PEST COMPLEX ASSOCIATED WITH MANGO (*Mangifera indica* Linn) INFLORESCENCE AND THEIR CONTROL

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "Pest Complex associated with Mango (*Mangifera indica* Linn.) inflorescence and their control" is a *bona fide* record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship, or other similar title, of any other University or Society.

Vellanikkara
5 -12- 1984

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CERTIFICATE

Certified that this thesis, entitled "Pest Complex associated with Mango (Mangifera indica Linn.) inflorescence and their control" is a record of research work done independently by Sri Satheesan. N.V. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship, or associateship to him.

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Introduction

INTRODUCTION

Mango, Mangifera indica L. is decidely one of the most popular fruits in India. This crop suffers from many serious pests and diseases. Among the pests, those infesting flowers and fruit are far more destructive to the crop, causing considerable financial losses. Very little information is available on the various species of insect pests occurring on mango inflorescence in Kerala.

Application of insecticides against the Idiocerine hoppers infesting inflorescence is a routine practice in commercial mango orchards. Effective coverage of the huge dense canopy of mango trees by water-borne spray or dust formulations of insecticides from ground-based machines will be extremely difficult. Environmental pollution and hazards to bees and other pollinators can be other serious disadvantages of conventional application methods. Application of stable systemic insecticides by stem injection or by stem banding methods is likely to be much easier, economic and relatively less hazardous, provided that bio-efficiency could be realised in the floral branches at required levels. Apart from preliminary studies on stem injection carried out at the University of Agri.Science,

Dharwad (Thontadarya *et al.*, 1978), detailed studies on this line are lacking.

The present investigations were undertaken to gather information on the major insect pests occurring on the mango inflorescence in Kerala with reference to their seasonal history. The bio-efficiency of monocrotophos against the Idiocerine hoppers infesting mango inflorescence was also evaluated in the present study by adopting two methods of administration, namely, stem injection and stem banding.

Review of Literature

REVIEW OF LITERATURE

2.1 Pests infesting mango inflorescence

2.1.01 Order : Hemiptera
Suborder: Homoptera
Family : Cicadellidae

Three species of mango hoppers have been reported to occur in India. These were first reported from Saharanpur (Uttar Pradesh) and described by Lethierry as Idiocerus atkinsoni, I. clypealis and I. niveosparsus (Lethierry, 1889). Baker erected a new genus Idioscopus and placed I. clypealis under this genus (Baker, 1915). Later Maldonada-Copriles transferred atkinsoni and niveosparsus also to Idioscopus (Maldonada - Copriles, 1964). Anufriev (1970) shifted atkinsoni to a new genus Amritodus. Of these Idiocerus clypealis Leth. and I.niveosparsus Leth. are more common in South India (Lefroy, 1909). The adults are light-greenish with black and yellow markings. Amritodus atkinsoni Leth. is the largest among the species of hoppers. This is light brown with two spots on the scutellum. I. niveosparsus is slightly smaller with three spots on the scutellum and prominent white band across its brown wings. I. clypealis is the smallest with two spots on the scutellum and dark spots on vertex and is light brown in colour (Srivastava, 1958). Viraktamath and Murphy (1980) based on a field survey conducted in India

and Singapore reported two new species of mango hoppers, I. nigroclypeatus Melich and I. clavosignatus Maldonada - Copriles.

The hoppers are found in abundance during November-February, synchronising with the flowering of mango trees (Tandon et al., 1983). Wen and Lee (1980) reported that under conditions in Taiwan the mango hopper laid eggs singly in slits made on the shoots and leaves and the young ones reach maturity in about 10 days passing through four nymphal instars. The peak populations in Taiwan were attained in March-April (Wen and Lee, 1978 and Tandon et al., 1983).

In Taiwan, Chunrocerus niveosparsus Leth. (I. niveosparsus) mainly laid eggs within 12-18 cm length of the panicles apically, causing injury. Nymphs and adults suck sap from the inflorescence in large numbers causing withering and shedding of flower buds and flowers (Wen and Lee, 1980; Rao, 1930 and Rahman, 1939). Tandon et al. (1983) established significant negative correlation between the hopper populations on the one hand and the relative humidity percentage values on the other.

Studies on the hoppers occurring in South Gujarat showed that the females out-numbered males in all months,

except in the month of February, June and November. The adult life-span was longest reaching up to four days when bred on inflorescence. Adult populations started multiplying, synchronising with the commencement of flowering in mango trees, the peak being attained in June (Patel et al., 1975).

In Behara, there is only one brood in the early hot weather season (March-April) and the adults survive on the tree until the next blossom season. They have not been found to breed in the off-season, but remain alive and active throughout the year as adults on the bark or on leaves (Lefroy, 1909).

The mango hoppers have been reported to cause a loss of 20 to 100 per cent of floral branches (Rao, 1930). Cheema et al. (1957) estimated the quantitative losses at 25 to 60 per cent.

Family : Coccidae
Pulvinaria ixorae Green

It feeds on leaves, petioles, flower panicles and tender shoots. The infested tissues were later covered over with honeydew. The trees growing under shade were not affected (Tandon and Lal, 1977).

Family : Pseudococcidae

Rastrococcus iceryoides Green

The mango coccid Rastrococcus iceryoides Green has been recorded for the first time on Mangifera indica, Boswellia sp. and Capparis horrida in India (Green, 1908). This mealy bug has later been reported on Ordina wodier Roxb., Hibiscus rosasinensis and cocoa by several workers (Ayyar, 1919; Rawat and Jakhmola, 1970; Abraham and Padmanabhan, 1967).

Nymphs and adult females suck sap from the leaves, tender terminal shoots, inflorescence and fruit. They secrete honeydew on which the sootymold develops. As a result of attack, fruit setting is reduced considerably and often the young fruits are shed off (Rawat and Jakhmola, 1970).

Family : Aphididae

Toxoptera odinae Vdg.

Ortiz (1980) reported the occurrence of Toxoptera odinae Vdg. in colonies on the floral branches of mango during December-March.

Sub Order : Heteroptera

Family : Pentatomidae

Antestia cruciata Fabricius

This bug occurs in clusters on mango inflorescence causing damage in Bengal (Nair, 1975).

Chrysocoris particius Fabricius

This bug is found in large number sucking sap from mango inflorescence and also tender leaves (Tandon and Lal, 1977).

Bagrada cruciferarum Kirka.

Colonies of this bug are found to occur on inflorescence causing desapping along with Nezara viridula (Tandon and Lal, 1977).

Polycoris indicus Stal.

This Pentatomid suck sap from inflorescence and new leaves and recorded for the first time on mango from Uttar Pradesh (Tandon, 1980).

Family : Pyrrhocoridae
Dysdercus singulatus Fabricius

Red cotton bug, the serious pest of malvaceous crops suck sap from flower panicles and tender leaves in nymphal and adult stages (Tandon and Lal, 1977).

2.1.02 Order : Diptera
Family : Cecidomyiidae

The gall midges Dasineura amaramanjarae Grover, Procystiphora indica Grover, P. mangiferae Felt. (D. mangiferae) D. citri Grover and Erosomyia indica Grover and Prasad have all been recorded to cause considerable damage to mango flowers in India. Of these,

the multiphase feeder E. indica is the most harmful pest. It feeds on inflorescence buds, inflorescence axes, newly formed fruit and shoots. All other midges are blossom feeders (Prasad, 1971).

Erosomyia indica Grover and Prasad

The mango blister midge, E. indica are minute yellowish midges with greyish back. Ravages of this pest can be seen from Kanyakumari in the south to [illegible] Amritsar in the north. It lays eggs in between the sepals of the flower buds, in groups of 1 to 3. The hatching larvae penetrate the bud and form small blister like conical galls. The larvae grow inside the galls feeding on the tissue. On reaching the fourth instar stage, they work their way out to pupate in the soil. Since the attack is mainly concentrated on the shoot bud, flowering in the following year is suppressed. The midges then attack newly formed inflorescence buds by depositing eggs in between the fleshy leaves. As the larvae infest the scale leaves, inflorescence bud elongates. The midges continue egg laying along the inflorescence axes and these infested axes become stunted and deformed. Then the midges start laying eggs in the newly opened flowers. On hatching, the larvae enter the ovaries of the flowers (Prasad and Grover, 1976).

Chandrika and Nair (1970) recorded the incidence of E. indica as a new pest of mango in Kerala. Practically every flower is infested by the insect leading to total crop loss.

Procystiphora mangiferae Felt.

Prasad (1967) studied the biology of the bud midge P. mangiferae. The adult is a minute orange coloured midge. The eggs are laid between the sepals of the flower buds in groups of 1 to 3, but often, several females oviposit in the same bud. However, only one individual in a bud survives to the pupal stage. The larvae penetrate the bud and feed on reproductive organs, preventing it from opening and causing it to assume a conical shape (Kulkarny, 1955; Prasad, 1967). Pupation occur. within the bud, but the pupa forces itself half way out of the bud before adult emergence. The whole development period averages 15 days. The extent of damage depends on the extent of hermaphrodite flowers among the infested ones. The population of the pest increases between December and March (Prasad, 1967).

This species is widely distributed in South India. It has been reported from the former State of Cochin

where it causes 60 to 70 per cent damage to flower buds (Iyer, 1940).

Dasineura amaramanjarae Grover

The infestation by this midge depends largely on the occurrence of bright, calm weather with a temperature ranging from 25 to 30°C. The extent of loss is heavy when the proportion of hermaphrodite flowers is heavier (Prasad, 1966).

2.1.03 Order : Lepidoptera

Family: Noctuidae

In Southern China, three species of Noctuids have been found to cause injury to mango inflorescence. These are Chlumetia transversa Wlk. Bombotelia jocosatrix Gn. and C. cyanyoxinesia spn. the former being more injurious (Wu and Zhu, 1981). Chlumetia transversa Wlk. reported from India (Anon, 1903), Java (Voute, 1935) and the Philippines (Palo, 1932; Palo and Garcia, 1936). In the Philippines it is stated to be a serious pest affecting the inflorescence, whereas in other countries it bores through the vegetative shoots only. Kushwaha et al. (1964) and Singh (1957) have reported the incidence C. transversa in Rajasthan and Uttar Pradesh, respectively.

Chlumetia transversa Wlk.

The larvae of the shoot borer C. transversa are yellowish-orange with characteristic dark-brown prothoracic shield. Full grown caterpillars are dark pink with dirty spots and measure 20 to 24 mm in length. Adults have thorax and abdomen clothed with rufous, fuscous and grey scales. Forewings are dark grey, beautifully patterned with wavy design. Moths of C. alternas differ from C. transversa in being bigger and having thorax and abdoman darker, forewings greener with basal area dark rufous and hindwings with a marginal series of dark striae (Hampson, 1894).

The incubation, larval and pupal periods range from 2 to 3, 10 to 12 and 15 to 18 days respectively (Singh, 1957). Females lays an average of 54.44 eggs. The egg stage lasts for 2.44 days, the five successive larval instars occupying 2, 2, 2, 3 and 3 days respectively. The pre-pupal and pupal stages lasts 2.25 and 13.25 days. The life-span of adult male and female mothhs lasts for 2.33 and 5.54 days respectively. The pre-oviposition and oviposition periods are of same duration, being one day (Mohite and Dumbre, 1981).

The shoot borer mainly attacks new vegetative flushes by tunnelling up to a maximum of 15 cm downwards from the tip.

The floral branches are also attacked (Tandon et al., 1975).

Eublemma spp.

Among the flower webbers occurring on the mango inflorescence, Eublemma spp. are relatively more important.

In E. versicolor Walker, the female moth has purplish grey wings with a dark oblique line and the male has purplish-pink or light orange wings with an apical patch. The full grown larva is smooth, greenish-yellow with light brown head and prothoracic shield (Nair, 1975).

Aiyar, 1944 had reported E. angulifera in the erstwhile State of Travancore. It is brownish or greyish brown with an oblique line on the wings. Eggs are laid singly on pedicels and sepals of flower buds. Larvae feed on sepals for three to four days after hatching. Then they spin webbs and feed on buds and flowers for five days. Subsequently, they feed on the surface of the inflorescence stalk and floral branches under cover of a gallery spun out of silk and frass. Pupation takes place in cocoons at or near the base of the inflorescence. Larval and pupal periods last for 16 to 18 and 13 days respectively. The attacked inflorescence becomes weak and eventually dry up.

In Central India, E. silicula Swinhoe have been found damaging mango flowers and buds (Nair, 1975). This has also been reared at Pusa from flowers of Nyctanthes arbortristis as well as from mango buds and inflorescence. In Nagpur, it is reported to damage mango flowers and juar heads (Fletcher, 1914).

Nair (1975) recorded E. abrupta Wlk. and E. brachygonia Hmps. as flower feeding pests in Kerala.

Charocoma nilotica Rogenh

Habib (1980) has reared out C. nilotica from larvae feeding on mango inflorescence. This also feeds on Tamarix spp. Campsis radicans, Quisqualis indica, Lagestromia indica, Hibiscus rosa-sinensis, Rosa indica and peach flowers.

Family : Pyralidae

Orthaga eudrasalis Wlk.

Tandon and Srivastava (1982) reported O. eudrasalis as a minor pest feeding on the floral branches of mango.

Phycita umbratelis H.

Larvae of P. umbratelis causes damage to mango flowers in Tamil Nadu (Nair, 1975).

Dichocrosis punctiferalis Guen.

Larvae of this insect feed on flowers and tender fruit of mango in India (Nair, 1975).

Family : Gelechiidae

Anarsia melanoplecta Meyrick

Anarsia melanoplecta has been recorded from Bihar and Maharashtra where it bores into shoots, twigs and inflorescence (Beeson, 1941).

Chelaria rhicnota Meyr.

Nair (1975) recorded the occurrence of C. rhicnota as a pest of flowers.

Hypatima haligramma Meyr.

In South India H. haligramma damage mango flowers (Nair, 1975).

Family : Geometridae

Chloroclystis sp.

The adult moth is small, delicate with greyish wings bearing wavy markings. Eggs are laid singly or in groups on the flower buds. Larvae enter the bud and feed on the

ovary. It is commonly observed during the flowering season in the Kerala State (Aiyar, 1944).

Family : Cosmopterygidae

Anatrachyntis simplex Wlsm.

In Bihar Anatrachyntis simplex causes damage to mango inflorescence (Nair, 1975).

Family : Eucosmidae

Enarmonia anticipans Meyr.

Enarmonia anticipans webs up mango flowers in South India (Nair, 1975).

Arqyroploce aprobola Meyr.

Aiyar (1944) and Nair (1975) recorded this insect as a pest of mango inflorescence in Kerala. Larvae webs together the young leaves and bores on the adjacent buds and flowers, chiefly on the epidermal tissues of the branches of panicles and on pedicels.

Family : Blastobasidae

Prosintis florivora Meyr.

In Bihar, larvae of P. florivora cause damage to the inflorescence (Nair, 1975).

Family : Lycaenidae

Rapala manea Hewitson

This has been reported for first time from Kerala during 1977-1979, infesting mango inflorescence. The female oviposited on the newly formed flowers and the larvae feed on both opened and unopened flowers. The egg period of this, insect lasted for two days, the larval and pupal periods being 13 and 5.5 days respectively (Johnson et al., 1980).

Family : Lymantriidae

Lymantria beatrix Still

Larvae of L. beatrix feed on leaves and flowers in Maharashtra and Bihar causing considerable damage (Nair, 1975).

Lymantria mathura Moore

Singh (1954) reported L. mathura as a pest of mango in the Doon Valley. The caterpillars damage the bark of mango trees and destroy the inflorescence completely. They also attack the tender vegetative shoots and partially destroy them (Singh, 1960).

2.1.04 : Order : Coleoptera
Family : Chrysomelidae
Altica coerulea oliver

Banerji and Chatterji (1951) reported Altica caerulea as feeding on mango flowers.

Aetheomorpha suturata Jac.

In Lucknow, yellowish brown beetles were found feeding on tender leaves and inflorescence (Tandon, 1980).

Raphidopalpa (Aulacophora) foveicollis Lucas

The adults of this insect cause damage to leaves and inflorescence of mango in Lucknow (Tandon and Lal, 1977).

Gynandrophthalma sp.

These beetles occurred in swarms and feed on mango inflorescence. In each inflorescence 10 to 15 beetles were noticed (Tandon and Lal, 1977).

Amblyrhinus poricollis Boh.

This insect feeds on new flushes and inflorescence in Bihar (Nair, 1975).

Atmetorchus perigrinus Oliv.

Nair (1975) recorded this weevil as feeding on mango inflorescence in Bihar.

Family : Lathridiidae

Corticarina gibbosa Herbst

This light brown beetles are found in large colonies in association with Gynandrophthalma sp, feeding on mango inflorescence. They are voracious feeders and cause total deblossoming (Tandon and Lal, 1977).

2.1.05: Order : Thysanoptera

The thrips commonly recorded on mango inflorescence are Scirtothrips dorsalis Hood, S. mangiferae, Ramaswamiahiella subrudula Karney, Neoheegeria mangiferae Priesner and Haplothrips ganglbaueri Schmutz (Butani, 1979).

Scirtothrips mangiferae have been recorded on mango in Egypt and Isreal by Mound and Palmer (1981).

In Taiwan Thrips hawaiensis Morg occur only when the crop is in bloom, while S. dorsalis and Rhipiphorothrips cruentatus are abundant throughout the year. The population densities of R. cruentatus and S. dorsalis were inversely related to the amount of precipitation. The injury caused by

puncturing and desapping serve as infestation points for parasitic fungi (Lee and Wen, 1982).

2.1.06 Order : Acarina

Fletchtmann et al. (1970) reported involvement of the mite Acerina mangiferae Sayed (Eriophes mangiferae) in the incitation of the mango malformation syndrome characterised by the transformation of the inflorescence into a compact mass of sterile flowers in grown-up trees and the production of thick vegetative shoots at the growing points or in leaf axes of seedlings. However, surveys conducted in Israel showed that A. mangiferae associated with mango trees does not incite inflorescence malformation directly. The interaction of the mite with another biotic factor in the incitation of malformation is not excluded (Sternlicht and Goldenberg, 1976).

Mites such as A. mangiferae, Typhlodromus roshanlali Narayanan and Ghai, Anthoseious rheanus Oudm. and T. nesbitt; Wom. have been listed as possible vectors of pathogenic fungus Gibberella fujikuroi (Fusarium moniliforme) which is the main cause of the malformation symptoms (Dang and Daulta, 1982).

Peak numbers of A. mangiferae are generally found in February and again in September coinciding with blossoming and new vegetative growth. The damage occur when population of mite exceed about 33/bud (Wafa and Osman, 1974).

In the laboratory, A. mangiferae took at least 15 days to complete their lifecycle. In field, mite takes about eight generation in a year with the population peak in May and in October (Abou-Awad, 1981)[2].

A new species of eriophid Vasates aegyptiacus sp. n found in the terminal buds of mango at Embala (Oiza) caused malformation such as rosetting in the buds and stunting in the inflorescence (Abou-Awad, 1980). This mite which is ovo-viviparous took 7.5 days to complete a generation at 25-29°C and 70% RH. The population density of this mite increases in spring and early summer with distinct peaks in late April and early June (Abou-Awad, 1981)[1].

Though all varieties of mango are infested by A. mangiferae, most of them show no signs of injury (Anon, 1969). In a survey it was found that the varieties Langra, Neelum and Kishen Bhog showed fair degree of resistance to this pest, while most other varieties revealed high degree of susceptibility (Khan and Khan, 1960). The varieties

Malda (Bombay Green), Alphoso and Pairi were the most prone to malformation. Langra and Dasheri were found to be least affected (Singh and Jawanda, 1961).

2.2 Injection of soluble chemicals into tree crops

Injection of soluble systemic fungicides were tried by a few workers for the control of plant diseases (McWain and Gregory 1971; Jones and Gregory, 1971; Schreiber, 1969 and Lawrence et al., 1973).

2.2.01 Stem injection in tree crops with systemic insecticides for pest management

The tree crops are subject to infestation by many major pests. Because of the huge size of the trees, pest control operations in tree crops are often tedious. While applying toxicants on tree crops by the conventional methods for controlling defoliators and other open feeders, there is likely to be considerable drift which may cause pollution. Most of the serious pests of tree crops are tissue borers feeding on sapwood, phloem or pith. Conventional canopy application does not offer any substantial action against such concealed feeders. For control of tissue borers application of systemic toxicants as stem injections appear to be quite useful.

Investigations on the control of the various insect pests of coconut have been reported from time to time. Thus Stelzer (1970) in the case of stick insect Graeffea crouantii Le Guillou in Western Samoa, Rai (1973) in the case of the caterpillar pest Brassolis sophorae L. and the moth borer Castinia daedallus Cramer in Guyana, Wood et al. (1974) in the bag worm Metisa plana Wlk. and Ooi et al. (1975) in the case of coconut leaf moth Artona cataxantha Hemps. used the injection as a technique for applying systemic insecticide with varying degrees of success. Craighead and George (1938) carried out certain preliminary studies on the introduction of chemicals into the sap stream of trees for control of insects. But such work on insect pest control using stem injection of systemic insecticide is very scanty.

The only exhaustive work done in India on pest management by stem injection of systemic insecticides relate to the studies on the injection of monocrotophos to coconut palm.

Sundaramoorthy (1979) studied the effect of trunk injection for coconut against pest complex of the crop. Nadarajan et al. (1980) in their studies on the efficiency of monocrotophos applied by stem injection at 7.0 ml ai/tree in the 9-10 year old coconut palms found that the treated palms could be protected against the black headed caterpillar

Nephantis serinopa and the palm mite Raoiella indica for up to 60 days.

Thontadarya et al. (1978) reported the results of preliminary trials conducted in Dharwad, Karnataka, on the effect of stem injection of dimethoate at 0.5 ml ai/cm girth of trees against the mango hoppers. The decline in hopper population was recorded from third day of application and the residual toxicity persisted even after eight weeks.

2.2.02 Uptake of systemic insecticides in tree crops

Norries (1965) comprehensively reviewed the work on the uptake of systemic pesticides in woody trees. Uptake involve the vascular transport of systemics from the point of application in the plant into the target sites. Uptake may also entail non-vascular movement. Uptake can occur through any portion of the tree, but usually this property is more effective when applied through roots or basal trunk. Adequately uniform distribution of such toxicants into the various functional tissue of tree is the most important requirement for overall effectiveness of such treatments. Application to the roots or basal trunk most consistently yield such distribution (de Pietri-Tonelli, 1965 and Norries, 1965).

In systemic treatment of trees, the soil route of uptake has been used extensively (de Pietri-Tonelli, 1965). In this approach the nutrient uptake and transfer through roots is utilised indirectly for the uptake of toxicants also. Many highly effective systemic insecticides like phorate, Meta-systox R, dimethoate and dimatilan are absorbed readily by the plant roots when applied to the soil. The toxicants such as phosdrin undergo rapid hydrolysis and are, therefore, relatively ineffective and unstable in the soil environment. Some of the systemic insecticides are adsorbed on the soil particles and are hence not effectively absorbed through the roots. The phenomenon of adsorption is more pronounced in colloidal soils than in sandy soils. Leaching, evaporation and decomposition of insecticides which are applied in the soil has been reported to be another limiting factor in realisation of the efficiency of soil applied insecticides (Hanna and Nicol, 1954).

2.2.03 Methods of application of systemic insecticides to the basal trunk

The insecticides required to be applied through the stem are only 1/10 to 1/15th of the dose required for conventional soil application (Norries, 1965). Banding around the circumference of the basal trunk with suitable insecticide will ensure very uniform distribution of the pesticide in the

tree (de Pietri-Tonelli et al., 1962; Coppel and Norries, 1966). In soil application the uptake of systemic insecticides is dependent very much on the process of moisture absorption through the roots, but the uptake of insecticide through the basal stem is not very much dependent on the process of moisture absorption (Norries, 1965; de Pietri Tonelli et al., 1962). The stem application also allows a more accurate timing to build up required concentrations in trees.

Several systemics when applied in technical form have been shown to penetrate the bark of trees and bring about adequate level of insect control in the foliage, but such dosages commonly cause phytotoxicity to the tissue underlying the treatment site (de Pietri-Tonelli et al., 1962). Significant differences in phytotoxicity of tissues under trunk treatment sites on different species of trees treated with dimethoate were observed (de-Pietri-Tonelli, 1965).

By extending the toxicants with several non-toxic chemicals such as liquid plastics gave practical levels of systemic insecticidal action against the larvae of Diprion similis Hartig without causing injury to the underlying tissues (Coppel and Norries, 1966). It is thus indicated that systemics can be so formulated that their uptake through the

bark is kept at safer levels that do not cause phytotoxicity in the tree. Such combination of active systemics with diluent-adhesives is also reported to be helpful to extend the persistence of the toxic stimulus considerably.

Another disadvantage of bark application of systemic insecticides is the high mammalian toxicity of some toxicants such as dicrotophos (Bidrin). The application of technical material of such insecticides to the exposed bark of the basal trunk can thus cause hazards to the applicators and also to non-target organisms in the environment. By dilution, the systemic to 10% or less concentration using non-toxic diluent adhesives, the product may be made relatively more safer for general use. Application of systemics in the pure form to trunk of trees usually have demanded more accuracy in dosage levels than application to the soil around roots. The dilution of systemics in a diluent adhesive chemical largely remove the necessity of accurate dosage application. The suspension of crystalline systemics in diluent adhesives allows penetration without phytotoxic side effects of conventional solvents (Coppel and Norries, 1966).

In terms of the actual uptake of bark applied systemics active entry is found to be mainly responsible for

the ingress from the rhytidome (Norries, 1965). The uptake of dimethoate P^{23} (dissolved in tri-n-nutyl phosphate) from the surface of the bark of potted lemon plants was studied by de Pietri-Tonelli (1965). The insecticide was traced through the periderm of the trunk into the cortical parenchyma. The chemical moved into the pholem and outer xylem by radial cell to cell transfer.

It was found that in the leaves of sour orange seedlings schradan accumulated at the same rate from bark application as well as root treatment the dosage applied to the bark was only 0.03 parts of the dose used for root feeding. Both lipoid and non-lippid soluble systemics penetrate intact bark (Bennet, 1957). The area of surface contact between the insecticide and the bark greatly influences the extent of insect mortality (Coppel and Norries, 1966).

The bark of mature, slow growing trees can become largely impermeable to systemics. This situation render application of systemics in such situation ineffective. The development of practical techniques for the injection of systemics through the bark into the vascular tissues would largely overcome this problem (Norries, 1965).

The development of insecticidal injection for the control of the elm bark beetle Hylurgopinus rafipes Eichhoff appears to be the first fully commercial use of this approach for pest management. Norries, 1965 has suggested that in this method dosage per tree is to be adjusted on the basis of the following criteria:

(a) An estimation of the volume of functional wood and bark in the tree-crown

(b) A rating of the volume of the canopy foliage

(c) A measurement of tree height

(d) A consideration of obvious disruption of the overall root system such as root pruning, change in grade etc.

(e) A judgement of the overall balance (proportion) of the trunk to the foliage.

2.2.04 Translocation of water soluble chemicals in trees

This refers to the movement of pesticide in the vascular system of the tree. It is apparent that transpiration greatly influence the direction of movement of foreign chemicals in the xylem (Crafts, 1961 and Zimmermann, 1964). The normal pattern of rise of pesticidal chemicals in the xylem of various species of trees largely conform to the arrangement of the functional vascular xylem element in such

plants (de Pietri - Tonelli, 1965: de Pietri Tonelli et al.,1962; Bouman and Casida, 1958).

The depth of injection or implantation of the chemical into the xylem probably would influence the initial pattern of movement. The concentrations of dimethoate and its derivatives were found in phloem of tree and it occurred due to radial transfer from the xylem (de Pietri-Tonelli, 1965).

The stem to root downward translocation of a chemical in insecticidal concentrations through the phloem of a tree occurs at a very slow rate. This occurs during the crests in the movement of photosynthetic products to the roots (de Pietri-Tonelli, 1965).

The seasonal changes in the physiology of trees greatly affect the rate of movement of systemics, as seen in stem application of such chemicals in citrus. In January and February the movement is ineffective, but the implantation made in March to August were successful (Jeppson et al., 1952 and 1954).

2.2.05 Persistence and Metabolism

Persistence and metabolism of systemics in plants are obviously interrelated. Persistence refers to the time

interval between the initiation and cessation of insecticidal action in a tree that was systemically treated. It is found that 0.4 to 0.7 g ai dimefox per seedling of cocoa would yield satisfactory control of mealy bugs on the foliage for six weeks (Hanna et al., 1955).

The dosage of an insecticide injection into a tree of given size also influence the persistence of insecticidal stimulus in the plant. In white pines when 8 g ai/tree of dicrotophos was given as stem injection there was 75% mortality of sawfly larvae while at 4 g ai/tree there was no such control (Coppel and Norries, 1961).

The persistence of a systemic insecticide in pine trees can vary from about two years in the case of phosdrin to several years with Chipman R-6100 (Casida et al., 1956).

Among the systemic organo-phosphates, dimethoate undergoes oxidation and hydrolysis in plants and the P = O analogue, O, O-dimethyl S (N-methyl - Carbaryl methyl) phosphate is apparently responsible for the most of the systemic insecticidal action (de Pietri-Tonelli, 1965).

Nadarajan et al. (1980) reported that monocrotophos applied at 7 ml ai/9-10 years old coconut palms as stem

injection persisted in coconut meat for up to 60 days, the residues being well below tolerance limit.

Monocrotophos applied at 0.5 ml ai/cm girth of mango tree of 21 years age by stem injection persisted in fruit for three weeks after application in mango (Thontadarya et al., 1978).

2.2.06 Phytotoxicity

The rate of uptake and translocation of the systemic insecticide by the tree and the uniformity of distribution of the toxicant in the physiologically functional tissues of the plant are the major factors that cause phytotoxicity in trees, even though the total applied dosage of the systemic was correct.

Giese et al. (1958) reported that when dimetox of 50% purity was implanted into the stem of balsam fir trees at 4 g/tree, there was rapid kill of the balsam gall midge, but all the needles yellowed and dropped from the trees within 10 days after treatment.

Materials and Methods

MATERIALS AND METHODS

3.1 Studies on the pest complex occurring on mango inflorescence

3.1.01 In order to study the pest complex associated with mango inflorescence, a survey was conducted in various districts of the Kerala State during the flowering season. In each district, one representative orchard was selected (Fig.1) and sampling was done at periodic intervals. The details of orchards selected for the survey are as follows:

Districts	Farms
Trivandrum	Instructional Farm, College of Agriculture, Vellayani (KAU)*
Quilon	District Agricultural Farm, Anchal (DOA)**
Kottayam	District Agricultural Farm, Kozha (DOA)
Alleppey	District Agricultural Farm, Mavelikara (DOA)
Ernakulam	District Agricultural Farm, Neriamangalam (DOA)
Trichur	Agricultural Research Station (KAU)
Palghat	Central Orchard, Pattambi (DOA)
Malappuram	Instructional Farm attached to the Institute of Agricultural Technology, Tavanur (KAU)

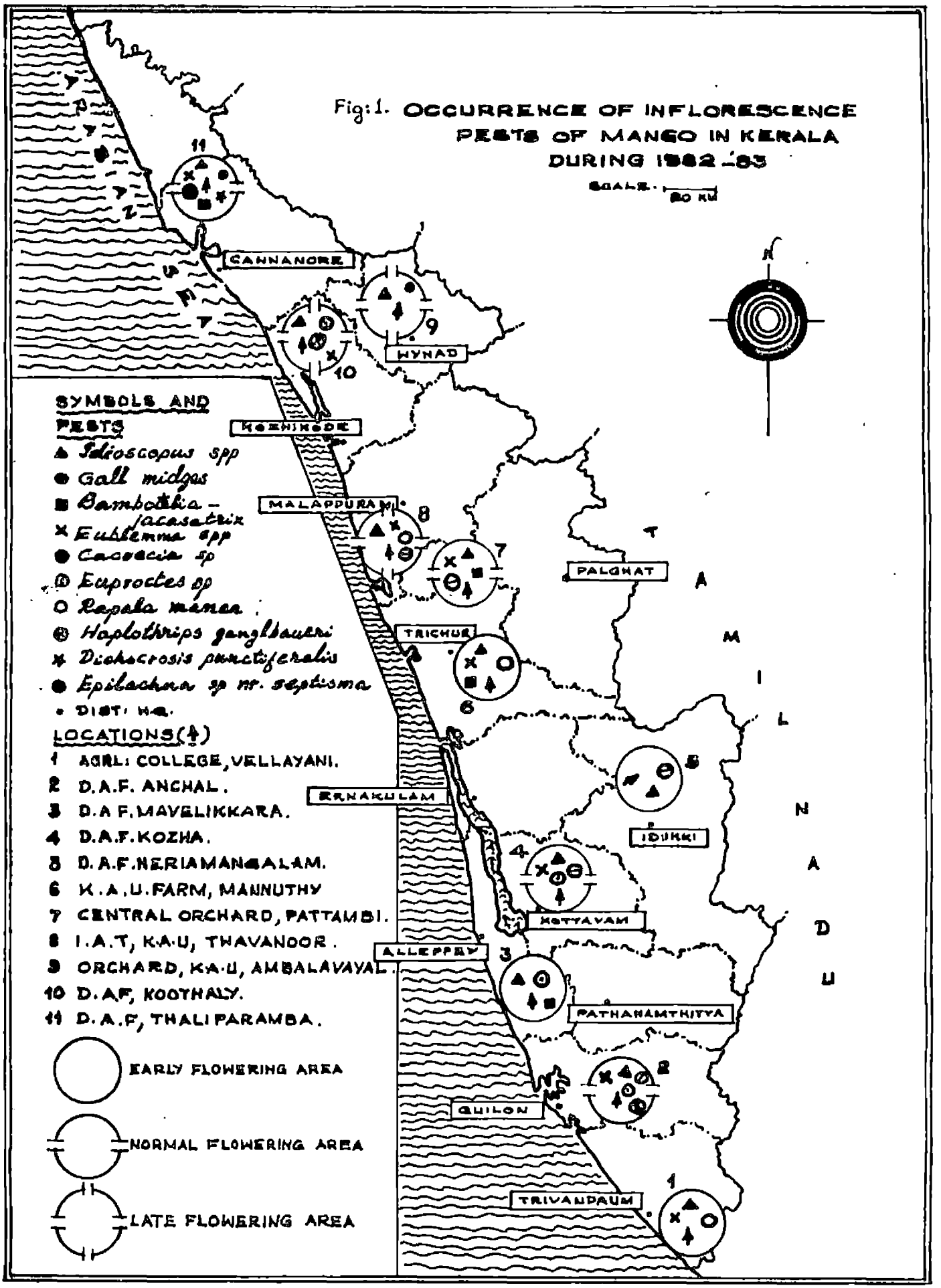


Fig:1. OCCURRENCE OF INFLORESCENCE PESTS OF MANGO IN KERALA DURING 1982-83
SCALE: 50 KM
N
CANNANORE
HYNAD
KOZHIKODE
MALAPPURAM
PALGHAT
TRICHUR
ERNAKULAM
IDUKKI
KOTTAYAM
ALLEPPEY
PATHANAMTHITTA
QUILON
TRIVANDRUM
TAMILNADU
SYMBOLS AND PESTS
Idioscopus spp
Gall midges
Bambothia - facasatrix
Eublemma spp
Cacoecia sp
Euproctes sp
Rapala manea
Haplothrips ganglbaueri
Dichocrosis punctiferalis
Epilachna sp nr. septisma
DIST. HQ.
LOCATIONS
1 AGRL: COLLEGE, VELLAYANI.
2 D.A.F. ANCHAL.
3 D.A.F. MAVELIKKARA.
4 D.A.F. KOZHA.
5 D.A.F. NERIAMANGALAM.
6 K.A.U. FARM, MANNUTHY
7 CENTRAL ORCHARD, PATTAMBI.
8 I.A.T, K.A.U, THAVANOOR.
9 ORCHARD, K.A.U, AMBALAVAYAL.
10 D.A.F, KOOTHALY.
11 D.A.F, THALIPARAMBA.
EARLY FLOWERING AREA
NORMAL FLOWERING AREA
LATE FLOWERING AREA

Calicut	District Agricultural Farm, Koothali (DOA)
Wynad	Regional Agrl. Research Station, Ambalavayal (KAU)
Cannanore	District Agricultural Farm, Taliparamba (DOA)

KAU* Kerala Agricultural University
DOA** Department of Agriculture

3.1.02 Collection of samples

A preliminary survey was conducted in the year 1981-82 to ascertain the actual blossoming season in mango varieties in the different farms selected for the study.

3.1.03 Sampling units and sampling procedure

The State of Kerala was divided into 12 districts at the time of survey. Among these, the district of Idukki was excluded from the survey because the area under mango was negligibly small as compared to other districts. The remaining 11 districts of Kerala State constituted the different strata of the sampling design. These districts were further grouped into three homogenous zones on the basis of the flowering pattern. The districts of Quilon, Kottayam, Palghat and Cannanore where flowering started in December and extended

up to January represented the first group. The districts of Malappuram, Calicut and Wynad where flowering started in January and extended up to March were grouped into second cluster. The districts of Trivandrum, Alleppey, Trichur and Ernakulam were grouped into a third zone where flowering started quite early in the season in November and continued up to January.

Periodic samples of the inflorescence were drawn from the selected farms in various districts during the blossoming periods within the above time frames.

Data were recorded periodically on the populations of insect pests occurring on the inflorescence. The first observation was recorded at the initial stage of flowering, when about thirty per cent of trees came to bloom. The second observation was registered during the next month which syncronised with the peak period of flowering in the orchard. The third observation was recorded during the succeeding month in which flowering was almost complete.

The study was conducted using the stratified multi-stage random sampling design with districts as strata, orchards as first stage unit, trees as second stage units and floral branches as third stage units.

3.1.04 Sampling procedure

In each orchard ten trees were selected randomly from among those having uniform age, irrespective of varietal considerations. The canopy of the trees thus selected were then divided radially into quadrants of uniform size. From each of these quadrants, three floral branches were collected randomly. The branches thus collected were carefully put in polybags (150 guage) of size 30 x 26 cm without causing any disturbance to the insect fauna occurring on the branches. The pooled sample from each tree was brought to the laboratory after putting a rubber band tightly around the open end.

3.1.05 Identification of insects and studies on the nature of damage inflicted by them

In the laboratory, each panicle was carefully examined under stereoscopic microscope to locate adult and immature stages of the various insects present. The larvae occurring on the floral branches were reared inside glass chimneys on fresh floral branches up to adult stage. The stalk end of the floral branches were inserted into small conical flasks containing water, to maintain the turgidity of the tissues. After pupation, the insects were

transferred to deep petri dishes covered over with musline cloth for adult emergence.

While rearing, the feeding habits and the nature of damage inflicted by the immature stages were closely observed. The adults were killed in bottles containing ethyl acetate soaked cotton pads. The taxonomic identities of the Lepidopteran insects were established by referring to the Head of the Department of Entomology, Indian Agricultural Research Institute, New Delhi-12. The Coleopterans were got identified from the Zoological Survey of India, Calcutta-34 and the midges were identified by Dr.P. Grover of Cecidological Society of India, Allahabad-4. The thrips were identified by Dr. T.N. Ananthakrishnan of the Entomology Research Unit, Loyola College, Madras-34. The parasitoids were identified by Dr.M.S. Mani of the Marine Biological Station, Zoological Survey of India, Madras-28.

3.2 Control of mango hoppers

In this experiment, monocrotophos was evaluated for its systemic action against the mango hopper species Idioscopus niveosparsus. Two application methods were tried in this study. The terminal insecticide residues of the floral branches and fruit were also monitored.

3.2.01 Layout of the experiment

The experiments were conducted on uniformly aged trees (23 years) of Banglora, Alampur, Baneshan, Mundappa and Banganappally varieties, since these varieties showed synchronous flowering habit. These trees have attained fairly uniform stem girth of 115 cm to 155 cm, the tree height being in the range of 7.0 to 9.0 metres. Monocrotophos was applied at 2 ml and 4 ml ai/tree by following two methods, namely, stem injection and stem banding. There were thus four treatments and one control, each with four replications. Fourth instar nymphs of Idioscopus niveosparsus was used as the test insect to assess the toxic effect of monocrotophos translocated systemically to floral branches.

3.2.02 Maintenance of Idioscopus niveosparsus culture

The fourth instar nymphs of I. niveosparsus required for the experiment were drawn from stock culture maintained on the floral branches of Alphonso variety which bloomed early in the season. Ten adult pairs were confined on each of the floral branches for multiplication. Nylon net of sufficiently small mesh size was used for confining the adult insects on floral branches.

3.2.03 Stem injection of monocrotophos

For injecting monocrotophos suspension into the trunk a special transfusion device was developed, substantially modifying the contrivance used by Ghosh and Balasundaran (1980). The nozzles were fabricated from galvanised iron pipe pieces (diameter 1.25 cm) each of 5 cm length. One end of the pipe was cut off obliquely and the edges were sharpened so as to facilitate easy driving of this end into trunk to serve as injection nozzles. Through the outer end of the nozzle, a rubber stopper having two holes were inserted and glass tubes of 5 mm diameter were inserted through these holes. Four such nozzles were driven into the bark at equidistant intervals along the girth of the trunk and these were then interconnected with latex tubing to function as a single unit for injection. The free end of the tube was linked to the saline glass bottle (500 ml) suspended at a height of 2 m above the nozzle level. The bottle was used as the reservoir for monocrotophos suspension. From the fourth nozzle, rubber tubing of 30 cm length was fitted to serve as an outlet for the system (Plate I and 2).

Two doses of monocrotophos, namely, 2 ml and 4 ml ai/tree were evaluated in this experiment. For injection

Plate 1. Stem injection of monocrotophos using transfusion set - View 1

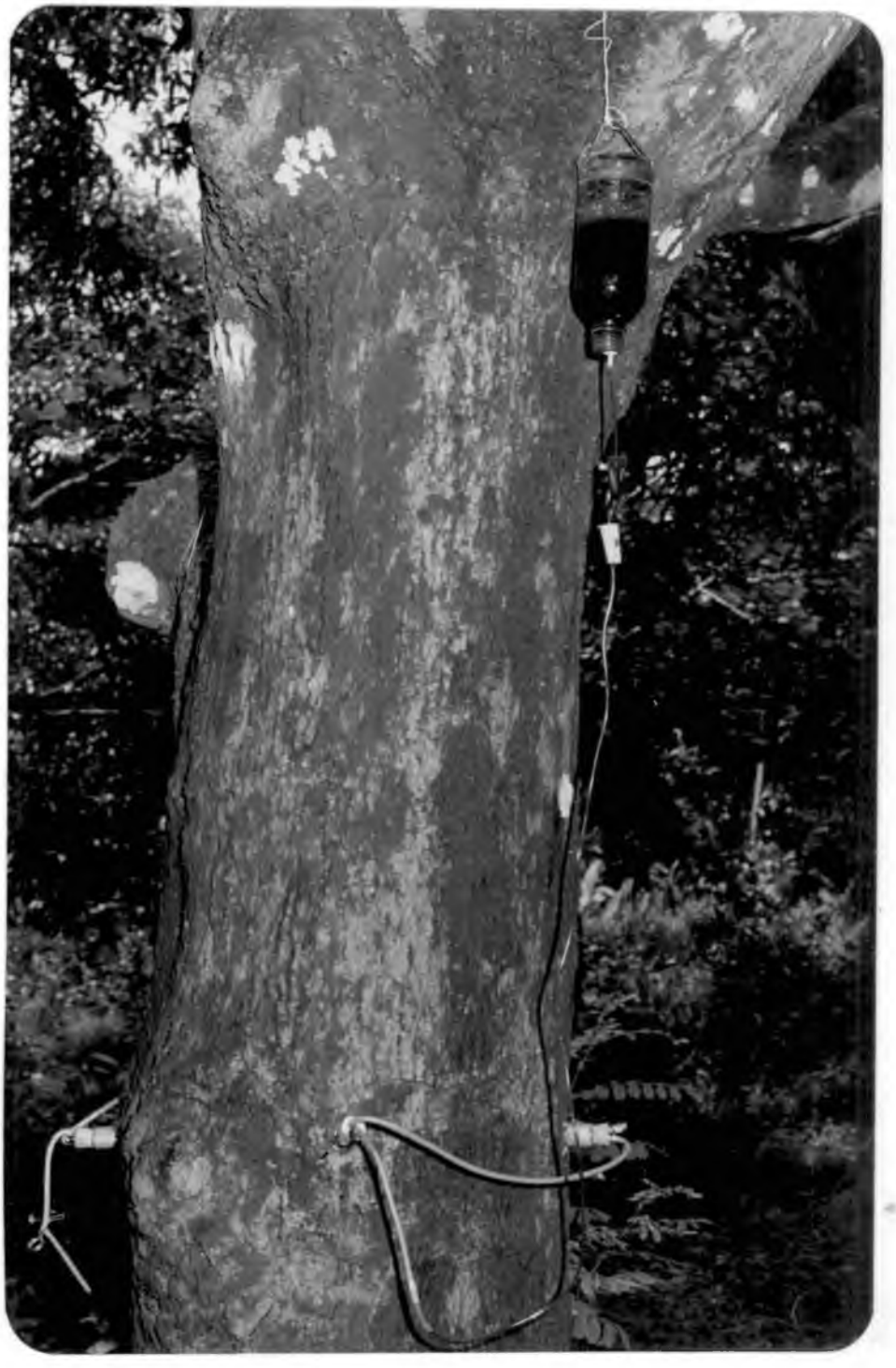


Plate 2. Stem injection of monocrotophos using transfusion set - View 2

of monocrotophos, the active ingredient was extended with an aqueous solution of rhodamine-B (0.02%) to make up the total volume to 200 ml. For preparing the suspension, the required quantity of the technical material of the insecticide was first diluted with 10 ml of aqueous suspension of rhodamine-B using distilled water.

Four holes each of 7.5 cm depth and 1.75 cm diameter were drilled in the tree trunk as already described using a hand auger at a height of one meter from ground level. The sharpened ends of the nozzles were then pressed into the bark around the orifice such that the insecticidal suspension from the system flows into the bore hole. The nozzle was fixed in that position by gentle tapping. Care was taken to ensure that the bark did not suffer any injury due to the insertion of the nozzle.

The free end of the first nozzle in this series was then connected to the drip bottle and the exit hose from the fourth nozzle was held in an upright position in the beginning. The insecticide suspension kept in the drip bottle was allowed to reach bore holes by opening the stop cock fitted on to the exit hose from the fourth nozzle and by keeping it in the open position until the fluid over-flowed through the exit hose. In the drip bottle about

300 ml of the insecticidal suspension was taken and the overflow was allowed until the bottle retained exactly 200 ml of the suspension. This was necessary to clear off the delivery system and to exclude air pockets. The exit as well as the inlet hoses were then closed. The inlet stop cock was then very slowly opened to adjust the flow rate and was kept in that position until the required quantity (200 ml) of the fluid reached the bore holes.

In order to monitor the toxicity of the insecticides to the hoppers, 20 test insects were released under confinement on each of the four floral branches selected in each of the canopy quadrants. For confinement nylon net cages were used.

3.2.04 Insecticide application by stem banding

Four blocks of bark each of 8 x 8 cm were scooped out with a chisel from the trunk at equidistant intervals so that there would be one such opening in each quadrant along the circumference. While removing the bark, care was taken to ensure that the underlying trunk was not bruised. The required quantities of the insecticide (2 ml and 4 ml) were extended first with 10 ml of 0.02% solution of rhodamine-B dye. This was then applied to cotton pads kept within the cavities of the bark using micropipettes. The pads

were then covered over tightly with the excised bark disc to serve as a plug. The padded region of the bark was then covered over closely with a poly film sheet (500 guage) of size 20 x 20 cm which was kept in that position by drawing pins driven into the bark.

The control trees were treated with 200 ml and 10 ml of 0.02% of rhodamine-B dye per tree following stem injection and stem banding methods respectively as already stated.

3.2.05 Confinement of test insect in treated trees

The fourth instar nymphs of I. niveosparsus were released into cages enclosing floral branches. The cages were made of aluminium wires fabricated in the form of an open cylinder of 80 cm height and 30 cm diameter. The three vertical ribs of the frame work on one side were extended to about 30 cm to use these for fixing the cages on the stalk of the floral branches (Plate 3). The body of the frame which enclosed the panicle was covered over with nylon cloth.

The mortality of the test insects at intervals of 12 hours was recorded.

Plate 3. Nylon net cage used to confine the *Idioscopus niveosparsus* nymphs on the floral branches

3.3 Monocrotophos residue assay

3.3.01 Reagents and solutions for cholinesterase inhibition

A - M/15 Potassium dihydrogen phosphate solution:

$\frac{136.09}{15}$ = 9.07266 g weighed in a monopan balance and made up to one litre with distilled water.

B - M/15 Disodium hydrogen phosphate solution:-

$\frac{178}{15}$ = 11.8666 g weighed in a monopan balance and made up to one litre with distilled water.

C - Phosphate buffer pH 8 - A:B :: 50:95

D - Phosphate buffer pH 7 - A:B :: 40:60

E - Enzyme working solution - Diluted 2 ml of out dated, refrigerated human blood plasma with 250 ml of phosphate buffer pH 8 (C).

F - Reagent stock solution : Dissolved 100 mg of 5, 5' - dinitrobis - 2 - nitrobenzoic acid (DTNB) in 50 ml of phosphate buffer pH 7 (D) stored in refrigerator at 0-2^{o}C.

G - Substrate - reagent working solution: Dissolved 50 mg of butyryl thiocholine-iodide (BSch) in 45 ml of distilled water, added 5 ml of Reagent stock solution (F), and stored under ice cooled condition for a day's work. Fresh solution was prepared daily.

H - Standard monocrotophos solution:Details furnished in Section 3.3.02

3.3.02 Sample collection, clean up and procedure of residue analysis

The residues of monocrotophos in the inflorescence and mango fruit were chemically assayed following the method suggested by Ellman et al. (1961). In order to determine the terminal residues of monocrotophos in treated trees, samples of inflorescence were taken a fortnight after application of the insecticide. Five weeks after application, tender mango fruit were collected from each canopy quadrant of the treated trees. The fruit were also analysed to detect the amount of monocrotophos residues.

The floral branches were first chopped into small bits and representative samples weighing 25 g from each treatment were macerated in a blender at high speed for 2-3 minutes with 100 ml chloroform. This was then filtered through a Buchner funnel using Whatman 42 filter paper into a 500 ml Erlenmeyer flask under vacuum. The extracted samples after filteration were re-extracted in 50 ml chloroform and the contents were again filtered to the same container. Thirty grammes of anhydrous sodium sulphate was then added to the filtrate and the extract was then decanted through a folded filter paper into a 500 ml pear shaped flask. The sodium sulphate remaining in the filter paper was washed twice with 50 ml aliquots of chloroform

and the extracts were collected along with the first filtrate. The extracts were then condensed approximately to 10 ml in rotating type evaporator at 45°C on water bath. Hexane was added thrice each time at 25 ml and this was evaporated to approximately 10 ml. The concentrate thus obtained was transferred to a 25 ml volumetric flask and the evaporation vessel was rinsed with small quantities of hexane until the volume was made up to 25 ml.

A 5 ml aliquot of the hexane solution was then taken into a 20 ml centrifuge tube to which was added 5 ml distilled water and 30-40 mg of celite 545. The mixture was shaked vigorously for seconds and the two phases were separated by centrifuging at 3000 rpm for 30 minutes. The upper organic layer was removed by suctioning with pipette. The absorbance of this aqueous phase was determined calorimetrically at 420 m/u .

The terminal residues of monocrotophos in tender mango fruit were also determined using the above clean-up and calorimetrical assay procedure.

3.3.03 Reference curve preparation for cholinesterase inhibition technique

A set of 11+2 tubes were used for measuring absorbance. Into the tubes numbered 1, 2 and 3, 2 ml each of distilled water were taken initially. Two milli litres each of 0.1 ppm,

0.2 ppm, 0.4 ppm and 0.6 ppm of monocroptophos solutions were taken in the tubes such that the tube pair 4 and 5 contained 0.1 ppm 6 and 7 contained 0.2 ppm; 8 and 9 contained 0.4 ppm and the pair 10 and 11 contained 0.6 ppm. In the remaining two tubes of Sl. Nos.12 and 13, blanks were taken.

At zero time the stop watch was started and 2 ml of buffer of pH 8 was added to tube No.1 and this was placed on the stand. The room temperature was 30°C and hence water bath was not used. Exactly 30 seconds later, 2 ml of the enzyme solution (E) was added to the tube No.2 and this was kept on the stand. In the same manner, enzyme solution was added to the remaining tubes also at intervals of 30 seconds.

Exactly 30 minutes after the zero time, 1 ml of the substrate-reagent working solution (G) was added to the tube No.1 and was then shaked well and kept at 30°C. The reagent was added to the remaining tubes also in the same manner at intervals of 30 seconds. When the stop watch showed 37 minutes, i.e. 7 minutes after the addition of solution G into the first tube, the calorimeter was brought to zero with tube No.1 and at intervals of 30 seconds the absorbance of the yellow solutions in the remaining 10 tubes and two sample tubes were measured.

The percentage of residual enzyme activity in the four inhibited samples was worked out by taking the uninhibited control (Tubes No.2 and 3) as 100% active and these were plotted on logarithmic scale against the inhibitor concentration of monocrotophos on a linear scale (Fig.7).

3.4 Statistical analysis

The data collected for the conduct of the sample survey to study the extent of variation of the populations of different insects were subjected to statistical analysis following analysis of variance technique for the Hierarchal design as suggested by Snedecor and Cochran, 1967 after transforming the data into square root of (x + 1) values.

Comparisons were made among different districts and stages within each district by computing the critical difference values wherever significant differences were detected.

The experimental data relating to the experiment for evaluating the toxic stimuli of monocrotophos against the mango hoppers were subjected to Probit analysis to determine the LP-50 values for different treatments as described by Finney (1971).

RESULTS

4.1 Insect pest complex associated with mango inflorescence

A survey was conducted in different parts of the State to identify the different species of insects occurring on the inflorescence of mango trees and also to study the nature of damage inflicted by them. The species of insects recorded during the survey are the following:

4.1.01 Idioscopus spp. (Cicadellidae : Homoptera)

Idioscopus niveosparsus populations

Idioscopus niveosparsus Lethierry and I. clypealis Lethierry were found to occur on inflorescence throughout the State during the blossoming period. I. niveosparsus measures 4 to 5.5 mm in length. I. clypealis is smaller than I. niveosparsus and the former has two black spots at the anterior margin of the vertex. The vertex of I. niveosparsus has light greenish yellow hue longitudinally along the sides of the median region which shows a pale dull elongate patch. Data on the incidence of the Idiocerine hoppers during the period November, 1982 to March, 1983 in different parts of the State are furnished in Tables 1 and 2.

Table 1. Seasonal occurrence of Idioscopus niveosparsus nymphs and adults in different parts of the Kerala State*+

Month and year	Trivandrum	Quilon	Kottayam	Alleppey	Ernakulam	Trichur	Palghat	Malappuram	Calicut	Wynad	Cannanore
November, 1982	8.4 (2.99)**	-	-	16.0 (4.05)	17.4 (4.08)	28.5 (5.38)	-	-	-	-	-
December, 1982	2.7 (1.86)	14.3 (3.82)	19.4 (4.34)	10.5 (3.33)	20.4 (4.40)	32.4 (5.75)	41.8 (6.36)	-	-	-	33.0 (5.77)
January, 1983	13.9 (3.77)	8.1 (2.99)	21.6 (4.50)	9.2 (3.15)	11.7 (3.44)	22.2 (4.64)	69.0 (8.24)	15.9 (3.86)	7.6 (2.89)	15.6 (4.05)	32.6 (5.69)
February, 1983	-	18.8 (4.26)	13.7 (3.70)	-	-	-	4.3 (2.22)	21.2 (4.55)	10.9 (3.41)	53.8 (7.26)	29.1 (5.42)
March, 1983	-	-	-	-	-	-	-	16.8 (3.94)	20.2 (4.49)	45.6 (6.71)	-
No.of larvae/ month	8.33	13.73	18.23	11.9	16.5	27.7	38.37	17.97	12.9	38.33	31.57
No.of larvae/ month (mean of transformed values)	(2.87)	(3.69)	(4.21)	(3.51)	(3.97)	(5.26)	(5.61)	(4.11)	(3.60)	(6.01)	(5.63)

* Number of trees in each district = 10

\+ Mean population/tree based on counts from four panicles

** Figures in parentheses are $\sqrt{x + 1}$ values

CD (0.05) for comparison of mean populations within a particular district at various points of time = 2.018227

Table 2. Seasonal occurrence of *Idioscopus clypealis* nymphs and adults in different parts of the Kerala State*+

Month and year	Trivandrum	Quilon	Kottayam	Alleppey	Ernakulam	Trichur	Palghat	Malappuram	Calicut	Wynad	Cannanore
November, 1982	25.7 (5.06)**	-	-	13.1 (3.60)	23.8 (4.75)	24.4 (4.97)	-	-	-	-	-
December, 1982	9.3 (3.16)	18.5 (4.35)	25.3 (5.02)	9.4 (3.12)	25.2 (5.07)	26.5 (4.96)	6.3 (2.52)	-	-	-	18.6 (4.25)
January, 1983	14.0 (3.76)	21.6 (4.63)	26.1 (5.13)	6.7 (2.59)	12.4 (3.35)	20.7 (4.52)	10.4 (3.05)	13.0 (3.61)	22.0 (4.52)	13.7 (3.72)	22.5 (4.74)
February, 1983	-	12.9 (3.58)	10.1 (3.29)	-	-	-	4.7 (2.29)	10.4 (3.34)	30.2 (5.55)	8.1 (3.10)	27.4 (5.25)
March, 1983	-	-	-	-	-	-	-	13.6 (3.81)	36.3 (6.07)	6.4 (2.85)	-
No.of larvae/ month	16.33	17.67	20.5	9.83	20.47	23.87	7.47	12.33	29.5	9.4	22.83
No.of larvae/ month (mean of transformed values)	(3.99)	(4.18)	(4.48)	(3.10)	(4.39)	(4.82)	(2.62)	(3.58)	(5.38)	(3.22)	(4.75)

* Number of trees in each district = 10
\+ Mean population/tree on counts from four panicles
** Figures in parentheses are $\sqrt{x + 1}$ values
CD (0.05) for comparison of mean population in the different districts = 0.936607
CD (0.05) for comparison of mean populations within a particular district at various points of time = 1.113474

The hoppers make oviposition injuries on the unopened flowers and the mechanical injury to the tissues due to oviposition wound causes inflorescence blight. The adult and nymphs also cause damage by feeding on buds, flowers and floral branches, causing flower drop.

The populations of I. niveosparsus did not show any significant variations in the different districts of State. Variability in the populations could not be detected among the three zones of the State demarcated on the basis of the flowering pattern of the crop.

In the Trivandrum District, the population of I. niveosparsus, showed considerable increase from December to January 1983, but the variations were not statistically significant.

In the Quilon District there was a moderate increase in the populations of I. niveosparsus in February 1983 as compared to the previous month.

In the Kottayam District, the populations showed a slight reduction in February 1983 as compared to the preceding month.

In the Alleppey District, the populations of I. niveosparsus remained almost static in November and

December, but there was then a slight decline in the populations in January 1983.

In the Ernakulam District the population remained without appreciable changes during the blossoming period.

The population trends in the Trichur District were quite similar to the general trend observed in the Ernakulam District.

There was a well defined peak in pest populations in January 1983 and the population load in this month was statistically higher to the load registered in December 1982. Thereafter the population dwindled sharply, in February 1983.

In the Malappuram District, the build up of populations of I. niveosparsus was noticed in January 1983, but, the populations remained at stable levels up to March 1983.

In the Calicut District also the build up of I. niveosparsus populations commenced in January 1983 and there was a moderate increase in March 1983, but the trend failed to attain statistical significance.

In the Wynad District, the populations increased significantly from January 1983 to March 1983, but the populations in February and March 1983 remained without fluctuations.

The Cannanore District was unique in that the populations of the hopper species remained stable throughout the blossoming season.

Idioscopus clypealis populations

Significant differences in total populations loads of I. clypealis were detected among the districts of the State. The variability of populations between the three zones was, however not significant.

The highest populations of this insect was recorded from the Calicut District (Table 2) and the lowest population was registered from Palghat, this difference being significant. In the Districts of Kottayam, Trichur and Cannanore the populations were on par with the level recorded in Calicut. The pest population in the Palghat, Alleppey and Wynad Districts were also on par and significantly lower than in the above four districts, namely, Calicut, Kottayam, Trichur and Cannanore.

The Trivandrum District showed a numerical preponderance of I. clypealis which registered a distinct peak in November followed by a sharp decrease in December. In January, the population remained without changes. In the Quilon District also, there was a relative dominance of I. clypealis, but

in this District the populations remained at stable levels without appreciable changes.

In the Kottayam District, I. clypealis and I. niveosparsus occurred at almost same levels. The I. clypealis population in the Kottayam District was recorded only from December 1982 and this remained up to January 1983 without considerable changes, but later, there was a sharp significant reduction in the population in February 1983.

In the Alleppey District, the size of the populations of I. clypealis remained at stable levels.

In the Ernakulam District, the populations of I. clypealis during November and December did not show significant variations, but the populations showed significant decline in January 1983.

In the Trichur District, the population remained almost static throughout the flowering season.

In the Palghat District also, the populations of I. clypealis remained without changes, during the blossoming period.

In the Malappuram and Wynad Districts also, Significant variations in the populations could not be recorded.

In the Calicut District, there was a significant increase in the pest population from January to March 1983.

The populations of I. clypealis registered a progressive increase in the Cannanore District from December to February 1983, there being a well defined peak in February 1983.

4.1.02 Procystiphora mangiferae Felt (Cecidomyiidae : Diptera)

During December 1982, January and February 1983, the midge Procystiphora mangiferae Felt was recorded in the Wynad and Cannanore Districts (Table 3). These occurred in association with Erosomyia indica Grover and Prasad. The infestation by P. mangiferae led to the formation of galls and the total gall counts in the Wynad District in January and February 1983 was 20.1 and 19.8 respectively and the peak was attained in March 1983 when the gall count reached fifty six. Studies to assess the injury caused to the tender buds were carried out in the laboratory by confining field collected floral branches in which fresh infestation occurred under natural conditions. Tender buds on which oviposition occurred at the stalk end

Table 3. Seasonal occurrence of Procystiphora mangiferae galls in various parts of the Kerala State*+

Month and year	Trivan-drum	Qui-lon	Kotta-yam	Alle-ppey	Erna-kulam	Trichur	Pal-ghat	Mala-ppuram	Cali-cut	Wynad	Canna-nore
November, 1982	0	-	-	0	0	0	-	-	-	-	-
December, 1982	0	0	0	0	0	0	0	-	-	-	24.2
January, 1983	0	0	0	0	0	0	0	0	0	20.1	27.9
February, 1983	-	0	0	-	-	-	0	0	0	19.8	8.3
March, 1983	-	-	-	-	-	-	-	0	0	56.0	-
Galls per month	0	0	0	0	0	0	0	0	0	31.97	20.13

* Number of trees in each district = 10

\+ Mean population/tree based on counts from four panicles

were found to shed as a result of the oviposition injury. Those buds in which the maggots fed internally, showed malformation in the form of galls. The total damage to the buds and flowers ranged from 15 to 75 per cent.

The fully mature maggot is yellowish-orange in colour. The antennae are stout, with a broader basal segment and it tapers off distally. The sternal spatula is heavily sclerotised and brownish, the crown being bidentate, the groove in between the dents being shallower. The shaft of this spatula is fully formed and is lodged in a pocket-shaped pouch. The fully mature maggots pupated within the galls. Adults could not be reared from pupae.

4.1.03 Erosomyia indica Grover and Prasad
(Cecidomyiidae, Diptera)

This mango gall midge was recorded from the Cannanore District during December to February while in the Wynad District the pest was recorded from January to March 1983. The pest occurred in company with Procystiphora mangiferae. The damage by E. indica was relatively more serious in the Cannanore District. In the Wynad District, the mean number of galls/tree recorded from four floral branches was nine in February and the population remained without substantial changes up to March the counts for February and March being

8.4 and 11.7 respectively (Table 4). In the Cannanore District the population remained stable in December and January but in February 1983, there was a sharp fall in the number of galls.

The larvae occurred on the main inflorescence axes where they tunnelled internally at many points leading to the development of small ovate galls. Around the point of entry of the larvae on the main rachis, a blister like circumscribed discolouration appears after initiation of infection. Later the portion of the rachis bulges out around the infested region leaving the blistered part as such without swelling further. The galls thus formed are asymetrical since the blistered regions remain without bulging. Eventually, the rachis bents at the galled portion. In badly affected inflorescence the growth and development of inflorescence were found to be stunted.

The mature larvae of E. indica are cylindrical with heavily sclerotised head. The anterior tentorial bars are narrow, while the posterior bars are massive, being bent inwards. Under laboratory conditions, the mature maggots pupated in a layer of sand kept in petri dishes. But the adults failed to emerge out. The identification was established on the basis of the larval characters.

Table 4. Seasonal occurrence of Erosomyia indica galls in various parts of the Kerala State*+

Month and year	Trivandrum	Quilon	Kottayam	Alleppey	Ernakulam	Trichur	Palghat	Malappuram	Calicut	Wynad	Cannanore
November, 1982	0	-	-	0	0	0	-	-	-	-	-
December, 1982	0	0	0	0	0	0	0	-	-	-	18.5
January, 1983	0	0	0	0	0	0	0	0	0	9.0	22.0
February, 1983	-	0	0	-	-	-	0	0	0	8.4	4.6
March, 1983	-	-	-	-	-	-	-	0	0	11.7	-
Galls per month	0	0	0	0	0	0	0	0	0	9.7	15.03

* Number of trees in each district = 10

\+ Mean population/tree based on counts from four panicles

4.1.04 Bombotelia jocosatrix Gn. (Noctuidae:Lepidoptera)

The larvae of Bombotelia jocosatrix were collected from the Cannanore, Palghat, Trichur and Alleppey Districts throughout the flowering season. The data on the mean number of B. jocosatrix collected from the various districts are furnished in Table 5.

This pest was relatively more numerous in the Palghat and Cannanore Districts and the infestation was serious in the latter district. In the Palghat District, the larval populations in December and January were 7.3 and 4.4 per tree respectively, the peak being in February 1983 (14 larvae). In the Cannanore District, there were heavy populations in December and January (15.8 and 13.6 respectively) after which the population declined to 8.5 per tree. This pest was found in the Alleppey, Trichur Districts at very low populations. In the other districts infestation was not recorded.

The full grown larvae of B. jocosatrix is about 18 mm long. They are greenish with sub-lateral dark striae, the segments with small purple spots and a few hairs from the tubercles. The moths are medium sized, dark purple-brown in colour having a wing expanse of 27-30 mm. Hind wings have two small, round dark spots at the centre (Fig.2).

Table 5. Seasonal occurrence of Bombotelia jocosatrix larvae in different parts parts of the Kerala State*+

Month and year	Trivandrum	Quilon	Kottayam	Alleppey	Ernakulam	Trichur	Palghat	Malappuram	Calicut	Wynad	Cannanore
November, 1982	0	-	-	2.3	0	0	-	-	-	-	-
December, 1982	0	0	0	4.1	0	1.8	7.3	-	-	-	15.8
January, 1983	0	0	0	0	0	0.9	4.4	0	0	0	13.6
February, 1983	-	0	0	-	-	-	14.0	0	0	0	8.5
March, 1983	-	-	-	-	-	-	-	0	0	0	-
Larvae per month	0	0	0	2.13	0	0.9	8.57	0	0	0	12.63

* Number of trees in each district = 10

+ Mean population/tree based on counts from four panicles

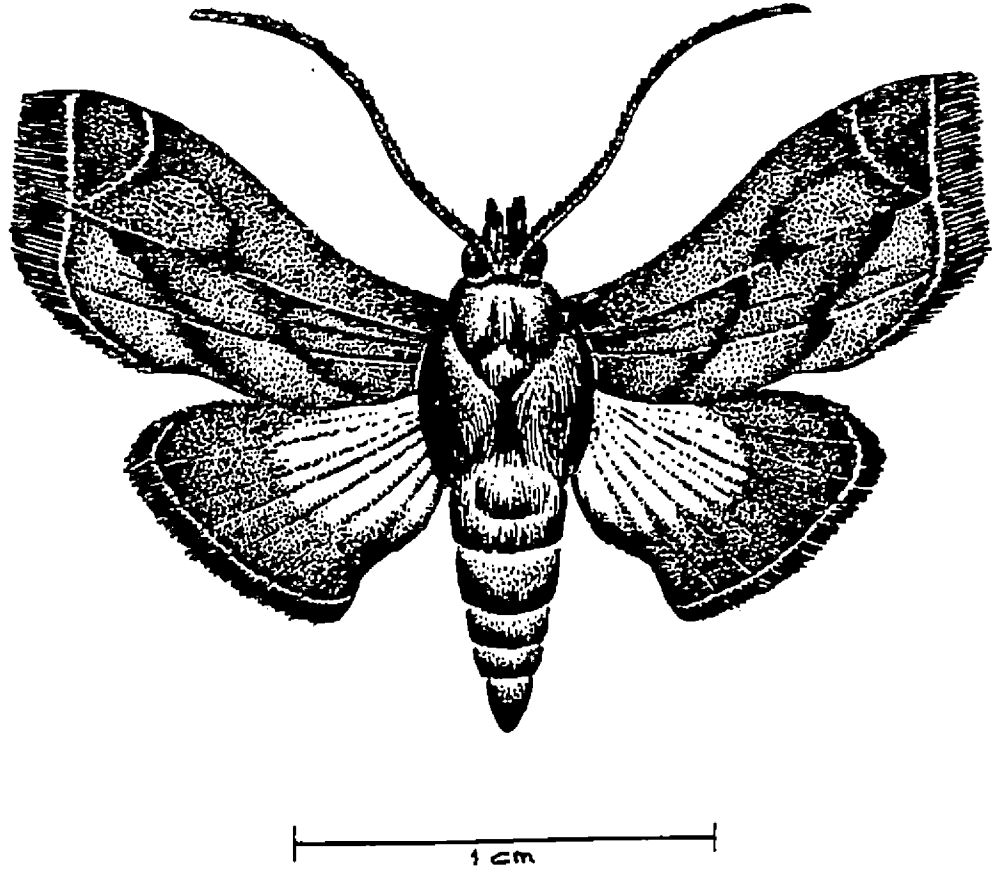


Fig:2. *Bombotelia jocosatrix* Gn.

Pupation of B. jocosatrix takes place on the main branches of the inflorescence. While rearing out the larvae, adults of Apanteles sp. (Braconidae, Hymenopetra) emerged out from the samples collected from the Palghat District. The taxonomic identity of the larval parasitoid was established by Dr. M.S.Mani of the Marine Biological Station, Zoological Survey of India, Madras. The larval parasitism by Apanteles sp. was, however, found to be quite negligible in the Palghat District. This parasite was not recorded from any other district.

The larvae at all stages, particularly in the last two instars were found to be voracious feeders of the floral buds, flowers, rachides and other parts of the inflorescence.

4.1.05 Eublemma spp. (Noctuidae; Lepidoptera)

Eublemma anquilifera Moore and another species of Eublemma were recorded to occur widely in the State as pests of inflorescence except in the Wynad District. The fully grown larvae of this insect are about 20 mm long, pale greenish in colour, moderately stout with scattered fine hairs arising from yellow tubercles. The caterpillar webs together the parts of the inflorescence and externally feed on the tissues. Moths are greyish-buff coloured with an oblique wavy line on the wings; wing span is 18 to 22 mm (Fig.3).

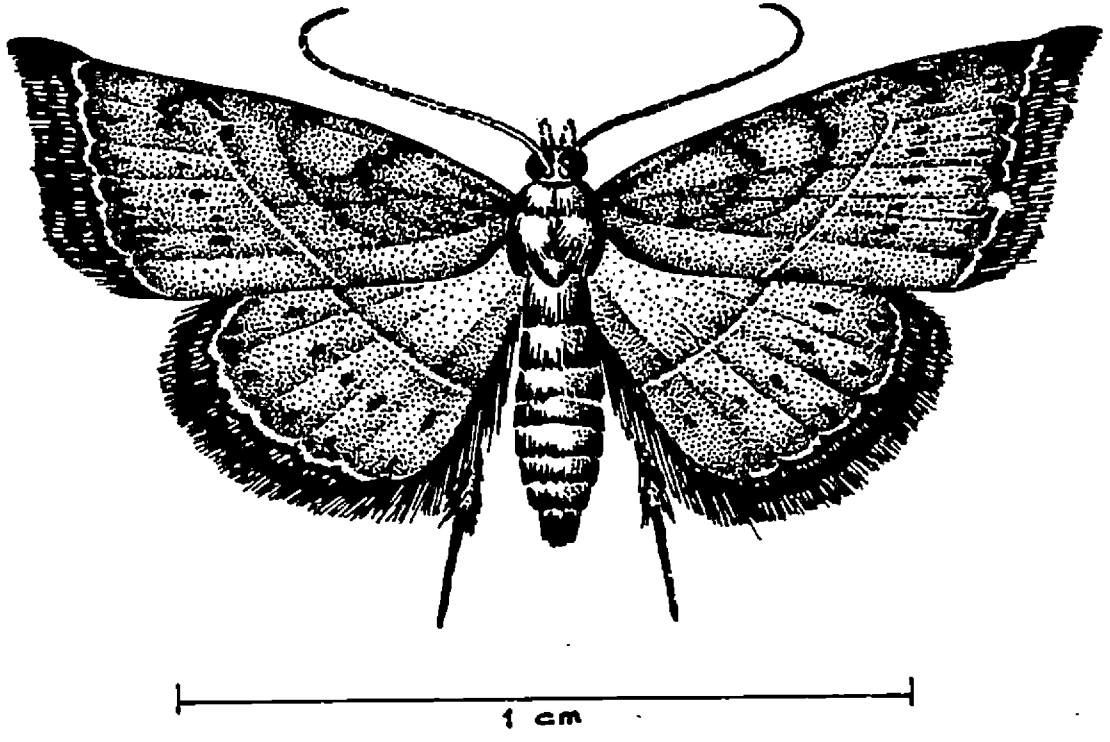


Fig:3. *Eublemma anguilifera* Moore.

Significant variability was detected among the mean population loads of the insect occurring in different districts of the State. There were however no variations among the populations occurring in these zones of the State.

Among the districts, the heaviest populations of Eublemma spp were recorded from the Malappuram District (Table 6). In the Districts of Trivandrum, Alleppey, Quilon, Kottayam, Ernakulam and Calicut the populations were significantly lower than in the Malappuram District. The pest was not recorded from the Wynad District.

In the Trivandrum District the populations of this pest were relatively of a very low order, there being no significant difference between the populations for December and January 1983.

The Quilon District showed populations at low levels from December to February, the difference being not significant.

In the Kottayam District, there was a gradual reduction in pest population during the period from December to February but the decline in population was not significant.

In the Alleppey District, the Eublemma spp occurred at appreciable levels in the month of November 1982 and

Table 6. Seasonal occurrence of Eublemma spp. in different parts of the Kerala State*+

Month and year	Trivandrum	Quilon	Kottayam	Alleppey	Ernakulam	Trichur	Palghat	Malappuram	Calicut	Wynad	Cannanore
November, 1982	0 (1.00)**	-	-	5.0 (2.4)	2.9 (1.88)	9.3 (3.17)	-	-	-	-	-
December, 1982	5.4 (2.41)	7.0 (2.77)	7.2 (2.70)	1.8 (1.56)	5.3 (2.22)	7.6 (2.63)	6.1 (2.46)	-	-	-	12.1 (3.44)
January, 1983	5.6 (2.37)	5.4 (2.50)	6.4 (2.59)	0 (1.00)	8.5 (2.90)	6.2 (2.45)	29.0 (5.33)	27.5 (5.18)	6.3 (2.45)	0 (1.00)	11.8 (3.26)
February, 1983	-	3.9 (2.03)	2.8 (1.91)	-	-	-	2.3 (1.69)	25.6 (4.96)	1.1 (1.36)	0 (1.00)	15.5 (4.00)
March, 1983	-	-	-	-	-	-	-	20.8 (4.42)	5.7 (2.53)	0 (1.00)	-
No.of larvae/ month	3.67	5.43	5.47	2.27	5.57	7.7	12.47	24.63	4.37	0	13.13
No.of larvae/ month (mean of transformed values)	(1.93)	(2.43)	(2.40)	(1.65)	(2.33)	(2.75)	(3.16)	(4.85)	(2.11)	(1.00)	(3.57)

* Number of trees in each district = 10

\+ Mean population/tree based on counts from four panicles

** Figures in parentheses are $\sqrt{x + 1}$ values

CD (0.05) for comparison of mean populations in different districts = 0.8166786

CD (0.05) for comparison of mean populations within a particular district at various points of time = 1.279903

and thereafter the population declined but there was no significant differences.

In the Ernakulam District the population of Eublemma spp remained static throughout the blossoming season.

In the Trichur District, the pest occurred almost stable during the period from November-January.

In the Palghat District, there was very well defined population peak in January 1983. In February, the populations were reduced drastically.

The Malappuram District showed moderately heavy populations during the period January-March 1983, there being a reduction towards March 1983. The decline in population were however, not significant.

In the Calicut District, Eublemma populations remained without significant changes during the blossoming period.

In the adjoining Cannanore District the pest occurred during the period December to February without major changes.

4.1.06 Cacoecia sp (Totricidae; Lepidoptera)

Larvae of an unidentified species of the Genus Cacoecia were recorded for the first time as pests of mango

inflorescence, from various parts of the State. This pest occurred at high population levels in the Malappuram and Cannanore Districts (Table 7), the mean population per tree being 34.8 and 37.5 larvae respectively in these two districts. This pest was not recorded from Calicut, Wynad, Trivandrum and Alleppey Districts. In Quilon, Kottayam, Ernakulam and Palghat Districts, the populations were low being 11.2, 11.2, 16.7 and 4.0 larvae per tree respectively. Well defined peaks in population were not observed in any of the districts.

The larvae fed on the flowers and floral buds inside silken galleries and thus caused damage. The fully grown larvae are brownish with characteristic 'V' shaped marking on the dorsum of the abdominal segments.

The adult moth has a wing expanse of 20-21 mm across the thorax. The forewings are nearly trapezoidal and is greyish black except for broken linear whitish patches in the anterior half and elongated diffused whitish patches along the hind margin. In the forewings very small elongate semi-lunar markings are present along the distal margin (Fig.4).

4.1.07 Rapala manea Hewitson (Lepidoptera; Lycaenidae)

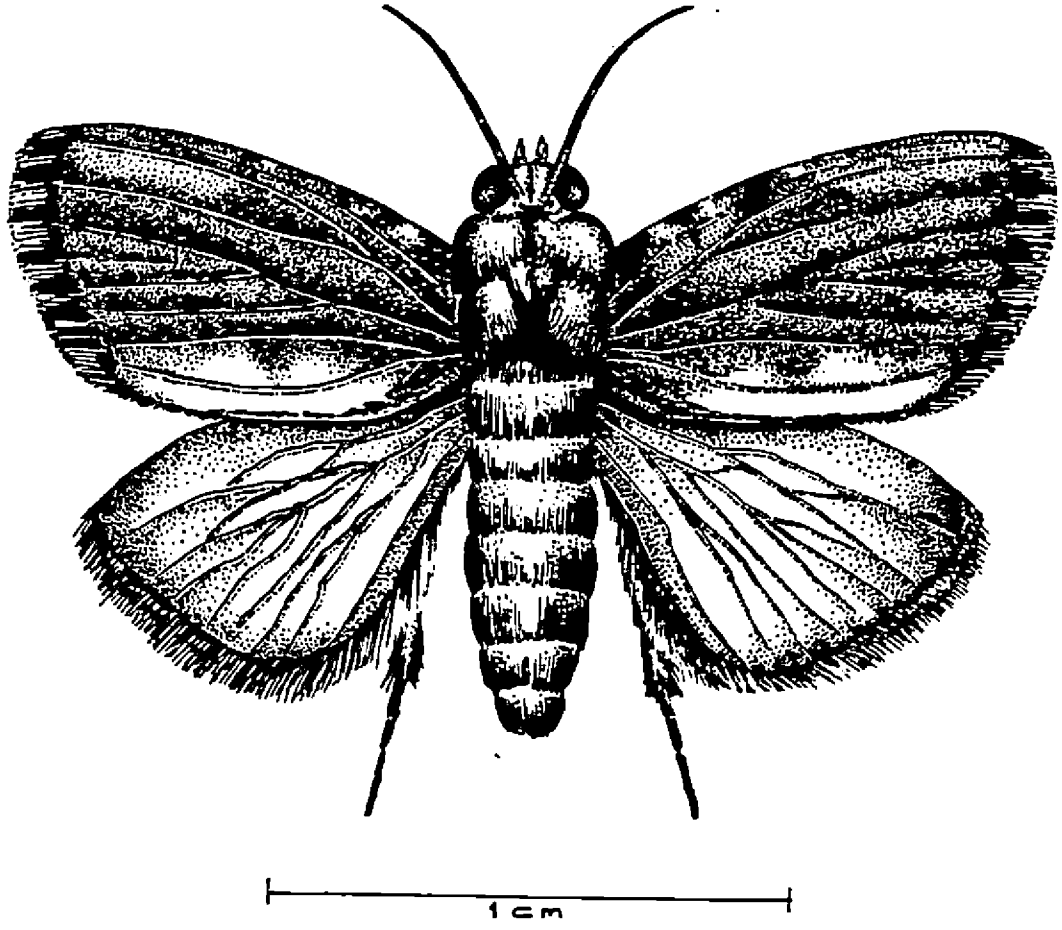
This pest was found in the Trivandrum, Trichur and Malappuram Districts. The larvae varied in colour and shade

Table 7. Seasonal occurrence of Cacoecia sp. in different parts of the Kerala State *+

Month and year	Trivandrum	Quilon	Kottayam	Alleppey	Ernakulam	Trichur	Palghat	Malappuram	Calicut	Wynad	Cannanore
November, 1982	0	-	-	0	1.3	0	-	-	-	-	-
December, 1982	0	4.2	6.0	0	8.3	0	0	-	-	-	7.4
January, 1983	0	2.2	3.9	0	7.1	0	1.0	11.0	0	0	18.5
February, 1983	-	4.8	1.3	-	-	-	3.0	15.8	0	0	11.6
March, 1983	-	-	-	-	-	-	-	8.0	0	0	-
Larvae per month	0	3.73	3.73	0	5.57	0	1.33	11.6	0	0	12.5

* Number of trees in each district = 10

+ Mean population/tree based on counts from four panicles



Fiq:4. *Cacoecia* sp.

from green to orange. The sluggish larvae were found to feed voraciously on all parts of the inflorescence causing heavy damage. Relatively heavier populations of this pest occurred in the Malappuram District (Table 8).

The wing expanse of the moth is 28-30 mm across the thorax. Forewings are dark-brownish, the undersurface being of a faded tint. The hind wing is almost concolourous with dark centred eyespots near the base of the delicate tail like prolongation (Fig.5).

Pupation take place in a cocoon made out of frass, petals etc. Pupae were attached to main rachis. A larval parasite Baryconus sp. was recorded on R. manea collected from the Malappuram District.

4.1.08 Haplothrips ganglbauri Schmutz
(Thysanoptera : Phlaeothripidae)

These were collected from the Quilon and Calicut Districts in very low populations during February-March. Adults and numphs feed on buds and tender floral branches causing injury by desapping.

Table 8. Seasonal occurrence of Rapala manea in different parts of the Kerala State*+

Month and year	Trivandrum	Quilon	Kottayam	Alleppey	Ernakulam	Trichur	Palghat	Malappuram	Calicut	Wynad	Cannanore
November, 1982	0	2.8	-	0	0	1.0	-	-	-	-	-
December, 1982	0	0	0	0	0	2.5	0	-	-	-	0
January, 1983	0	1.1	0	0	0	1.3	0	7.0	0	0	0
February, 1983	-	-	0	-	-	-	0	8.4	0	0	0
March, 1983	-	-	-	-	-	-	-	1.9	0	0	-
Larvae per month	0	1.3	0	0	0	1.6	0	5.77	0	0	0

* Number of trees in each district = 10

\+ Mean population/tree based on counts from four panicles

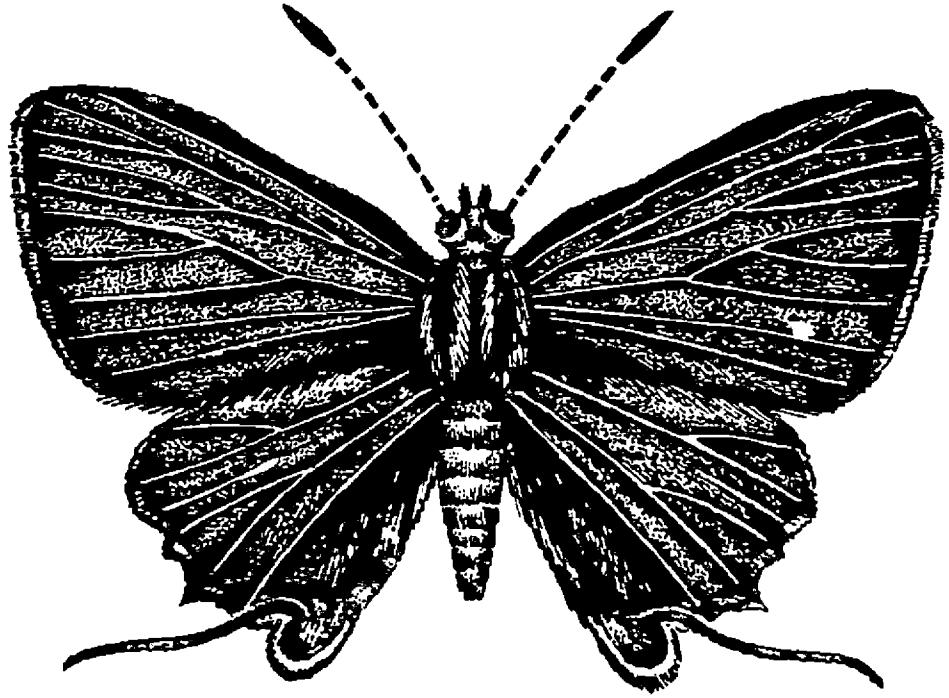


Fig:5. *Rapala manea* Hewitson.

4.1.09 Dichocrosis punctiferalis Guenee
(Pyralidae : Lepidoptera)

This pest was recorded only from the Cannanore District. Full grown larvae measured 22 mm and were reddish-brown in colour. The larvae feed on flower buds and inflorescence.

4.1.10 Unidentified Geometridae

Larvae of an unidentified Geometridae were recorded from the Quilon, Kottayam, Alleppey and Calicut Districts (Table 9). The populations were relatively heavier in the Quilon District where population build up commenced in December and the peak was recorded in February 1983. In other districts, the populations were of a very low order.

The larvae were recorded to feed on sepals of freshly opened flowers. The damage caused by this pest was of a very minor nature.

The adult moth with a wing expanse 12.2 mm across the thorax is uniformly dull greenish in the forewing and hind wing. Across the forewing a 'C' shaped discontinuous brownish marking is present near to the distal margin. In the forewing near the centre, an irregularly circular marking

Table 9. Seasonal occurrence of unidentified Geometrid species in different parts of Kerala State*+

Month and year	Trivandrum	Quilon	Kottayam	Alleppey	Ernakulam	Trichur	Palghat	Malappuram	Calicut	Wynad	Cannanore
November, 1982	0	-	-	0	0	0	-	-	-	-	-
December, 1982	0	7.5	2.1	0	0	0	0	-	-	-	0
January, 1983	0	13.6	0.8	1.3	0	0	0	0	0	0	0
February, 1983	-	16.0	3.2	-	-	-	0	0	2.7	0	0
March, 1983	-	-	-	-	-	-	-	0	0.8	0	-
Larvae per month	0	12.37	2.37	0.43	0	0	0	0	1.17	0	0

* Number of trees in each district = 10

\+ Mean population/tree based on counts from four panicles

with tinge of copper is visible. Both in the fore and hindwings the distal margins are irregularly wavy, bearing elongate cilia all over the margins (Fig.6).

4.2 Determination of LT50 values of monocrotophos to Idioscopus niveosparsus consequent on stem injection and stem banding methods

The mortality response of I. niveosparsus in terms of the LT50 values has been worked out separately for the stem injection and the stem banding methods to serve as indices of the toxic stimulus of monocrotophos in the inflorescence. Monocrotophos at 2 ml and 4 ml ai/tree was applied by stem injection (section 3.2.03) and also by stem banding (section 3.2.04) and the mortality values of the fourth instar nymphs of I. niveosparsus were recorded at intervals of 12 hours until the mortality exceeded 50 per cent.

The mortality data commencing from 12 hours after treatment as well as at subsequent intervals of 12 hours are presented in Table 10. The probit kill mortality time relationships for the fourth instar nymphs of I. niveosparsus for monocrotophos applied at 2 ml and 4 ml ai per tree by the two methods of applications namely, stem injection and stem banding methods are graphically depicted in the Figures

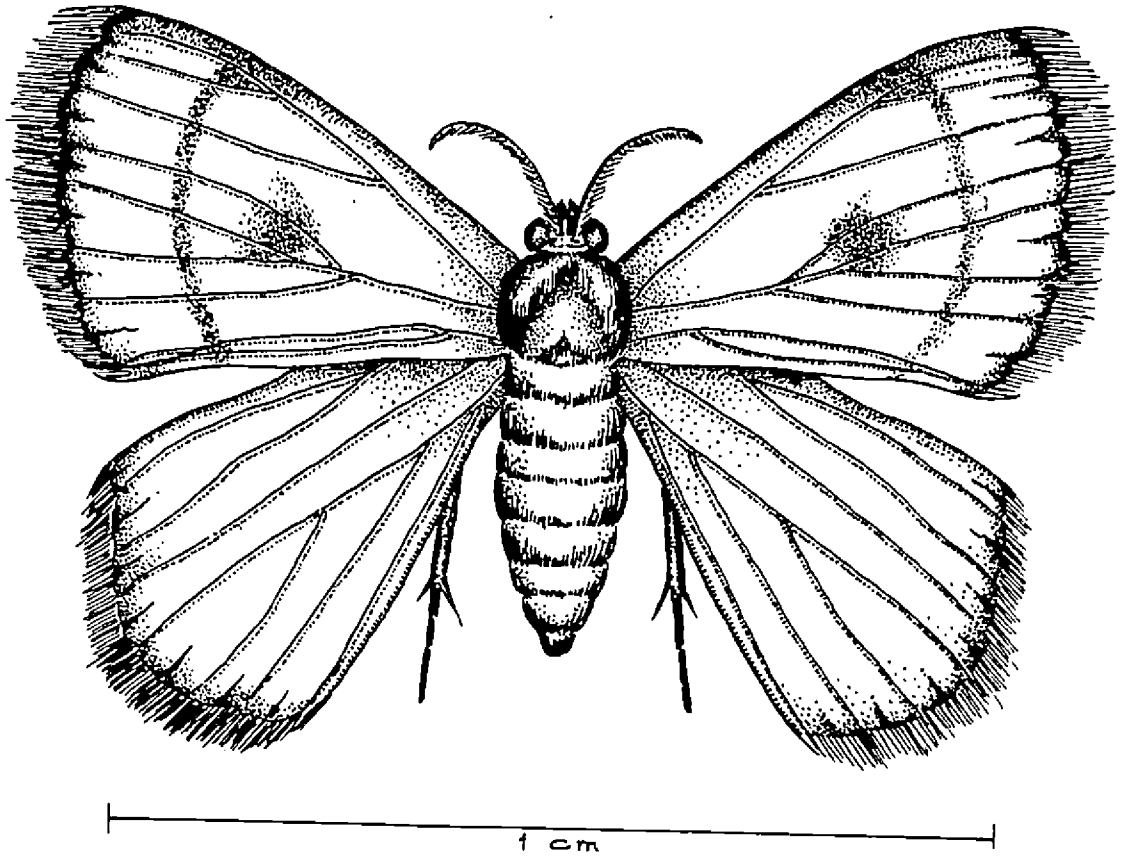


Fig:6. Unidentified Geometrid.

Table 10. Percentage of mortality and corrected percentage mortality of mango hopper nymphs

Interval of observation in hours	Stem injection with 4 ml. monocrotophos (T1)		Stem banding with 4 ml. of monocrotophos (T2)		Stem injection with 2 ml. monocrotophos (T3)		Stem banding with 2 ml. monocrotophos (T4)		Control (T5)
	Percentage of mortality	Corrected mortality percentage	Percentage of mortality	Corrected mortality percentage	Percentage of mortality	Corrected mortality percentage	Percentage of mortality	Corrected mortality percentage	Percentage of mortality correction factor
12	38.70	33.73	32.50	27.03	7.50	0	7.50	0	7.50
24	66.25	63.51	33.75	27.38	10.00	20.73	10.00	3.50	7.50
36	72.50	69.44	42.50	36.11	20.00	11.11	10.00	0.00	10.00
48	81.25	79.17	52.50	47.22	32.50	25.00	20.00	11.11	10.00
60	90.00	88.89	60.00	55.56	47.50	41.67	26.25	18.06	10.00
72	90.25	89.27	67.50	63.89	50.50	44.44	35.00	27.78	10.00
84	-	-	-	-	58.8	48.15	42.00	35.56	10.00
96	-	-	-	-	65.0	53.00	48.00	40.23	13.00
108	-	-	-	-	-	-	53.00	45.98	13.00
120	-	-	-	-	-	-	56.00	48.24	15.00
132	-	-	-	-	-	-	58.00	48.78	18.00
144	-	-	-	-	-	-	62.00	53.65	18.00
156	-	-	-	-	-	-	63.00	54.88	18.00

8, 9, 10 and 11. The details of computation of the LT-50 values are given in Appendix Tables I to IV.

4.2.01 LT-50 values of monocrotophos at 4 ml ai per tree to I. niveosparsus

The LT-50 value for I. niveosparsus nymphs in the stem injection method was found to be 18.34 hrs. The LT-50 value for I. niveosparsus of monocrotophos applied by stem banding technique was found to be relatively longer, being 49.37 hrs. It is thus found that the translocation of the toxicant to inflorescence is accelerated when it is applied by stem injection technique.

4.2.02 LT-50 values of monocrotophos at 2 ml ai per tree to I. niveosparsus

The LT-50 values for monocrotophos applied by stem injection at the lower dose is found to be 82.56 hrs.

When monocrotophos was applied by stem banding method at the dose of 2 ml ai per tree, 50% mortality time is found to be extended substantially, the LT-50 value being 128.47 hrs.

In the lower dose also, it is indicated that the translocation of monocrotophos is faster, when it is applied by the stem injection method.

4.2.03 Monocrotophos residues on mango inflorescence and tender mango

The terminal residues of monocrotophos in the inflorescence was assayed two weeks after application of the insecticide. The tender mango fruit of five weeks development were also sampled for determination of monocrotophos residues (Section 3.3).

The reference curve showing the relationship between concentration of monocrotophos in ppm on the one hand and log value of residual activity of chE on the other hand are presented in Figure 7.

The data on the values read out from the reference curve are presented in Table 11.

The terminal residue of monocrotophos in the inflorescence at two weeks after application of the insecticide by injection method at 4 ml ai per tree was found to be 0.3750 ppm and when the insecticide was applied at 2 ml ai per tree the residue was only 0.1750 ppm.

When the insecticide was applied by the stem banding method at 4 ml ai per tree, the residues in the inflorescence after two weeks of application was estimated at 0.2550 ppm

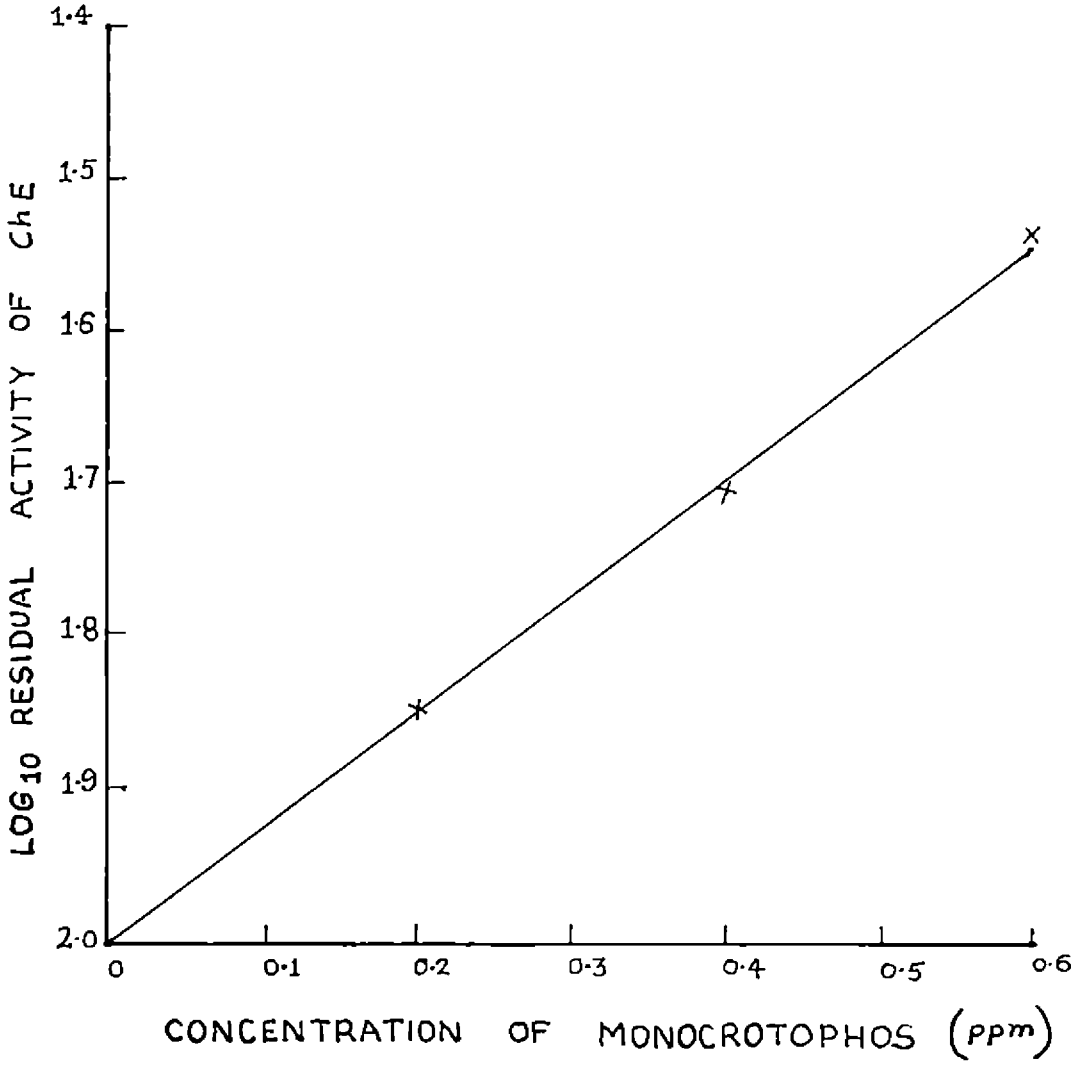


Fig:7 Standard curve showing the relationship between monocrotophos concentration (ppm) and the Log value of residual activity of ChE.

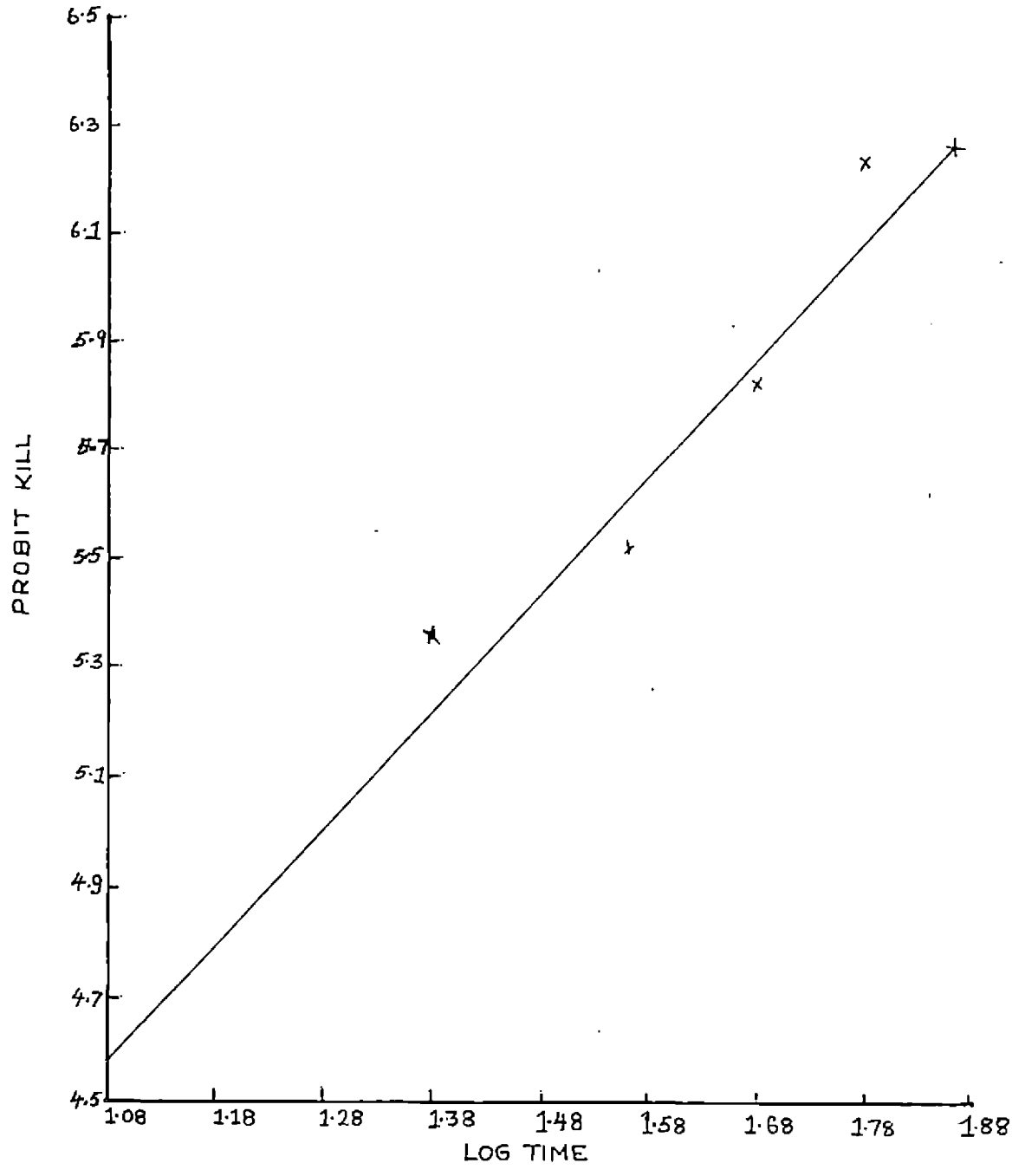


Fig: 8 Probit kill- Mortality time relationship in fourth instar nymphs of *Idioscopus niveosparsus* consequent on application of monocrotophos at 4ml ai by stem injection.

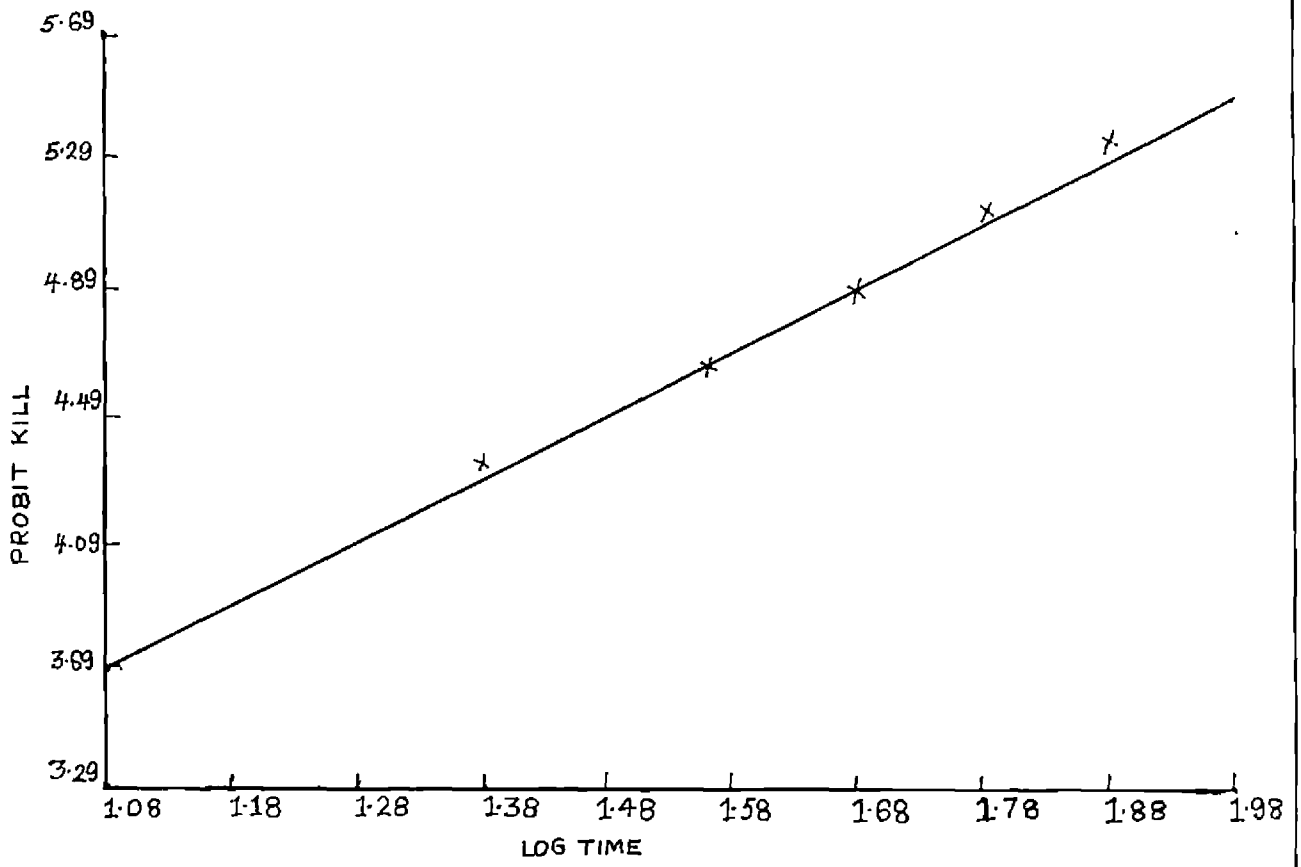


Fig:9 Probit kill – Mortality time relationship in fourth instar nymphs of *Idioscopus niveosparsus* consequent on application of monocrotophos at 4ml ai by stem banding technique.

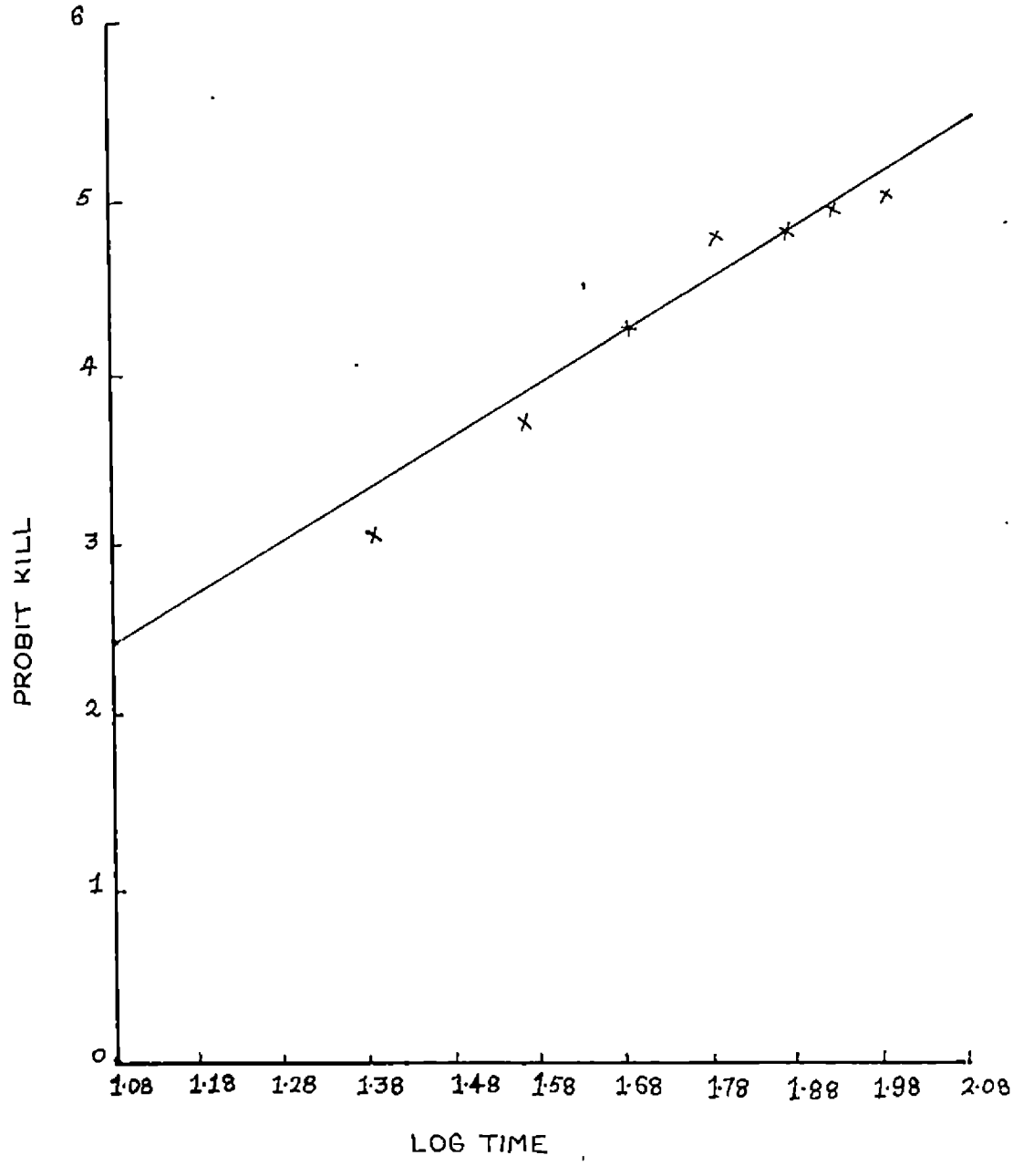


Fig: 10 Probit kill – Mortality time relationship in fourth instar nymphs of *Idioscopus niveosparsus* consequent on application of monocrotophos at 2ml ai by stem injection technique.

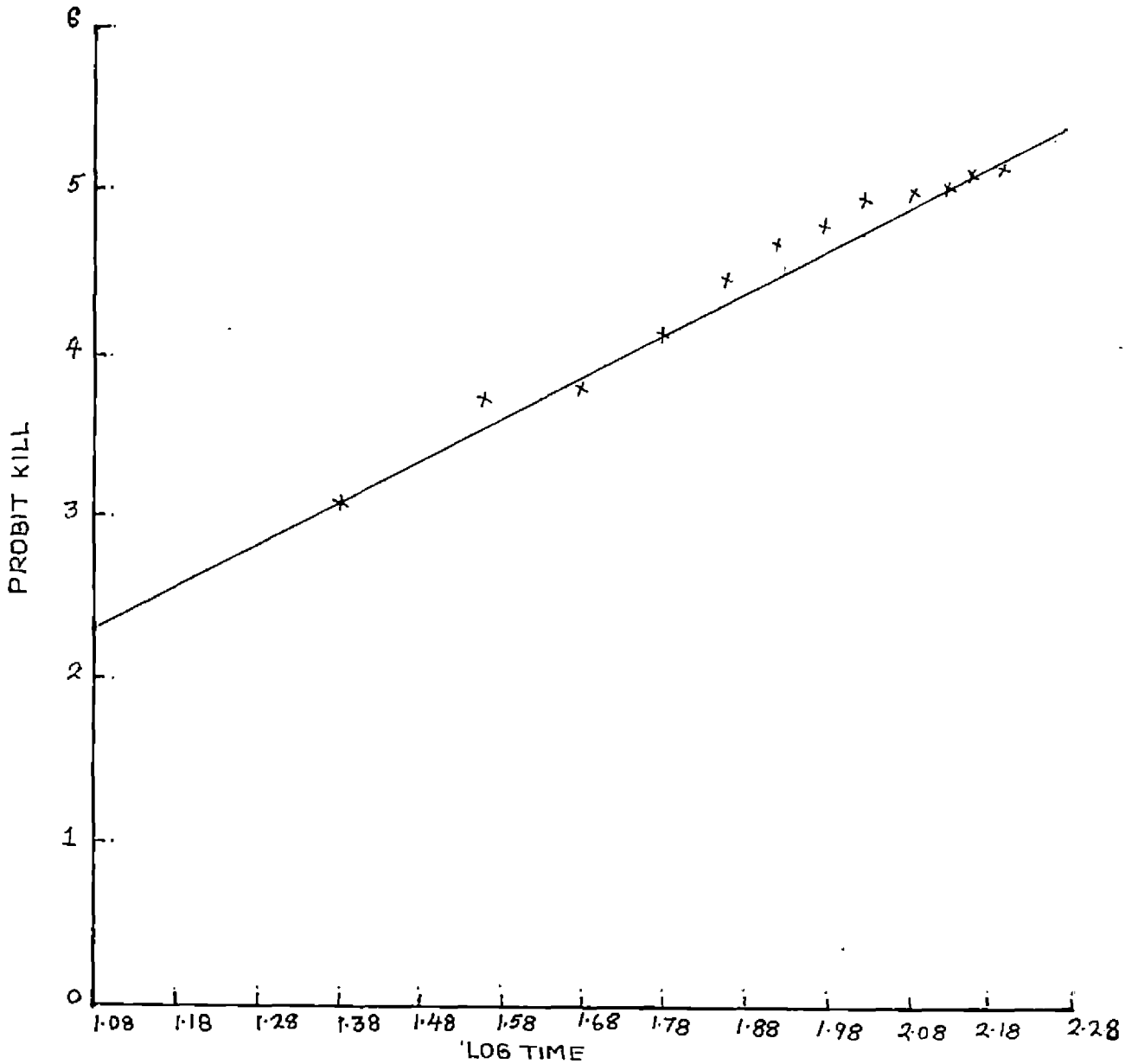


Fig:11 Probit kill - Mortality time relationship in fourth instar nymphs of *Idioscopus niveosparsus* consequent on application of monocrotophos at 2ml ai by stem banding technique.

Table 11. Monocrotophos residue of inflorescence and fruit consequent on it's application by stem injection and stem banding methods

Period of collection of inflorescence/ mangoes	Treatments	Residual monocrotophos (ppm)
Two weeks after treatment on inflorescence	T_1	0.3750
	T_2	0.2550
	T_3	0.1750
	T_4	BDL*
Five weeks after treatment on tender mangoes	T_1	0.3600
	T_2	0.2655
	T_3	0.3750
	T_4	0.0550

T_1 = Stem injection with 4 ml ai of monocrotophos

T_2 = Stem banding with 4 ml ai of monocrotophos

T_3 = Stem injection with 2 ml ai of monocrotophos

T_4 = Stem banding with 2 ml ai of monocrotophos

*BDL - Below detectable limits

while under a lower dose 2 ml ai per tree the residues were below detectable limits.

The terminal residue of monocrotophos in tender mango at five weeks after application of the insecticide by injection method at 4 ml ai per tree was only 0.3600 ppm. When the insecticide was applied by injection method at 2 ml ai per tree, the residue was found to be 0.3750 ppm. When the insecticide was applied by stem banding method at 4 ml ai per tree, the residues in the tender mangoes after five weeks of application was estimated at 0.2655 ppm while under a lower dose of 2 ml ai per tree, the residues were 0.0550 ppm.

Discussion

DISCUSSION

The present studies were carried out to gather information on the species of major insect pests occurring on the mango inflorescence in various parts of the Kerala State with reference to their seasonal history.

The relative efficiency of applying the systemic insecticide monocrotophos by two methods, namely, stem injection and stem banding, in controlling the Idiocerine hoppers infesting the blossoms was also assessed in these studies.

5.1 Insect pests associated with mango inflorescence

Based on the uniformity of flowering pattern of the crop, the districts in the State were grouped into three clusters as stated in section 3.1.03 under 'Materials and Methods'. Periodic samplings of the floral branches were made as outlined in section 3.1.04 to identify the associated insects and to study the nature of their damage.

5.1.01 Idioscopus spp.

Among the various pests recorded on the mango inflorescence, the Idiocerine hoppers were found to be of

considerable economic importance in the State in view of the severe damage inflicted to the buds, flowers and floral branches, often leading to heavy losses. I. niveosparsus and I. clypealis were the only species recorded in the present study.

Idioscopus niveosparsus

Significant variability was not detected in the populations of I. niveosparsus occurring in various districts and zones in the State.

The population changes of I. niveosparsus within each district have been monitored to assess the seasonal trends in populations within the districts. The populations of the insect remained without significant changes in the the Trivandrum, Quilon, Kottayam, Alleppey, Ernakulam, Trichur, Malappuram and Calicut Districts.

In the Palghat District, there was a well defined peak in January 1983. The population loads being significantly higher than in previous month. Thereafter, up to February 1983, the decline in populations were sharp and remarkable.

In the Wynad District, the population increased significantly from January to March 1983. In the Wynad District

on account of the higher elevation (900 m above MSL), cooler conditions are quite common during the flowering period. In the Palghat District also, on account of its proximity to Coimbatore-Mettupalayam belt, night temperatures are relatively much lower in December-January, than in the adjoining districts.

Wagle (1928) recorded that I. niveosparsus is highly susceptible to high temperatures and that the adult longevity is extended in cooler places. According to Butani (1979), a spell of cold weather leads to increase in fecundity of this insect.

The seasonal peaks of I. niveosparsus in the Palghat and Wynad Districts may be explained on the basis of the cooler climatic conditions in these districts which are congenial for the rapid multiplication of the pest.

The substantial decline in populations in the Palghat District in February 1983 may perhaps be due to fall in relative humidity below the range of effective humidity. Tandon et al. (1983) reported that there is significant negative correlation between the hopper populations on the one hand and relative humidity levels on the other. The negative correlation between these two aspects can be

expected to operate only within the effective zone of relative humidity and it is probable that the relative humidity level dropped substantially below the optimum during February 1983.

The relative stability of the I. niveosparsus populations in the districts other than Palghat and Wynad is explicable on the basis of a relatively stable environment in these districts.

Idioscopus clypealis

Significant differences in total population loads of I. clypealis were detected among the various districts in the State. The variability of populations between the three zones was however not significant.

Regarding I. clypealis, the maximum population was recorded from the Calicut District, the minimum being from the Palghat District. Significant seasonal changes in I. clypealis populations were recorded only in two districts, namely, Calicut and Trivandrum. In the Trivandrum District, there was a distinct peak in November followed by a decline in December and a plateuing in January 1983. In the Calicut District, the trend was of a different nature altogether, the

peak being March 1983. The flowering season in Trivandrum District was from November to January, while the season in the Calicut District was late being from January-March. In the Trivandrum District peak was registered at the commencement of the blossoming season while in the Calicut District, the peak was recorded in the fag end of the blossoming season. It is probable that the off - season survival of I. clypealis is responsible for an early peak in Trivandrum.

The stability of populations in Quilon, Kottayam, Alleppey, Ernakulam, Trichur, Palghat, Malappuram and Wynad Districts is a reflection of stability of the biotic and abiotic environments. The seasonal changes in populations in the Calicut and Trivandrum Districts may be due to variations in the stress from natural enemies, since if abiotic factors could be implicated, similar fluctuations should have occurred in the adjoining districts as well.

It is to be noted that the populations loads of I. clypealis in the Districts of Wynad and Alleppey having marked variations in climatic conditions showed parity with the loads in the Palghat District. This clearly shows that the populations of the pest in the State are generally regulated by biotic factors such as natural enemies.

Occurrence of *Idioscopus* spp in Kerala - Overall considerations

Both *I. niveosparsus* and *I. clypealis* were found to be widely distributed in the State. In the present study, the population loads of these species were not tested, but the stress was on their seasonal fluctuations.

I. niveosparsus occurred in all the districts of the State without regional variations in the population loads, while *I. clypealis* occurred at higher levels in Calicut than in the Palghat District.

Pruthy (1969) already recorded that the widespread species in the peninsular India is *I. niveosparsus*. Rao (1930) has also reported the dominance of *I. niveosparsus* in South India.

The dominance of *I. clypealis* among the Idiocerine hoppers has been recorded from Andhra Pradesh and Bihar (Rao and Rama Krishnan, 1979) and also from the Maharashtra and Gujarat States (Pruthi, 1969).

The present studies do not indicate the striking dominance of either *I. niveosparsus* or *I. clypealis* in the State of Kerala.

The seasonal fluctuations of I. niveosparsus were significant only in Palghat and Wynad Districts, the peaks in these districts being in January and March 1983 respectively. Regarding I. clypealis the population changes were striking only in the Trivandrum and Calicut Districts, where the peaks were recorded in November 1982 and March 1983 respectively. The seasonal changes in these districts can be due to the impact of abiotic and/or biotic environmental factors. Studies on the influence of temperature and humidity on the populations of Idiocerine hoppers are very scanty. Information on the natural enemies associated with the stages of the hoppers in Kerala is also lacking.

5.1.02 Procystiphora mangiferae

P. mangiferae infestation were recorded only from two districts, namely, Wynad and Cannanore (Table 3). The populations in the Wynad District were substantially higher than in the Cannanore District. In the Wynad District, there was a well defined peak in March, while in the Cannanore District, a distinct crest was lacking. In the Wynad District, there was a progressive increase in the pest population leading to the peak in the March, whereas, in the Cannanore District the population remained stable from January to February followed by a sharp decline in March.

Infestation by P. mangiferae led to the transformation of the floral buds to conical galls. The progressive increase in the populations of P. mangiferae in the Wynad District during the blossoming season is suggestive of the favourability of the environment in this district for the multiplication of this insect.

It is also probable that the extended flowering season in this District ensures the availability of floral buds almost throughout the blossoming season which in turn becomes favourable for the uninterrupted multiplication of P. mangiferae which breeds exclusively on the floral buds. A climax in the population is thus possible due to continuous breeding of the pest over successive generations. The present finding that the pest attains a peak in March is in close agreement with report of Prasad (1967).

The occurrence of P. mangiferae from the erstwhile State of Cochin, which now form part of the Kerala State was recorded by Iyer (1940). The present report from the Wynad and Cannanore Districts is the first record of the pest in these areas. Prasad and Grover (1976) have reported that the midges occur right from Kanyakumari to Amritsar. The present studies clearly reveal that within the State the pest is localised in certain districts only.

The decline in the population in the Cannanore District from January to February as compared to stability of the populations during this period in the Wynad District is suggestive of the possible adverse effect environments in the Cannanore District during February. The ecological requirements of P. mangiferae have not been reported in literature.

5.1.03 Eriosomyia indica

The mango (blister) gall midge was also recorded only from Wynad and Cannanore Districts in association with Procystiphora mangiferae (Table 4). In the Wynad District, the infestion was recorded from January to March, while in the Cannanore District infestation occurred from December to February. The populations in the Wynad area appeared to be almost static without any distinct peaks. But in the Cannanore District there was an apparent plateauing in population during December-January, followed by an abrupt decline in February.

It is quite likely that the ecological requirements of E. indica and P. mangiferae are quite similar, due to obvious seasons. This being the case, the lower population loads of E. indica in the Wynad District appears to be

regulated principally by the natural enemies associated with the stages of the pest.

The drastic decline of population of E. indica as in the case of P. mangiferae in the Cannanore District in February points out the environmental adversities during this month. Studies on the effects of these components of abiotic environment have not been reported.

Chandrika and Nair (1970) have recorded E. indica as a new pest of mango in Kerala.

5.1.04 Bombotelia jocosatrix

This insect was relatively more numerous in the Palghat and Cannanore Districts. In the Alleppey and Trichur Districts, very low levels of populations were recorded, while the pest could not be collected during the flowering season from the other districts.

The larvae at all stage fed on the floral buds, flowers, rachides and other parts of the inflorescence without much discrimination.

Well defined peaks of the populations of B. jocosatrix were not recorded in the Palghat and Cannanore Districts. B. jocosatrix is reported to be a pest of vegetative flushes

in mango (Ayyar, 1940). As a pest of inflorescence the only report of the insect is by Wu and Zhu (1981). The low population loads of B. jocosatrix on the inflorescence may be due to its decided preference to vegetative flushes.

5.1.05 Eublemma spp

Eublemma angulifera populations were recorded from all the districts of the State except the Wynad District (Table 6). Significant differences in the population loads of the insect were noticed in different districts of the State. The maximum population was recorded from the Malappuram District. The heavy populations of E. angulifera in the Malappuram District may either be due to favourable environmental conditions and availability of alternate host plants. The significantly low population loads in the adjoining Districts of Palghat and Calicut is probably due to the influence of the associated natural enemies.

The complete absence of the pest in the Wynad area is perhaps a reflection of the highly adverse environment.

The seasonal fluctuations were significant only in the Palghat District, where there was a sharp increase from December to January 1983, followed by a sharp reduction in February 1983. It appears that the pest population is

mainly regulated by natural enemies, though the incidence of such biotic stress factors could not be recorded in the present limited survey.

However in the Alleppey District the population appeared in November, declined in December followed by total disappearance in January.

The trend in the populations of Eublemma spp appears to be regulated by the environment.

Nair (1975) recorded E. abrupta and E. brachygonia as pests of mango inflorescence in Kerala without giving details of distribution and its status as a pest. In the present studies, it was found that except for stray records of another undetermined species of Eublemma, bulk of the population belonged to E. angulifera.

5.1.06 Cacoecia sp

The survey indicated that Cacoecia sp is widely distributed in the State. Sizable population of the pest occurred only in the Malappuram and Cannanore Districts, where well defined peaks in the populations were not evident (Table 7). The pest was absent in Trivandrum, Calicut, Wynad, Alleppey and Trichur Districts.

This is the first record of the pest on mango inflorescence. The occurrence of Phycoloma (Cacoecia sp.) as severe pest of apple fruit has been recorded by Sylven (1958) while Butani (1979) reported this as the most harmful leaf roller pest of apple in India.

5.1.07 Rapala manea

The distribution of Rapala manea in the State was not found to be uniform and its occurrence could be recorded only from Quilon, Trichur and Malappuram Districts. The populations in the Malappuram District were found to be relatively heavier (Table 8).

As a pest infesting mango inflorescence Johnson et al. (1980) recorded this insect from Vellayani, Trivandrum District. The present study shows that the insect is also distributed in the Quilon, Trichur and the Malappuram Districts.

5.1.08 Haplothrips ganglbauri

Adults and nymphs of H. ganglbauri were collected only from Quilon and Calicut Districts in very low population during February-March.

Abraham et al. (1972) reported the occurrence of H. ganglbauri as a serious pest of earheads in Kerala.

Ananthakrishnan (1979) recorded heavy populations of H. ganglbauri on the cashew inflorescence causing immature shedding of flowers. Butani (1979) recorded H. ganglbauri as a pest of mango without mentioning the nature of damage inflicted by the pest. In the light of occurrence in cashew, it is quite likely that mango which also belongs to Anacardiaceae is prone to infestation by the insect. The occurrence on rice ensure subsistence of the insect throughout the year in the State and it is likely that during the mango flowering season, they move on to this crop also.

5.1.09 Dichocrosis punctiferalis

This pest was recorded only from the Cannanore District in very low population, the damage was of a very minor nature. Nair (1975) has already recorded D. punctiferalis as a pest of flowers and tender fruits of mango in South India.

5.1.10 Unidentified Geometridae

The larvae of an undetermined Geometridae were recorded from Quilon, Alleppey, Kottayam and the Calicut Districts, the populations in the Quilon District being heavier.

The larvae feed on freshly opened flowers. In the Quilon District the populations were almost distributed during the month of December to February.

The only record of Geometridae on mango inflorescence is Chloroclystis sp by Aiyar (1944).

5.2 Determination of LT50 values of monocrotophos to Idioscopus niveosparsus

The object of this study was to explore the possibility of controlling the idiocerine hoppers occurring on mango inflorescence by applying monocrotophos following two methods, namely, by stem injection and stem banding. In both methods, the uptake of the toxicant was expected due to the transpirational pull through the xylem vessels.

Monocrotophos at 2 ml and 4 ml ai/tree was applied by stem injection and stem banding methods as described in section 3.2.03 and 3.2.04 under 'Materials and Methods'. The relative toxicity of monocrotophos applied by the two methods at these two concentrations was determined from the time-mortality relationship between the insecticide reaching the inflorescence at intervals of 12 hours commencing from the twelfth hour after treatment and the mortality to the fourth instar nymphs of Idioscopus niveosparsus confined on the inflorescence of treated trees

to ensure continuous feeding. The time required to cause 50% mortality of I. niveosparsus nymphs was computed and expressed as LT-50 values separately for the two methods of application for the two doses of 2 ml and 4 ml ai/tree. The LT-50 values denotes the time taken by the insect to pick up that much quantity of the insecticide which is sufficient to bring about 50 per cent mortality. This method of expressing the accumulation and retention of the toxicant in the inflorescence is based on the principle that the pick up of the insecticide by the test insect is directly proportional to the duration of feeding which in turn is dependent on the duration of exposure of the insect on the floral branches.

The LT-50 values for I. niveosparsus nymphs following application of monocrotophos at the doses of 4 ml ai and 2 ml ai per tree by injection method were found to be substantially lower, being 18.34 and 82.56 hours (Fig.8 and 10) as compared to the corresponding figures in the case of stem banding method. The LT-50 values for the stem banding method were found to be 49.37 and 128.47 hours for 4 ml ai/tree and 2 ml ai/tree respectively (Fig.9 and 11).

Thus it is evident that the insecticide moved at a slower pace through the stem when applied by the stem banding method. In mango, which has numerous compact vascular bundles in the stem located well within the band of the pericycle (Sing, 1960), relatively faster upward movement of the systemic insecticide can be normally expected when the toxicant is injected right into the stem, thus easily reaching the vascular stream. In the stem banding method, the translocation of the toxicant beyond the pericycle would be a slower process since the region of the stem beyond the bark is not bruised in this method. In this case, the translocation of the toxicant can occur by radial cell-to-cell transfer from the pericycle on to the xylem vessels which would receive the active ingredient through minute perforations on the end and side walls. That there was considerable mortality to I. niveosparsus even under stem banding method suggests this type of translocation of the insecticide. Fahn (1977) reported that in the case of vascular plants, movement of fluid by cell-to-cell transfer is quite possible. de Petri-Tonelli (1965) also indicated the possibility of cell-to-cell transfer of systemic insecticides from

cortical parenchyma and outer xylem

into inner xylem.

In studies conducted by Bennet (1957) on the administration of schradan in sour oranges by bark application as well as root treatment, it was found that two methods were found to be equally effective. In root feeding the systemic insecticide will be picked up into the vascular stream for direct upward translocation and this method is essentially similar to stem injection technique with reference to translocation pathways, except for the possible degradation of the toxicant in the soil prior to uptake. The retarded translocation of monocrotophos in the stem banding method of administration in mango is explicable on the basis of the time lag for cell-to-cell transfer until the chemical reach the vascular stream. It is also possible that the cell-to-cell movement of the toxicant is partially blocked by the resinuous exudation from the abraded secondary phloem cells (Fahn, 1977).

The variations in these results with the present studies can be explained on the basis of the anatomical and physiological variations in mango and sour orange and also on the basis of the chemical nature of schradan and monocrotophos.

Thontadarya et al. (1978) carried out preliminary studies on the control of mango hoppers by applying dimethoate

at 0.5 ml ai/cm girth of the main trunk. In this experiment which was conducted on trees of 21 year's growth, it was found that the populations of hoppers started declining from the third day of treatment and this trend continued up to third week. This shows that in this case the accumulation of monocrotophos in bioactive concentrations in floral branches took a period of about two days. In the present investigation, when monocrotophos applied at 4 ml ai/tree of 23 years growth, it is found that the LT-50 value is 18.34 hours and it is thus to be surmised that the mortality should have commenced well in advance, say on the very first day after application. The dose of dimethoate applied by the Thontadarya et al. (1980) is 0.5 ml ai/cm girth of trees which would easily work out to 50 ml ai/tree on the assumption that the girth would not be less than one metre. Even when this high dose of insecticide was administered, the toxic stimulus was manifested only after a time lag of 48 hours. This is probably due to the variations in the equipment used for injection and also due to the injection of the insecticide into the trunk through two holes driven at an angle of 45° to the main axis of the tree. In present experiment injection was carried out in a different method (See section 3.2.03).

Nadarajan et al. (1980) have already reported that the toxic stimulous of monocrotophos given as stem injections at

3.5-7.0 ml ai/tree as started manifesting on the coconut palm leaves from the second day of the present study are in close agreement with this finding.

For bringing about a reasonable level of control of the hoppers infesting mango inflorescence, accumulation of the toxicant in the floral branches within a period of 24 hours after treatment would be desirable. In the present study it is indicated that by injecting monocrotophos at 4 ml ai/tree a fairly good amount of toxic stimulus against I. niveosparsus could be realised in the floral branches. It would therefore, appear that by slightly increasing the dose of the toxicant from 4 ml ai/tree, faster and more effective control of the Idiocerine hoppers could be reasonably expected.

5.3 Monocrotophos residues on mango inflorescence and tender mango fruit

The residues of monocrotophos in the inflorescence at two weeks after application of the insecticide and in the fruit of five week's development were assayed following the method of Ellman et al. (1961).

In the stem injection method, the residue of monocrotophos in the inflorescence for the two doses of 4 ml and 2 ml ai per tree were 0.3750 and 0.1750 ppm respectively

(Table 11). When the insecticide was applied by the stem banding method the residues in the inflorescence could be detected only at higher dose of 4 ml ai/tree being 0.2550 ppm.

In the freshly formed tender mango fruit of five week's development, the residue level of monocrotophos applied by injection at 4 ml ai/tree was 0.3600 ppm, while at 2 ml ai/tree the residue was 0.3750 ppm. It will be seen that in the stem injection method at 4 ml ai/tree, there was a marginal reduction in residues during the span of three weeks. But in the case of stem injection with monocrotophos at the lower dose of 2 ml ai/tree the residues showed considerable increase during the period of three weeks. At the lower dose of 2 ml ai/tree, the accumulation of the toxicant in the target tissues took place at a retarded pace, perhaps due to the reduction in the concentration of the toxicant solution in the sap stream and the consequential retardation in translocation in the transpiration stream. The relative persistence of monocrotophos in the plant tissue following it's application by the stem injection technique has already been recorded by Nadarajan et al. (1980) who reported that the toxicant even at the low dose of 3.5 ml ai/coconut palm remained effective in the crown for a period up to 90 days. In 9-10 years old palms as well as in still older palms up to 45 years monocrotophos applied by stem

injection at the rate of 7 ml ai/tree remained bio-effective in the crown for a period of up to 60 days. In the present studies also it is found that the insecticide persisted at a stable level up to five weeks after application. In the case of lower dose of 2 ml ai/tree by stem injection there was a substantial increase up to five weeks after application.

It may be noted that monocrotophos persisted in mango fruit up to five weeks after application in the case of the dose of 4 ml ai/tree applied by the stem injection method, the residue level being above the tolerance limit of 0.2 ppm reported by Agnihothrudu and Mithyantha, 1978.

In the present study, fruits were sampled out at five weeks after fruit set when they reached the mid-adolescent stage. The fruit will be reaching maturity only after a further period of 77-80 days (Srivastava, 1967) and it is quite probable that by this time the residues get further dissipated below the tolerance limit. Further studies are needed to elucidate the pattern of dissipation. The present studies indicate for mango fruit which are to be harvested in the tender stage for culinary purposes, the stem injection technique cannot be advocated due to possible hazards from terminal residues.

Nadarajan et al. (1980) have reported that even with the higher dose of 5.0 g of monocrotophos ai/palm the residues of the toxicant expressed as P in coconut water dropped to 0.005 ppm which is well below tolerance limit. The residues in the coconut meat was relatively higher a week after injection this being 0.2342 ppm.

Although the pick up, translocation and retention of systemic insecticide in the members of family of Anacardiaceae to which mango belong cannot be compared with these traits in the coconut palm, due to striking variations in the vascular system in these two plants, the present study also show that the persistence of monocrotophos in target tissues in mango is relatively longer.

The dissipation of the insecticide by stem banding as revealed by the residues in tender mango fruit of five weeks development was found to be 0.2655 ppm. This shows that there was a marginal increase in the residues during the span of three weeks under the stem banding method also. The general trend of accumulation of the toxicant in the floral branches and the mango fruit is basically found to be similar for the stem injection and stem banding method, there being retention of insecticide in the tissues without degradation

right up to five weeks after application. At the lower dose of 2 ml ai/tree the monocrotophos residues in the inflorescence were well below detectable limit. Even under this lower dose the stem injection method showed gradual build up of residues in the floral branches and in the mango fruit. This showed that stem injection is a much more effective method of administering the toxicant into the vascular stream.

Summary

SUMMARY

Studies were undertaken to gather information on the major insect pests occurring on the mango inflorescence in Kerala with reference to their seasonal history in different parts of the State. The bio-efficiency of monocrotophos against the Idiocerine hoppers infesting mango inflorescence was evaluated in another experiment by adopting the stem injection and stem banding methods of administration.

Insect pests associated with mango inflorescence

A survey was conducted during 1982-83 in the State to study the incidence of the various pests. For the survey, the State was divided into three zones on the basis of the flowering pattern of the crop. In the first zone comprising the Quilon, Kottayam, Palghat and Cannanore Districts, flowering started in December and was extended up to January. In the Districts of Malappuram, Calicut and Wynad, blossoming occurred from January to March and these districts formed the second zone. In the Districts of Trivandrum, Alleppey, Trichur and Ernakulam, the flowering period was from November to January and these formed a third zone.

The following pests were recorded in the survey.

Both Idiocerus niveosparsus and I. clypealis were found to be widely distributed in the State.

I. niveosparsus Leth. (Cicadellidae, Hemiptera)

Significant variability was not detected in the population of I. niveosparsus occurring in the various districts and zones of the State. The population changes of the pest within each district were monitored to assess the seasonal trends and it was found that the insect remained without significant changes in their populations in the Districts of Trivandrum, Quilon, Kottayam, Alleppey, Ernakulam, Trichur and Malappuram. In the Palghat District, there was a well defined peak in January 1983. In the Wynad District, the populations increased significantly from January to March 1983.

The seasonal peaks in the Palghat and Wynad Districts have been discussed in the light of congenial climatic conditions, mainly atmospheric temperature and relative humidity profiles. The stability of I. niveosparsus populations in other districts has been ascribed to stable environment in these areas.

I. clypealis Leth.

Significant differences in total population loads of I. clypealis were detected in the State. The population variability between the zones was not significant. The maximum population of the pest was recorded from the Calicut District, the minimum being from the Palghat District. The possible reason for these variations have been discussed. Significant seasonal changes in I. clypealis populations were recorded only in two districts, there was a distinct peak in November followed by a decline in December and a plateauing in January 1983. In the Calicut District, the peak was in March 1983. These variations have been discussed in terms of off-season survival of the pest and stress from natural enemies.

Procystiphora mangiferae Felt. (Cecidomyiidae : Diptera)

This is reported for the first time from the two districts of Wynad and Cannanore. Infestation by this insect led to transformation of the floral buds to conical galls.

Erosomyia indica Grover and Prasad (Cecidomyiidae:Diptera)

The mango (blister) gall midge, E. indica was recorded in association with P. mangiferae in the Wynad and

Cannanore Districts. The larvae tunnel into the inflorescence axes at many points causing small ovate galls around the blistered points of entry.

Bombotelia jocosatrix Gn. (Noctuidae : Lepidoptera)

This pest was recorded from Cannanore, Palghat, Trichur and Alleppey Districts throughout the flowering season. The larvae are voraceous feeders of the floral buds, flowers, rachides and other parts of the inflorescence.

Eublemma spp. (Noctuidae : Lepidoptera)

Eublemma anguilifera Moore and another unidentified species of Eublemma were recorded to occur widely in the State. The caterpillars web the parts of floral branches together and extensively feed on the tissues. Significant variability was detected among the population loads of this pest in different districts. Among the districts, the heaviest populations were recorded from the Malappuram District. This was not recorded from the Wynad District. The seasonal fluctuations of the pest were significant only in Palghat District where there was a sharp increase in populations from December 1982 to January 1983.

Unidentified species of Cacoecia (Totricidae : Lepidoptera)

Larvae of an unidentified species of Cacoecia were observed for the first time as a minor pest of mango inflorescence, from various parts of the State. The larvae fed on flowers and floral buds inside silken galleries and caused considerable damage.

Rapala manea Hewitson (Lycaenidae : Lepidoptera)

This pest was recorded from the Trivandrum, Trichur and Malappuram Districts. The sluggish larvae were found to feed voraceously on all parts of the floral branches causing heavy damage.

Haplothrips ganglbauri Schmutz (Phlaeothripidae:Thysanoptera)

These were collected from the Quilon and Calicut Districts in very low populations. Adults and nymphs fed on buds and tender floral branches causing heavy injury by desapping.

Dichocrosis punctiferalis Guen (Pyralidae : Lepidoptera)

As a minor pest of mango inflorescence, this was recorded from the Cannanore District only.

Unidentified Geometrid

Larvae of this insect were recorded to feed on sepals of freshly opened flowers.

Bio-efficiency of monocrotophos against fourth instar nymphs of Idiocerus niveosparsus

Monocrotophos at 2 ml and 4 ml ai/tree was applied by stem injection and stem banding methods. The relative toxicity of the insecticide was determined from the time-mortality relationship between the insecticide reaching the inflorescence at intervals of 12 hours and the mortality to the fourth instar larvae of I. niveosparsus confined on the inflorescence of treated trees to ensure continuous feeding.

The LT-50 values of I. niveosparsus nymphs following application of the insecticide at doses of 4 ml and 2 ml ai/tree by injection method was found to be substantially lower (18.34 and 82.56 hrs respectively) than the corresponding values for the stem banding method of application (49.37 and 128.47 hrs respectively). It was thus found that the toxicant moved at a faster pace when administered by the stem injection method. The variations in translocation of the toxicant under the two methods have

been discussed in the light of the structure of the vascular system of mango trees.

The residues of monocrotophos in the inflorescence at two weeks after application of the insecticide by stem injection method were assayed and the residues at the two doses of 4 ml and 2 ml ai/tree were found to be 0.3750 and 0.1750 ppm respectively. When applied by stem banding method, the corresponding residues were lower, being 0.2550 ppm at 4 ml ai/tree. At the lower dose of 2 ml ai/tree the residues were below detectable levels.

The residues of the insecticide on freshly formed mango fruit at five weeks after application by stem injection method at 4 ml and 2 ml ai/tree were 0.3600 ppm and 0.3750 ppm respectively. The corresponding residues in the mango fruit consequent on stem banding method of administration were 0.26555 and 0.0550 ppm for the doses of 4 ml and 2 ml ai/tree, respectively.

In the present study, the fruit were sampled out at five weeks after fruit-set when they reached the mid-adolescent stage. The fruit will be reaching maturity

only after a further period of 77-80 days and it is quite probable that by this time the residues get further dissipated well below the tolerance limit. The implications of the results in formulating control methods against Idiocerine hoppers infesting mango inflorescence have been discussed.

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Appendices

Appendix I. The LT-50 value computed by Probit analysis for the mango hopper nymphs consequent on the application of monocrotophos 4 ml ai/tree by stem injection

Hours	Control mortality	Log of time (x)	Total insects (n)	Observed kill	% kill (P')	Net % kill (P)	Empirical probit	Expected probit (Y)	Working probit (y)	Weighting coefficient (w)	nw	nwx	nwy	nwx^2	nwxy	nwy^2
12	7.5	1.08	80	31	38.70	33.73	4.58	4.6	4.59	0.480	38.400	41.4720	176.2560	44.789600	190.356	809.01504
24	7.5	1.38	80	53	66.25	63.51	5.35	5.2	5.36	0.546	43.680	60.2784	234.1248	83.184192	323.093	1254.90890
36	10.0	1.56	80	57	72.50	69.44	5.51	5.6	5.49	0.484	38.720	60.4032	212.5728	94.228992	331.614	1167.02460
48	10.0	1.68	80	65	81.25	79.17	5.81	5.9	5.80	0.415	33.200	55.7760	192.5600	93.703680	323.501	1116.94800
60	10.0	1.78	80	72	90.00	88.89	6.22	6.1	6.22	0.359	28.720	51.1216	178.6384	90.996448	317.979	1111.13080
72	10.0	1.86	80	74	90.25	89.27	6.24	6.2	6.23	0.329	26.320	48.9552	163.9736	91.056672	304.992	1021.55550
Total (S)											209.040	318.0064	1158.1256	497.959684	1791.535	6480.48284

$\bar{x} = \frac{Snwx}{Snw} = 1.521271$

$\bar{y} = \frac{Snwy}{Snw} = 5.54025$

$A = \frac{(Snwx)^2}{Snw} = 483.77377$

$B = \frac{Snwx \times Snwy}{Snw} = 1761.8223$

$C = \frac{(Snwy)^2}{Snw} = 6416.2595$

$Sxx = Snwx^2 - A = 14.18591$

$Sxy = Snwxy - B = 29.7127$

$Syy = Snwy^2 - C = 64.2233$

$b = \frac{Sxy}{Sxx} = 2.095219$

$y = \bar{y} + b\ (x - \bar{x})$

$5 = 5.54025 + 2.0952\ (x - 1.5213)$

$x = 1.2634486$

Antolog of x = 18.34

$\therefore$ LT-50 = 18.34 hrs

LT-50 from Computer = 18.34 hrs

Fiducial Limits (21.97386, 14.1503)

Appendix II. The LT-50 value computed by Probit analysis for the mango hopper nymphs consequent on the application of monocrotophos 4 ml ai/tree by stem banding

Hours	Control mortality	Log of time (x)	Total insects (n)	Observed kill	% kill (P')	Net % kill (P)	Empirical probit	Expected probit (Y)	Working probit (y)	Weighting coefficient (w)	nw	nwx	nwy	nwx^2	nwxy	nwy^2
12	7.5	1.08	80	26	32.50	27.03	4.39	3.70	4.598	0.2174000	17.392000	18.783360	79.968416	20.286028	86.365889	367.69477
24	7.5	1.38	80	27	33.75	28.38	4.23	4.28	4.417	0.2880000	23.040000	31.795200	101.767680	43.877376	140.439390	449.50784
36	10.0	1.56	80	34	42.50	36.11	4.64	4.60	4.642	0.4770000	38.160000	59.529600	177.138720	92.866176	276.336400	822.27793
48	10.0	1.68	80	42	52.50	47.25	4.93	4.90	4.926	0.5110001	40.880008	68.678413	201.374910	15.379730	338.309860	991.97285
60	10.0	1.78	80	48	60.00	55.56	5.14	5.10	5.151	0.5260000	42.080000	74.902400	216.754080	133.326270	395.822600	1116.50020
72	10.0	1.86	80	54	67.50	63.89	5.36	5.20	5.358	0.5220000	41.760000	77.673600	223.750080	144.472890	416.175140	1198.95290
Total (S)											203.312008	331.362573	1000.752886	550.208470	1643.449279	4946.80649

$\bar{x} = \frac{Snwx}{Snw} = 1.629823$

$\bar{y} = \frac{Snwy}{Snw} = 4.922252$

$A = \frac{(Snwx)^2}{Snw} = 540.06231$

$B = \frac{Snwx \times Snwy}{Snw} = 1631.0498$

$C = \frac{(Snwy)^2}{Snw} = 4925.9566$

$Sxx = Snwx^2 - A = 10.1463$

$Sxy = Snwxy - B = 12.3994$

$Syy = Snwy^2 - C = 20.8498$

$b = \frac{Sxy}{Sxx} = 1.2220612$

$y = \bar{y} + b\ (x - \bar{x})$

$5 = 4.922252 + 1.2220612\ (x - 1.629823)$

$x = 1.6934433$

Antilog of x = 49.36846

∴ LT-50 = 49.37 hrs

LT-50 from Computer = 49.37 hrs

Fiducial Limits (71.1509, 37.84052)

Appendix III. The LT-50 value computed by Probit analysis for the mango hopper nymphs consequent on the application of monocrotophos 2 ml a/tree by stem injection

Hours	Control mortality	Log of time (x)	Total insects (n)	Observed kill	% kill (P')	Net % kill (P)	Empirical probit	Expected probit (Y)	Working probit (y)	Weighting coefficient (w)	nw	nwx	nwy	nwx^2	nwxy	nwy^2
12	7.5	1.08	80	6	7.5	0	0	2.8	2.408	0.0130000	1.04	1.1232	2.504	1.213	2.705	6.030
24	7.5	1.38	80	8	10.0	2.70	3.07	3.5	3.193	0.1170000	9.36	12.9168	29.896	17.825	41.243	95.428
36	10.0	1.56	80	16	20.0	11.11	3.78	4.0	3.804	0.2580000	20.64	32.1984	78.515	50.230	122.483	298.659
48	10.0	1.68	80	26	32.5	25.00	4.33	4.3	4.326	0.3640000	29.12	48.9216	125.973	82.188	211.635	544.960
60	10.0	1.78	80	38	47.5	41.67	4.79	4.6	4.796	0.4540000	36.32	64.6496	174.191	115.076	310.059	835.419
72	10.0	1.86	80	40	50.5	44.44	4.86	4.8	4.860	0.4960000	39.68	73.8048	192.845	137.277	358.691	937.226
84	10.0	1.92	80	47	58.8	48.75	4.97	4.9	4.969	0.5110001	40.88	78.4896	203.133	150.700	390.148	1009.366
96	13.0	1.98	80	52	65.0	53.00	5.08	5.1	5.075	0.4970000	39.76	78.7248	201.782	155.875	399.528	1024.044
Total (S)											216.80	390.9288	1008.829	710.384	1836.492	4751.142

$\bar{x} = \frac{Snwx}{Snw} = 1.802716$

$\bar{y} = \frac{Snwy}{Snw} = 4.653269$

$A = \frac{(Snwx)^2}{Snw} = 704.55327$

$B = \frac{(Snwx \times Snwy)}{Snw} = 1818.632$

$C = \frac{(Snwy)^2}{Snw} = 4694.3537$

$Sxx = Snwx^2 - A = 5.8307$

$Sxy = Snwxy - B = 17.86$

$Syy = Snwy^2 - C = 56.7883$

$b = \frac{Sxy}{Sxx} = 3.063097$

$Y = \bar{y} + b(x - \bar{x})$

$S = 4.653269 + 3.063097 (x - 1.802716)$

$x = 1.9159119$

Antilog of $x = 82.39$

$\therefore$ LT-50 = 82.39 hrs

LT-50 from Computer = 82.56 hrs

Fiducial Limits (95.83986, 74.04398)

Appendix IV. The LT-50 value computed by Probit analysis for the mango hopper nymphs consequent on the application of monocrotophos 2 ml ai/tree : by stem banding

Hours	Control mortality	Log of time (x)	Total insects (n)	Observed kill	% kill (p^1)	Net % kill (P)	Empirical probit	Expected probit (Y)	Working probit (y)	Weighting coefficient (w)	nw	nwx	nwy	nwx^2	nxwy	nwy^2
12	7.5	1.08	80	6	7.50	0.00	0.00	2.4	2.057000	0.0020000	0.160000	0.172800	0.32912	0.1866240	0.355	0.6769920
24	7.5	1.38	80	8	10.00	3.50	3.19	3.2	3.198000	0.0530000	4.240000	5.851200	13.55952	8.0746560	18.712	43.3633440
36	10.0	1.56	80	8	10.00	0.00	0.00	3.6	3.061000	0.1270000	10.160000	15.849600	31.09976	24.7253760	48.516	95.1963600
48	10.0	1.68	80	16	20.00	11.11	3.78	3.9	3.787000	0.2230000	17.840000	29.971200	67.56008	50.3516160	113.501	255.8500100
60	10.0	1.78	80	21	26.25	18.06	4.09	4.1	4.085000	0.2940000	23.520000	41.865600	96.07920	74.5207600	171.021	392.4835200
72	10.0	1.86	80	28	35.00	27.78	4.41	4.3	4.415000	0.3640000	29.120000	54.163200	128.56480	100.7440000	239.131	567.6135900
84	10.0	1.92	80	34	42.00	35.56	4.63	4.5	4.634000	0.4270000	34.160000	65.587200	158.29744	125.9274200	303.931	733.5503300
96	13.0	1.98	80	38	48.00	40.23	4.75	4.6	4.756000	0.4190000	33.520000	66.369600	159.42112	131.4118000	315.434	758.2068400
108	13.0	2.03	80	42	53.00	45.98	4.90	4.8	4.900000	0.4630000	37.040000	75.191200	181.49600	152.6381300	368.437	889.3304000
120	15.0	2.09	80	45	56.00	48.24	4.95	4.9	4.956001	0.4580000	36.640000	76.577600	181.58787	160.0471800	379.519	899.9496000
132	18.0	2.13	80	46	58.00	48.78	4.97	5.0	4.970000	0.4420001	35.360008	75.316817	175.73923	160.4248200	374.324	873.4240000
144	18.0	2.16	80	50	62.00	53.65	5.09	5.1	5.091000	0.4510001	36.080008	77.932817	183.68332	168.3348800	396.756	935.1317600
156	18.0	2.20	80	51	63.00	54.88	5.12	5.1	5.123000	0.4510001	36.080008	79.376017	184.83788	174.6272300	406.643	946.9244000
Total (S)											333.920024	664.224851	1562.2552	1332.0144920	3136.480	7391.7011460

$\bar{x} = \frac{Snwx}{Snw} = 1.9891743$

$\bar{y} = \frac{Snwy}{Snw} = 4.678531$

$A = \frac{(Snwx)^2}{Snw} = 1321.2584$

$B = \frac{(Snwx \times Snwy)}{Snw} = 3107.5965$

$C = \frac{(Snwy)^2}{Snw} = 7309.0595$

$Sxx = Snwx^2 - A = 10.7561$

$Sxy = Snwxy - B = 28.8835$

$Syy = Snwy^2 - C = 82.6416$

$b = \frac{Sxy}{Sxx} = 2.6853$

$y = \bar{y} + b\ (x - \bar{x})$

$5 = 4.6785 + 2.6853\ (x-1.9892)$

$x = 2.1089256$

Antilog of x = 128.50

r. LT-50 = 128.50 hrs

LT-50 from computer = 128.47 hrs

Fiducial Limits (146.0907, 116.261)

PEST COMPLEX ASSOCIATED WITH MANGO (*Mangifera indica* Linn) INFLORESCENCE AND THEIR CONTROL

By

SATHEESAN N. V.

ABSTRACT OF A THESIS

Submitted in partial fulfilment of the requirement for the degree

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ABSTRACT

In a survey conducted during 1982-83 in the State of Kerala to study the incidence of various insect pests associated with mango inflorescence with reference to their seasonal history, a total of ten insect pests were recorded. The hoppers Idioscopus niveosparsus Leth. and I. clypealis Leth. were found to be widely distributed in the State. Significant variability was not detected among the population loads of I. niveosparsus in different districts, while in the case of I. clypealis such variations were significant. The heaviest populations of the latter was recorded from the Calicut District. The seasonal changes in I. clypealis populations were recorded only in the two Districts of Calicut and Trivandrum. I. niveosparsus showed a well defined peaks in the Palghat and Wynad districts. The fluctuations I. niveosparsus and I. clypealis populations have been discussed with reference environmental conditions.

Procystiphora mangiferae Felt. is reported for the first time from the State from the Wynad and Cannanore Districts. Infestations by the pest led to transformation of the floral buds to conical galls. In the Wynad District,

there was a well defined population peak in March, while in the Cannanore District a distinct crest was lacking. The mango blister midge, Erosomyia indica Grover and Prasad was recorded to occur in association with P. mangiferae in these two districts. The larvae of E. indica tunnel into inflorescence axis and cause ovate galls thereby causing losses. Bombotelia jocosatrix Gn. was recorded from the Cannanore, Palghat, Trichur and Alleppey Districts throughout the flowering season. Eublemma anguilifera Moore as well as another unidentified spp. of Eublemma were recorded to occur throughout the State, except in the Wynad District. The seasonal fluctuations of this pest were significant only in the Palghat District.

An unidentified species of Cacoecia was recorded for the first time as a minor pest of mango inflorescence. The larvae fed on flowers and floral buds.

The other pests observed during the course of the survey were Rapala manea Hewitson, Haplothrips ganglbaueri Schmutz, Dichocrosis punctiferalis Guenee and an unidentified Geometrid.

The bio-efficiency of monocrotophos applied by two methods, namely, stem injection and stem banding, against the Idiocerine hoppers infesting mango inflorescence was evaluated in a separate experiment. The relative toxicity of the insecticide was determined from the time mortality relationship between the insecticide reaching the inflorescence of treated trees and the mortality of the fourth instar nymphs of I. niveosparsus. The LT-50 values of the nymphs following application of the insecticides by the stem injection method was found to be substantially lower than the corresponding values for the stem banding method of application. It was thus evident that the toxicant moved at a faster pace when administered by the stem injection method. The variations in the pattern of translocation of the toxicant under the two methods of administration have been discussed.

The residues of monocrotophos on freshly formed mango fruit at five weeks after application by the stem injection method at 4 ml and 2 ml ai/tree were 0.3600 ppm and 0.3750 ppm respectively. The corresponding residues in the mango fruit consequent on stem banding method of administration were 0.2655 ppm and 0.0550 ppm. The implications of the above results in formulating control methods against Idiocerine hoppers infesting mango inflorescence have been discussed.