2 Order : Thysanoptera
Suborder : Terebrantia
Family : Thripidae

Corbett and Hassan (1936) found *Anaphothrips corbetti* Priesn. associated with the flowers of *Vanda* spp. in Malaya. Mendes (1935) recorded *A. orchidearum* Bondar from various orchids in Bahai, Brazil and Rio de Janeiro.

Bondar (1931) recommended nicotene or lime-sulphur against *A. orchidearum*.

Watson (1925) noted *Coccolobis laurifolia* on *Cattleya* sp. from Trinidad. Kajita *et al.* (1992) found *Dichromothrips corbetti* Priesn, feeding on orchids in Thailand. According to Sasscer and Weigel (1922) *Euthrips orchidii* Moult. is a serious pest of orchids in Hawaii. They also reported that the pest can be effectively controlled by hydrocyanic acid gas fumigation.

Schliephake (1990) reported *Frankliniella occidentalis* Pergande as a pest of orchids in Europe.

Miles (1927) found *Heliothrips femoralis* Reut. infesting orchids in Britain. According to him, calcium cyanide gives a fair control of the adult thrips but does not destroy the immature stages.

A pest of cereals, *Limothrips cerealium* Hal. was recorded on orchids in Europe (Armitage, 1945). Rojanavongse *et al.* (1982) recorded liva-thrips on orchid flowers of Japan.

Williams (1917) described *Physothrips xanthius* Williams, which has caused considerable damage to orchids in Trinidad.

Takahashi (1935) recorded *Taeniothrips smithi* Zimm. from the flowers of orchids in Formosa. Cory (1941) reported that the egg, nymphal, prepupal and pupal stages of *T. xanthius* Williams, infesting orchids lasted 9, 6, 1 and 3 days, respectively.

Priesner (1923) recorded *Thrips klapaleki* Uz from the flowers of *Orchis sp.* in Austria. Schliephake (1990) reported *T. palmi* Karny, as pest of orchids from Europe. Wang and Chu (1990) noted that *T. palmi* on orchids require 11.4-13 days to develop from egg to adult. Wang and Yang (1990) recorded *T. simplex* on orchids for the first time in Taiwan. Kajita *et al.* (1992) found *T. sumatrensis* feeding on orchids from Thailand. Timmerman and Vrie (1982) noted *T. tabaci* Lind. on orchids in Germany.

Timmerman and Vrie (1982) also obtained the control of *T. tabaci* by spraying with 25-50 ml permethrin, 100g propoxur, 50 g acephate or 100 ml pirimiphosmethyl.

According to Nishida and Boyle (1957) thrips that feed on orchid leaves have successfully been controlled by the use of DDT. Dipping with methonyl and a new synthetic pyrethroid, N-1002 have been found effective for controlling thrips on orchids (Rojanavongse *et al.*, 1982).

Suborder : Tubulifera

Family : Phlaeothripidae

Life history studies of *Liothrips vaneeckei* priesn. attacking orchids, by Schopp and Doucette (1932) indicate that the female starts oviposition 8-10 days after emergence, lay eggs singly at the rate of one or two per day. The incubation period averaged 12 days and the first and second larval instars averaged 11 and 13 days, respectively. The pupal stage ranged between 10 and 13 days.

2.1.3 Order : Lepidoptera

Suborder : Ditrysia

Family : Lycaenidae

Roepke (1919) observed a lycaenid caterpillar, *Chilaria dendrobii* Roepke, destroying the flowers of *Arundina*, *Dendrobium* and *Phalaenopsis spp*.

Family : Tortricidae

According to Nazarov (1987) the pods of orchids in U.S.S.R were damaged by the larvae of a leaf roller, *Lobesia crimea* Flkv, which consume the immature seeds.

2.1.4 Order : Diptera
Suborder : Nematocera
Family : Cecidomyiidae

Gagne (1995) found *Contarinia maculipennis* on *Dendrobium sp.* in Florida. Rojanavongse (1986) reported the deformation and subsequent decay of the young orchid flowers due to the feeding of *Contarinia sp.*

2.1.5 Order : Hymenoptera
Suborder : Apocrita
Family : Eurytomidae

Treherne (1916) reported cattleya fly, *Eurytoma orchidearum* westw. as a pest of orchids from Italy. Maskew (1917) found the larvae and adults of the pest infesting orchids of the genus *Cattleya* at Colombia and Santos. According to Doucette (1925) the total period from egg deposition to emergence of adults of *E. orchidearum* varies from 100-158 days. Contrary to this, Figueiredo (1942) reported that the development of the same from oviposition to adult emergence lasted 50-60 days.

Weiss (1916b) recommended fumigation with nicotene extracts to kill the adults of *E. orchidearum*. Infestation by this pest can also be controlled by the destruction of parts showing signs of injury or by injecting nicotene sulphate into the cavity containing the larva or pupa piercing it (Figueiredo, 1942).

Family : Formicidae

Frisque (1934) observed an ant, *Iridomyrmex humilis* Mayr in a number of green houses in Belgium on orchids of several genera. Smith (1929) recorded *I.*

iniquus Mayr on orchids in Brazil. Keall (1980a) found *I. purpureus* F. Sm. mainly associated with stored orchids.

Ehrhorn (1919) found *Monomorium pharaonis* L., on orchids from Java. Santschi (1920) observed *Plagiolepis foreli* Sant., on orchids in the botanical garden at Zurich.

Keall (1980b) noted seven species of ants on an orchid, *Laelia sp.* from Honduras.

2.1.6 Order : Coleoptera
Suborder : Polyphaga
Family : Apionidae

Fleury (1934) recorded *Cylas formicarius* F. in the psuedobulbs of an orchid in Philippines.

Family : Cerambycidae

Weiss (1917) found *Diaxenes dendrobii* Gahan feeding on orchids in New Jersey. Fisher (1937) reported *D. phalaenopsidis* Fisher as an important pest of orchids in Java and Sumatra. According to him, the egg and larval stages of the pest lasted 12-13 and 50-60 days, respectively, and adults remained alive for three months.

Family : Chrysomelidae

Leefmans (1919) reported a chrysomelid beetle, *Crioceris subpolita* Motsch., injuring various kinds of orchids in Java. According to him, the eggs are

laid on flowers or flower stems, incubation and larval period averaged 4-5 and 9-10 days respectively. The matured larva construct cocoon of white frothy substance and before pupating it remains inactive in the cocoon for 4-6 days. The pupal stage lasts 6-7 days and the whole life cycle lasts from 25-31 days.

During a survey in Thailand and Malaysia *Lema pectoralis* Baly was observed feeding exclusively on both leaves and flowers of orchids (Jolivet, 1971).

Gough *et al.* (1994) recorded *Stethopachys formosa* Baly feeding on 27 species of orchids incorporating 67 varieties in Queensland. He also reported that orchids were the only hosts of this pest, most commonly *Dendrobium* spp. Gough and Montgomery (1994) attempted to control *S. formosa* on the orange crucifix orchid. Their studies showed that bendiocarb at 0.4 g per litre, carbaryl at 10 g per litre, methidathion at 0.5 g per litre and methiocarb at 1.5 g per litre were the most effective spray treatments for rapid killing of the adults.

Family : Curculionidae

Ehrhorn (1916a) observed a grub of the weevil, *Acythopeus aterrimus* Waterh. in the stem of *Phalaenopsis* sp. in Manila. Whiteny (1929) noted the grub of *A. aterrimus* from the Philippines. Helle (1958) suggested spraying of 0.2 per cent thiodan emulsion at three weeks interval for three months to control *A. aterrimus* attacking *Paphiopedilum callosum*.

Barber (1917) found the weevil, *A. gilvonotatus* Barber among Philippine orchids in Washington greenhouses and on *Phalaenopsis* sp. in New Jersey. Buchanan (1934) observed *A. gilvonotatus* on orchids at Honolulu.

Weiss (1917) recorded a weevil, *A. orchivora* Blackb. on pseudobulbs of *Dendrobium* spp. in New Jersey.

Buchanan (1934) reported *Apotomorrhinus orchidearum* kolbe infesting orchids at Washington, Honolulu and Oahu.

Champion (1916) described *Cholus cattleyae* Champ. breeding in bulbs of *Cattleya gigas* in Tropical America. Vinal (1917) reported that *C. cattleyae* has a life cycle occupying from six months to an year. Weiss (1918) reported that the weevil, *Cholus forbesii* Pasc. have become established in New Jersey orchid houses.

Champion (1916) described *Diorymerellus laevimargo* Champion, attacking the roots of orchids and feeding on the leaves and flowers of *Cattleya* sp. and the flowers of *Dendrobium* sp. in Tropical America. Weiss (1917) reported *D. laevimargo* feeding on pseudobulbs of *Dendrobium* spp. in New Jersey. The adult weevil of *D. laevimargo* causes serious damage to the buds and flowers of orchids and they are usually found sheltering just below the surface of the peat in which the plants are grown (Hamilton, 1932). Hamilton (1938) reported that the young larvae of the pest feed on the new roots of the orchid, hollowing them out and causing the tips to turn black and die. According to him, the adults hide in the curled up basal part of the leaf or in the sheath surrounding the flower bud, making small irregular holes and causing the blooms to open imperfectly and the sheath to rot and die. Fonseca (1958) reported *D. laevimargo* on orchids from Sao Paulo.

Armitage (1942) observed that the fumigation of orchid houses with methyl bromide gave satisfactory control of *D. laevimargo* in Hawaii. Pirone (1978) recommended methoxychlor spray against *D. laevimargo*.

Monte (1942) described two weevils, *D. lepagi* Monte and *D. minensis* Monte, from orchids in the states of Paulo and Minas Gerais respectively. Orchids of the genera *Laelia* and *Cattleya* in Brazil were found severely damaged by *Diorymerellus* sp. (Ferriera, 1943).

Marshall (1927) recorded a weevil, *Omobaris calanthes* on an orchid, *Calanthe veratrifolium* in java.

Fullaway (1937) reported that the larvae of the weevil, *Orchidophilus atterimus* Waterh. burrows in the base of the stem of *Vanda* sp. causing discoloration or die back in Hawaii. Mau (1983) reported that all the immature stages of *O. atterimus* developed within the orchid pseudobulbs. According to him, the eggs were laid in cavities made by adult feeding and hatched in 11.3 days on an average. The larval and pupal stages averaged 117 and 15.9 days, respectively. Morimoto (1994) recorded *O. atterimus* on orchids from Japan.

Hara and Mau (1986) reported that control of *O. atterimus* with acephate or bendiocarb at 120 g per 100 litre of water significantly increased the number of marketable flowers of *Vanda* sp. in Hawaii.

Anonymous (1945) reported that *O. peregrinator* Buchannan reduced the production of *Vanda* sp. blooms in a commercial orchid garden at Oahu. It is also reported that a dust containing 3 per cent DDT destroyed *O. peregrinator* on *Vanda teres* within 48 hours in Hawaii.

According to Nishida and Boyle (1957) DDT controls orchid weevils, *Orchidophilus* spp.

Kemner (1916) reported that the larva of the weevil, *Otiorrhyncus sulcatus* F. damages the leaves of orchids in Stockholm. Hustache (1941) described *Ovanius cattleyae* Hust, as attacking the blossoms of *Cattleya* sp. in Normandy orchid house.

Family : Mordellidae

Lengerken (1922) recorded *Mordellistena cattleyana* Champion injuring *Cattleya labiata* near Berlin. Tempel (1926) found the larva of the pest causing damage to the leaves of the same orchid at Dresden.

Family : Scolytidae

Wilkinson (1938) noted *Xyleborus coffeae* Wurth, boring in orchids at Queensland. Kalshoven (1961) described the twig borer, *X. morigerus* Bldf on orchids from Britain.

Dixon and Woodruff (1983) found *Xylosandrus compactus* Eichhoff, attacking *Dendrobium* and *Cattleya* spp. in U.S.A. Pritchard (1959) reported *X. morigerus* Bldf boring in the stems of *Dendrobium* sp. in Formosa. Baltazar (1985) reported that *Dendrobium* sp. in Philippines were subjected to the depredation of *X. morigerus*.

2.1.7 Non Insect Pests

2.1.7.1 Mites

Cory *et al.* (1953) reported that the egg and larval stages of eriophyid mite, *Aceria* sp. attacking *Cattleya* sp. in Maryland lasted for averages of 5.6 and

4.9 days, the protonymphal period for 5.5 days and the deutonymphal period for 7.5 days. He also reported that the injury to orchids of the genus *Cattleya* comprising small brown areas just above the line of the sheath and dark brown or black discoloration of the sheath was due to the infestation by this pest.

Manglitz (1953) noted *Brevipalpus australis* Tucker, on orchids at Fiji and he also recommended methyl carbinol for the control of the pest. The *Oncidium* mite, *B.oncidii* Baker is recorded as a serious pest of orchids in England and California (Bose and Yadav, 1989).

Yagi (1918) recorded orchids as one of the food plants of the bulb mite, *Rhizoglyphus echinopus* F. Mc Daniel (1928) made a detailed study on the biology of *R. hyacinthi* Banks attacking orchids. According to him, a single female lays 50-100 eggs and lives for a month. The life cycle is completed in 30 days.

According to Denmark (1987) the false spider mite, *Tenuipalpus pacificus* Baker is one of the most destructive mite pests on the leaves of orchids in Florida. Lo *et al.* (1993) reported it as one of the common pests which infest orchids in Taiwan.

Denmark (1987) recommended ethion for the control of *T. pacificus*.

Pritchard (1951) reported that parathion is effective against the two spotted spider mite, *Tetranychus bimaculatus* Harvey, attacking orchids. Pruszynski *et al.* (1985) used the predaceous mite, *Phytoseiulus persimilis* At.Hen., for the biological control of tetranychidae on orchids in glasshouses in Poland.

Denmark and Woodring (1965) found that the occasional damage to the aerial roots of orchids in Florida was due to the mite, *Tyrophagus curvipenis* F. Fain and Fauvel (1993) noted *T. curvipenis* from orchids in Portugal, feeding on algae covering the wooden structures of the green house and occasionally entered the flowers where they feed on pollen.

2.1.7.2 Slugs and Snails

Alicata (1957) reported that the slug, *Deroceras laeve* feed voraciously on orchids in Hawaii. He also recommended two ground sprays of 1 per cent metaldehyde at an interval of three weeks for controlling the pest. Application of pinches of 3 per cent metaldehyde powder plus the spray was also found to be effective.

Pritchard (1959) reported that the tiny bush snail, *Zonitoides arboreus* Say., is particularly a noteworthy pest of orchids in North America. Porcelli and Parenzan (1988) found *Z. nitidus* Muller, causing serious damage to various orchid species in Italy.

2.1.7.3 Nematodes

Feder (1951) recorded a leaf nematode, *Aphelenchoides ritzemabosi* which caused a great loss in the cultivation of *Vanda sp.*, the most widely grown orchid in Hawaii.

Wood lice

Collinge (1914) recorded the wood lice, *Trichoniscus roseus* Koch, causing considerable damage to orchids of South Paulo. He also reported that kerosene emulsion and sprinkling of Paris green on the floor of greenhouses is effective against this pest.

Materials and Methods

MATERIALS AND METHODS

A survey was conducted in Trichur, Ernakulam, Alapuzha and Kottayam districts of Kerala during the period from March '96 to September '97 to study the various pests occurring on orchids. Different stages of the pests collected during the survey were reared in the laboratory and preserved for further studies.

3.1 Collection, preservation and identification of insects

The leaves along with the last instar nymphs or pupae of whiteflies were collected from the field and they were killed by dipping the leaves in methanol. The specimens were air dried, labelled and preserved for further identification.

Thrips were collected by tapping the inflorescence on a white paper and the adults were transferred to petridishes containing methanol (50%) and ethyl acetate (5%) solution and later stored in 70 per cent alcohol..

The adults of Coleoptera, Hymenoptera and Lepidoptera were transferred to a killing bottle in which cotton swabbed in ethyl acetate was provided. After killing, they were dried in an oven at 40-45°C for about five hours. The specimens were properly labelled and preserved for further identification.

Slugs, snails and sowbugs were preserved in 5 per cent formalin.

The identity of all the collected pests was determined after confirming with specialists.

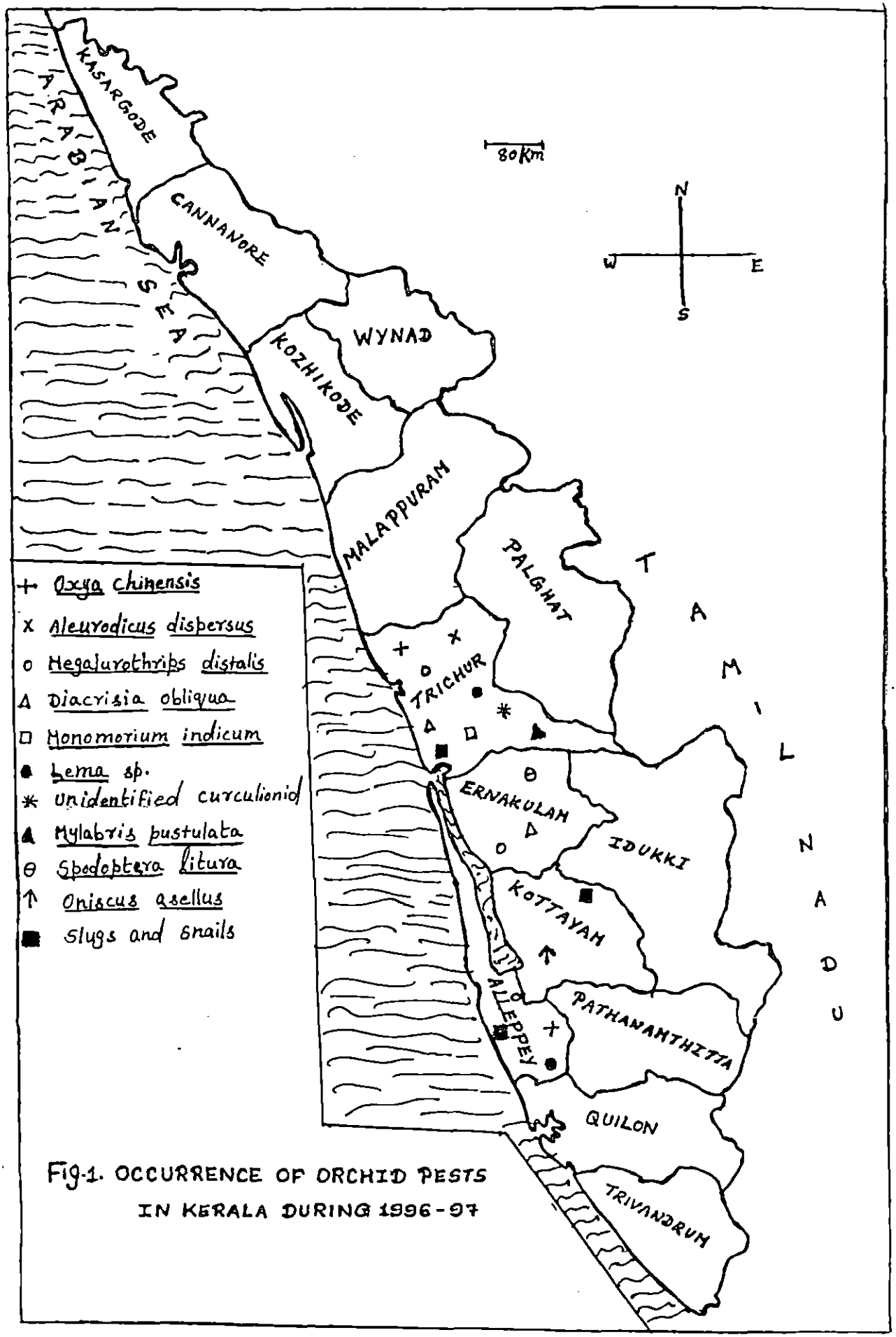


Fig-1. OCCURRENCE OF ORCHID PESTS IN KERALA DURING 1996-97

3.2 Morphological studies

The morphological characters of all the collected pests were studied by observing the colour and size and measurements were made on body length, breadth and wing span according to the pests.

3.2.1 Preparation of specimens

The adults killed were transferred into petridishes containing five per cent potassium hydroxide and kept overnight. The tissues were removed and the specimens were transferred to glycerine and were retained for three minutes. The required parts were then dissected out and observed under stereo binocular microscope.

3.2.2 Micrometry

Measurements of various life stages and different parts of the adult insects were recorded using the technique of micrometry.

First, the ocular micrometer was calibrated. For this, the ocular micrometer was placed in the intermediate image plane of the eye piece and stage micrometer on stage. Both the micrometers were brought into focus and the number of divisions between two coinciding divisions on both the micrometric scales were counted. Then the ocular micrometer was calibrated as

$$\text{One ocular division} = \frac{\text{Stage reading}}{\text{Ocular reading}} \times 0.01 \text{ mm}$$

From ten such sets of values, the average was taken.

After calibrating the ocular micrometer, the stage micrometer was removed and the specimens arranged on a slide was placed. The ocular divisions corresponding to the length and breadth of each specimen were recorded and multiplied with the calibrated value to get the actual measurement in millimetres.

The details of length and width of various stages and parts of the thrips recorded are presented below:

Stage/parts	Length	Width
1. Egg	End to end	Across the middle portion
2. Larva to pupa	Anterior tip of head to posterior tip of abdomen	-
a) Head	Anterior margin to posterior margin on the dorsal side	-
b) Antenna/antennal sheath	Base to apex	-
c) Wing pads/wing sheath	Base to tip	
3. Adult	Anterior tip of head to posterior tip of abdomen	Across the widest area
a) Head	Anterior margin to posterior margin	,,
b) Antenna	Base to apex	-
c) Prothorax	Anterior margin to posterior margin	Across the middle portion
d) Mesothorax	,,	,,

Contd.

Stage/parts	Length	Width
e) Metathorax	Anterior margin to posterior margin	Across the middle portion
f) Fore wing	Base to apex	Across the widest area
g) Hind wing	,,	,,
h) Legs	Coxa to end of bladder	-
1) Segments	End to end	-
I) Abdomen	Posterior margin of metathorax to tip of last abdominal segment	Across the widest area

3.3 Biological studies

Detailed studies on the biology of whitefly, *Aleurodicus dispersus* Russell and thrips, *Megalurothrips distalis* karny were carried out under laboratory conditions during 1996-97. The temperature and relative humidity during the rearing period were recorded.

3.3.1 *Aleurodicus dispersus*

The spiralling whitefly, *A. dispersus* was reared on caged *Spathoglottis* plants. Nymphs along with the leaves were collected from the field and conical flasks with water were used for keeping the leaves. When adults emerged, they were sexed and five pairs were released in separate caged plants. The adults were removed after they laid eggs. The incubation period, duration of different instars

were found out separately. Adult longevity was determined by maintaining freshly emerged adults. For studying the mating, pre-ovipositional period, ovipositional period and fecundity, one pair of freshly emerged adults were introduced into the plants.

3.3.2 *Megalurothrips distalis*

The thrips were reared on *Spathoglottis* inflorescence. Test tubes of 9 x 8 cm were used for keeping the inflorescence and the test tubes were kept inside a glass container 24 x 15 cm and the mouth of the containers were closed tightly with a closely knitted cloth held by rubber band. The larvae of thrips were collected by tapping the inflorescence on to a white paper and was picked with a fine camel hair brush. They were transferred to glass tubes plugged with cotton. The collected larvae were released on the inflorescence that was kept immersed in water. Ten freshly emerged adults were used for the study. The flowers were checked under stereo binocular microscope for the presence of eggs.

3.3.2.1 Egg

The eggs laid were removed along with the petals and each egg was kept for hatching in separate petridishes. The incubation period was thus recorded.

3.3.2.2 Duration of different instars

Duration of different instars after hatching was determined by observing the flowers and buds under stereo binocular microscope. Observations were made on the duration of larval, prepupal and pupal stages in detail and the mean duration was arrived at.

3.3.2.3 Adult

Emerging adults were collected and ten freshly emerged adults were kept singly for the study.

3.3.2.3.1 Pre-ovipositional period

Each newly emerged adult was released to separate test tubes supplied with flowers. The introduced flowers were dissected out on the next day under a stereo binocular microscope and checked for the eggs. The pre-ovipositional period was thus calculated.

3.3.2.3.2 Ovipositional period

A single adult was released into the flowers and the ovipositional period was computed.

3.3.2.3.3 Fecundity

The number of eggs laid per female per day was noted for the whole ovipositional period and the fecundity was recorded.

3.3.2.3.4 Adult longevity

Ten freshly emerged adults were placed separately on an inflorescence fixed in each test tube of 9 x 8 cm. The dates of mortality of the adult insects were noted and thus the adult longevity was calculated.

3.4 Studies on the nature of damage

During the survey, the various pests collected were brought into laboratory and the nature of damage caused by them was studied. The plant parts were wrapped in moist cotton at its basal portion and kept in glass containers containing the test insects. The mouth of the glass containers were closed with muslin cloth held by rubber band.

3.5 Correlation of population of *Megalurothrips distalis* with weather factors

From October, 1996 to September, 1997 the influence of weather factors on the population of *M. distalis* was worked out. For this purpose mean temperature, relative humidity and rainfall were correlated with the population. The data were collected from the field and the number of the pest present on five randomly selected flowers were recorded.

3.6 Seasonal incidence and population dynamics of *Aleurodicus dispersus*

Seasonal incidence and population dynamics of *A. dispersus* on *Spathoglottis* leaves were also studied. The plants were randomly selected and incidence of the nymphs and adults was recorded at monthly interval on ten randomly selected leaves. Observations were made from July, 1996 to June, 1997. The extent of infestation was calculated using the following formula (Wheeler, 1969).

$$\text{Incidence index} = \frac{\text{S (Frequency in each grade x grade value)}}{\text{Total number of leaves observed x Value of highest grade}} \times 100$$

For computing this, the leaves were graded based on the presence of total number of nymphs and adults as follows:

Grade value	Number of whitefly per leaf
0	No whitefly
1	1-10
2	11-20
3	21-30
4	31-40
5	41-50
6	51-60
7	above 60

Population dynamics at different months during the dry season was also studied. Meteorological data for the entire period is depicted in Appendix 1.

3.7 Preliminary management studies

3.7.1 *A. dispersus*

Investigations were carried out in the laboratory to ascertain how far application of insecticides against *A. dispersus* on *Spathoglottis* spp. is effective. Infested leaves were collected from the field and was brought in to laboratory. The eggs, adults and excess nymphs were removed off from the leaves leaving only 25 nymphs. Six insecticides were sprayed on the leaves using a hand sprayer at concentrations described in Table 6. The untreated check was sprayed with water.

Each treatment was replicated thrice. Mortality was recorded after two days of treatment.

3.7.2 Slugs

Management studies of slugs were carried out in the laboratory in petridishes of 15 cm diameter. Three insecticides, viz., carbaryl (sevin 50 W.P), phorate (thimet 10 G), carbofuran (furadan 3 G) and a molluscide metaldehyde at different concentrations were tested in this study.

Sevin and metaldehyde were used both as baits and sprays. Powdered metaldehyde was used in the experiment. The baits were prepared by mixing the toxicant with the base material (rice bran) and powdered sugar. A little quantity of water was also added to moisten it. One gram of the bait was placed in each petridish and the petridishes with untreated bran were used as control.

In the experiment with sprays, one ml of the solution was poured in to the upper and lower dish of each petridish. The dishes were then swirled to get a uniform coating of the solution and was then allowed to dry. As control, petridishes treated with water alone were used. In the granular application, the insecticides were sprinkled in the petridishes.

Each concentration was taken as separate treatments and three replications were made of each treatment. Three field collected slugs were released to each petridishes along with tender leaves of *Dendrobium* spp. as food. Observations on the mortality were taken at intervals of 24, 48 and 72 hours and per cent mortality was calculated.

The treatments were as follows:

1. Baits

T_1 - Metaldehyde - 3%

T_2 - „ - 5%

T_3 - Carbaryl - 3%

T_4 - „ - 5%

T_5 - Metaldehyde-Carbaryl - 1.5-1.5%

T_6 - „ - 2.5-2.5%

2. Sprays

T_7 - Metaldehyde - 1%

T_8 - „ - 3%

T_9 - Metaldehyde - 5%

T_{10} - Carbaryl - 1%

T_{11} - „ - 3%

T_{12} - „ - 5%

3. Granules

T_{13} - Phorate - 0.5 g/petridish

T_{14} - „ - 1.0 g/ „

T_{15} - „ - 1.5 g/ „

T_{16} - Carbofuran - 0.5g/petridish

T_{17} - „ - 1.0 g/ „

T_{18} - „ - 1.5 g/ „

T_{19} - Control

Statistical analysis

Statistical analysis of the data generated in the experiment was done by employing the methods described by Snedecor and Cochran (1967).

Results

RESULTS

A detailed survey of the pests associated with orchids was conducted in Trichur, Ernakulam, Alapuzha and Kottayam districts during March 1996 to September 1997. Observations were made on the biology, morphology, nature of damage and on preliminary management studies of the pests. The results of the studies are given below.

4.1 Orchid pests

4.1.1 Grasshopper: *Oxya chinensis* (Thunberg)

Acrididae : Orthoptera

The grasshopper is green coloured, with a dark stripe dorsally, running laterally from each eye to the base of the wings. Antennae filiform. Legs long, slender and green. Hind tibiae bluish with ten black tipped spines including an outer apical spine (Plate 1). Measures about 40 mm in length.

Both nymphs and adults cause damage by making elongate, irregular holes on the mature leaves of *Spathoglottis* spp.

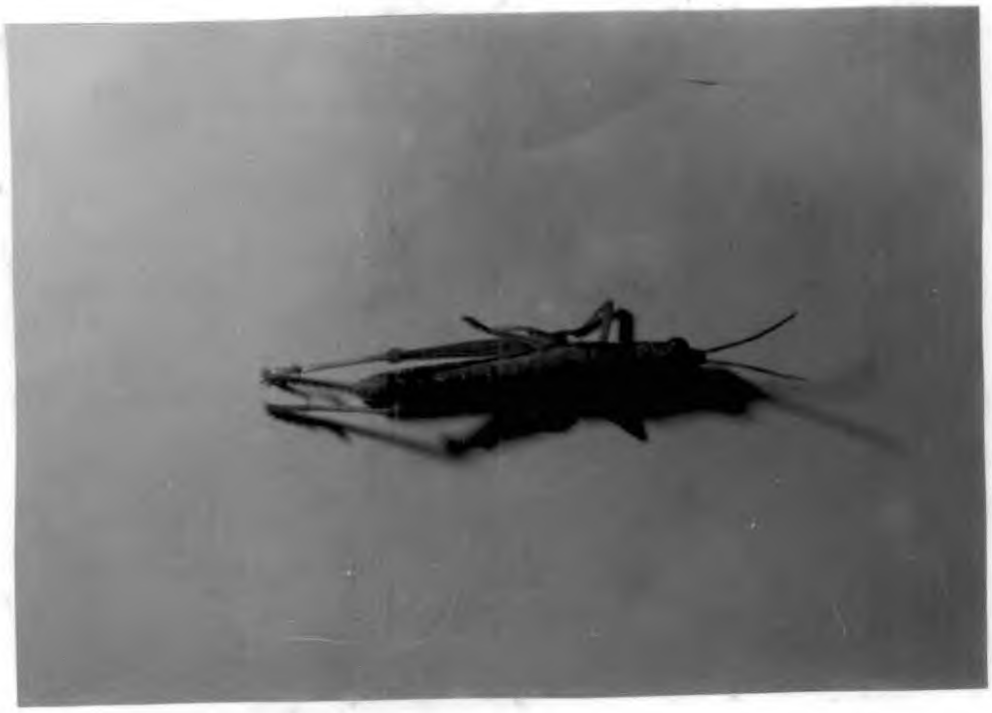
4.1.2 Spiralling whitefly: *Aleurodicus dispersus* Russell

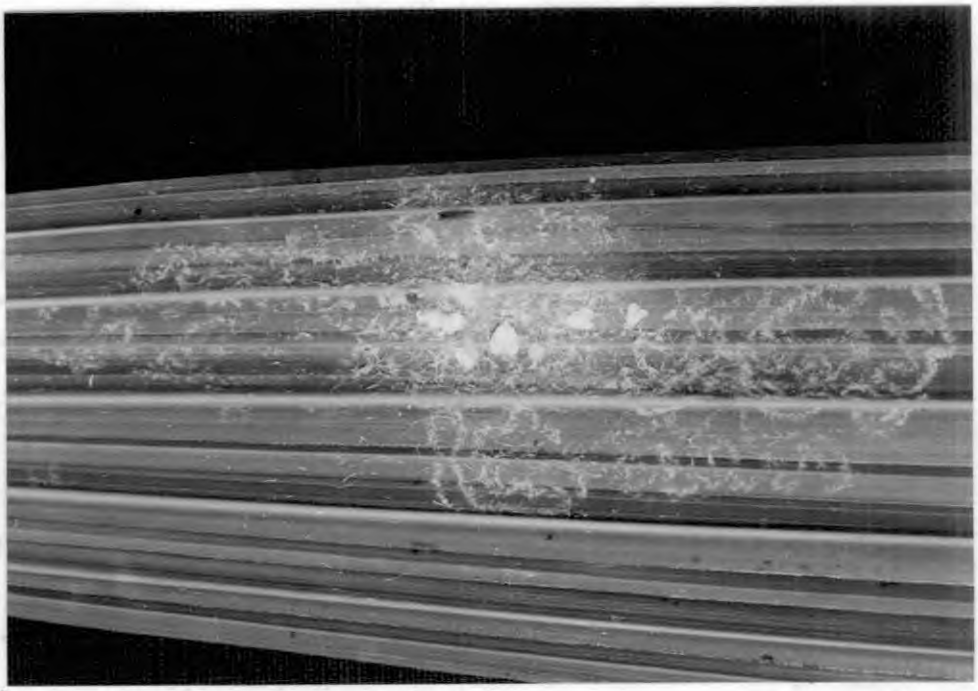
Aleyrodidae : Hemiptera

The adults are small, 0.5 mm in length and pale yellow in colour with two pairs of white wings. Appears white due to the white powdery wax secretions. Males are larger in size and with a pair of prominent clasper. Females lay eggs on the underside of the *Spathoglottis* leaves in a loose spiral like fingerprint impression

Plate 1. *Oxya chinensis* - nymph (2x)

Plate 2. Fingerprints on the undersurface of *Spathoglottis* leaves





of wax deposits (Plate 2). There are four nymphal instars. Only the first instar is mobile and the later instars immobile.

Both the nymphs and adults congregate on the lower surface of the leaves and suck sap. As a result, leaves turn pale and the vitality of the plants get lowered.

4.1.3 Flower thrips: *Megalurothrips distalis* Karny
Thripidae : Thysanoptera

The insect infests the flowers of *Dendrobium* and *Spathoglottis spp.* Deep black coloured thrips measuring about 1.65 mm in length. Antennae eight segmented. Three ocelli present. Prothorax well developed, mesothorax broader than metathorax. Tarsi of the leg ends in a bladder. Fringed wings present, hind wings more slender than fore wings.

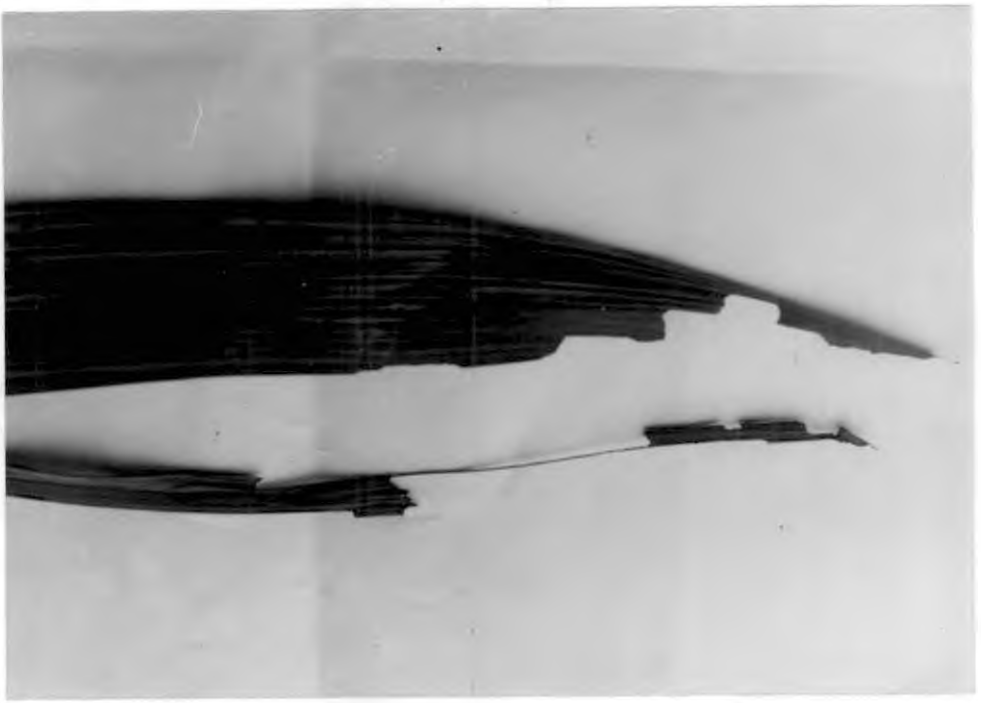
Females lay eggs singly in the tissues of the petals. Injury is caused by both nymphs and adults rasping the buds and flowers.

4.1.4 Bihar hairy caterpillar: *Diacrisia obliqua* Walker
Arctiidae : Lepidoptera

Full grown caterpillars are profusely covered with long greyish hairs and measures about 40 mm in length. Pupa is enclosed in a loose silken cocoon. Adult measures about 50 mm across the wing spread. Wings white coloured with black dots. Abdomen yellow coloured with black bands and dots.

Plate 3. Damage caused by *Diacrisia obliqua*

Plate 4. *Monomorium indicum* (4x)



The caterpillars feed on the leaves of *Spathoglottis* spp. leaving the midribs (Plate 3). In the case of severe infestation, plants are completely denuded of leaves.

4.1.5 Tobacco caterpillar: *Spodoptera litura* F.

Noctuidae : Lepidoptera

Full grown larva is stout, pale greenish brown with dark markings and measures about 35-40 mm in length. The caterpillar feeds gregariously on the flowers of *Spathoglottis* spp. and *Dendrobium* spp.. Also recorded to feed on tender leaves of *Dendrobium* spp.

4.1.6 Red ant: *Monomorium indicum* Forel

Formicidae : Hymenoptera

The ant (Plate 4) inhabits soil and damages the plants by feeding on the roots.

4.1.7 Beetle: *Lema* sp.

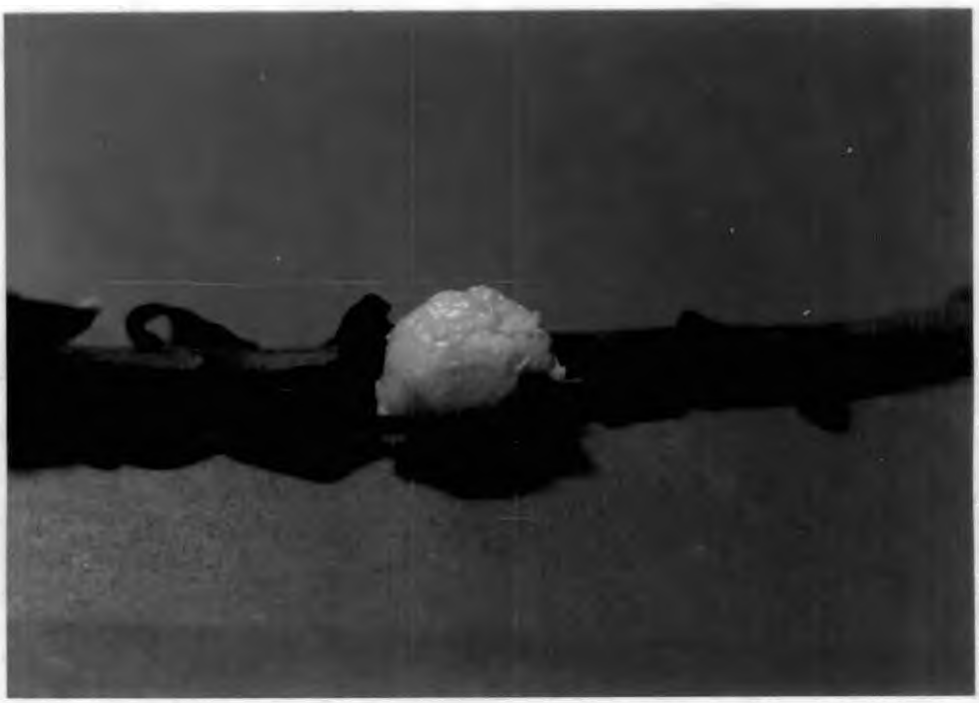
Chrysomelidae : Coleoptera

Adult is a small beetle, pale flavous, measuring about 9 mm in length. Antennae filiform. Head constricted posteriorly, eyes large and complete. Thorax convex, impunctate and constricted at the sides. Elytra raised at base and provided with rows of punctures. Legs elongate with three segmented tarsi. Third segment bilobed. Claws black, joined at base (Plate 5a).

Plate 5a. *Lema* sp. - adult beetle (4x)

Plate 5b. Grub of *Lema* sp. (1x)

Plate 5c. Cocoon of *Lema* sp. (1x)



The grub is yellowish white with head, thoracic shield and legs black. The abdomen of the larva is swollen and humped (Plate 5b). Carries on its back the faecal matter and the body is always wet with brownish fluid. The final instar grub stops feeding after 2-3 days of its moulting and constructs a cocoon made of white frothy substance for pupation (Plate 5c). Larval and pupal period lasts for 10-13 and 12-16 days respectively.

Damage is caused by both grubs and adults feeding on the flowers of *Spathoglottis* spp. and *Epidendrum* spp. The beetle appeared in the field with the commencement of rains in May.

4.1.8 Unidentified weevil

Curculionidae : Coleoptera

Black weevil of about 8 mm long and 3 mm wide, snout and legs thickened. Thorax wider than long. Elytra convex and broadly rounded to apex. Head is finely punctured, thoracic dorsum more coarsely pitted and elytra marked with punctured striae. The ventral surface and legs also finely pitted (Fig.2).

Grub creamy white with head chestnut brown in colour. Adult makes irregular holes at the base of *Dendrobium* leaves and also gnaws large irregular depressions in the pseudobulb. The grub lives in the pseudobulb and destroys much of the interior resulting in decay. Pupation also takes place in the pseudobulb.

4.1.9 Banded blister beetle: *Mylabris pustulata* (Thunberg)

Meloidae : Coleoptera

Black and red striped beetle (Plate 6) measuring 26 mm in length. Head vertical with a distinct neck. The beetles cause injury to the flowers of *Spathoglottis* sp.

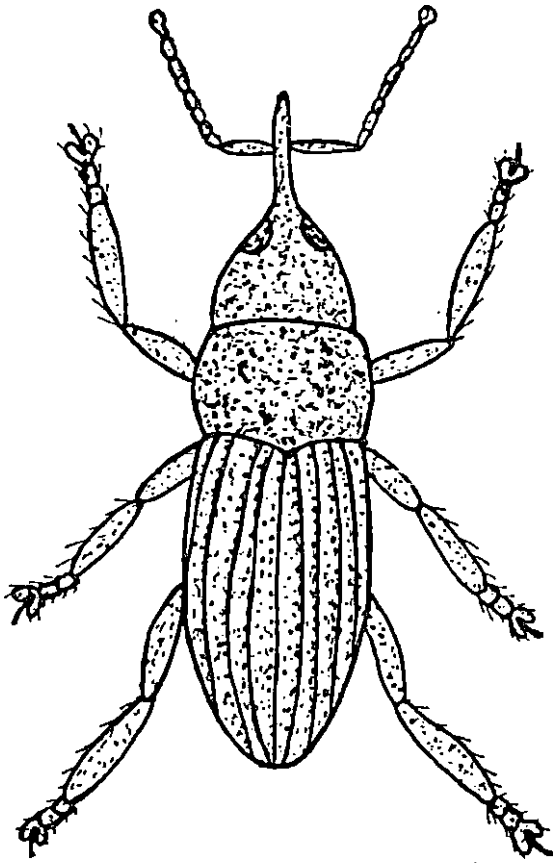
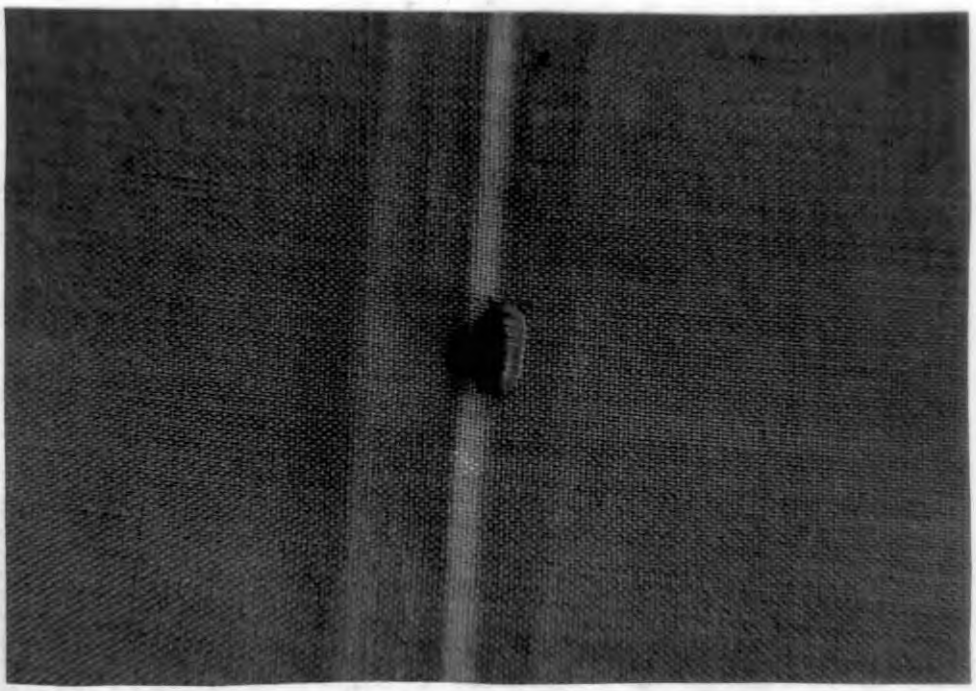


Fig.2. Unidentified curculionid

Plate 6. *Mylabris pustulata* - adult beetle (2x)

Plate 7. *Oniscus asellus* (3x)



4.1.10 Sowbug: *Oniscus asellus* L.

Oniscidae : Isopoda

Pale to slate-grey coloured, body flat with thirteen distinct segments. Terga of the thoracic and abdominal segments project laterally. Compound eyes typically present. Possess a pair of five segmented antenna. Basal antennal segment is cream coloured, second segment light orange in colour and the terminal three segments brown coloured. The first seven body segments are with a pair of legs. Abdominal segments six, the terminal segment fused with the telson (Fig.3). Abdomen and thorax have same width and not clearly demarcated dorsally (Plate 7).

Immature stages resemble the adult in appearance but body segmentation not distinct and bears only three pairs of legs. Adult measures about 5 mm in length and width of 3 mm. They hide in the potting media and feed on the tender roots of *Dendrobium* spp. It cuts the roots and makes a sleeve inside. As a result the plant remains stunted and later it dries off.

4.1.11 Snails and slugs

Phylum : Mollusca

Class : Gastropoda

Both snails and slugs have soft, unsegmented body consisting of an anterior head, a ventral flat foot and a dorsal visceral mass. Two pairs of unequal contractile tentacles known as anterior tentacles and posterior tentacles present. Eyes are borne on the tips of the posterior pair. Head well developed and bears the mouth at its anterior end.

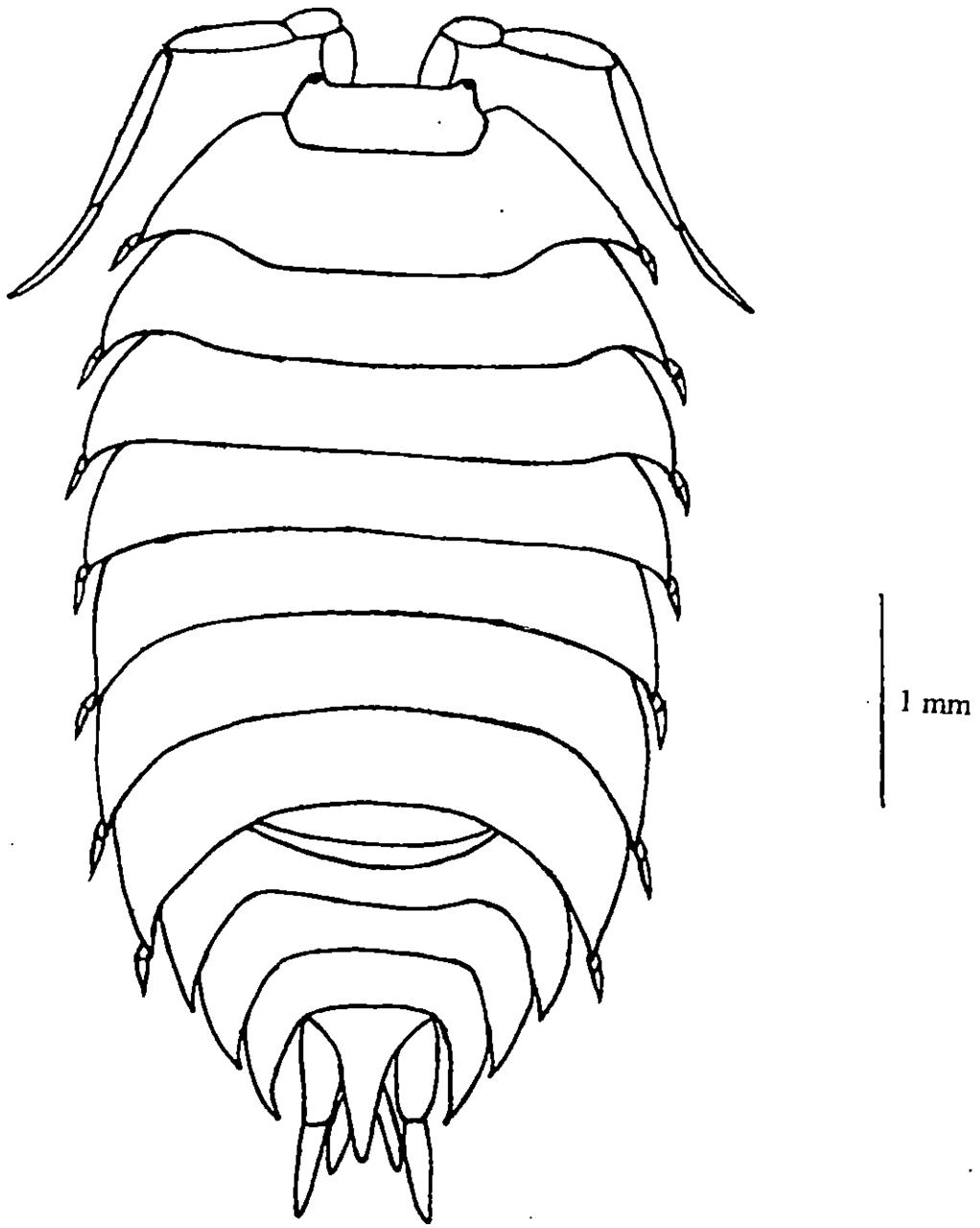


Fig:3. Dorsal view of ***Oniscus asellus***

4.1.11.1 Land snail: *Ariophanta* sp.

Ariophantidae : Stylommatophora

Snail with a spiral shell (Plate 8a) with its head protruded out of the shell. When disturbed the head and foot are withdrawn into the shell. Active during rainy season and nocturnal in habit. During the day they hide in crevices or under pots with the head and foot withdrawn into the shell. Lay eggs in a loose mass and hatch in about 16-22 days. Feed on tender leaves, flowers and also cut down the buds. The food is moistened by the salivary secretions and later rasped off in small bits leaving the midribs (Plate 8b).

4.1.11.2 Black slug: *Arion* sp.

Arionidae : Stylommatophora

4.1.11.3 Grey slug: *Limax* sp.

Limacidae : Stylommatophora

Black slug (Plate 9) and grey slug (Plate 10) are sheellless and slide by means of foot and lubricate their path with a trail of slime. Feeds at night and hide in the day time under the plant parts or the rim of the pot. Prefers young leaves and flowers.

4.2 Morphological studies

4.2.1 *Megalurothrips distalis*

Detailed studies were carried out on the morphology and morphometrics of *M. distalis*. Measurement on the dimensions of immature stages and length and

Plate 8a. *Ariophanta* sp.

Plate 8b. Damage caused by *Ariophanta* sp.

Plate 9. *Arion* sp.

Plate 10. *Limax* sp.

breadth of various body parts of the adult insect were recorded and presented in Table 1 and 2.

4.2.1.1 Egg

Eggs were oval to bean shaped, creamy white and opaque (Plate 11), with a mean length of 0.3 mm and width of 0.2 mm (Table 1).

4.2.1.2 First instar larva

Freshly emerged larvae were creamy white in colour, turn yellowish white during the course of development. Eyes black coloured. Antennae six segmented, fourth segment longer. Terminal three segments with small sense cones. Abdomen eleven segmented, provided with lateral and dorsal setae. Eleventh segment smaller in size (Fig.4a). The mean length of the instar was 0.77 mm. Head and antennae on an average measured 0.10 and 0.23 mm, respectively (Table 1).

4.2.1.3 Second instar larva

Light orange to deep orange in colour. Antennae slightly longer than in the first instar, measuring an average of 0.28 mm in length. Third segment longer than broad. Fourth elongate and longer than third. Fifth shorter than fourth one. Sense cones present on terminal four segments. Eyes deep orange in colour. Eleven segmented abdomen, ninth and tenth segments conical. Eleventh segment much more reduced (Fig.4b). Mean body length were 1 mm and length of the head were 0.09 mm (Table 1).

Plate 11. Egg of *Megalurothrips distaiis* (10x)

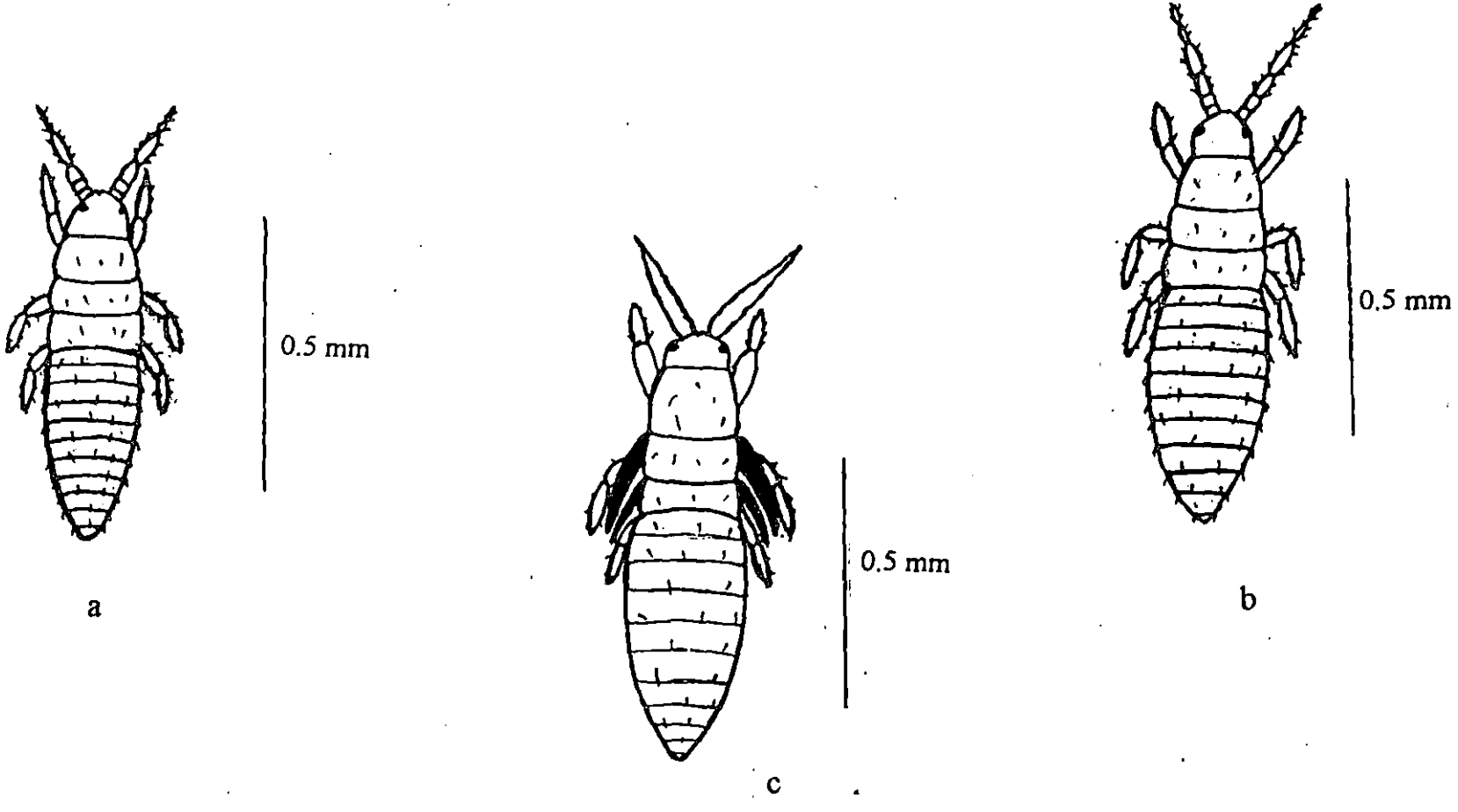


Fig.4. Immature stages of ***Megalurothrips distalis***
a) 1 instar (b) II instar (c) Prepupa

Table 1. Morphometrical studies of immature stages of *Megalurothrips distalis*

Stage	Length of immature stages (mm)			Length of head (mm)			Length of antennae/antennal sheath (mm)			Length of wing pads/wing sheath (mm)		
	Mean	Range	Standard error	Mean	Range	Standard error	Mean	Range	Standard error	Mean	Range	Standard error
Egg	0.30	0.30-0.50	0.01	-	-	-	-	-	-	-	-	-
Larva												
1. Instar	0.77	0.78-0.80	0.01	0.10	0.08-0.10	0.01	0.23	0.10-0.20	0	-	-	-
2. Instar	1.00	1.05-1.16	0.02	0.09	0.11-0.12	0.01	0.28	0.15-0.17	0.001	-	-	-
Prepupa	1.03	1.02-1.05	0.01	0.09	0.08-0.09	0.02	0.25	0.24-0.25	0.01	0.13	0.12-0.14	0.01
Pupa	0.95	0.91-0.97	0.01	0.08	0.07-0.09	0.01	0.33	0.31-0.35	0.01	0.39	0.35-0.42	0.03

4.2.1.4 Prepupa

Prepupa with long forwardly directed antennal sheaths and short wing pads. Segmentation of antennal sheaths not distinct. Tarsal segments are not separated and vesicle not developed. Abdominal segments not clearly separated (Fig.4c). Mean body length was measured as 1.03 mm. The head, antennal sheaths and wing pads on an average measured 0.09, 0.25 and 0.13 mm respectively (Table 1).

4.2.1.5 Pupa

Smaller in size compared to prepupa. Antennal sheaths longer, bent backwards on head, measuring an average of 0.33 mm in length. Possess long wing sheaths, measuring an average of 0.39 mm (Fig.5a).

Mean body length was 0.95 mm and length of the head on an average measured 0.08 mm (Table 1).

4.2.1.6 Adult

Freshly emerged adults were yellowish black in colour which later turned to deep black (Fig.5b). Average length and width of the insect was 1.65 and 0.32 mm respectively (Table 2).

4.2.1.6.1 Head

Hypognathous, produced below in to a rostrum containing the mouth parts. Mouth parts rasping and sucking type. Eyes black on anterolateral corners of

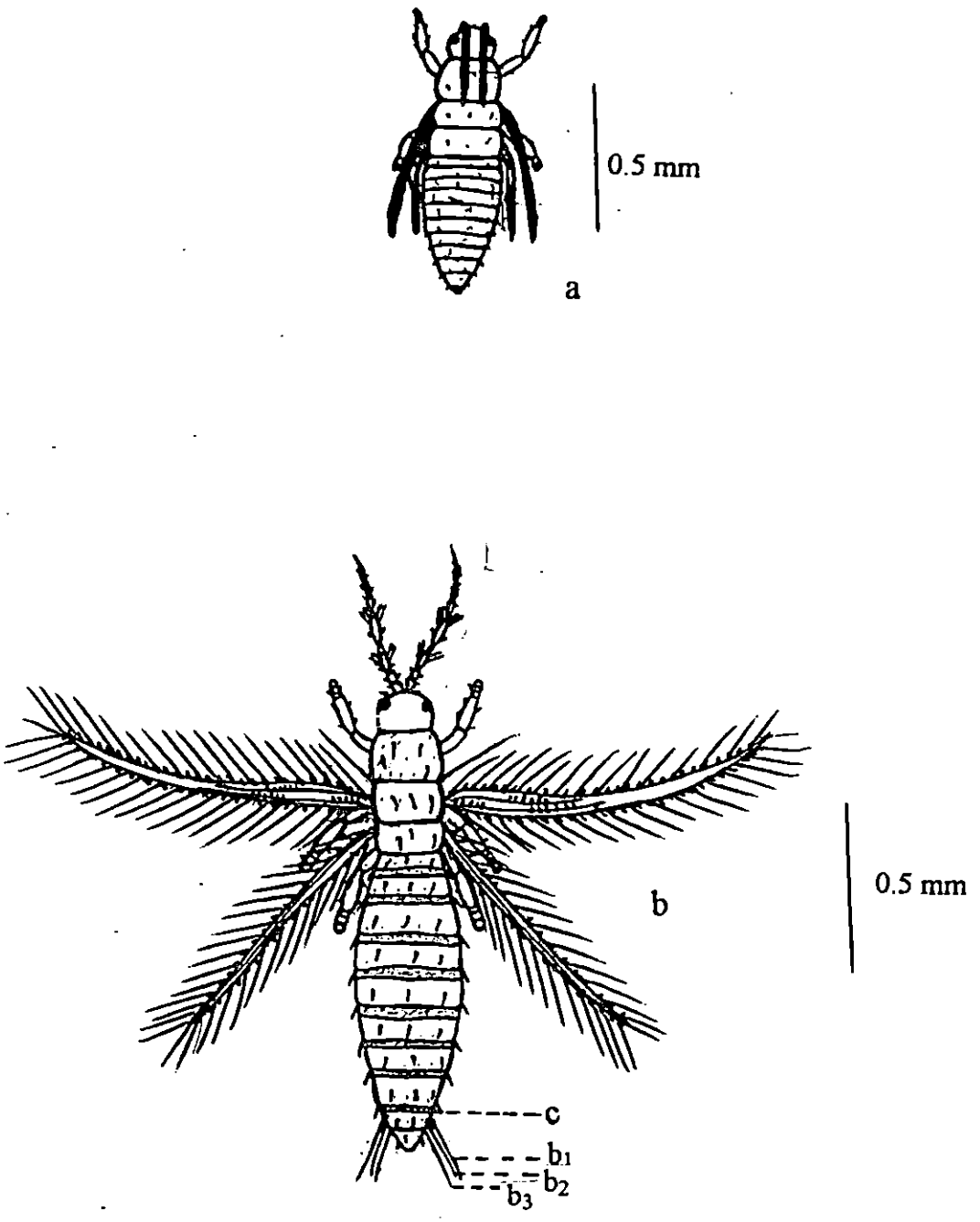


Fig.5. Pupa and adult of ***M. distalis***
a) pupa (b) Adult: b_1, b_2, b_3 - bristles
C - Comb

the head, composed of a number of ommatidia. Three ocelli between the eyes, arranged in a distinct triangle, an anterior median and two lateral ones (Fig.6b). Head on an average measured 0.21 mm in length and 0.18 mm in width.

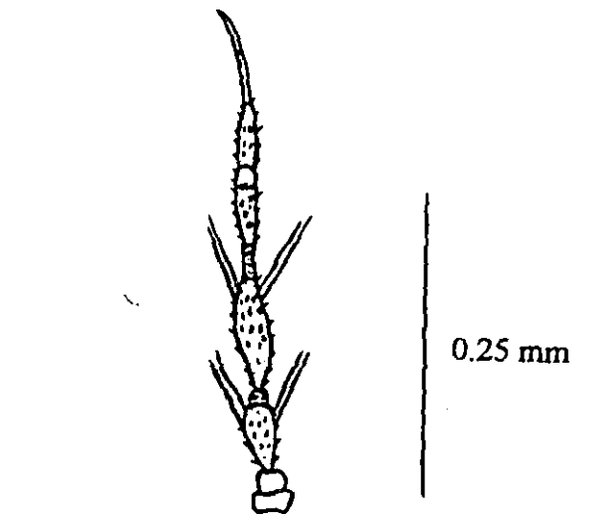
4.2.1.6.2 Antennae

Inserted close together in front of the head. Eight segmented, stouter, measuring an average of 0.42 mm in length. Terminal two segments forming style. First segment short and transverse measuring an average of 0.04 mm in length. Second segment also measures about 0.04 mm in length (Table 2). Third narrowed at apex, fourth elongate, longer than third. Sense cones on third and fourth long and as fine structures on other segments. The mean length of third and fourth segment was 0.07 and 0.1 mm respectively (Table 2). The terminal four segments very short and narrow (Fig.6a).

4.2.1.6.3 Thorax

Prothorax well developed, clearly separated from head and mesothorax. Broader than long, measuring an average length of 0.23 mm and width of 0.39 mm (Table 2). Pronotum with three pairs of posterior marginal setae in addition to the dorsal setae and a single strong seta at each posterior angle (Fig.6b).

Metathorax narrower than mesothorax. Spinula on mesosternum, absent on metasternum. Meso and metathorax on an average measured 0.22 and 0.14 mm in length and width of 0.30 and 0.23 mm respectively (Table 2).



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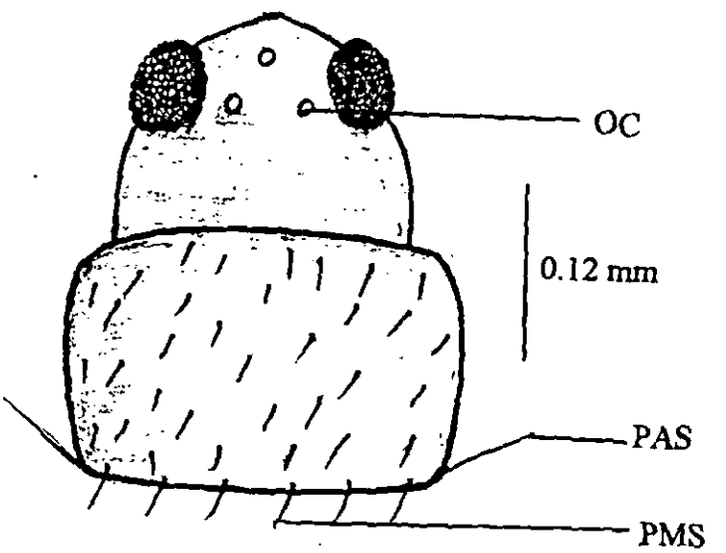


b

Fig.6. (a) Antenna of ***M. distalis***
(b) Head and prothorax of ***M. distalis***
OC - Ocelli, PAS - Postangular seta
PMS - Posteromarginal seta

Table 2. Measurements of various body parts of the adults of *M. distalis*

Part of the insect measured	Length/ width	Measurements (mm)		Standard error
		Mean	Range	
1	2	3	4	5
Adult	L	1.65	1.64-1.65	0.03
	W	0.32	0.31-0.32	0.07
a. Antenna	L	0.42	0.42-0.43	0.02
1) 1st segment	L	0.04	0.039-0.041	0
2) 2nd segment	L	0.04	0.039-0.041	0
3) 3rd segment	L	0.07	0.073-0.082	0
4) 4th segment	L	0.10	0.092-0.124	0
b. Head	L	0.21	0.21-0.22	0.07
	W	0.18	0.17-0.18	0.03
c. Prothorax	L	0.23	0.17-0.28	0.02
	W	0.39	0.21-0.38	0.03
d. Mesothorax	L	0.22	0.17-0.31	0.03
	W	0.30	0.35-0.44	0.02
e. Metathorax	L	0.14	0.13-0.14	0.01
	W	0.23	0.21-0.25	0.08
f. Fore wing	L	0.93	0.92-0.95	0.06
	W	0.08	0.07-0.10	0.07
g. Hind wing	L	0.91	0.94-0.95	0.01
	W	0.07	0.06-0.07	0.09
h. Legs				
a) Total length				
1) Fore leg		0.44	0.42-0.47	0.09
2) Mid leg		0.48	0.45-0.50	0.06
3) Hind leg		0.55	0.49-0.60	0.02

Contd.

Table 2. Continued

1	2	3	4	5
b) Coxa	L			
1) Fore coxa		0.10	0.10-0.11	0
2) Mid coxa		0.09	0.09-0.10	0
3) Hind coxa		0.10	0.10-0.11	0
c) Trochanter	L	0.04	0.04-0.041	0
d) Femur	L			
1) Fore femur		0.14	0.13-0.14	0.01
2) Mid femur		0.17	0.14-0.17	0.05
3) Hind femur		0.18	0.17-0.18	0
e) Tibia	L			
1) Fore tibia		0.14	0.12-0.14	0
2) Mid tibia		0.18	0.14-0.19	0.01
3) Hind tibia		0.18	0.17-0.19	0
f) Tarsi	L	0.07	0.06-0.07	0
g) Bladder	L	0.04	0.04-0.042	0
i) Abdomen	L	1.2	1.16-1.17	0.03
	W	0.32	0.31-0.32	0

4.2.1.6.4 Legs

Each leg made up of a coxa, trochanter, femur, tibia and a two segmented tarsi, distal segment ending in a bladder (Fig.7).

4.2.1.6.4.1 Coxa

Fore coxa spherical, mid and hind coxae conical. Fore (0.1 mm) and hind (0.1 mm) coxae slightly longer than mid coxa (0.09 mm) (Table 2).

4.2.1.6.4.2 Trochanter

Small, distinct segment, partially fused with the femur. Measured an average of 0.04 mm in length (Table 2).

4.2.1.6.4.3 Femora

Stoutest part of the leg. Fore femora simple, not armed with spines. Meso and metafemora clothed with spines. Fore femora shorter (0.14 mm) than mid (0.17 mm) and hind femora (0.18 mm) (Table 2).

4.2.1.6.4.4 Tibia

Slender, little constricted at base, widened distally. Fore, mid and hind tibiae armed with series of spines along the inner and outer margin. Fore, mid and hind tibiae on an average measured a length of 0.14, 0.18 and 0.18 mm respectively (Table 2).

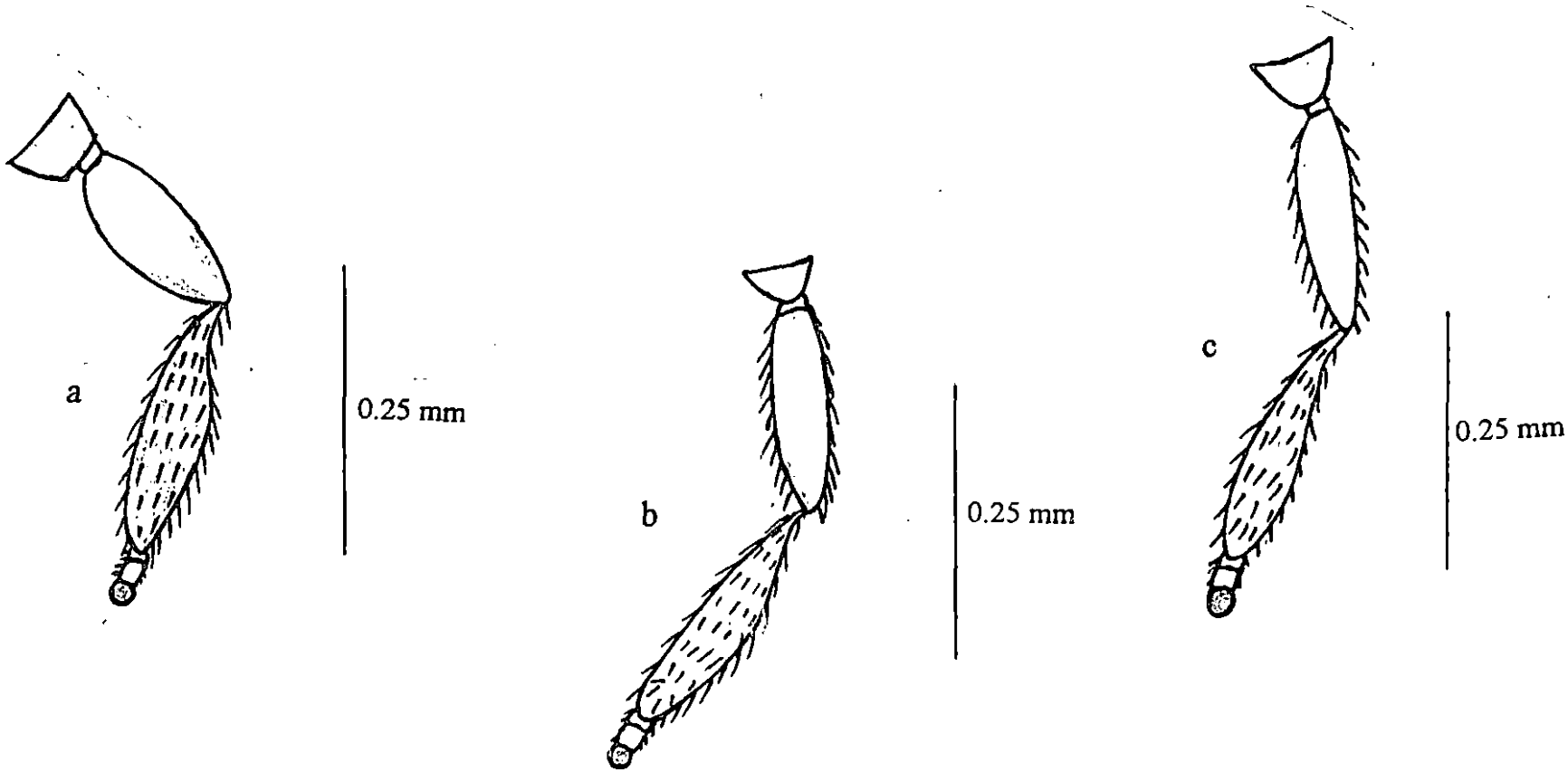


Fig.7. Legs of ***M. distalis***
(a) Fore leg (b) Middle leg (c) Hind leg

4.2.1.6.4.5 Tarsi

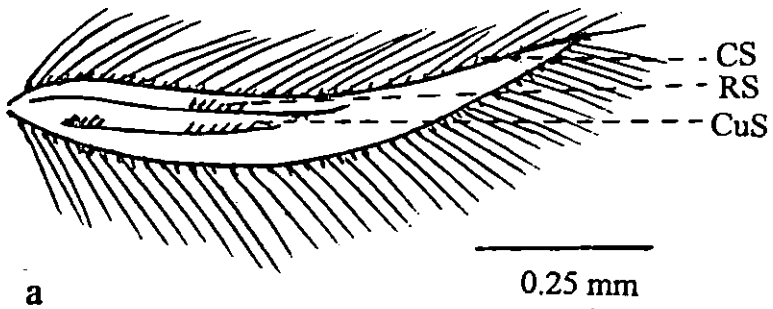
Two segmented, armed with spines. Basal segment much shorter than the distal one. The distal segment ends in a bladder.

4.2.1.6.5 Wings

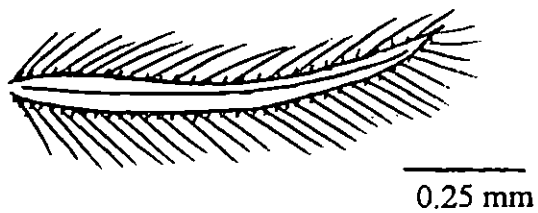
Wings are fringed and fringes are on both margins. They are narrow and pointed at apex. Anterior margin of wings concave. The upper and lower margin of the wing with a continuous row of setae up to the apex. Fore wings with three longitudinal veins viz., costa, radius and cubitus. Radial and cubital veins do not reach the apex. The radial vein with six setae starting from the middle and the cubital vein with five basal setae reaching up to middle and an apical group of six setae with a gap in between (Fig.8a). Hind wings more slender than fore wings and venation absent except a longitudinal vein running to the apex (Fig.8b). Fore wings on an average measured 0.93 mm x 0.08 mm and hind wings measured 0.91 mm x 0.07 mm (Table 2).

4.2.1.6.6 Abdomen

Ten visible segments. First segment much reduced and segments 2-10 well developed. Tergites 2-10 with one pair of lateral setae in addition to the dorsal setae. The hind margin of eighth segment bears dorsal comb of fine hair like prominences. Three pairs of bristles present on ninth segment. In females, the apex is round and the hind margin of the ninth segment concave. Abdomen on an average measured 1.2 mm in length and 0.32 mm in width (Table 2).



a



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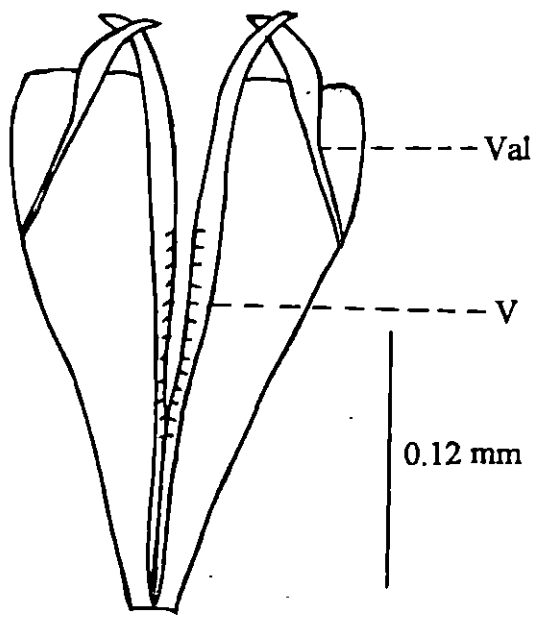


c

Fig.8. a) Fore wing: CS - Costal seta, RS - Radial seta, CuS - Cubital seta
b) Hind wing
c) Genitalia: V- valves, Val - Valvifers

4.2.1.6.6.1 Genitalia

Genitalia between eighth and ninth abdominal segments. Ovipositor with two pairs of chitinous, yellowish valves and edges with saw like teeth. Valves closely opposed, enclosing the egg channel. One side of each valve convex. Valves associated with valvifers at their base (Fig.8c).

4.3 Biological studies

4.3.1 *Aleurodicus dispersus*

The result of the studies on the biology of the insect at a temperature of 27°C and a relative humidity of 72 per cent are presented in Table 3 and the measurements on the size of the different stages are presented in Table 4.

4.3.1.1 Eggs

Eggs were elongate, oval, transluscent, creamy white and they turned yellowish white at the time of hatching (Plate 12a). Laid singly covered with wax in loose whorls like fingerprints on the lower surface of the leaves (Plate 2). Each egg is with a small stalk on the basal end with which it is attached to the leaf surface. Eggs on an average measured 0.31 mm in length and 0.12 mm in width (Table 4). Incubation period varied from 4-6 days, average being 5.4 days (Table 3).

4.3.1.2 First instar nymphs

Mobile, transparent to opaque. Two narrow tail like wax secretions seen at the posterior end of the body. Later settles down and produce small amount of powdery white wax all over the body (Plate 12b). The first instar measured an

Table 3. Biology of *Aleurodicus dispersus* reared under controlled conditions

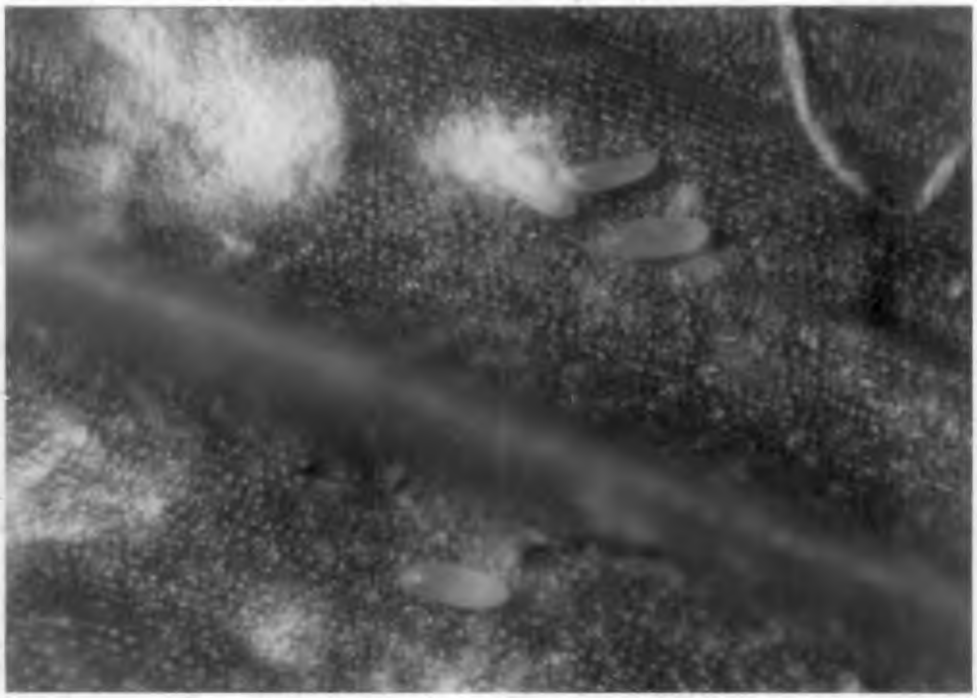
Stage/period	Mean (days)	Range (days)	Standard error
Pre-ovipositional	3.6	3-4	0.22
Ovipositional	5.4	4-6	0.36
Incubation	5.4	4-6	0.36
Nymphs			
I instar	6.4	5-7	0.36
II instar	3.6	3-4	0.22
III instar	7.4	6-9	0.46
Pupa	8.2	6-10	0.59
Adult longevity			
Male	10.6	9-12	0.46
Female	13.5	11-16	0.5
Fecundity	14	10-17	1.06

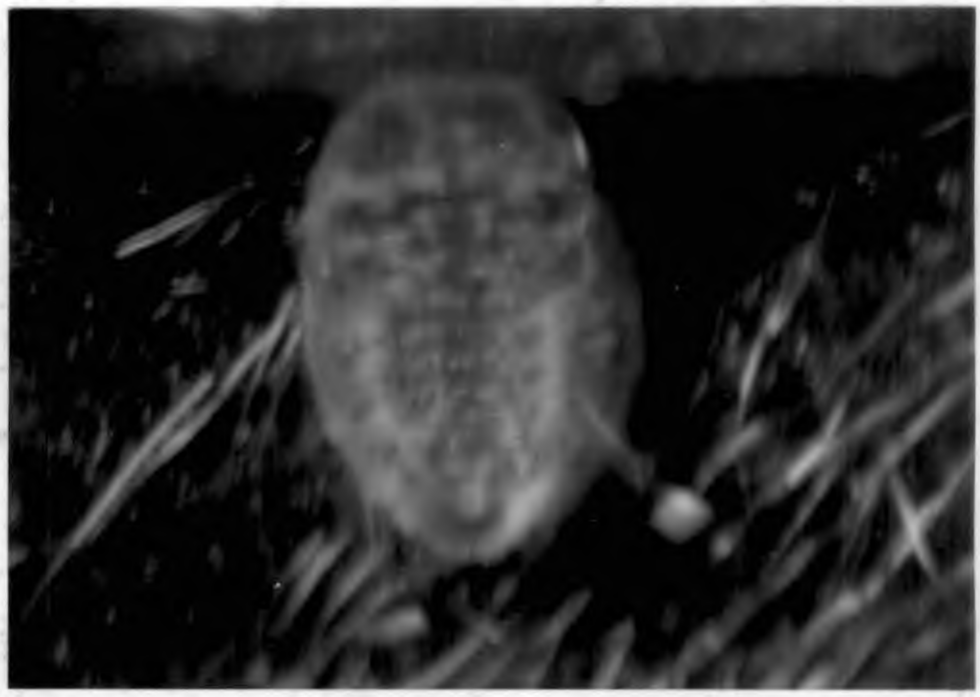
Table 4. Mean size of immature stages of *A. dispersus*

Stage	Length (mm)	Breadth (mm)
Egg	0.31 ± 0.02	0.12 ± 0.01
Nymphs		
I instar	0.83 ± 0.06	0.61 ± 0.02
II instar	1.58 ± 0.00	1.05 ± 0.00
III instar	1.58 ± 0.00	1.05 ± 0.00
Pupa	1.72 ± 0.03	1.58 ± 0.00

Plate 12a. Eggs of *Aleurodicus dispersus* (5x)

Plate 12b. *A. dispersus* - First instar nymph (8x)





average of 0.83 mm in length and 0.61 mm in width (Table 4). The first instar was completed in about 5-7 days (Table 3).

4.3.1.3 Second instar nymphs

Moulted skin of the first instar attached to the back of the second instar soon after moulting. Thick wax deposits along the margin of the body (Plate 12c). Tail like wax secretion clearly visible. Mean length and width were 1.58 and 1.05 mm respectively (Table 4). The nymphal period was completed in about 3-4 days (Table 3).

4.3.1.4 Third instar nymphs

Third instar nymphs with tufts of wax all over the body (Plate 12d). Three short, brittle wax filaments present on either side of the body. Mean length was 1.58 mm and width was 1.05 mm (Table 4). The nymphal period lasted for 6-9 days (Table 3).

4.3.1.5 Pupa

Body completely covered with white puffy wax secretion. Two broad and curled tail like wax filament on the posterior end. Brittle wax filament seen all over the body. An inverted T-shaped split visible dorsally after the emergence of adults (Plate 12e). Their mean length and width were 1.72 and 1.58 mm respectively (Table 4). The pupal period ranged from 6-10 days, average being 8.2 days (Table 3).

Plate 12c. *A. dispersus* - Second instar nymph (6x)

Plate 12d. *A. dispersus* - Third instar nymph (5x)

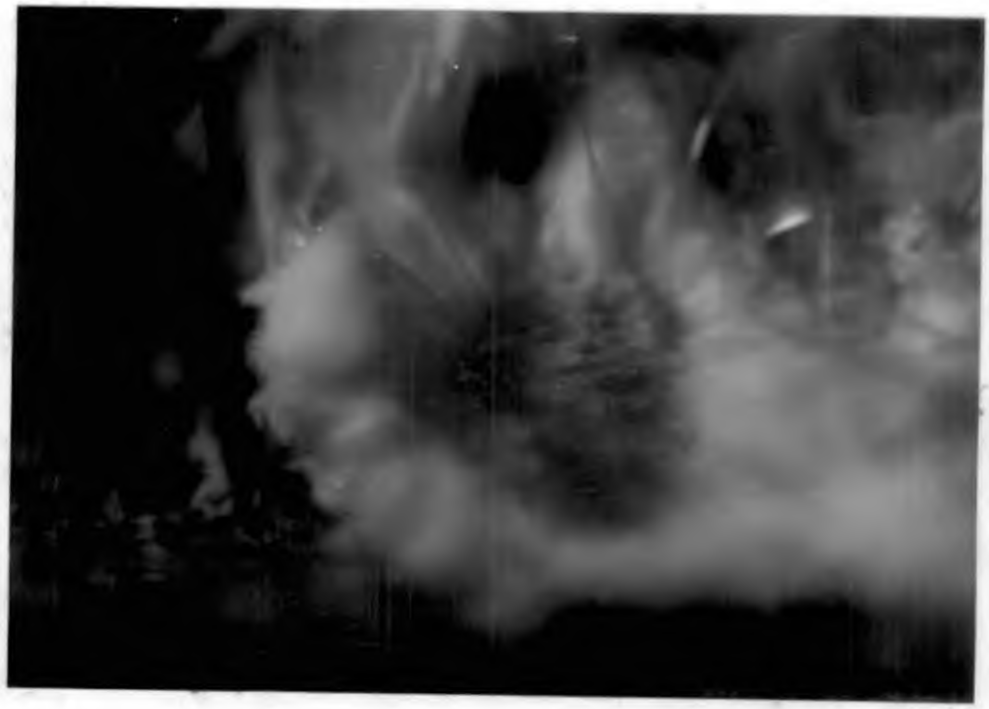
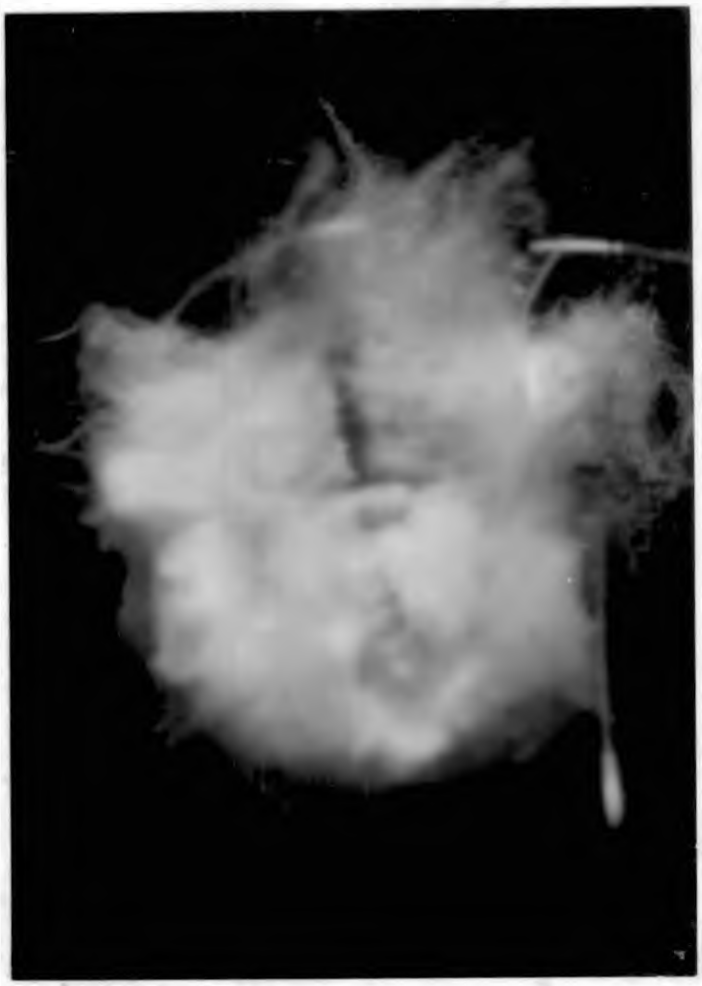
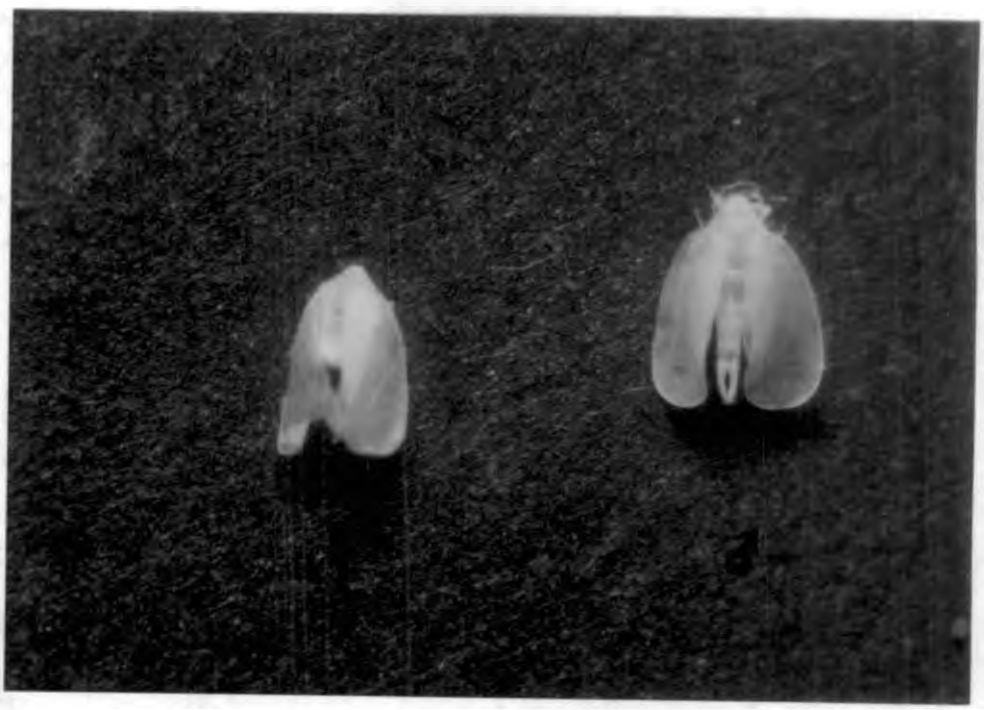


Plate 12e. Pupa of *A. dispersus* (7x)

Plate 12f. Adults of *A. dispersus* (10x)





4.3.1.6 Adults

After emergence pale yellow in colour with two pairs of white wings. Later appears white owing to the white powdery wax secretions. Remains near the pupal case for 4-5 hrs and then moves away. Adults also congregate on the lower surface of the leaves. Males were larger in size with tubular abdomen while females were smaller with conical abdomen (Plate 12f). Adult males and females lived for a period of 9-12 and 11-16 days, average being 10.6 and 13.5 days respectively (Table 3).

Pre-ovipositional period ranged from 3 to 4 days, average being 3.6 days. Ovipositional period prolonged for 4 to 6 days and the number of eggs laid by a single female varied from 10-17, mean being 14 eggs (Table 3).

4.3.2 *Megalurothrips distalis*

Results of the studies on biology of the insect reared at a temperature of 27°C and relative humidity 71 per cent are presented below. The insect had egg, two larval stages, prepupal and pupal stages (Fig.9).

4.3.2.1 Eggs

Eggs were laid singly, inserted inside the tissues of the petals. Incubation period varied from 2 to 4 days, the average being 1.6 days (Table 5). The eggs appeared creamy white with a delicate shell.

4.3.2.2 Larva, prepupa and pupa

The newly hatched larva remains at the base of petals. The second instar and the prepupa were found on opening buds or at the base of the petals. The pupa

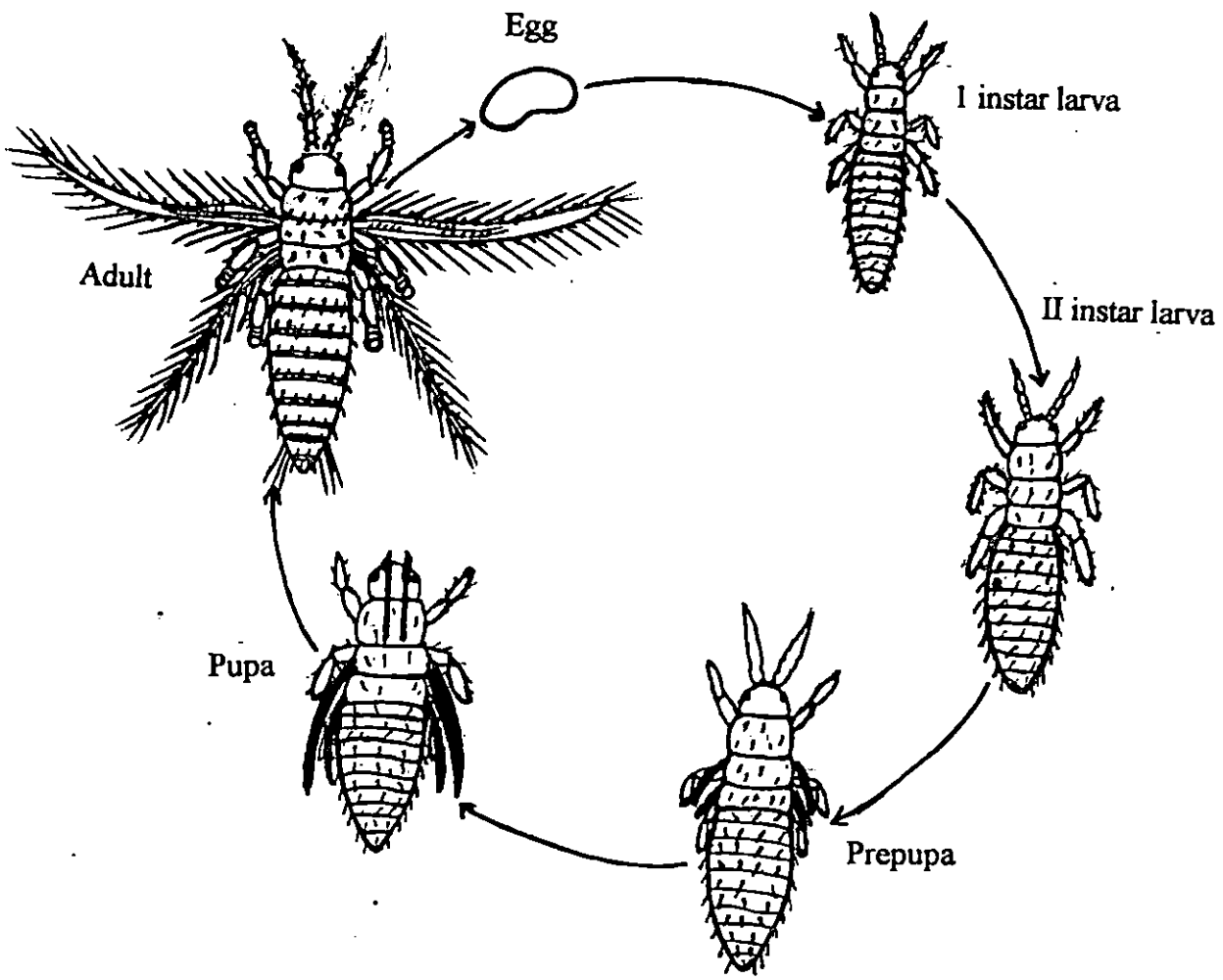


Fig.9. Life stages of *M. distalis*

Table 5. Duration of different life stages of *Megalurothrips distalis* reared under controlled conditions

Sl. No.	Stage	Period (days)		Standard error
		Mean	Range	
1	Egg	1.6	2-4	0.31
2	Nymphs			
	I instar	2.0	1-3	0.28
	II instar	4.0	2-6	0.63
3	Prepupa	1.4	1-2	0.31
4	Pupa	5.0	3-7	0.63
5	Adult	9.0	8-10	0.28

moves out of the flower and were found at the base of the rearing container. The first and second instars were completed in about 1-3 and 2-6 days respectively. Prepupal and pupal period ranged from 1-2 days and 3-7 days, the average being 1.4 days and 5 days respectively (Table 5).

4.3.2.3 Adult

The emerging adults were yellowish brown in colour which later turned to deep black. Adults lived for a period of nine days and the range being 8-10 days (Table 5).

4.3.2.4 Courtship behaviour

Males were not found and mating pairs were never noticed during the period of study.

4.3.2.5 Pre-ovipositional period

Pre-ovipositional period ranged from 1 to 3 days, the average being 2 days.

4.3.2.6 Ovipositional period

The ovipositional period continued for 2 to 3 days.

4.3.2.7 Fecundity

The total number of eggs laid during the whole life period ranged from 14 to 20 (mean 16.8 eggs).

4.4 Nature of damage caused by *Megalurothrips distalis*

Both the larvae and adults cause damage in the form of elongated brownish streaks in buds and flowers. The insect punctures by driving the stylets in to the tissues and suck sap. It then moves a little and repeats the operation. The injured tissues harden and turn brownish. They remain hidden in the buds and flowers resulting in distorted and disfigured buds and flowers. Larvae cause more damage than the adults.

First sign of injury occurs in the form of silvery patches. The typical damage as a result of feeding appears in the form of silvering, scarring and destortion of buds and flowers (Plate 13). Sometimes buds fail to blossom. The deposition of eggs by saw like ovipositor also causes mechanical injury to the flowers.

4.5 Correlation of *Megalurothrips distalis* with weather data

The studies on the correlation of thrips with weather data showed that the thrips were maximum during the months of January-April, when the temperature was 28-30°C, relative humidity 60-66 per cent and rainfall insignificant. After summer there was a slow decline and heavy rains in June-August brought about a total decline in the population. September marked a steady revival of population. Thus early spring marked an ascending phase in population and during summer the peak was attained (Fig.10).

4.6 Seasonal incidence and population dynamics of *Aleurodicus dispersus*

The population was high during January to March, when the temperature was 28-30°C and during rainy period it was low. The population declined after

Plate 13. Damage caused by *M. distalis*

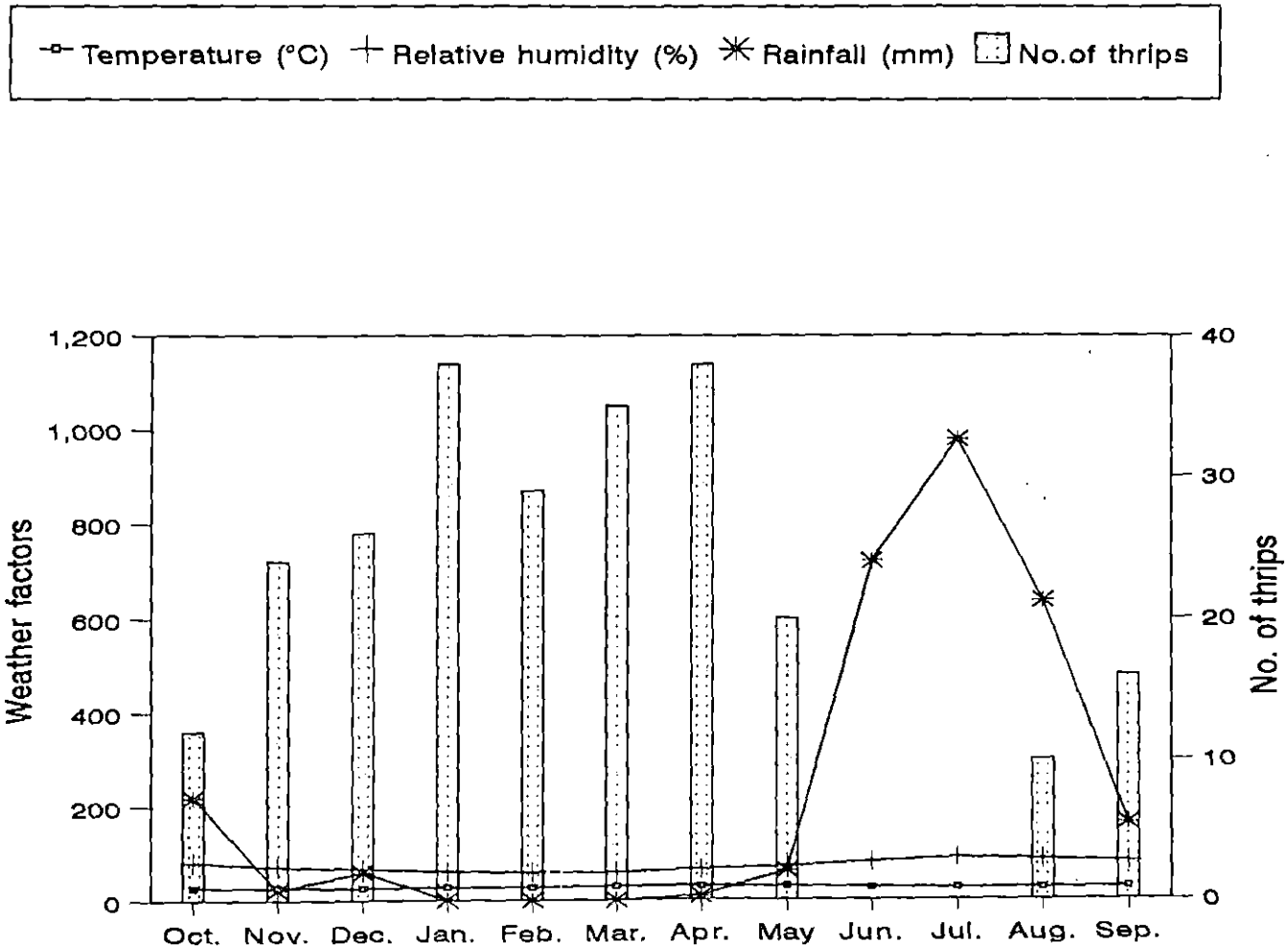


Fig.10. Seasonal fluctuations of *Megalurothrips distalis* in relation to meteorological data (1996-97)

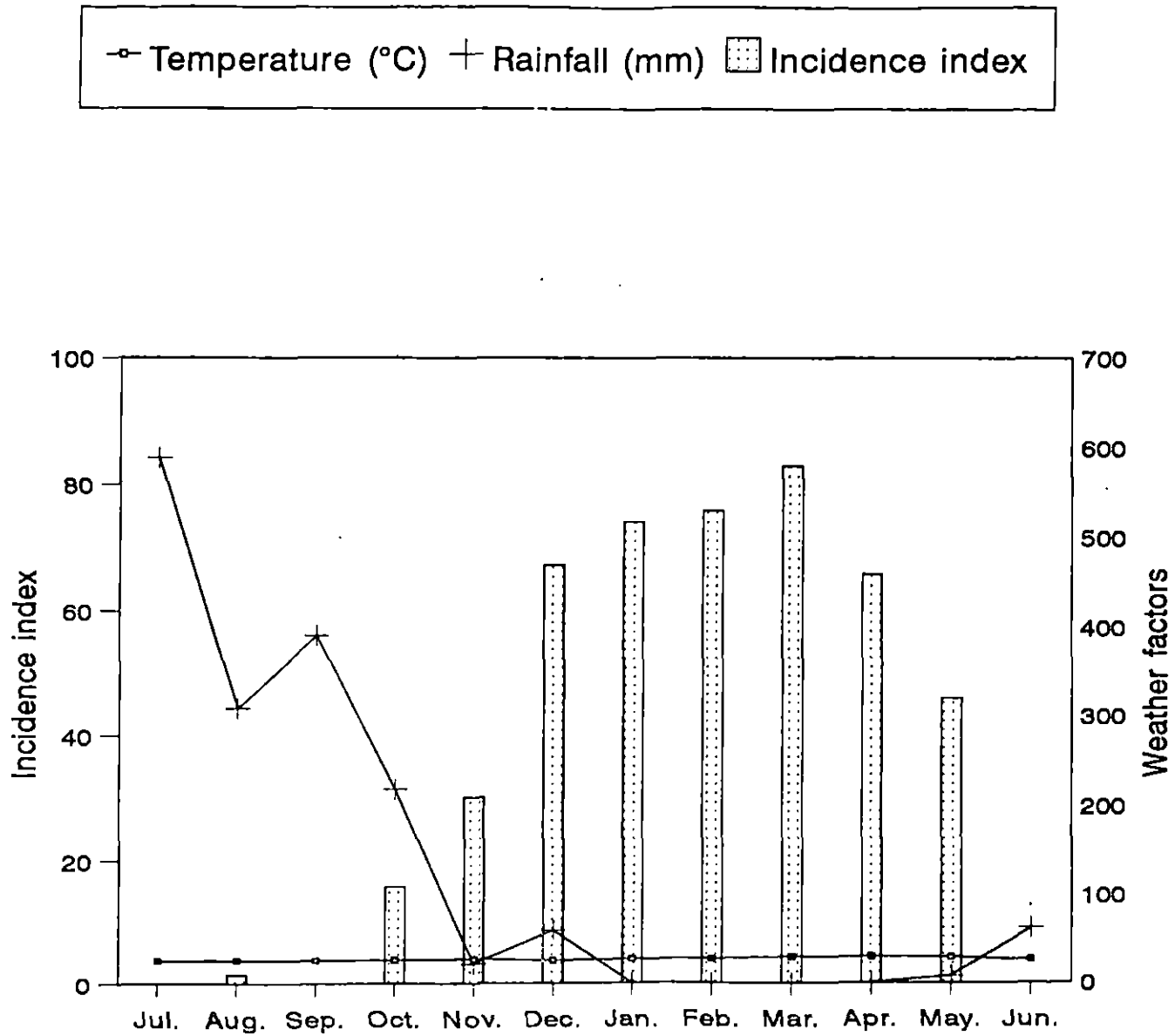


Fig.11. Population fluctuation of *Aleurodicus dispersus* in relation to meteorological data (1996-97)

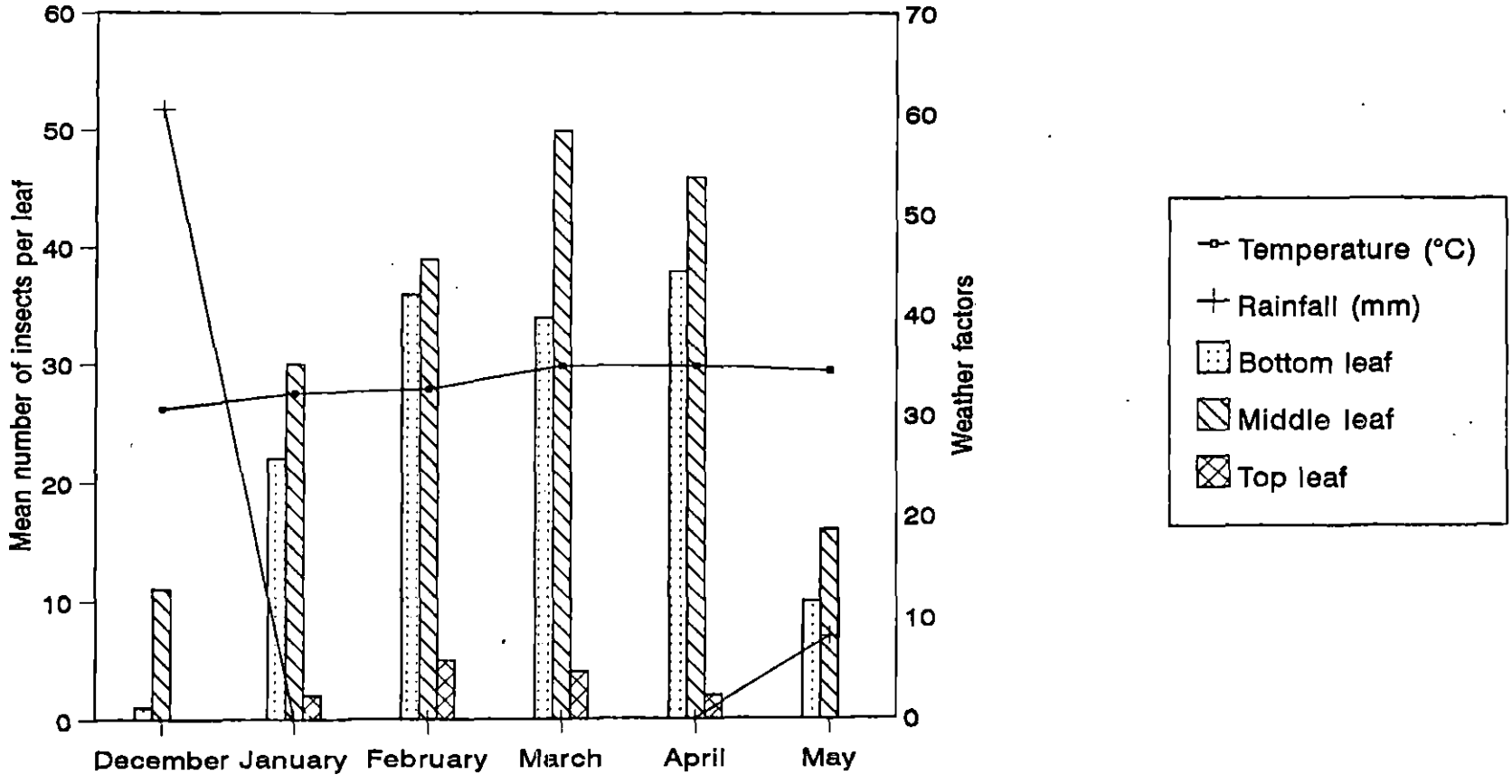


Fig.12. Population dynamics of whitefly at different months during dry season

heavy summer showers. Thus the highest incidence was recorded during January-March followed by November and December. Figure 11 indicate the seasonal incidence of *A. dispersus*.

Studies on the population dynamics of whitefly at different months during dry season showed that nymphal, pupal and adult population was maximum on middle leaves followed by lower leaves while it was minimum in the upper leaves. Population density averaged from 1 to 50 insects per leaf, mostly on middle leaves (Fig.12).

4.7 Preliminary management studies

4.7.1 *Aleurodicus dispersus*

The data on the effectiveness of various insecticides against *A. dispersus* are given in Table 6. The results shows that maximum mean mortality was with quinalphos (48%) followed by dimethoate (46.7%). Treatment with monocrotophos recorded lowest mean mortality of 14.6 per cent. There was no significant difference between treatments with dimethoate (0.05%) and quinalphos (0.05%) and they differed significantly from all other treatments. Treatments with carbaryl (0.2%), malathion (0.05%), monocrotophos (0.05%) and phosphamidon (0.05%) showed no significant difference. All treatments were significantly different from control.

4.7.2 Slugs

Results of the laboratory evaluation of insecticides and molluscide against slugs are presented in Table 7 and the ANOVA is presented in Appendix IV. A maximum mean mortality of 44.44 per cent was recorded in treatments T_2 and T_6,

Table 6. Mean per cent mortality of nymphs of *Aleurodicus dispersus* after two days of insecticidal treatment

Treatment	Dosage (%)	Nymphal mortality
Carbaryl	0.2	24.0 (0.5110)[b]
Dimethoate	0.05	46.7 (0.7510)[a]
Malathion	0.05	25.3 (0.5260)[b]
Monocrotophos	0.05	14.6 (0.3840)[b]
Phosphamidon	0.05	16.0 (0.4100)[b]
Quinalphos	0.05	48.0 (0.7650)[a]
Control		2.6 (0.1270)[c]

Figures in the parentheses are arc sin $\sqrt{p}$ transformed values

Treatment means followed by common letters do not differ significantly as per DMRT

Table 7. Mean per cent mortality of slugs treated with insecticides and molluscide

Treatments	% mortality at hours indicated			Mean
	t < 24 ψ	24 < t < 48	48 < t < 72	
T_1	22.22(0.508)^{cde}	33.33(0.583)^{bcd}	11.11(0.400)^{de}	22.22(0.508)^{bcde}
T_2	44.44(0.729)^{abc}	44.44(0.729)^{abc}	0 (0.292)^{e}	29.62(0.583)^{abcd}
T_3	0 (0.292)^{e}	11.11(0.400)^{de}	22.22(0.508)^{cde}	11.11(0.400)^{efg}
T_4	0 (0.292)^{e}	22.22(0.508)^{cde}	44.44(0.729)^{abc}	22.22(0.508)^{bcde}
T_5	0 (0.292)^{e}	44.44(0.729)^{abc}	44.44(0.729)^{abc}	29.62(0.583)^{abcd}
T_6	44.44(0.729)^{abc}	55.55(0.842)^{ab}	0 (0.292)^{e}	33.33(0.621)^{abc}
T_7	0 (0.292)^{e}	0 (0.292)^{e}	22.22(0.508)^{cde}	7.41(0.364)^{efg}
T_8	0 (0.292)^{e}	22.22(0.508)^{cde}	11.11(0.400)^{de}	11.11(0.400)^{efg}
T_9	0 (0.292)^{e}	22.22(0.508)^{cde}	33.33(0.615)^{bcd}	18.52(0.471)^{cdef}
T_{10}	0 (0.292)^{e}	0 (0.292)^{e}	11.11(0.400)^{de}	3.70(0.328)^{fg}
T_{11}	0 (0.292)^{e}	0 (0.292)^{e}	33.33(0.615)^{bcd}	11.11(0.400)^{efg}
T_{12}	0 (0.292)^{e}	11.11(0.400)^{de}	33.33(0.615)^{bcd}	14.81(0.436)^{defg}
T_{13}	22.22(0.508)^{cde}	33.33(0.615)^{bcd}	44.44(0.729)^{abc}	33.33(0.615)^{abc}
T_{14}	33.33(0.615)^{bcd}	33.33(0.615)^{bcd}	66.67(0.955)^{a}	44.44(0.729)^{a}
T_{15}	22.22(0.508)^{cde}	55.55(0.842)^{ab}	33.33(0.621)^{bcd}	37.03(0.657)^{ab}
T_{16}	0 (0.292)^{e}	0 (0.292)^{e}	22.22(0.508)^{cde}	7.40(0.364)^{efg}
T_{17}	0 (0.292)^{e}	22.22(0.508)^{cde}	22.22(0.508)^{cde}	14.81(0.436)^{defg}
T_{18}	0 (0.292)^{e}	22.22(0.508)^{cde}	33.33(0.615)^{bcd}	18.52(0.472)^{cdef}
T_{19}	0 (0.292)^{e}	0 (0.292)^{e}	0 (0.292)^{e}	0 (0.292)^{e}
Mean	9.94(0.389)	21.79(0.515)	26.36(0.544)	

ψ - time period; Figures in the parentheses are arc sin $\sqrt{p}$ transformed values

Treatment means followed by common letters do not differ significantly as per DMRT

followed by T_{14} (33.33%) and T_1, T_{13} and T_{15} (22.22%) within 24 hours of treatment. No mortality was observed in other treatments. Treatments T_1, T_2, T_6, T_{13}, T_{14} and T_{15} were on par and differed significantly from other treatments (Table 7).

Highest mean mortality of 55.55 per cent was obtained with treatments T_6 and T_{15} within 48 hrs of treatment. Treatments T_7, T_{10}, T_{11} and T_{16} yielded no mortality and these treatments were on par with T_{19} (control) and differed significantly from T_6 and T_{15}. T_6 and T_{15} were also significantly different from T_3, T_4, T_8, T_9, T_{12}, T_{17} and T_{18} (Table 7).

Treatments T_{14} showed the highest mean mortality of 66.67 per cent after 48 hrs and within 72 hrs of treatment. This was on par with treatments T_4, T_5 and T_{13}, which yielded a mean mortality of 44.44 per cent. Treatments T_2 and T_6 were on par with T_{19} (control) and differed significantly from all other treatments (Table 7).

Among the various treatments, maximum mean mortality of 44.44 per cent was recorded with T_{14} irrespective of the time period and lowest mean mortality of 3.7 per cent was recorded with T_{10}. There was no significant difference between T_{14} and T_2, T_5, T_6, T_{13}, T_{15} but T_{14} differed significantly from all other treatments.

Discussion

DISCUSSION

The present studies were carried out to gather informations on orchid pests occurring in various parts of Kerala, with reference to their biology, morphology and nature of damage. Management of the key pests were also attempted. The results of the present investigations are discussed here.

5.1 Pests of orchids

5.1.1 *Oxya chinensis*

The pest was collected from Trichur district and it causes damage by making elongate, irregular holes on the leaves. This may be an occasional feeder of *Spathoglottis* spp. and has not brought any commentable damage to the plant. Nair (1989) has reported the occurrence of *O. chinensis* as a pest of rice in Kerala. Hence the occurrence on rice ensure subsistence of the insect throughout the year.

5.1.2 *Aleurodicus dispersus*

A. dispersus was recorded on *Spathoglottis* spp. from Trichur and Alapuzha districts. The pest has been recorded on a number of economically important plants including *Spathoglottis* spp. by Prathapan (1996). David and Regu (1995) and Ranjith *et al.* (1996) had also reported it on a number of economically important plants. Both the nymphs and adults congregate on the lower surface of the leaves and suck sap. As a result, leaves turn pale and the vitality of the plants gets lowered. Palaniswami *et al.* (1995) reported that severely infested leaves of cassava showed crinkling and mosaic like symptoms with sooty mold fungus.

5.1.3 *Megalurothrips distalis*

This was collected from Trichur, Ernakulam and Alapuzha districts. The insect infests the flowers of *Dendrobium* spp. and *Spathoglottis* spp. Ananthakrishnan (1969) had reported *M. distalis* as one of the commonest flower infesting thrips causing severe damage to the flowers of *Dolichos lab lab, Cajanus cajan, Pisum sativum, Glycine max, Arachis hypogaea, Phaseolus mungo* and *Cicer arietinum*.

5.1.4 *Diacrisia obliqua*

The larvae of *D. obliqua* was collected from Trichur and Ernakulam districts during June-July. They were found feeding vigorously on the leaves of *Spathoglottis* spp. This is a casual feeder of orchids. This pest is reported to have a wide host range including cowpea, groundnut, soyabean, turmeric, mustard, cotton, castor, cauliflower, sweet potato and lantana (Panwar, 1995).

5.1.5 *Spodoptera litura*

The caterpillars of *S. litura* were collected from Ernakulam district and was found to cause commentable damage to the flowers of *Spathoglottis* and *Dendrobium* spp. Tender leaves of *Dendrobium* spp. was also preferred. Nair (1989) and Panwar (1995) had reported it on a number of economically important plants.

5.1.6 *Monomorium indicum*

The ant damages the plants by feeding on the roots. The record of *M. indicum* as a pest on orchids is reported for the first time.

5.1.7 *Lema* sp.

The grubs and adults were collected from Trichur and Alapuzha districts. Both grubs and adults cause considerable damage to the flowers of *Spathoglottis* spp. and *Epidendrum* spp. Corbett and Hassan (1936) recorded *Lema pectoralis* associated with the flowers of *Vanda joaquim* in Malaya. Jolivet (1971) also recorded *L. pectoralis* feeding exclusively on orchidaceae in Thailand and Malaysia.

The adult is a small beetle, pale flavous with the tarsal claws black. The grubs were yellowish white with the abdomen swollen and humped. It has the criocerine habit of concealing itself with coverings of its excrement carried dorsally. Hence the grubs are not easily recognizable in the field. Nair (1989) had reported the criocerine habit of *L. lacordairei* and *L.* spp. attacking yam and cardamom, respectively.

5.1.8 Unidentified weevil

Both the grubs and adults of this weevil were found in the pseudobulbs of *Dendrobium* spp. excavating quite a large cavity and incurring considerable damage to the plant. Weiss (1917) recorded two weevils, viz., *Acythopeus orchivora* and *Diorymerellus laevimargo* as pests of *Dendrobium* spp. feeding on the pseudobulbs.

5.1.9 *Mylabris pustulata*

This was collected from Trichur district and found feeding on the flowers of *Spathoglottis* sp. These appeared only as a casual feeder and their population was extremely low for effecting any appreciable damage on the plant.

There is no previous record of *M. pustulata* on orchids. But it is recorded as a flower feeder of groundnut, bhindi, cucurbits, cowpea, redgram and black gram (Panwar, 1995).

5.1.10 *Oniscus asellus*

This pest was recorded from Kottayam district feeding on the tender roots of *Dendrobium* spp. They remain hidden in the potting media and cause severe damage resulting in the death of plants. Metcalf *et al.* (1962) recorded *O. asellus* in green houses, flower beds and gardens, hiding about the bases of plants or under clods of manure. They also reported the feeding nature of the pest on the roots and tender growth of nearly all green house plants. Collinge (1914) had reported a sowbug, *Trichoniscus roseus* causing considerable damage to the roots of orchids in South Paulo. The record of *O. asellus* as a pest on orchids is reported for the first time from Kerala.

5.1.11 Slugs and snails

Slugs and snails were present in most of the surveyed areas. Both are nocturnal in habit and are active during rainy season. The nature of damage caused by them is almost similar. The snail, *Ariophanta* sp. is with a spiral shell and they feed on tender leaves, flowers and also cut down the buds. The slugs, *Arion* sp. and *Limax* sp. preferred young leaves and flowers and they lubricate their path with a trail of slime. In *Arion* sp., the foot shows marginal furrows by which it can readily be distinguished from *Limax* sp. *L. maximus* was reported to attack ornamental plants, viz., geranium, marigold and snapdragon (Metcalf *et al.*, 1962).

5.2 Morphology of *Megalurothrips distalis*

5.2.1 Immature stages

The eggs were bean shaped, delicate, pale white, entirely embeded in the tissues of petals and the site can be marked by the raised surface. The details of the larvae are presented in para 4.2.1.2. to 4.2.1.5. The first and second instar larvae can be differentiated by the colour. The first instar was yellowish white with black eyes and second instar was fully orange coloured. The length and size of antennal segments were also larger in the second instar. Prepupa can be easily distinguished because of the presence of wing pads and antennal sheaths. Compared to the prepupa, pupa is smaller and is provided with long wing sheaths and backwardly directed antennal sheaths.

5.2.2 Adult

Since the males were not recorded during the study, morphological characters of the female was only attempted.Detailed morphology of the adult is described in para 4.2.1.6.1 to 4.2.1.6.6.1. The total number of antennal segments, distribution of sense cones and the number of segments forming the style are of taxonomic value. *M. distalis* has eight segmented antennae, terminal two forming the style and four long sense cones on each, third and fourth segment present.

The chaetotaxy of the prothorax and presence of spinula on meso and metathorax are very characteristic and are of importance in classification. It was observed from the present study that the pronotum was provided with three pairs of posterior marginal setae in addition to the dorsal and a single strong seta at each posterior angle. Spinula was present on the mesosternum and absent on metasternum.

No reports are available on the morphology of *M. distalis* and this forms the first report.

5.3 Biological studies

5.3.1 *Aleurodicus dispersus*

The results of the studies on biology showed that the insect oviposited on the lower surface of the leaves and the eggs were deposited singly on a loose spiral with waxy out growths resembling fingerprints. Due to its above mentioned egg laying habit it is referred as spiralling whitefly. This was supported by Palaniswami *et al.* (1995).

Each egg is with a stalk by which the female attaches it to the leaf surface. The stalk may serve as a conduit for moisture which protects the egg from dehydration.

In the present study, the mean life cycle of the pest was found to be 45 days. No reports are available on the biology of *A. dispersus* on *Spathoglottis spp.* However, Palaniswami *et al.* (1995) reported a life cycle of 23 days on cassava and Wijesekera and Kudagamage (1990) reported a life cycle of 37 days on guava. This variation may be due to the differences in the host and climatic conditions.

The first instar nymphs are mobile and later it settles down producing small amount of powdery white wax all over the body. Second, third and the pupal instars are completely covered with white waxy secretion. Ranjith *et al.* (1996) described it as mealy white fly because the numphs resemble the mealy bug due to the secretion of white waxy out growth on their body. The pupa of the white fly cannot be designated as a true pupa because feeding occurs during the first part of

this stage and transformation into adult takes place in the last part without a pupal moult.

The adult emerges out by making an inverted 'T' shaped cut. Males are relatively larger in size compared to the females.

5.3.2 *Megalurothrips distalis*

The studies on the biology of the pest showed that the insect passes through two larval instars, a prepupal and pupal stages before becoming adults. Life cycle ranged from 17-32 days. The life cycle period recorded by Ananthakrishnan (1983) on papilionaceous flowers was 10-15 days. This variation is quite natural in view of the variation in the host and climatic conditions.

In the present study, the egg, larval, prepupal and pupal periods were completed in about 1.6, 6.0, 1.4 and 5.0 days, respectively. No reports are available on the duration of different stages.

During the study, mating pairs were never noticed and hence the reproduction is by parthenogenesis. This observation is in confirmity with the observation of Ananthakrishnan (1983), who reported that, the females dominate in the population and males are comparatively low and reproduction is mainly by parthenogenesis.

5.4 Nature of damage caused by *Megalurothrips distalis*

Both the larvae and adults cause damage on buds and flowers in the form of elongated brownish streaks resulting in the destortion of buds and flowers. The

first sign of injury occurs in the form of silvery patches. It was observed that the larvae do more damage than the adults because they are less active and confine their feeding to limited areas. Damage is also due to oviposition resulting in lesions made with ovipositor. Rawat *et al.* (1969) had reported *M. distalis* causing severe damage to the flowers of *D. lab lab, Hibiscus sp.* and *Pisum sativum* resulting in the prevention of pod setting.

5.5 Correlation of *Megalurothrips distalis* population with weather data

Correlation of microclimatic data such as temperature, humidity and rainfall with the population revealed that the population was maximum during the months of January-April, when the temperature was 28-30°C, relative humidity 60-66 per cent and rainfall insignificant. Thus the study confirms that *M. distalis* preferred dry period than a rainy condition. The result of the study is in line with the observations of Gupta and Singh (1990). According to them the drier conditions of the atmosphere encourage the abundance of thrips on flowers and wet conditions had induced scarcity of thrips.

5.6 Seasonal incidence and population dynamics of *Aleurodicus dispersus*

Studies on the seasonal incidence and population dynamics of the pest showed that the population was maximum during January-March and after heavy summer showers the population declined. This finding is in confirmity with the observation of Palaniswami *et al.* (1996).

5.7 Preliminary management studies

5.7.1 *Aleurodicus dispersus*

The results of the study showed that the insecticide quinalphos gave the highest mean mortality of the nymphs (48%) followed by dimethoate (46.7%). The

other insecticides gave significantly lower effect. The less toxic nature of the insecticides may be due to the thick mealy coating over its body. The present finding of non toxic nature of the insecticides is in agreement with the reports of Ranjith *et al.* (1997). According to them, most of the inseciticides could not manage the insect population satisfactorily because insecticides fail to penetrate the thick mealy covering over its body. Wijesekera and Kudagamage (1990) had reported that insecticidal treatment against this pest is not practicable in the long run.

5.7.2 Slugs

The objective of the study was to test the efficacy of insecticides and metaldehyde against slugs in the laboratory.

The toxicants were subjected by the methods as described in para 3.7.2 under "Materials and Methods". Observations on the mortality of slugs at different intervals were noted to calculate the percentage mortality.

The results of the study showed that 44.44 per cent mean mortality was brought within 24 hours of treatment with 5 per cent metaldehyde bait and also with metaldehyde mixed carbaryl bait (2.5-2.5%). The mean per cent mortality was poor in the other treatments.

Highest mean mortality of 55.55 per cent was obtained with metaldehyde mixed carbaryl bait (2.5-2.5 per cent) and with 1.5 g phorate within 48 hrs of treatment. Metaldehyde mixed carbaryl bait (1.5-1.5 per cent) also yielded a mean mortality of 44.44 per cent.

Treatment with 1 g phorate per petridish showed the highest mean mortality of 66.67 per cent after 48 hrs of treatment. A maximum mean mortality (44.44%) was also recorded with this treatment irrespective of the time period.

Among the treatments with baits, highest mean mortality of 33.33 per cent was obtained with metaldehyde mixed carbaryl bait (2.5-2.5 per cent) followed by 5 per cent metaldehyde bait alone (29.6 per cent). With sprays, mortality per cent was very low and highest mean mortality of 18 per cent was recorded in 5 per cent metaldehyde. Treatments with granular insecticides showed a highest mean mortality of 44.44 per cent in 1 g phorate treated petridishes.

Thus it can be concluded that a higher concentration of metaldehyde baits and metaldehyde mixed carbaryl baits appear to be promising for control of slugs. It has also been observed that phorate granules are effective. Further investigations are necessary to test the field efficacy of these toxicants.

Alicata (1957) had reported that pinches of 3 per cent metaldehyde powder plus the spray and two ground sprays of 1 per cent metaldehyde at an interval of three weeks are effective against the slug, *Deroceras laeve* attacking orchids in Hawaii. Basinger (1923) reported that a combination bait containing both metaldehyde and calcium arsenate gave satisfactory results against snails. Ruppel (1950) also reported that baits of carbaryl mixed with metaldehyde are highly effective against the grey garden slugs.

Summary

SUMMARY

Studies were undertaken to gather informations on the pests occurring on orchids in Kerala with reference to their biology, morphology and nature of damage. Management of the key pests were also attempted. The survey was conducted during 1996-97 in Trichur, Ernakulam, Alapuzha and Kottayam districts and the following pests were recorded in the survey.

***Oxya chinensis* (Thunberg) (Acrididae : Orthoptera)**

The pest was recorded from Trichur district. The grasshopper is green coloured with a dark stripe dorsally, running laterally from each eye to the base of the wings. Hind tibiae is bluish with ten black tipped spines. Both nymphs and adults cause damage by making elongate, irregular holes on the mature leaves of *Spathoglottis* spp.

***Aleurodicus dispersus* Russell (Aleyrodidae : Hemiptera)**

The insect was recorded on *Spathoglottis* spp. from Trichur and Alapuzha districts. Female lays eggs on the underside of the leaves in a loose spiral like fingerprint impression of wax deposits. Nymphs and adults also congregate on the lower surface of the leaves and suck sap. As a result leaves turn pale and the vitality of the plants get lowered.

***Megalurothrips distalis* Karny (Thripidae : Thysanoptera)**

This was collected from Trichur, Ernakulam and Alapuzha districts. Nymphs and adults infest the buds and flowers of *Dendrobium* and *Spathoglottis* spp. causing severe damage.

***Diacrisia obliqua* Walker (Arctiidae : Lepidoptera)**

The larvae of *D. obliqua* was collected from Trichur and Ernakulam districts and were recorded to feed vigorously on the leaves of *Spathoglottis spp.* leaving the midribs. Full grown caterpillars are profusely covered with long greyish hairs and measures about 40 mm in length. These appeared as a casual feeder of orchids.

***Spodoptera litura* F. (Noctuidae : Lepidoptera)**

The caterpillars were recorded to feed on the flowers of *Spathoglottis* and *Dendrobium* spp. from Ernakulam district.

***Monomorium indicum* Forel (Formicidae : Hymenoptera)**

The ant was collected from Trichur district and damages the plants by feeding on the roots.

***Lema* sp. (Chrysomelidae : Coleoptera)**

The grubs and adults were collected from Trichur and Alapuzha districts. The beetle appeared in the field with the commencement of rains in May. The adult is a small beetle, pale flavous and claws black. The grub is yellowish white with head, thoracic shield and legs black. The abdomen of the larva is swollen and humped. It carried on its back the faecal matter and the body is always wet with brownish fluid. The final instar grub constructs a cocoon made of white frothy

substance for pupation. Both grubs and adults cause damage by feeding on the flowers of *Spathoglottis* and *Epidendrum* spp.

Unidentified weevil (Curculionidae : Coleoptera)

Grubs and adults of the weevil were recorded to feed on the pseudobulbs of *Dendrobium* spp. excavating quite a large cavity and incurring considerable damage to the plant. The adult is black, about 8 mm long. Head is finely punctured, thoracic dorsum more coarsely pitted and elytra is marked with punctured striae. Grub is creamy white with head chestnut brown in colour. This pest was collected from Trichur district.

***Mylabris pustulata* (Thunberg) (Meloidae : Coleoptera)**

Noted at Trichur district feeding on the flowers of *Spathoglottis* sp. Black and red striped beetle, measuring about 26 mm in length. These appeared only as a casual feeder and their population was extremely low for effecting any appreciable damage on the plant.

***Oniscus asellus* L. (Oniscidae : Isopoda)**

The pest was collected from Kottayam district feeding on the tender roots of *Dendrobium* spp. It is pale to slate grey coloured and about 5 mm in length. Body is flat with thirteen distinct segments. They remain hidden in the potting media and cut the roots and make a sleeve inside. As a result the plant remains stunted and later it dries off.

Snails and slugs

Both snails and slugs were present in most of the surveyed areas. They have soft, unsegmented body consisting of an anterior head, a ventral flat foot and a dorsal visceral mass. Two pairs of unequal contractile tentacles known as anterior tentacles and posterior tentacles are present on the head. Eyes are borne on the tips of the posterior pair.

Land snail: *Ariophanta* sp. (Ariophantidae : Stylommatophora)

Ariophanta sp. is with a spiral shell with its head protruded out of the shell. When disturbed the head and foot are withdrawn into the shell. They are nocturnal in habit and are active during rainy season. They feed on tender leaves, flowers and also cut down the buds.

Black slug: *Arion* sp. (Arionidae : Stylommatophora)
Grey slug: *Limax* sp.(Limacidae : Stylommatophora)

These are shell-less and slide by means of foot and lubricate their path with a trail of slime. Feed at night and prefer young leaves and flowers.

Morphology and morphometrics of *Megalurothrips distalis*

Eggs were bean shaped with a mean length and width of 0.3 mm and 0.2 mm respectively. The first instar was yellowish white with black eyes and second instar was fully orange coloured. Prepupa can be easily distinguished because of the presence of wing pads and antennal sheaths. Pupa is smaller compared to the

prepupa and is provided with long wing sheaths and backwardly directed antennal sheaths.

Adults were deep black coloured with eight segmented antennae. Pronotum was provided with three pairs of posterior marginal setae in addition to the dorsal and a single strong seta at each posterior angle. The first instar, second instar, prepupa, pupa and adult on an average measured 0.77, 1.00, 1.03, 0.95 and 1.65 mm, respectively.

Biological studies

Aleurodicus dispersus

The results of the studies on the biology showed that the insect oviposited on the lower surface of the leaves and the eggs were deposited singly on a loose spiral with waxy outgrowths. The mean incubation period was 5 days. The first, second and third instars were completed in about 5-7, 3-4 and 6-9 days, respectively. The pupal period on an average was 8.2 days. Adults emerged out by making an inverted 'T' shaped cut dorsally on the pupa. Males were relatively larger in size compared to the females. Adult males and females lived for a period of 9-12 and 11-16 days.

Megalurothrips distalis

The studies on the biology of the pest showed that the egg, larval, prepupal and pupal periods were completed in about 1.6, 6.0, 1.4 and 5.0 days, respectively. Mating pairs were never noticed and hence the reproduction is by parthenogenesis. Adult females lived for a period of 8-10 days.

Nature of damage caused by *Megalurothrips distalis*

Both the larvae and adults caused damage on buds and flowers in the form of elongated brownish streaks resulting in distortion of buds and flowers. Damage was also due to oviposition resulting in lesions made with ovipositor.

Correlation of *Megalurothrips distalis* with weather data

The studies on seasonal fluctuation of *M. distalis* showed that the thrips were maximum during the months, January-April when the temperature was 28-30°C, relative humidity 60-66 per cent and rainfall insignificant.

Seasonal incidence and population dynamics of *Aleurodicus dispersus*

The population was maximum during January-March and after heavy summer showers it declined. Studies on the population dynamics showed that nymphal, pupal and adult population was maximum on the middle leaves followed by the lower leaves.

Preliminary management studies

Aleurodicus dispersus

The results of the study showed that the insecticide quinalphos recorded the highest mean mortality of nymphs (48%) followed by dimethoate (46.7%). Carbaryl, malathion, monocrotophos and phosphamidon gave significantly poor effect.

Slugs

Results of the laboratory evaluation of insecticides and molluscide against slugs showed that 5 per cent metaldehyde bait and metaldehyde mixed carbaryl bait (2.5-2.5 per cent) brought the highest mean mortality of 44.44 per cent within 24 hrs of treatment. And with in 48 hrs of treatment highest mean mortality of 55.55 per cent was obtained with metaldehyde mixed carbaryl bait (2.5-2.5 per cent) and 1.5 g phorate. Treatment with 1 g phorate showed the highest mean mortality of 66.67 per cent after 48 hrs of treatment.

The results of the study stress the need to test the field efficacy of these toxicants against the slugs.

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*Originals not seen

APPENDIX - I

Weather data at monthly intervals during the experimental period (July 1996-September 1997)

Months	Mean temperature (°C)	Mean humidity (%)	Rainfall (mm)
July 1996	26.0	89.5	588.7
August	26.4	86.5	310.0
September	26.5	84.0	391.5
October	26.8	81.5	219.3
November	27.6	71.5	22.1
December	26.2	67.5	60.4
January 1997	27.5	61.5	0
February	27.9	60.5	0
March	29.9	59.5	0
April	29.9	66.5	8.2
May	29.5	72.0	63.0
June	27.1	82.0	720.5
July	25.2	90.0	979.2
August	25.9	87.0	636.8
September	27.0	82.0	164.0

APPENDIX - II

Seasonal fluctuations of *Aleurodicus dispersus* and *Megalurothrips distalis* in relation to meteorological data (1996-1997)

Months	White fly incidence index	Number of thrips
July 1996	0	--
August	1.42	--
September	0	--
October	15.70	12
November	30.00	24
December	67.10	26
January 1997	74.00	38
February	75.70	29
March	82.80	35
April	65.70	38
May	45.80	20
June	0	0
July	-	0
August	-	10
September	-	16

APPENDIX - III

Population dynamics of whitefuly at different months during dry season

Months	Mean number of insects per leaf		
	Bottom leaf	Middle leaf	Top leaf
December	1	11	0
January	22	30	2
February	36	39	5
March	34	50	4
April	38	46	2
May	10	16	0

APPENDIX - IV

Summary of analysis of variance table of mean percentage mortality of slugs treated with insecticides and molluscide

Source	df	S.S.	M.S.S.	F
Treatments	18	2.372	0.132	6.4938*
Periods	2	0.773	0.386	19.0417*
Treatment x period	36	2.471	0.069	3.3822*
Error	114	2.313	0.020	
Total	170	7.928		

*Significant at 1 per cent level

APPENDIX - V

Summary of analysis of variance table of mean percentage mortality of nymphs of *A. dispersus* treated with insecticides

Source	df	S.S.	M.S.S.	F
Treatments	6	0.885	0.148	22.625*
Error	14	0.091	0.007	
Total	20	0.977		

*Significant at 1 per cent level

BIOLOGY AND MANAGEMENT OF ORCHID PESTS

By
SAJITHA KUMARI

ABSTRACT OF A THESIS

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Kerala Agricultural University

Department of Agricultural Entomology
COLLEGE OF HORTICULTURE
VELLANIKKARA, THRISSUR-680 654
KERALA, INDIA

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ABSTRACT

In a survey conducted during 1996-97 in Kerala to study the various pests associated with orchids with reference to their biology, morphology, nature of damage and preliminary management studies on the selected pests, a total of thirteen pests were recorded. The grasshopper, *Oxya chinensis* (Thunberg); spiralling whitefly, *Aleurodicus dispersus* Russell; bihar hairy caterpillar, *Diacrisia obliqua* Walker; were recorded from the leaves of *Spathoglottis* spp. The larvae and adult of *Megalurothrips distalis* Karny was found infesting the buds and flowers of *Dendrobium* spp. and *Spathoglottis* spp. resulting in the destortion of buds and flowers. The tobacco catterpillar, *Spodoptera litura* F. was recorded from the flowers of *Spathoglottis* and *Dendrobium* spp. The ant, *Monomorium indicum* Forel was recorded to damage the roots of the plants. An unidentified species of *Lema* was recorded damaging the flowers of *Spathoglottis* spp. and *Epidendrum* spp. The grubs and adults of an unidentified curculionid was reported to cause considerable damage to *Dendrobium* spp. by feeding on the pseudobulbs. The banded blister beetle, *Mylabris pustulata* (Thunberg) was found as an occasional feeder of *Spathoglottis* spp.

The other pests observed during the survey were sowbug, *Oniscus asellus* L., land snail *Ariophanta* sp., black slug, *Arion* sp. and grey slug, *Limax* sp.

During the studies on the morphology and biology of *M. distalis*, the eggs were found to be bean shaped and the immature stages can be differentiated by the presence of wing pads or wing sheaths and antennal sheaths. The females inserted the eggs in the tissues of the petals and the whole life cycle ranged from 17-32 days.

The adults of *A. dispersus* laid eggs singly covered with wax in loose whorls like fingerprints on the lower surface of the leaves. Incubation period was 5 days and the mean life cycle was found to be 45 days.

During the drier conditions of the atmosphere the population of *M. distalis* and *A. dispersus* increased and there was a decline after heavy summer showers.

Efficacy of insecticides against *A. dispersus* and insecticides and molluscide against slugs were tested. Among the insecticides tested, quinalphos brought the highest mean mortality of the nymphs of *A. dispersus* (48%). In the case of slugs, 5 per cent metaldehyde bait and metaldehyde mixed carbaryl bait (2.5-2.5%) gave the highest mean mortality of 44.44 per cent within 24 hrs of treatment. Treatment with 1 g phorate showed the highest mean mortality of 66.67 per cent after 48 hrs of treatment.