INSECT-PEST COMPLEX OF NURSERY PLANTS OF MANGO WITH SPECIAL REFERENCE TO BIOECOLOGY AND CONTROL OF KEY PEST

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To

My Beloved

Parents

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Certificate

This is to certify that the work recorded in the thesis entitled **INSECT- PEST COMPLEX OF NURSERY PLANTS OF MANGO WITH SPECIAL REFERENCE TO BIOECOLOGY AND CONTROL OF KEY PEST** submitted by **Md.Rafiquzzaman**, for the award of the Degree of Doctor of Philosophy in Agricultural Entomology of the Bidhan Chandra Krishi Viswavidyalaya, is the faithful and bonafide research work carried out under my personal supervision and guidance. The results of the investigation reported in the thesis have not so far been submitted for any other Degree or Diploma. The assistance and help received during the course of investigation have been duly acknowledged.

(B.Maity)

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Dated, Mohanpur
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Rafiquzzaman

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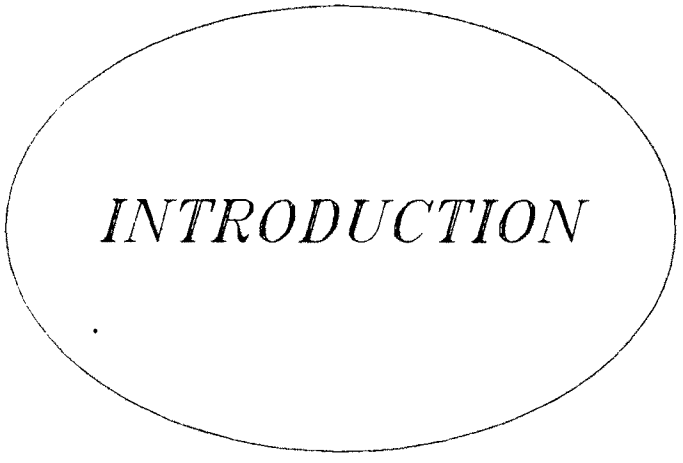


INTRODUCTION

Cultivation of mango dates back to the prehistoric time. Abul Fazal(1590) in his great work *Ain-i-Akbari* mentioned a number of mango varieties cultivated in India during that period. According to De Condelle, 1904; Popenone, 1920; Vavilov,1949-50 and Mukherjee, 1951, Indo-Burma region is said to be as the place of origin of mango. Basing their findings on the maximum number of allied species growing Malaya, some workers are led to believe that the Malaya region is the original home of the mango, for there as many as twenty species are found to grow. Besides, the history of the mango genus, the occurrence of numerous wild and cultivated varieties, philological, archaeological and other literary evidence, the number of ancient names particularly Sanskrit ones, phytogeographical distribution and phytogenetic taxonomy of all the species in relation with climatology and geology and its abundance in Bengal gardens and Deccan since ancient times proved that the mango originated in the Indo-Burma region without any doubt.

Being an important fruit crop of India and constituting an important horticultural asset of the country, mango is grown in at least 87 countries (Prakash and Srivastava,1987). 50% of the total area under fruit is occupied by this crop. The wide

adaptability of this crop to various soils and climatic conditions made it possible to fit in and to be grown in different countries throughout the globes, but undeniably it is most greatly valued in India in comparison to other countries amounting an area of 1.02 million hectare with an annual production of 8.83 million tonnes (Chadha,1985). The cultivation of this very fruit touches every length and breadth of the country with Uttar Pradesh having the largest area (3.13 lakh hectare) followed by Bihar (1.2795 lakh hectare), Andhra Pradesh (1.2709 lakh hectare), Orissa (0.725 lakh hectare), Kerala (0.6253 lakh hectare), West Bengal (0.57 lakh hectare) and Tamil Nadu(0.3917 lakh hectare) as quoted by Majumdar and Sharma, 1985.

In West Bengal, mango is grown in fifteen districts. Though quite a large number of districts falls within the purview of cultivation there it is Malda, Murshidabad, North-24 Parganas, Hooghly and Nadia which occupy the front line as regard to area and production. In West Bengal nearly 54,600 hectares of area (in 1000 ha) is occupied by mango fruits with the production (in 1000 tonnes) of about 40,7900 tonnes (Anonymous,1992) and the area under nursery cultivation of mango is roughly estimated to be 1,000 hectare.

Mango, a non-seasonal flowering plant is propagated vegetatively by grafting in *situ* in nursery through various

improved horticultural techniques. Plants grafted either during beginning of monsoon in light rainfall areas or during end of monsoon in heavy rainfall regions are ready to transplanting in field after six to twelve months. Beginning in monsoon in light rainfall areas or end of monsoon in heavy rainfall areas is the best time for planting. The plants usually bear fruits from fourth to fifth year onward with a full crop from tenth or eleventh year. Erratic bearing is well known, which depends upon the variety, weather and cultural conditions. Of late introduction of dwarf variety with a habit of frequent vegetative flushing during its growth phases giving regular bearing is the phenomenol success in mango cultivation.

Emphasis has been laid to bring new areas under plantation programme with increasing number of fruit trees particularly dwarf varieties. Over traditional tall varieties with irregular bearing,the dwarf type has gained great favour due to some desirable characteristics such as accomodation of more number of trees in the same area, increase exposure of foliage to sunlight, there by resulting more number of better quality fruits and scope of carrying out easy plant protection operation etc. But it is realised that one of the important constraints in popularising the high yielding cultivars is its high susceptibility to insect pests especially the leaf cutting weevil (*Eugnamptus marginellus* Fst.).

Insect problems in nursery cultivation is becoming more and more acute every year. The prime causes of seriousness of problem seem to be:

1) A large increase of nursery cultivation in consolidated holding providing increase in opportunity for food to insect pests

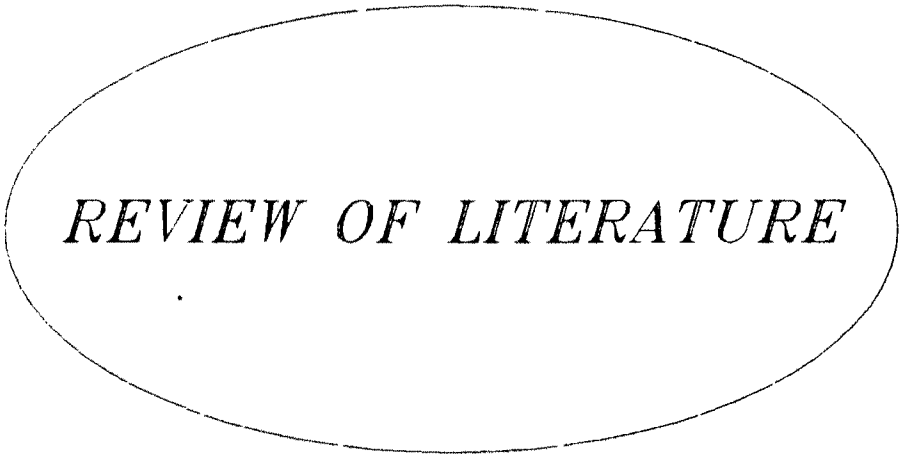
ii) Continuity of standing crop throughout the year which allows interrupted breeding and multiplication

iii) Introduction of cultivars having frequent flushing behaviour thus providing suitable feeding and breeding material

iv) Modification of nursery environment by use of high doses of nitrogenous fertilizer, indiscriminate use of pesticides etc. conducive to proliferation and survival of insect species

In view of the seriousness of the attack and the increasing incidence of the pests in nursery mango, investigation on the pest complex with special reference to bioecology and control of a key pest, *Eugnamptus marginellus* Fst.was under taken.

CHAPTER - 2



REVIEW OF LITERATURE

PEST COMPLEX IN NURSERY PLANTS OF MANGO

A number of reports have been made by various workers on insect pests associated with mango crop in the books dealing with economic entomology (Butani,1979; Nayar *et al.*,1976;Nair, 1986 and Stebbing,1914) and in various other publications in the form of annoted list of crop pests. Comprehensive review of major and minor insect pests of mango numbering over 175 species was published by Fletcher (1917), Wadhi and Batra (1964), Vevai (1969) and Nayar *et al.*, (1976).

Of the large number of insect species so far recorded following are enumerated as pests of mango occurring in the nursery stage of the crop.*Dasychira mendosa* (Hubner) and *Lymantria ampla* Walker are occasionally recorded causing no appreciable damage on mango leaves in various parts of India (Butani,1979). He further reported that *Porthesia scintillans* (Walker) is widely distributed in Indian subcontinent and recorded as polyphagous pest, damaging apple, mango,pomegranate etc. Nair (1986) reported *Euproctis scintillans* Wlk. and *Dasychira mendosa* Hb. feeding on tender leaves of mango in different regions. *Dasychira mendosa* Hb. is widely distributed in India and reported to feed on tea (Anonymous, 1916), lucerne (Ghosh, 1925),

sugarcane (Chopra,1928), mango (Mukherjii,1929), uncaria gambir (Millar,1930), castor (Ayyar,1936; Koshiya and Bharodia, 1976), cotton, redgram and groundnut (Varma and Mangal Sain, 1977). Sandhu *et al.*(1979) while studying on new record of host plant of *D.mendosa* reported that this pest species feeds and breeds on citrus, guava and pear at Horticultural Farm, Ludhiana which are the new and additional host plants from India and considered only as a minor pest of recorded hosts.

Mango shoot borer (*Chlumetia transversa* walker) has been reported boring the mango shoots (Beeson,1941 and Nair,1986). It was first reported only from Uttar Pradesh (Anonymous, 1903) and now found all over India. It has also been reported from Sri Lanka, Malayasia and East Indies (Hampson,1912); Philippines (Palo,1932; Palo and Garcia,1936) and Indonesia (Voute,1935). In Philippines it is stated to be a serious pest affecting the inflorescence where as in other countries it bores through the vegetative shoots only. Besides mango, it has been reared on litchi leaves (Lefroy and Howlett, 1909). It was reported as a minor pest in India (Gangoli *et al.*,1957; Ramakrishnan and Srivastava,1967). However, it has been reported to cause considerable damage in Uttar Pradesh (Singh,1957), in Rajasthan (Kushwaha *et al.*,1964) and in Orissa (Sen Gupta and Behura,1957). Chahal and Singh (1977) observed that the mango shoot borer, *C.transversa* has turned out to be a pest of economic importance

in all the mango growing areas of the Punjab especially in nurseries. According to Singh (1957) and Chahal and Singh (1977) freshly hatched caterpillars bore the midribs of the tender leaves and come out after a couple of days and then bore into tender shoots near the growing point tunnelling downwards (100 to 150 mm), throwing their excreta etc. out of the entrance hole. Leaves of affected shoots wither and drop down. Butani (1979) noted that the young grafted seedlings are severely affected and may even be killed and this pest is usually active from August to October. Singh (1957) further reported that this pest attacks the mango tree in all stages of its growth and the young saplings in nursery are attacked during the earlier part of April as a result, the attacked saplings instead of producing a straight and healthy stem, result in branched tops and such plants become unfit for grafting.

Nair (1986) reported *Thalassodes veraria* Guen., a looper is a feeder on the tender leaves of mango and Butani (1979) recorded this pest feeding on leaves of litchi,mango and tamarind causing minor damage. The slug caterpillar, *Trypenophora semihyalina* Koll. rarely occured in North-East and recorded from tea (Nair,1986).

The grey weevil, *Myllocerus discolor* Boheman was found to feed mango leaves (Butani,1979; Nair,1986). This insect has been observed in India to attack the leaves, shoots and inflores-

cence of mango (Marshall,1916). Das and Ghosh (1974) recorded it as and new pest of *Corchorus olitorius* L. while Thangavel *et al.* (1974) reported it as the worst pest only of *C.olitorius* in Tamil Nadu. According to Singh (1960) the insect was active throughout the year except during winter when it is in the adult stage, hiding under the bark and cracks and crevices of the trees and recorded as a minor pest. Hussain *et al.* (1987) while surveying the insect pests of mango in Rajshahi, Bangladesh, recorded *M.discolor* as a major species.

Astycus lateralis Fabr. was reported to feed on different host plants (Stebbing,1914; Nair,1986). Different species of genus *Monolepta,* a chrysomelid beetle, has also been recorded to attack the different host plants (Butani,1979 and Nair,1986).

The nymphs and adults of *Rastrococcus iceryoides* (Green) were found to feed on leaves, shoots and infloresence of citrus in Uttar Pradesh where as in Madhya Pradesh this is found infesting leavs, tender terminal shoots, inflorescence and fruits of mango (Nair,1986). This insect was also recorded on mango as reported by Ayyar,1924; Misra,1924 and Singh,1960.

Number of scale insects including fluted (Monophlebids), armoured (Diaspids) and soft (Lecanids) and few mealy bugs (Pseudococcids) have been reported damaging mango trees all over India (Butani,1979). Singh(1960) observed that the two scale

insects were severe on young mango plants particularly in nursery stage on trees upto three years of age. Tomasello (1951) recorded 30 species of these scales and reported to affect mango trees in Florida.

Black citrus aphid, *Toxoptera aurantii* Bd.F has been recorded as a major pest of citrus spp. and minor pest of various fruit trees including castard apple, jack-fruit, litchi, loquat, mango, sapota and tamarind (Butani, 1979) While Essig (1949) recorded the citrus as a main host of this pest species though it has been observed on over 50 host plants.

The thrips, *Scirtothrips dorsalis* Hood has been reported damaging gravevine in TamilNadu, Andhra Pradesh and Maharastra and recorded it as a polyphagous pest having a wide range of host plants (Ananthakrishnan,1971). Butani (1979) reported this species from India on mango.

The redmite, *Oligonychus mangiferus* (Rah.&Sap.) has been recorded damaging mango leaves in Punjab (Nair,1986) and this species also recorded from grapevine, jamun and mango (Butani,1979).

Available literature on insect pests of mango nursery with particular reference to leaf cutting weevil, *Deporaus marginatus* (Pascoe) renamed as *Eugnamptus marginellus* Fst. by Zoological Survey of India,Calcutta,W.B. showed that no compre-

hensive research on mango nursery entomology was under taken in India even though observation on mango nursery pests with special reference to leaf cutting weevil dates back as early as in 1914.

Review of literature revealed that *D.marginatus* has been recorded as a specific pest of mango and reported from India (Fletcher, 1914 & 1917), Ceylon (Hutson and Alwis,1934) and Bangladesh and Burma (Bhutani,1979). The weevil was also recorded in China (Zou,1982) and Malayasia (Yong *et al.*,1982). Stebbing (1914), however, reported *Eugnamptus marginellus* Fst. var. *semirufus* Fst. as a pest of mango tree garden in Chanda in the Central Provinces, India. Gupta and Singh (1986) observed *D.marginatus* damaging litchi trees at Saharanpur, Uttar Pradesh referring a new record of the host of this pest. Singh (1978), who reported the pest complex of litchi plants in the districts of Dehradun and Saharanpur, did not record *D.marginatus* as a pest of litchi. Bhole *et al.*(1987), while working on seasonal incidence of mango nursery pests in the Konkon region of Maharastra reported that *D.marginatus* was observed to be the serious pest of nursery was serious pest of mango and recorded throughout the mango growing regions of the country (Bhole and Dumbre,1989). Nair (1986) reported that *Deporaus(Eugnamptus) marginatus* Pasc., the leaf cutting weevil, widely distributed in the country and observed to be appeared often as a serious pest in South India.

Ahmad and Hossain (1979) while investigating on curcu-

lionids of the Bangladesh Agricultural University area, 31 species of curculionidae recorded from Bangladesh on a wild variety of food plants and other tropical fruit trees where *D.marginatus* was recorded for the first time on mango.

Dan *et al.* (1992) reported from China that the weevil, *D.marginatus* infected mango causing funnel rolling symptom. The authors studied the suitability of Nepal mango and three other mango varieties for the leaf cutting and for choice of food of the insect species under different conditions.

BIOECOLOGY OF LEAF CUTTING WEEVIL,*E.marginellus*(SYN:*D.marginatus*)

Period of activity of *D.marginatus* was reported by Fletcher (1917) and Singh (1960) from August to October and September to October respectively. Gupta and Singh (1986) noted the same to start the activity on mango and litchi plants simultaneously by the end of June and found to observe it damaging mango and litchi trees at Saharanpur from June to September although stray adults, 1 or 2 in number on a tree are met with till middle of October. The authors also noted that the weevils attacked new flushes of leaves both on young and older trees by scrapping the tissues of the new leaves and thus irregular small spots are formed on the leaves and such spots nearly coalasced to each other forming in separate patches and each patch may cover 5 to 50 per cent of the total area of the leaf . The area of the

affected leaves damaged by the weevil at the end of July in 1986 varied between 30 to 80 per cent in mango and 30 to 70 per cent in litchi under field conditions when the percentages of affected leaves in new flushes were between 62 to 100 in mango and 10 to 20 in litchi. The authors also showed that the damage in mango was more severe than litchi and mean percentage of damaged leaves of new flushes on mango trees was 90 and about 60 per cent of the damaged leaves had crumpled and dried up.

The pest appeared in June to July and their incidence was high in July to October after which it declined (Bhole *et al.*,1987). Singh and Pandey (1972) reported that the weevils cut the new leaves especially from June onwards, while Ahmad and Hossain (1979) recorded the insect species first time in June to August.

While studying on species composition and seasonal dynamics of stratocoenoses of curculionids on hazel, Holecova (1993) recorded a total of 57 species belonging to 24 genera, of which *Deporaus* was most abundant and peaked in May to June and was low in August to October.

Tigvattnanont (1988) while studying the biology and auteocology of this pest reported that the adults feed on the epidermis of young leaves causing browning and death of leaves. Three generations of the insect species have been reported from

July to October by Singh (1993).

Bhole and Dumbre (1989) while studying bionomics of *D.marginatus* under laboratory conditions observed that freshly laid egg was small, whitish, cylindrical and rounded at both ends and it was 0.7 mm long, 0.3 mm broad and mean incubation period was 2.5 days. The authors noted that the larva was apodous, flat and whitish, abdomen was ten segmented, pale white and completed its development by passing through three instars, the duration was 2,2 and 4 days respectively and the full grown larva was yellowish or dirty green and more active. The average length and breadth of different instars were 1.30, 2.25 and 3.49 mm in length and 0.68,099 and 1.03 mm in breadth. The authors further noted that the prepupa was whitish to pale yellow and lasted for 3.5 days, pupa was exarate, shining white when newly formed and gradually turned pale yellow and it was 3.02 mm long and 1.49 mm broad and the adults exhibited differences in colour such as reddish brown with yellowish abdomen and uniform black, average body length of male and female was found to 5.12 mm and 5.70 mm, respectively, while breadth was 1.22 mm and 1.46 mm with length of snout in male and female to be 1.18 mm and 1.43 mm, respectively.

Grubs of *D.marginatus* were dirty green and about 5 mm long. The adults were small, greyish brown having long brown snout and shining black elytra (Butani, 1976). Nair(1986) noted

that the adults of *D.marginatus* were small, black and brown.

Hutson and Alwis (1934) stated that the average life cycle of *D.marginatus* was 24.5 days. Tigvattnanont (1988) while studying the biology of *D.marginatus* under laboratory conditions showed the average duration of the egg, larval and pupal stages were 1.99, 11.13 and 7.7 days, respectively. Khanna (1952) recorded that the egg,grub and pupal duration were 2 to 3, 6 to 8 and 7 to 8 days, respectively.

Singh (1960) reported that the egg, larval and pupal periods of *D.marginatus* were 2 to 2.5, 7 and 11-12 days, respectively. The author observed that total life cycle completed in about 24 to 25 days.

Hossain (1989) reported in a manual on mango cultivation in Bangladesh that the egg, larval and pupal durations of *D.marginatus* ranged from 2 to 5, 6 to 8 and 7 to 8 days,respectively.

Regarding the number of eggs laid by a single female of *D.marginatus* in a single leaf, Von (1930), Butani (1979) and Nair (1986) reported that number of eggs laid by a single female in single leaf ranged from 10 to 22 eggs. Tigvattnanont (1988) observed 2 to 14 eggs laid by a single female in one leaf.

Ovipositional operation on tender leaves of mango,

larval habit and damage of adult female of *D.marginatus* have been reported by different authors.Bhole and Dumbre (1989) while studying bionomics of *D.marginatus* revealed that before oviposition, the female surveyed the whole leaf surface, then moved to dorsal side and made a minute cut by the side of midrib and prepared a 'c' shaped pouch for an egg. After that, the female turned about and bent the abdomen slightly to lay an egg singly inside it. Soon after oviposition, the female turned round again and repaired the opening of the pouch. The authors also noted that time taken to make a pouch was of about of two minutes and for the whole process of excavating the pouch, laying an egg and repairing of the opening took about four minutes. The average length, breadth and distance between two pouches were also measured and it was 1.1 mm, 0.5 mm and 1.89 cm, respectively and outer three quarters of a leaf were found utilised by the female for egg laying while about 2.5 cm portion still attached to the plant after cutting. The above authors were also noticed that the larvae on hatching from fallen leaves mined and fed between the leaf surface which were seen as a small narrow galleries with full of excreta and full grown larvae bored its way out of the withered leaves and entered into the soil where it constructed a small earthen shell for pupation which was round and measured about 1.2 cm in diameter and contained one larva.

Tigvattnanont (1988) showed that the females excavated

small cavities on either side of midribs on leaves and deposited one egg in each cavity, which was then cut near its base and droped down to the ground. The author also reported that the larvae on hatching fed by mining the tissue of fallen leaves and when it became mature and pupated in the soil.

Singh (1960) observed that the female of leaf cuting weevil laid eggs on the upper surface in the fleshy part of midribs of the leaves, after that it cut the leaves about 2 to 2.5 inch from the stalks and the portion containing the eggs droped down on the ground. The young grubs on hatching fed and developed on the same leaves and after full grown they came out from the leaves for pupation in the soil. It was also noted that the larvae could complete their development in the shrivelled leaves provided with a sufficient moisture. The author also recorded that the defoliation made by the adult female affected the growth and vigour of plants, particularly of young saplings.

Von (1930) reported that with tht help of the snout the weevil, *Eugnamptus marginatus* Pascoe excavated deep pouch into the tissues of the under surface of mango leaves on either side of the midrib and laid eggs singly in these cavities. After laying eggs the weevil proceed to cut right through the leaves near the stem and the leaves containing eggs fell down from the tree. The young grubs on emerging out from the eggs, mined between the epidermal layers.

Hossain (1989) observed that the adult female of leaf cutting weevil bored small holes on both sides of the midribs at the back of the leaves and laid eggs in them singly. After laying of eggs, the insect then cut off the leaves containing eggs near the petiole and the leaves dropped down on to the ground.

Butani (1979) and Singh (1993) also showed that the adult female of *D.marginatus* excavated small cavities on either side of the midribs on lower surface of the tender leaves and laid eggs singly in these cavities, after that, the females cut the leaves near the bases and the leaves fell down on to the ground and the grubs on hatching mined between the two epidermal layers of the leaves and then emerged out to pupate in the soil.

Nair (1986) reported that the eggs laid singly on the under side of tender leaves on either side of the midrib in small cavities excavated by the snout of the beetle. After laying the eggs, the beetle cut down the leaf at its base and the grubs hatching out of the eggs mined the fallen leaves feeding on the mesophyll. When full grown it emerged out of the mine and entered into soil to purpate in a small oval chamber.The author also showed that the adult caused damage by eating holes on the standing tender leaves and the pest appeared when new flushes emerged and these may be totally destroyed leaving behind only the stems without leaves.

Gupta and Singh (1986) while working on new record of *D.marginatus* as a pest of litchi showed that the weevil also cut away the young leaves of mango and litchi from near their bases after laying of eggs on them.

Hutson and Alwis (1934) reported that the egg punctures may be seen as minute dark spots on either side of midrib on the upper surface of the leavs. The authors further noted that the egg is well protected inside the midrib and the seal of the pit prevents the drying up during subsequent withering of cut leaves.

Regarding the periods of pre-oviposition and oviposition as reported by Bhole and Dumbre (1989) showed that mating took place throughout the day and lasted for 0.5 minute to 0.5 hour and mean preoviposition and oviposition periods were 1 day and 53 days, respectively.

Tigvattnanont (1988) noticed that mating behaviour began on the 5th-7th day after emergence and copulation time ranged from 50-60 minutes.

Different rules and hypotheses have been put forward for analysing different aspects of growth characteristics (Dyar,1890) of insects. Bhole and Dumbre (1989) while working on the bionomics of *D. marginatus* measured the body length and head length of different larval instars which according to him, are three in number and the number of larval instar was determined by

applying Dyar's law. Progression factor of 1.4 as propounded in Dyar's law in case of Lepidopterous larvae has also been found to be applicable in cases of non-Lepidopterous insect like banana pseudostem weevil, *Odoiporus longicollis* (Dutt and Maiti,1972) and soyabean girdler *Obereopsis (=oberea) brevis* (Pal,1983).Then the applicability of Dyar's law has been tested by Beri (1961) on *Plutella xylostella;* Paul and Ghosh (1987) on sphingid larva; Kelar (1933) on Lymantria *(=Porthetria) dispar;* Metcalf (1932) on *Sitodre papanicea;* Miles (1931) on tenthredinidae; Fisher (1924) on *Tortrix pronubana* Hb.; Alam(1952 & 1957) and Dhillon (1966) on hymenopteron insects. Mohan and Tonapi (1970) on *Dineutes indicus* Aube.

LARVAL DORMANCY OF *E.marginellus* (SYN:*D.marginatus*)

No earlier authors have reported any observation in dormancy of *D.marginatus* except Bhole and Dumbre (1989) who reported dormancy in larvae as hibernaton during winter with no details of the same.

CONTROL OF LEAF CUTTING WEEVIL *E.marginellus* (SYN:*D.marginatus*)

Various authors have worked on this pest species by use of chemicals and observed application of insectides to be effective in reducing the pest population.

Singh and Pandey (1972) while studying on control of

mango leaf cutting weevil, *D.marginatus* especially from June onwards with six insecticides applied as spray and dust showed that all the treatments were significantly better than non in protecting the leaves but wettable powder spray of DDT at 0.25% and an emulsion spray of dichlorvos (Nuvan) at 0.05% were the most consistently effective.

Butani (1975) recommended 0.03% monocrotophos or endosulfan for control of this pest. Butani (1979) further reported that affected and fallen leaves and their prompt destruction by burning was effective in checking the pest population and also recommended dusting with 5% BHC on young trees.

Singh (1960) also recommended that the leaves affected by this pest and cut away from their stalks should be collected daily and burned them and the author further reported that hoeing and ploughing the soil reduced the infestation.

Siddiqui and Mathur (1980) while working on the chemical control of *D.marginatus* in nursery plants, spraying with DDT (0.25%), methyl demeton (0.05%), endosulfan (0.05%) or fenthion (0.05%) and number of healthy or damaged leaves were assessed immediately before and 72 hours after spraying. It was revealed that all the insectididal treatments provided significant control of the pest while endosulfan being the most effective. The authors also recorded that the control had only 23.97 per cent

leaves undamaged by the pest compared with 76.72 to 89.00 per cent in case of treated plants.

Soh and Khoo (1983) studied field evaluation of four insecticides for the control of *D.marginatus* and obtained excellent control on mangoes (cv.Bombay Green) with deltamethrin (as Decis) at 0.0022%, applied at two weeks interval, while etrimfos (as Ekamet) at 0.075% was less effective. The authors were also obseverd that dicrotophos and acephate did not reduce pest damage significantly.

Bhole *et al.*(1987) while studying on chemical control of mango nursery pests in the Konkon region, Maharastra phorate 10 G, carbofuran 3G,monocrotophos(0.1% as drench and 0.04% as spray), endosulfan (0.1%),carbaryl(0.2% as drench and 10% as dust), BHC (0.2% as drench and 10% as dust), dimethoate (0.03%), cypermethrin (0.005%) and permethrin(0.005%) were tested and found all the insecticides except carbaryl drench and phorate were effective against *D.marginatus*.

Bhole and Dumbre(1989) studied chemical control of *D.marginatus* under laboratory conditions and its susceptibility to BHC,carbaryl and quinalphos was determined and the authors found that only 0.2% and 10% BHC were effective against the pest species causing 83.33 and 86.66 per cent adult mortality 48 hours after treatment.

CHAPTER - 3

MATERIALS AND METHODS

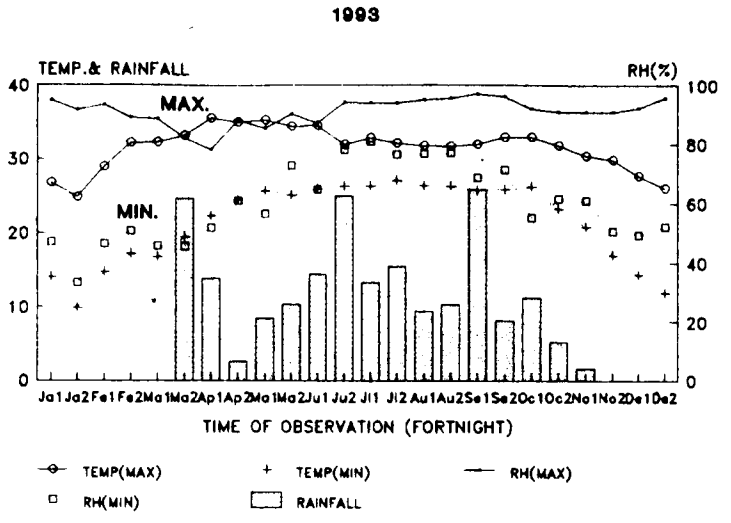
LOCATION

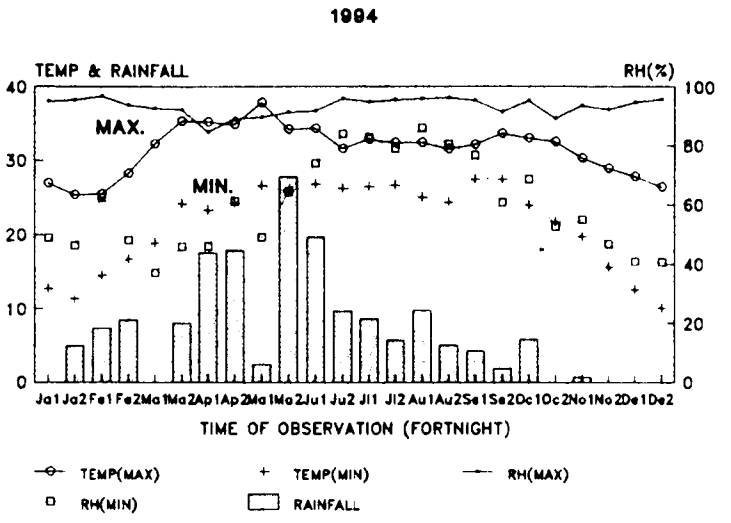
The experiment was conducted at Horticultural Nursery Farm, Bidhan Chandra Krishi Viswavidyalaya,Kalyani Nadia, West Bengal. Meteorological data were recorded during the course of investigation as represented in Fig.1.

PEST COMPLEX IN NURSERY PLANTS OF MANGO

A preliminary survey on insect-pest complex of nursery plants of mango was carried out during 1993,1994 and 1995. During the period large number of different insect species were collected from the field during each observation and brought to the laboratory for detailed morphological studies and at the same time, feeding habit caused by the insect species were also recorded.

Incidence of different insect species was also recorded from nursery mango plants. Of the various insect species recorded six different species were considered for the purpose either by direct counting the stages of insect species present or by counting the damaged plant parts. During the course of investigation, total number of plants were seventy five, each being replicated thrice and twenty five plants were selected for each replication. Only in case of mite, incidence was recorded from fifty plants separately.





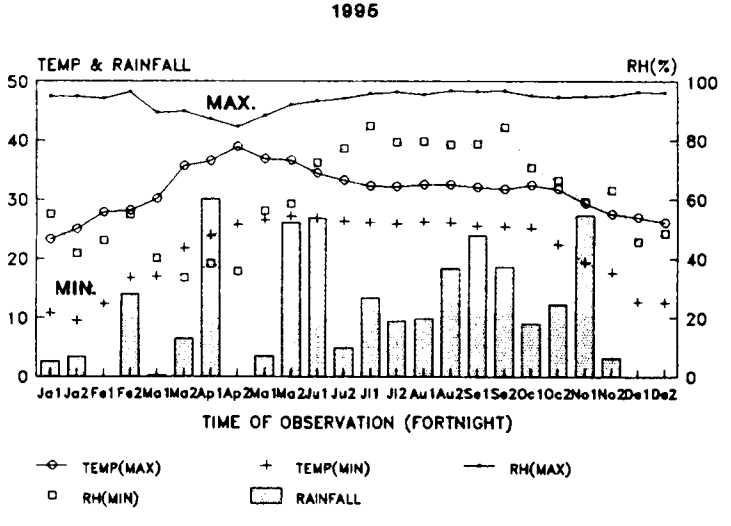


FIG.1 METEOROLOGICAL DATA PERTAINING TO THE PERIOD OF EXPERIMENT ('93-'95) AT KALYANI

In case of leaf cutting weevil, *Eugnamptus marginellus* Fst. and grey weevil, *Myllocerus discolor* Boh.. incidence was recorded by counting the number of leaves damaged showing scissor like cut leaves and nibbling symptoms respectively and data collected were expressed in per cent leaf damage.

The soft bodied insect like thrips, *Scirtothrips dorsalis* Hood., only tender leaves with the insect species were carefully removed from the plants at random and immersed in 70% alcohol for about 15 minutes and population was estimated by direct counting taking four tender leaves randomly both from dorsal and ventral side per plant and it was expressed as the average number of thrips per plant. All the above observation were made fortnightly and continued till disappearance of insect species from the field.

Larvae of a lepidopteran insect, *Metachrostis sp.*, weekly observations on the population and the amount of damage caused by the pest were made by direct counting of the larvae present per plant after dissecting out the bored shoots and per cent shoot damaged respectively. The observations on the insect species were recorded during the active period from third week of June to second seek of October during 1993, 1994 & 1995. Likewise population of bagworm in the field was estimated by careful removal of cases from the leaves during 1993 and 1994 started from third week of August to fourth week of November.

For the purpose of evaluation of dynamics of the said insect species with respect to weather parameters under field conditions the collected data were transformed accordingly before analysing the same in a statistical way.

To estimate the population of red mite, fifty plants were randomly selected. From each plant six leaves, two each from top, middle and bottom portions were chosen and number of mites including adults and nymphs were counted from 2 cm^2 dorsal area of each leaf through ocular field devise. The data as collected were expressed as number of mites present per leaf. The population of the mite was recorded weekly from 13th April to 3rd August during 1993 and 29th April to 5th August during 1994. Correlation between weather parameters including temperature, relative humidity and rainfall and fluctuation of mite population was worked out as outlined by Snedecor and Cochran (1967).

BIOECOLOGY OF A KEY PEST, *E. marginellus* Fst.

In this case, cut leaves with freshly deposited eggs of adult female of *E.marginellus* were collected from the field and reared in the laboratory. The leaves were kept on tray (30 cm x 25 cm) (plate 1) and a layer of 6 cm moist soil was maintained on the tray to keep the tenderness of leaves *vis-a-vis* to prevent the leaves from drying out. Required amount of water was sprayed as and when necessary on soil to maintain the soil moisture. The larval and pupal stages were allowed to complete over and inside

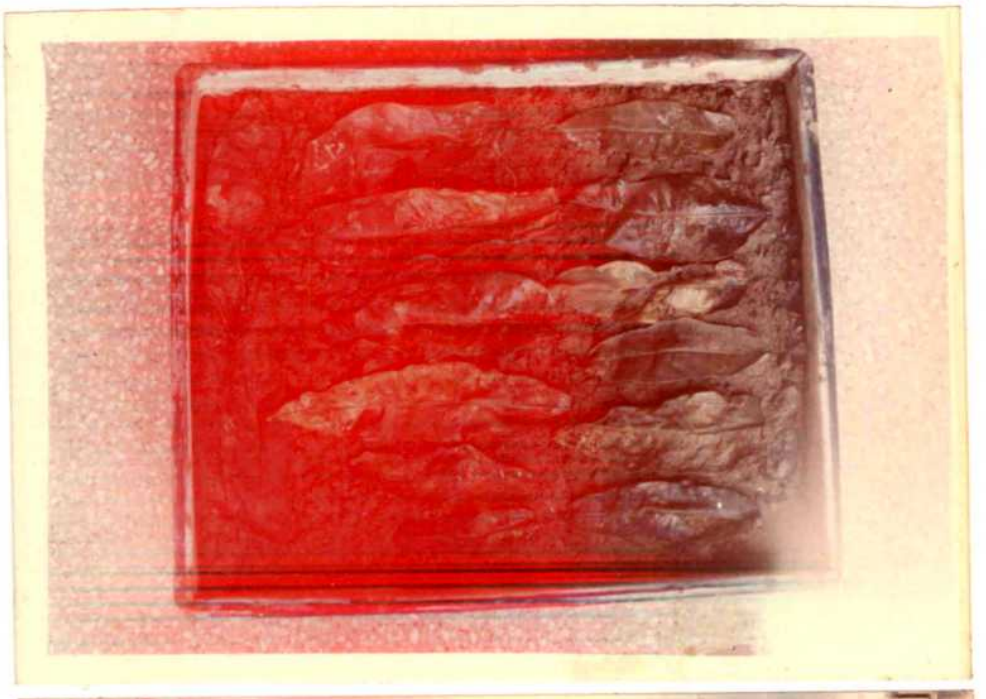


Plate 1 MATERIALS USED DURING EXPERIMENT

Top : (Tray) Grubs of E.marginellus mining and feeding within leaves

Bottom: Desiccator containing hibernated larvae in BOD incubator

the soil respectively. The observations on egg, larval, prepupal and pupal periods and cocoon formation in earthen shell were recorded.

In addition observation on time taken to make egg pouch, to lay egg and to repair the egg cavity after completion of egg laying, time taken to cut the tender leaves on either side of midrib after oviposition and measurement of egg cavities and leaves attached to the plant after cutting were recorded. For determining the measurement of egg cavities following method was employed:

Chromophyl of affected leaves of experimental plants were removed by putting the leaves in 10% sodium hydroxide (NaOH) solution for about half an hour and then put in 5% normal hydrochloric acid solution. Very small portions of punctures are thus visible distinctly and diameter of the egg cavity was measured under stereoscopic binocular with the help of ocular. Detailed morphology of immature and mature stages of *E.marginellus* including measurement on length and width of eggs, larvae, pupae and adult males and females were recorded. Also adult behaviour including mating behaviour, place and mode of egg laying along the midribs were recorded under field conditions.

Sexual dimorphism of *E.marginellus* was also carried out under laboratory conditions and for this, per cent increase of different body parts of female over male were calculated by using a following formula:

$$\left(\frac{\text{Female}}{\text{Male}} - 1\right) \times 100$$

BIOMETRICAL ANALYSIS OF *E.marginellus*

In this method, measurement on the body length and body width of twenty five larvae of each instar reared separately under laboratory condition as well as the width of head capsule shed at the end of each instar were recorded in connection with the studies of correlation between larval length and width and as well as the applicability of Dyar's law in the matter of progression factor relating to different instars.

During the experiment, twenty five leaves were taken and on each leaf hatched larvae allowed to feed were only four in number on either side of midrib. At each instar, twenty five larvae were removed carefully prior to shedding of skin and observations on body length and width were taken under binocular microscope.

Partial regression and multiple correlation on the variables viz. larval length, larval width and the width of the head capsule were calculated to test the reliability in case of individual larva. The equation was,

$$Y = b_0 + b_1x_1 + b_2x_2$$

Where, Y = Calculated value of the width of head capsule in mm

X_1 = Larval length in mm X_2 = Larval width in mm

b_0 = Regression constant

b_1 and b_2 = Coefficient of partial regression values of b_0, b_1 and b_2 were calculated by the method of least square. The regression equation obtained in the larvae having three instars were as follows:

$$Y = 0.1238 + 0.1152\ x_1 - 0.06434\ x_2$$

For the purpose of assigning single individual to their respective instar, relationship between instars and the mean width of the head capsules of larvae were ascertained by use of the regression equation as follows:

$$\log Y = a + bx$$

where Y = Width of head capsule in mm
a = Constant
b = Logarithm of growth ratio
x = Number of instar

Values of 'a' and 'b' were found out by the method of least squares. The equations were,

$$\log y = - 0.7118273 + 0.1613359$$

EFFECT OF CONSTANT TEMPERATURE ON DEVELOPMENTAL PERIOD OF IMMATURE STAGES OF *E.marginellus*

An investigation was carried out under constant temperature in BOD incubator to see whether the constant temperatures have any effect on the duration of different immature stages. In this case, seven different temperature regimes, *viz., 14±1°C, 15±1°C,20±1°C,25±1°C,30±1°C,35±1°C and 36±1°C* were considered

including a control where eggs were kept constantly at room temperature. Cut leaves with freshly laid eggs were kept at different temperatures separately inside the BOD incubator and observation on developmental period of eggs and per cent eggs hatched were recorded *vis-a-vis* the eggs failed to hatch at lower or at upper temperature, was also recorded and expressed as threshold of egg development. Observation on instarwise larval period was also recorded from different constant temperatures except at 35±1°C where only egg period was recorded. At each observation, larval periods were detected by shedding of head capsule seen under binocular microscope. At the end of larval stage, the prepupal larvae came out of the leaves and allowed to pupate in plastic containers (11 cm x 5 cm) provided with 6 cm soil layer. The containers were kept at different constant temperatures inside the BOD incubator till adult emergence. Simultaneously observations on prepupal and pupal periods were recorded. For the above experiment twenty five leaves having four newly hatched out larvae in each leaf were taken. Observation was recorded from twenty five individuals at random for each constant temperature.

EFFECT OF ALTERNATE TEMPERATURE ON DEVELOPMENT OF EGGS OF *E. marginellus*

An experiment was made to find out whether the different alternate temperatures have any effect on developmental period of eggs. For this, cut leaves with freshly deposited eggs were collected from field and kept for one day at different

constant temperature separately inside the BOD incubator and the eggs were then shifted and allowed to hatch at room temperature. Constant temperatures used during experiment were 15±1°C, 20±1°C, 25±1°C, 30±1°C and 36±1°C respectively. Observations on incubation period *vis-a-vis* their per cent hatching of eggs were recorded.

Simultaneously experiment was also carried out with freshly deposited eggs incubated for one day at room temperature and the eggs were then allowed to hatch at different constant temperature by keeping them in BOD incubator separately and observation on incubation period and per cent hatching of eggs were recorded. For the above experiment fifteen freshly egg deposited leaves were considered for each set of constant temperature alongwith control where a portion of fifteen leaves was kept constantly at room temperature and observation was recorded from twenty five individuals at random. The observation on per cent hatching and incubation period with respect to different temperature treatments were recorded till hatching.

EFFECT OF DIFFERENT SHORT EXPOSURE OF TEMPERATURE ON DEVELOPMENT OF EGGS OF *E.marginellus*

Freshly deposited eggs were collected from the field and immediately exposed to 14±1°C, 15±1°C, 20±1°C, 25±1°C, 30±1°C, 35±1°C, 36±1°C, 37±1°C, 38±1°C for a period of one, two and three hours respectively inside the BOD incubator and then the eggs were kept at room temperature and allowed to hatch. Likewise

an experiment was conducted with one day old eggs alongwith control. Observation on incubation period was recorded both from freshly laid and one day old eggs with different short exposures of temperature taking twenty five individuals from ten leaves. A portion of ten leaves was also kept constantly at room temperature to serve as control.

INDUCTION OF HIBERATION IN LARVAE OF *E.marginellus* UNDER LABORATORY CONDITION

Large number of larvae were collected from the field during October,November and December 1993 and 1994 and kept under laboratory condition inside a plastic container with perphorated lid (11 cm x 5 cm) containing sufficiently moist soil layer of 6 cm to ascertained their actual time of induction in larval hibernation.Observation on per cent larvae pupated *vis-a-vis* per cent larvae hibernated were recorded fortnightly.

To verify *E.marginellus* entering into dormancy with onset of winter months an experiment was conducted in the laboratory. Weekly observations on the weight of ten larvae randomly selected from large number of individuals reared in the laboratory were made during November 1995 to February 1996 and per cent loss or/gain of body weight of larvae was calculated by using following formula,

$$\frac{\text{Difference in weight}}{\text{Initial weight}} \times 100$$

TERMINATION OF LARVAL HIBERNATION OF *E.marginellus* UNDER LABORATORY CONDITION

Investigation with hibernated larvae was carried out to determine the factors responsible for termination of larval hibernation. For the purpose hibernated larvae were kept in a plastic container with sufficiently moist soil layer of 6 cm as mentioned above till termination of dormancy. Time to time water was sprayed inside the container to maintain the soil moisture and also to provide congenial condition for them. Observations on per cent pupae and adults emerged were also recorded weekly from fourth week of January to second week of March during 1994 and fourth week of January to first week of March during 1995.

EFFECT OF RELATIVE HUMIDITY ON TERMINATION OF LARVAL HIBERNATION *E.marginellus* UNDER LABORATORY CONDITION

An experiment was conducted to find out any effect of relative humidity on the dormancy of *E.marginellus*. For the purpose different per cent relative humidity *viz.* 40%,50%,60%,70%,80%,90% and 100% were prepared by dissolving potassium hydroxide (KOH) in water and were poured in desiccator (15 cm dia) separately as outlined by Solomon (1951). In each desiccator ten dormant larvae kept in a plastic container (7 cm x 5 cm) having sufficiently moist soil were placed and observations on the per cent larvae pupated and per cent adults emerged along with per cent dead if any, were recorded weekly.

EFFECT OF RELATIVE HUMIDITY ON TERMINATION OF LARVAL HIBERNATION OF *E.marginellus* AT A CONSTANT TEMPERATURE OF 30°± 1°C IN BOD INCUBATOR

Method of preparation and different level of relative humidity used in this experiment were same as mentioned earlier. The prepared solution was poured in a small sized desiccator (10 cm dia) and in each desiccator ten dormant larvae kept in a plastic container (7 cm x 5 cm) having sufficiently moist soil were put separately in each level of humidity in the same way. The desiccators containing different level of humidity with hibernated larvae were exposed to a constant temperature of 30° ± 1°C inside the BOD incubator (plate 1). Weekly observation on the per cent pupal and adult emergence along with the death if any, were recorded.

EFFECT OF DEPTH OF SOIL ON DORMANT LARVAE OF *E.marginellus* UNDER FIELD CONDITIONS

An investigation was carried out under field conditions keeping the hibernated larvae at different depth of soil *viz.* 0,1,2,3,4 and 5 cm, respectively. The hibernated larvae were put separately inside the small soil pots (11 cm x 8 cm) containing different depth of soil. Perphorated polythene sheets were fixed around the top of pots, so as to prevent the escape of the adults when emerged out. The top portion of pots were then covered with a thin layer of soil. Per cent pupation and adult emergence along with death if any, were recorded weekly.

CONTROL OF *E.marginellus*

RELATIVE TOXICITY OF INSECTICIDES TO THE ADULTS OF *E.marginellus*

Relative toxicity of four insecticides *viz.* carbaryl flowable, quinalphos, dichlorvos and cypermethrin against the key pest, *E.marginellus* was evaluated separately under laboratory conditions. Adults of same age were used for the experiment. Five concentrations *viz,0.1%, 0.01%, 0.001%, 0.0001% and 0.00001%* of each of the above mentioned commercial E C formulation were prepared by diluting with water. One ml from different concentrations prepared from each insecticide was uniformly smeared over the inner surfaces of the petridish pair (9 cm dia) under Potter's tower at 5 gm/cm^2 pressure and it was dried under electric fan for twenty minutes. In control treatment only water was sprayed over the inner surface of the petridish. Adults of *E.marginellus* were released into each of the treated petridishes and allowed to come in contact with insecticidal deposit for fifteen minutes and removed afterwards in clean petridishes with food. There were ten adults per treatment and each treatment was replicated three times. Subsequent observations on the mortality of the adults were recorded after one hour and twenty four hours. Moribund insects were considered as dead. Data on the mortality obtained were subjected to probit analysis as per method outlined by Finney (1971) and LC_{50} and their fiducial limits were obtained for different concentrations.

EFFECT OF THE INSECTICIDES IN SOIL ON PREPUPAL AND PUPAL STAGES OF *E.marginellus* UNDER LABORATORY CONDITION

Test was also carried out to find out the effectiveness of insecticides applied in the soil for control of *E.marginellus*. Commercially available EC formulation of chlorpyriphos (0.06% and 0.08%) and aldrin (0.03% and 0.05%) were selected for soil treatment. The test was carried out under laboratory condition in plastic container (11 cm x 5 cm) containing soil. Before conducting the experiment sufficiently pulverised moist soil was thinly spread over galvanised iron tray. With the help of a suitably devised hand operated sprayer calculated amount of different concentrations diluted with water at the rate of 200 lit / acre was sprayed over the soil and immediately after spraying the treated soil was mixed properly and the soil was then kept open for about one hour to evaporate the solvent and after one hour the plastic containers were filled with the treated soil of 6 cm depth. In each container ten each of same age prepupae and pupae were released separately in two separate tests and allowed to contact with treated soil for about one hour and they were then shifted from treated soil and kept in untreated soil in another similar plastic container as mentioned earlier with a soil of 6 cm depth. In case of control where in only water was sprayed. The mouth of the plastic container was fixed with markin cloth. Each treatment was replicated three times. Observations were recorded daily i.e. twenty four hours after the start of the experiment and it was continued up to 120 hours. Data on the

mortality obtained were subjected to statistical analysis.

EVALUATION OF SOME INSECTICIDES AGAINST *E.marginellus* UNDER FIELD CONDITIONS

A trial was carried out under field conditions using thirteen insecticides including their respective treatments to find out the effect of damage caused by *E.marginellus* in terms of cutting of tender leaves after oviposition and/or scrapping of green matter. For each treatment five mango saplings of about same age and same height were selected and it was replicated three times. Desired concentrations of all the insecticides prepared at the rate of 200 lit of water per acre were applied at an interval of ten days starting from 8th May and continuing upto 15th October during both 1994 and 1995. Observations on the incidence of the pest species in terms of leaf cutting and /or were recorded immediately, one, before treatment and other, one week after treatment and it was continued uninterruptedly up to 15th October during 1994 and 1995. Difference of pretreatment and post treatment observations were considered before computing the data and expressed stage.The data obtained were then subjected to analysis of two factor completely randomized design after angular transformation of recorded data.

Another field trial with granular insecticides was also carried out with phorate 10 G, carbofuran 3 G and carbaryl 4% + lindane 4% G to find out the effect of granular treatment on the incidence of *E.marginellus*. There were four treatments, one each

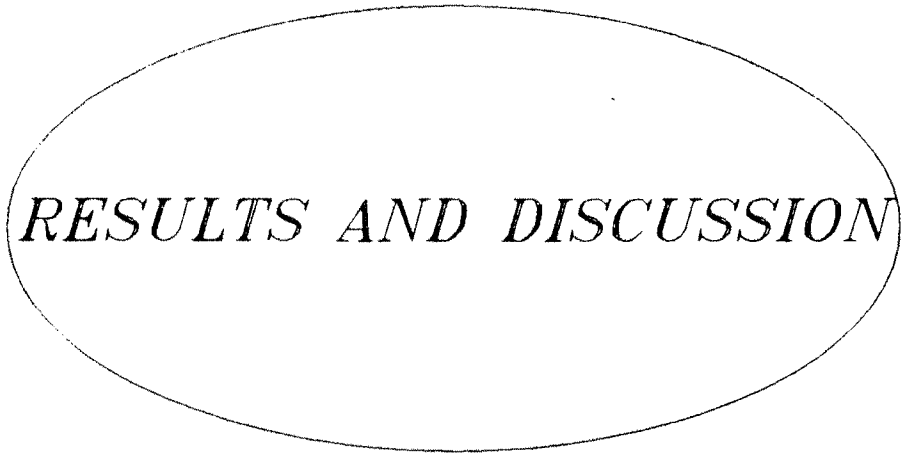
of phorate 10 G and carbofuran 3G @ 5 g per plant and two of Carbaryl 4% + lindane 4% G at the rate of 5g and 7.5 g. per plant. One control treatment was considered along with the above mentioned treatments. For each treatment five similar plants were selected as mentioned earlier and it was replicated two times. The granular insecticides were applied in the soil at an interval of four weeks starting from 29th May and continuing up to 2nd October during 1994 and 1995, and it was applied at the ring making from about 6" from the base of the plant immediately followed by sufficient watering. Observations on the incidence of the pest species were recorded in similar method as mentioned in case of surface application. Here also difference of pretreatment and post treatment observations were considered like above mentioned treatments and the data found, were then subjected to analysis of three factor completely randomized design after angular transformation of the recorded data.

Different insecticidal materials used during the course of investigation are given in Table 1.

Table 1 Insecticides used during the course of investigation

Name of insecticides	Trade Name	Source
1. Phosphamidon 85% SL	Sumidon	Sudarshan Chemical Industries Limited
2. Monocrotophos 36% SL	Sufos	Sudarshan Chemical Industries Limited
3. Quinalphos 25% EC	Suquin	Sudarshan Chemical Industries Limited
4. Monocrotophos 36% SL	Luphos	Lupin Agrochemicals (India) Limited
5. Chlorpyriphos 20% EC	Classic-20	Lupin Agrochemicals (India) Limited
6. Dichlorvos 76% EC	Luvon-76	Lupin Agrochemicals (India) Limited
7. Dichlorvos 76% EC	DIVAP-100	Pesticides India Limited
8. Oxydemeton-methyl 25% EC	Metasystox	Bayer (India) Limited
9. Cypermethrin 10% EC	Bilcyp	Bayer (India) Limited
10. Fenvalerate 20% EC	Sumicidin	Rallis India Limited
11. Cabaryl Flowable 42 % a.i(m/m)	Sevin Flo	Rhône-Poulenc Agrochemicals (India) Limited
12. Carbaryl 50% W.D.P.	Sevin	Rhône-Poulenc Agrochemicals (India) Limited
13. Azadirachtin-Iodine 15% a.i.	Bioneem	Bicco Agro Products Private Limited
14. Carbofuran 3 G	Diafuran	Pesticides India Limited
15. Carbaryl 4% + Lindane 4% G	Sevidol	Rhône-Poulenc Agrochemicals (India) Limited
16. Phorate 10 G	Anumet	Anu Products Limited.
17. Aldrin 30% EC	Aldrin	ECI Agrochemical Private Limited.

CHAPTER - 4



RESULTS AND DISCUSSION

4.1 PEST COMPLEX IN NURSERY PLANTS OF MANGO

The mango plants in the nursery stage are infested by several pest species. Preliminary informations about the pest spectrum and nature of infestation required for control measures to be recommended to the growers were recorded under a representative agroclimatic condition at Kalyani, West Bengal. During the period of investigation from 1993-1995 a total (Table 2) of twenty four pest species including insects and mite were found existed in the nursery plants. The pests were observed to infest particularly the leaves and shoots causing mild to severe damage. Gross morphology and their damage caused by pest species are given below:

4.1.1 Morphology

Order: Coleoptera

Family : Curculionidae

***Mylllocerus discolor* Boheman**

General body colour of adult dusky with irregular white patches, elongated; head hypognathous, antennae clavate, pedicel elongated and about half of antennal length, compound eyes black, slightly protubarent; prothorax enlarged, elytra hard with striae visible covering all abdominal segments; legs stout and well developed. Length varies from 6 to 10 mm (Plate 2).

Table 2 Period of occurrence of various pest species recorded on nursery plants of mango.

Pest species	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1. Eugnamptus marginellus Fst.		*	*		*	*	*	*	*	*	*	
2. Astycus lateralis Fabr.							*	*	*			
3. Myllocerus discolor Boh.		*	*	*	*	*	*	*	*	*	*	
4. Aspidolopha melanophthalma Lacord					*	*	*	*	*			
5. Diapromorpha pallens(F.)					*	*	*	*				
6. Monolepta sp.			*	*	*	*	*	*			*	*
7. Metachrostis sp.						*	*	*	*	*		
8. Dasychira mendosa basivitta (Walker)			*				*	*	*	*	*	
9. Euproctis scintillans walker								*	*	*	*	
10.Lymantria ampla Walker								*	*	*	*	
11.Thalassodes veraria Guenee				*	*			*	*	*	*	*
12.Leaf miner				*	*	*	*				*	*
13 a.Leaf webber				*	*	*	*	*	*	*	*	
b.Leaf folder		*		*	*	*	*	*	*	*	*	
c.Leaf folder		*		*	*	*	*	*	*	*	*	
14.Bagworm								*	*	*	*	
15.Trypenophora semihyalina Koll.								*	*	*		
16.Toxoptera aurantii Bd.F	*											*
17.Coptosoma sp.										*	*	
18.Rastrococcus iceryoides(Green)						*	*	*				
19.Soft scale	*	*										
20.Hard scale						*	*					
21.Scirtothrips dorsalis Hood		*	*	*	*	*	*					
22.Oligonychus mangiferus (Rah.& Sap.)					*	*	*	*				

***Astycus lateralis* Fabr.**

Young adults shiny green with golden yellow on sides and with a golden metallic iridescence; body elongated variable in size; eyes black, head slightly curved and blunt at apex, mouth parts chewing and cutting type, hypognathous, antennae clavate, pedicel short about 1/4th of total antennal length, enlarge anteriroly; prothorax enlarged and widest at the middle, elytra convex rugose and finely striated leaving no abdominal segment visible; fore femur highly swollen in the middle narrower at the both ends and firmly attach with the tibia, tibial spines prominent, tarsus three segmented ending with a pair of claw, third tarsal segment bilobed. It measures from 8 to 14 mm in length and width at thorax varies from 2 to 3.5 mm (Plate 2).

***Eugnamptus marginellus* Fst (Syn: *Deporaus marginatus* Pascoe)**

Detailed morphology of this species mentioned under chapter 4.2.

Family: Chrysomelidae

***Aspidolopha melanophthalma* Lacord**

Adults shiny;body globular in shape; head sunken, black, compound eyes black, antennae serrate, pe dicel short; mouth parts hypognathous with stout mandible; thorax smooth, concave, orange in colour, elytral punctation visible, last abdominal segment suddenly bent downward.Measures about 4.5 to 6.0 mm (Plate 2).

***Diapromorpha pallens*(F.)**

Adults shiny; body cylindrical; head sunken, black, compound eyes black, antennae serrate, pedicel short; mouth parts hypognathous with stout mandible; thorax smooth, orange in colour, ventral thoracic shield black, ventral abdominal sclerites reddish with black transverse stripes at the segmental joint, pygidium exposed. It measures about 5.5 to 7.5 mm (Plate 2).

Monolepta sp.

Head sunken, mouth parts hypognathous, antennae filiform, pedicel shorter than funicular segment; thoracic shield concave, semicircular, ventral thoracic region black, elytra dark brown encircling with a black markings,no striation; abdomen orange yellow, pygidium exposed. It measures about 5 to 7 mm.

Order:Lepidoptera

Family:Noctuidae

Metachrostis sp

Freshly emerged larvae pale white with dark black head and prominent legs; within one to two days when it becomes slightly larger in size turned light pink in colour; with the advancement of larval stage, the colour changed from pink to purple with dirty white spots dorsally and pale white ventrally; full grown lavae measures 20 to 23 mm in length (Plate 3). Moths medium size (Plate 4), smoky in colour, forewings nicely pattern; mesures about 10-12 mm across the wings.

Family : Lymantriidae

***Dasychira mendosa basivitta* (Walker)**

Caterpillars light brown, reddish brown head; prothorax banded whitish interspersed with tubercules bearing tufts of long hairs alongwith black much larger than former such long projecting laterally; body with lateral light orange stripe along the length; first to fourth abdominal dorsum provided with bright yellow cushion like elevation with small fine hairs; mesothorax and metathorax and all other abdominal segments with tufts of long grey hairs; full grown larvae measures 30-35 mm in length (Plate 3).

Moths medium size (Plate 4); forewings greyish-brown with dark markings and a patch in the centre, hindwings pale grey; antennae of males bipectinate and that of females serrate; wing expanse of males 26 to 28 mm where as females 34 to 38 mm.

***Euproctis scintillans* (Walker)**

Caterpillars deep brown with brownish head; each body segment provided with long and short black and white tufts of hairs arising from dorsolaterally placed tubercules; two whitish orange colour mid dorsal line on third to seventh abdominal segment, the first and second mid dorsal abdominal segment provided with median cushiony hump like elevation encircled by white and orange colour markings, all other abdominal tubercules blackish; prolegs enlarged and prominent with semicircular crochets; full grown caterpillars measure 20 to 25 mm (Plate 3).

Moths medium size; forewings yellowish with wavy lines covered with dark scales all over the wings excepting the outer-margin, hind wings yellowish; females larger than males; antennae of males bipectinate where as females serrate; eyes black and prominent; wing expanse 15 to 20 mm and 20 to 25 mm in case of males and females (Plate 4).

***Lymantria ampla* (Walker)**

Caterpillars dark greyish; thoracic and abdominal segments with tufts of long greyish hairs excepting the prothorax which having black long hairs on the lateral aspect; full grown caterpillar measures 30 to 34 mm (Plate 3).

Moths medium size (Plate 4), adult females dark grey with black markings on forewings and antennae serrate where as male antennae bipectinate with a greyish spots on underneath whitish forewinig, wing expanse of males 25 to 27 mm that of females 34-37 mm.

Family: Geometridae

***Thalassodes veraria*(Guen)**

General colour green resembling the leaf colour at the early stages and greenish brown when mature, body elongated tappering anteriorly; head rectangular, concoloured with the body, dorsum of the head with two horny bifid projection ; body smooth; spiracles prominent; three pairs of thoracic legs arise from first, second and third segement,the ninth abdominal segment

provided with proleg having strong incomplete crochet, no prolegs on other abdominal segment; ventral part of the body more or less identical to the dorsum. It measures 30-35 mm in length.

Larval locomotion is accomplished by placing the posterior end of the body near the thoracic legs moving then anterior end of the body with a pair of prolegs located at ninth abdominal segment and thoracic legs, thus the larvae progressing in a chracteristics looping fashion, the larvae when disturbed stand nearly erect on the posterior two prolegs and caudal claspers and remain motionless often assume a characteristic pose on the twigs that are mistaken for parts of the dried up twigs or thicker leaf vein.

Moths delicate, colouration green (Plate 4); wings semi-hyaline, forwings and hind wings dorsally green and ventrally whitish green; wing expanse of males 23-27 mm and females 30-35 mm; dorsal aspect of thoracic region greenish; eyes black and prominent.

Family : Gracillarridae

Leaf miner: Unidentified

Larvae small, flattened, cylindrical and agile; full grown larvae pale greenish yellow in colour; head brownish; body smooth and it measures 5 to 6 mm in length.

Moths tiny; silvery white with forewings having brown stripes and conspicuous black spots near apical region; hind and

forewings densely fringed; hind legs long and well developed tibia with numerous hairs; maxillary palp enlarged.

Family:Tortricidae

Leaf webber (unidentified)

General body colour light green, head light yellow; body smooth, slender, slighly tapering anteriorly, mouth parts strong; leg provided with short erect hairs; plicae and spiracles prominent; measures about 14-15 mm in length.

Moths medium size, smoky in colour with nicely pattern forewings, measures about 10-14 mm across the wing (Plate 4).

a) Leaf folder (unidentified)

Young larva orange green, dark green when mature; body cylindrical covered with sparsed dark setae with different length; head prognathous, dark brown with spares setae, mouth parts well developed, epicranial suture prominent,prothoracic shield dark colour; prothoracic leg dark, meso and meta thoracic more or less similar with that of thoracic colouration; spiracles prominent; several dark pigmented hairs present on last abdominal segment, measures about 18-20 mm in length.

Moths medium size, yellowish in colour; fore wing with black markings; measures about 8-10mm across the wings. (Plate 4).

b) Leaf folder (unidentified)

General body colour orange; head hypognathous, black in colour covered with sparse setae, prothoracic shield dark, mouth parts well developed; prothoracic leg dark, plicae prominent, crochet circular, proleg present on 3-6th and 10th segment; measures about 10-12 mm in length.Moths medium size; smoky in colour; fore wings with black markings ; measures about 6-8 mm across the wings.

Family: Psychidae

Bagworm (Unidentified)

General body colour yellowish-green; slender, slightly tapering both ends; head light brown, prothoracic shield light brown having a dark marking in between the first and second thoracic segment, four dark black oval spots on the dorsal aspect of the mesothorax; spiracles small, oval and dark; last segment dark brown modified into a pair of clasper; prothoracic legs dark brown, abodominal leg rudimentary, represented by dark brown oval shaped crochet and placed either end of a transverse cavity; full grown larva measures 5 to 7 mm in length and width at prothorax 1 to 1.5 mm. The larvae construct case and it is formed by bits of leaf and carried about by the larvae, the sclerotized head and thorax project from the case (Plate 3).

Adult males small, greyish with silvery markings on forewings; forewings apically fringed; eyes black and prominent; labial palp enlarged.

Family: Zygaenidae

Trypenophora semihyalina Koll.

Caterpillars brownish red to brick red; flat, cubical, slightly tapering posteriorly and bilaterally symmetrical; each segment bears two pairs lateral and one pair dorsal nipple shaped wart like out growh; mesothoracic lateral out growth bifurcated into two; mouth parts retracted; thoracic leg small, move with a creeping motion; larva when disturbed exude toxic fluid from posteriorly placed dorsal tubercules; full grown caterpillar measures 20-22 mm in length (Plate 3).

Moths greenish black with hyaline spots in the wings and orange band in the abdomen (Plate 4).

Order:Hemiptera

Family: Aphididae

Toxoptera aurantii Bd.F

Apterae,oval,shiny, reddish-brown or black with banded antennae; body length 1.1-2.0 mm.Immatures are brownish, alate are brown-black with a black pterostigma.

Family: Pentatomidae

Coptosoma sp.

Hemisperical,shiny black in colour with a white dot on each side of pronotum and along the lateral margin of the body. Measures about 1.5- 2.0 mm.

Family: Coccidae

***Rastrococcus iceryoides* (Green)**

The flat whitish mealy bugs are often found cluster together in masses on tender shoots leaves (Plate 5). Sometimes these are mistaken as fungal outgrowths. The adult female wingless, flattened oval creature covered with a white mealy powder.

Soft scale (unidentified)

Small flattened, concealed or just protected by a powdery covering. In earlier stages insects pale translucent in appearance and the later stages it becomes opaque and body colour changed to brown.

Hard scale (unidentified)

Minute, transparent,pale brown circular body appeared of mealy scar. Adult female turns from yellow to dark in appearance, insects are often found cluster together in masses on moderately older shoots (Plate 5).

Order: Thysonoptera

Family: Thripidae

***Scirtothrips dorsalis* Hood.**

Slide mounted specimen minute slender bodied; head short, antennae short, 6 segmented inserted on the extreme front of the head; large compound eyes, ocelli well developed, inconspicuous mouthparts on the under surface of the head towards the thorax; thorax and abdomen slender, abdomen tapering to the apex;

Plate 2 COLEOPTERAN PESTS ON MANGO SAPLINGS
Top :Myllocerus discolor Boh.
Middle :Astycus lateralis Fab.
Bottom :(From left) Diapromorpha pallens (F.)
and Aspidolopha melanophthalma Lacord

Plate 3 LEPIDOPTERAN LARVAE AS PEST OF MANGO SAPLINGS
Top :(From left) Dasychira mendosa basivitta(Walker), Lymantria ampla Walker and Trypenophora semihyalina Koll.
Bottom:(From left) Euproctis scintillans Walker, Metachrostis sp. and bagworm(unidentified)

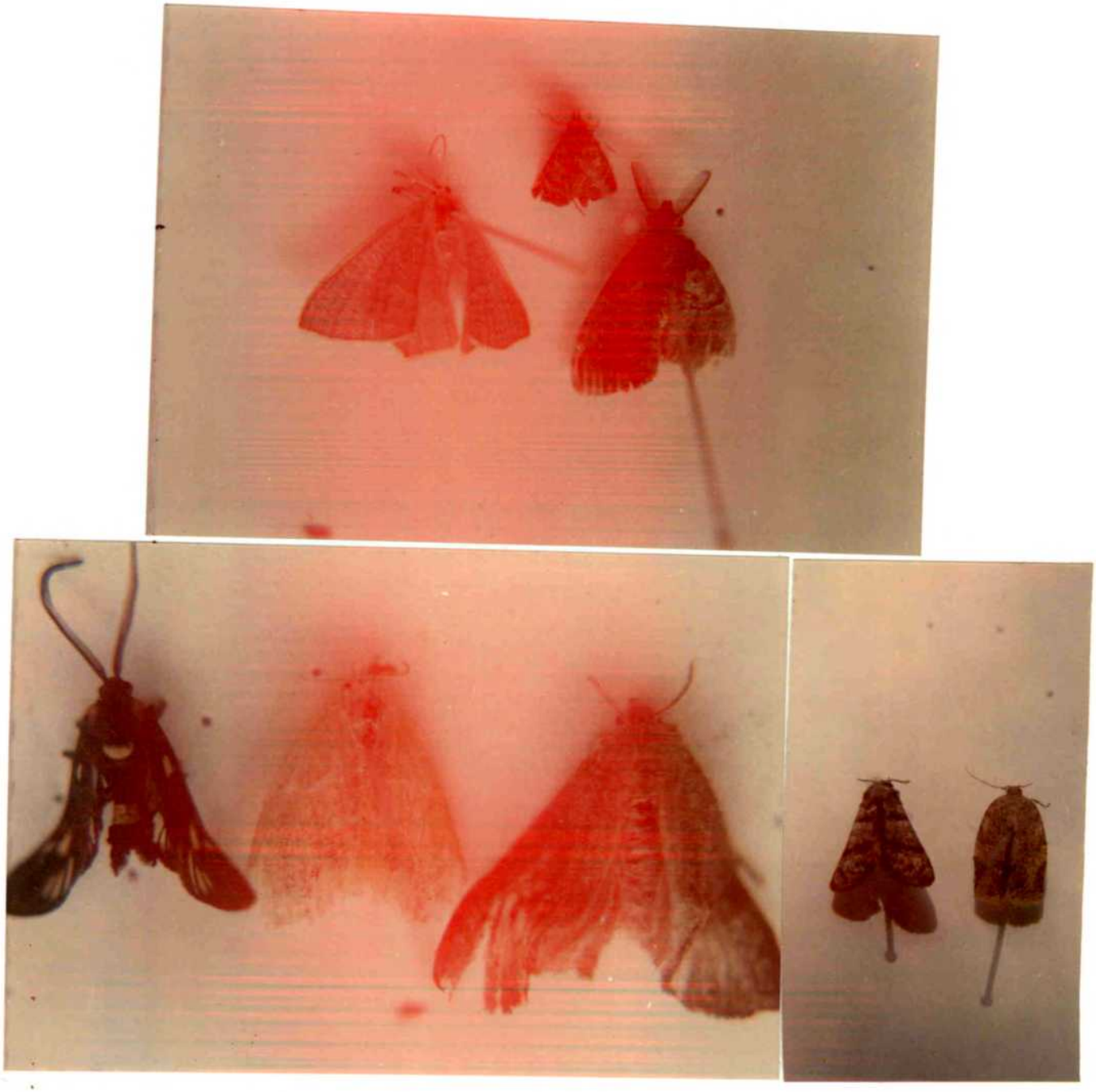


Plate 4 ADULT STAGES OF LEPIDOPTERAN PESTS ON MANGO SAPLINGS
Top :(From left) Thalassodes veraria Guenee, Metachrostis sp. and D.mendosa basivitta
Bottom:(From left) T.semihyalina, E.scintillans, L.ampla leaf webber and leaf folder (unidentified)

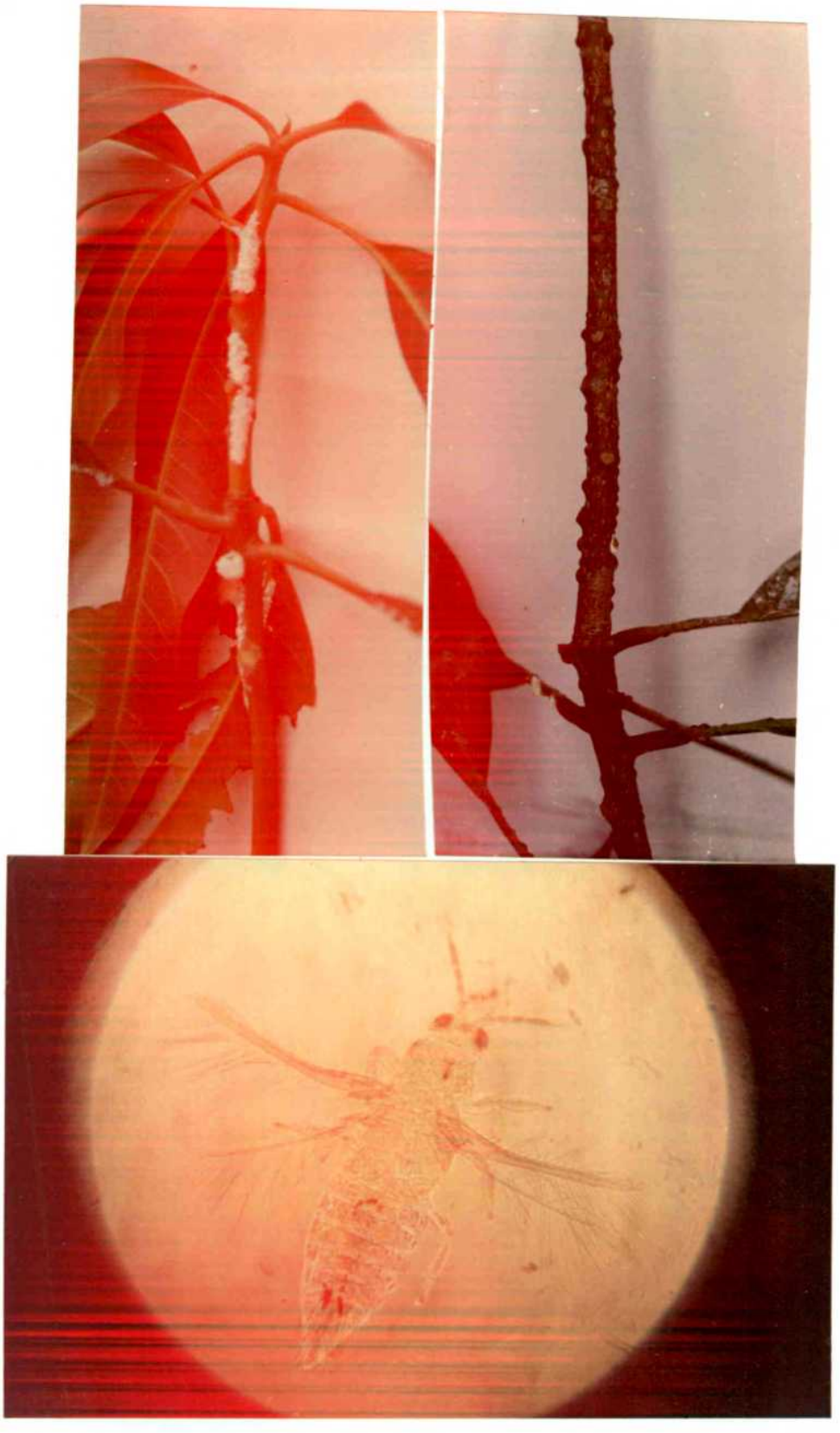


Plate 5 HEMIPTERAN AND THYSONOPTERAN PESTS ON MANGO SAPLINGS
Top :(From left) Rastrococcus iceryoides(Green), hard scale(unidentified)
Bottom : Scirtothrips dorsalis Hood

wings two pairs well developed; front pair often larger, both with a long fringe of fine hair along atleast the hind margin; legs stout,tarsi ending in a blunt tip containing an eversible pad; tip of of abdomen tubular (Plate 5).

Order: Acarina

Family:Tetranychidae

Oligonychus mangiferus **(Rah.& Sap.)**

Females nearly elliptical, abdomen broadly rounded at the posterior end than male.

4.1.2 Damage

Grey weevil

Moderate damage caused by *Myllocerus discolor* Boh. were recorded. The adults of this species were found to feed both on tender and moderately older leaves of the plant by nibbling irregular holes on leaves and in case of severe infestation they consume the entire leaf blade,leaving the midribs only (Plate 6). They preferred feeding on the tender leaves only after these have been completely eaten away do they migrate to the older leaves, where they feed by pinching off the interveinal part of the leaf lamina.

The another leaf weevil *Astycus lateralis* Fabr. was recorded causing minor to moderate damage to nursery mango. Damage by the adult weevils is done by making short holes on the tender leaves.

Leaf cutting weevil

The leaf cutting weevil, *Eugnamptus marginellus* Fst. belonging to family curculionidae was recorded and observed to be a dominant species and responsible for maximum damage to tender foliage flush of mango especially in the nursery stage. Its nature and symptoms of damage caused by female during oviposition and by feeding of both adult male and female are stated under chapter 4.2.

Flea beetle

Minor to moderate damage caused by the chrysomelid, *Monolepta sp.* was registered. The adult beetles were found to skeletonize the tender leaves thus reducing photosynthetic area. At times large number of beetles found feed on the same leaf resulted reduced vigour of the grafts.

Leaf beetle

The two chrysomelid beetles, *Aspidolopha melanophthalma* Lacord. and *Diapromorpha pallens*(F.) were also recorded minor and sporadic damage in nursery mango. The adults were found to feed on laminal part of the tender leaves by making irregular small holes.

Shoot borer

The shoot borer, *Metachrostis sp.* was recorded to be a serious pest causing substantial damage to tender shoot on nursery plants of mango. The freshly hatched larva fed on tender

leaves for a certain period and then bored into midrib of leaf or leaf stalk. There after it came out of the leaf/stalk and entered the tender shoot from apex just below the bracket. It could also bore into the shoot withour entering the midrib of the leaf. The attacked shoot gave a drooping look and the shoot showed wilting. After that the attacked shoot turned black and dried. By this time the larva had already left the infested shoot. The presence of larva could be identified by the excreta sticking at the bored hole in the shoot (Plate 6). The tunnel causd by the larvae varied from 4-8 cm.

Hairy caterpillar

Belonging to family, Lymantriidae,*Dasychira mendosa basivitta*(Walk.), *Euproctis scintillans*(Walk.) and *Lymantria ampla* (Walk) were recorded sometimes posing serious problem to foliage part of nursery mango. Damage to the crop is done by defoliating both young and moderately older leaves due to voracious feeding by the larvae.It was noted that the young caterpillars fed gragariously eating away the green chlorophyll of the leavs leaving behind the net work of veins while mature larvae chewed the leaves from margin inwards.

Looper

The larvae of *Thalassodes veraria* (Guenee) were found to feed on tender and moderately older leaves (Plate 6) devouring the tender growth of the shoots. Larvae resemble twigs in colour and form, when disturbed, the caterpillar straightens at an angle

to the surface to which it is clinging by its hind leg.If it is holding to the stem of plant it then resembles a twig.

Leaf miner

This species was observed to cause minor damage to the foliage of nursery mango. The larva after hatching attacked the dorsal tender leaf by making mines within the upper and lower epidermal layers resulting blister-like patches on them.

Leaf webber and leaf folder

Three different insects belonging to the family Tortricidae were recorded to cause minor damage to the nursery crop.The young larvae folded both the margins of the tender leaves together and thus the nest is formed in which to hide and fed the green matter from within. As a result of feeding, leaves become skeletonised. When the nests become old, they came out from the nests and folded the adjacent tender leaves in the same fashion. The larvae were also found to sandwich 2-3 leaves and fed from within. It was also found that sometimes larvae came out from folded leaves and fed the tender leaves by making more or less circular holes. In severe infestation entire leaves become eaten away leaving only midrib.

The larvae were also found to roll leaves or tie several leaves together with silk to form individual or colonical nests in which to hide. When disturbed, the larvae frequently wringgle backwards from the nest and drop on a silken thread.

Bagworm

The insect species belonging to family Psychidae was recorded to cause damage to the leaves of nursery plants. The caterpillars commonly referred to as bagworm due to peculiarity of living in self made cases which consist primarily of the silk produced by the larvae and leafy matter of various sorts. The mouth of the cases is generally provided with a diaphragm with an aperture in the middle. The larvae protrudes its anterior region including its thoracic legs through this opening and crawls about dragging along its case which is firmly held by the hind end of its body. It feeds on leaves preferring mature leaves and hemispherical cut was noted along the margin of leaves (Plate 6).

Slug caterpillar

Though this insect *Trypenophora semihyalina* Koll. was recorded as a minor pest of mango nursery it occasionally caused substantial loss by gragarious feeding in tender leaves leaving midribs only.

Aphid

Toxoptera aurantii Bd.F was recorded to be one of the important pests of nursery mango. The soft bodied minute greenish yellow slow moving creatures often found in numerous colonies clustering over the tender parts of the plant sucked up the plant sap. Due to sap drainage, the affected plant showed sickly growth.

Stink bug

Coptosoma sp. was only recorded belonging to the family Pentatomidae was found associated with tender shoots of the nursery plants. Very rarely were they found doing any serious damage by sucking cell sap.

Mealy bug

Rastrococcus iceryoides (Green) was recorded to be the potential pest species attacking nursery plants. White colonies of nymphs of this species were found on leaves and twigs sucking sap from the places resulting fading out of normal colouration and drying out of affected part. Honey dew secretion of the bugs encouraged growth of sooty mould on leaves.

Soft scale

The scale have the habit of appearing in colonies on tender parts of the plant sucking cell sap and adversely affecting vigorous growth of the plants. The leaves found badly infested exhibited dark blighted appearance. The damage was also activated with the growth of sooty mould. Severe infestations may greatly weaken or even kill the plants.

Hard scale

This is one of the commonest scales doing some serious damage to leaves by sucking sap and turning them pale yellow, there by reducing vitality of the host plant (Plate 6). As a result of attack by this scale young plants suffered more and became wilted. These scales had also the babit of appearing in

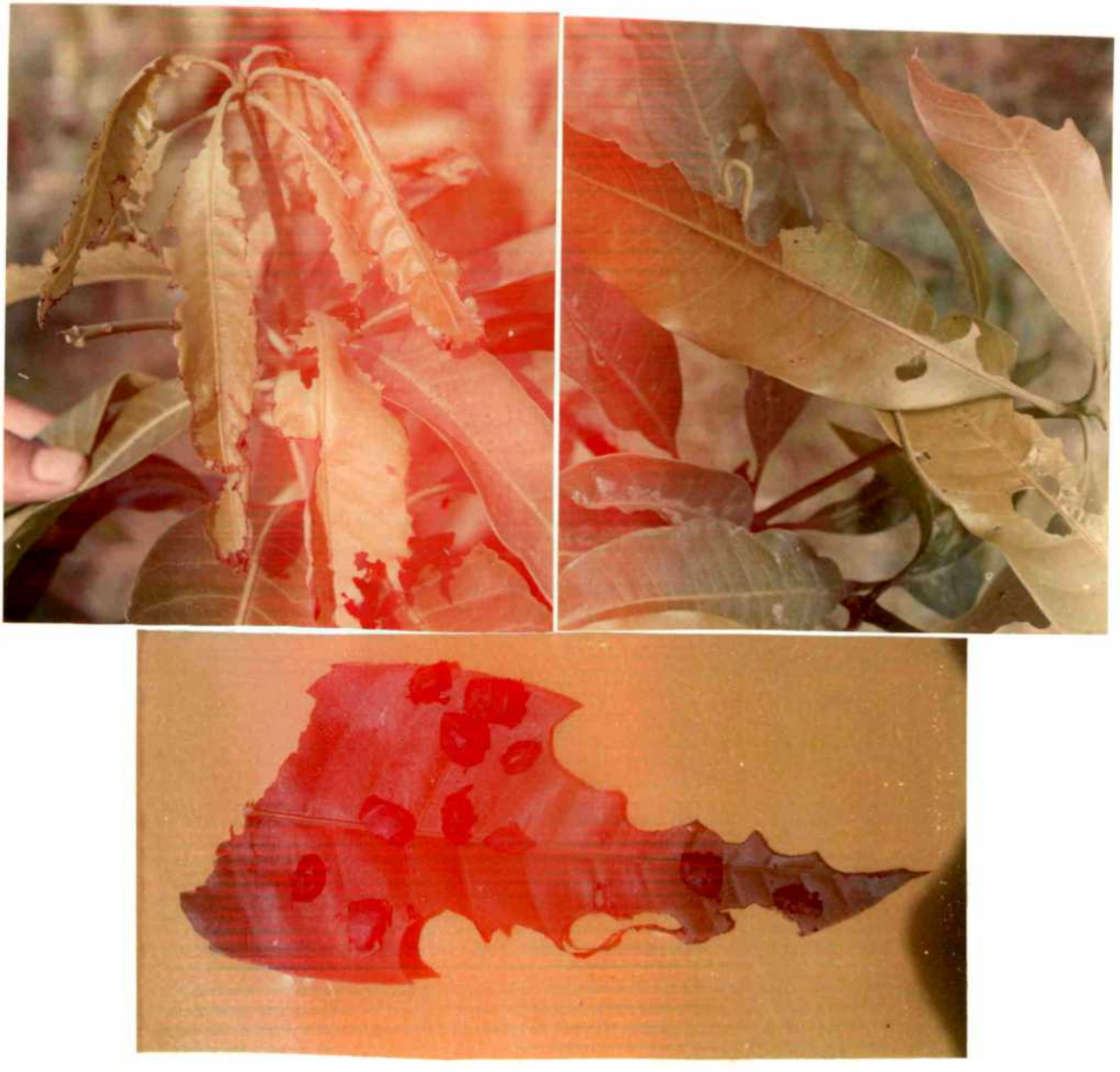


Plate 6 DAMAGE PARTS OF SOME PESTS OF MANGO SAPLINGS
Top : Leaf damaged by M.discolor
and T.veraria
Bottom : Leaf damaged by bagworm

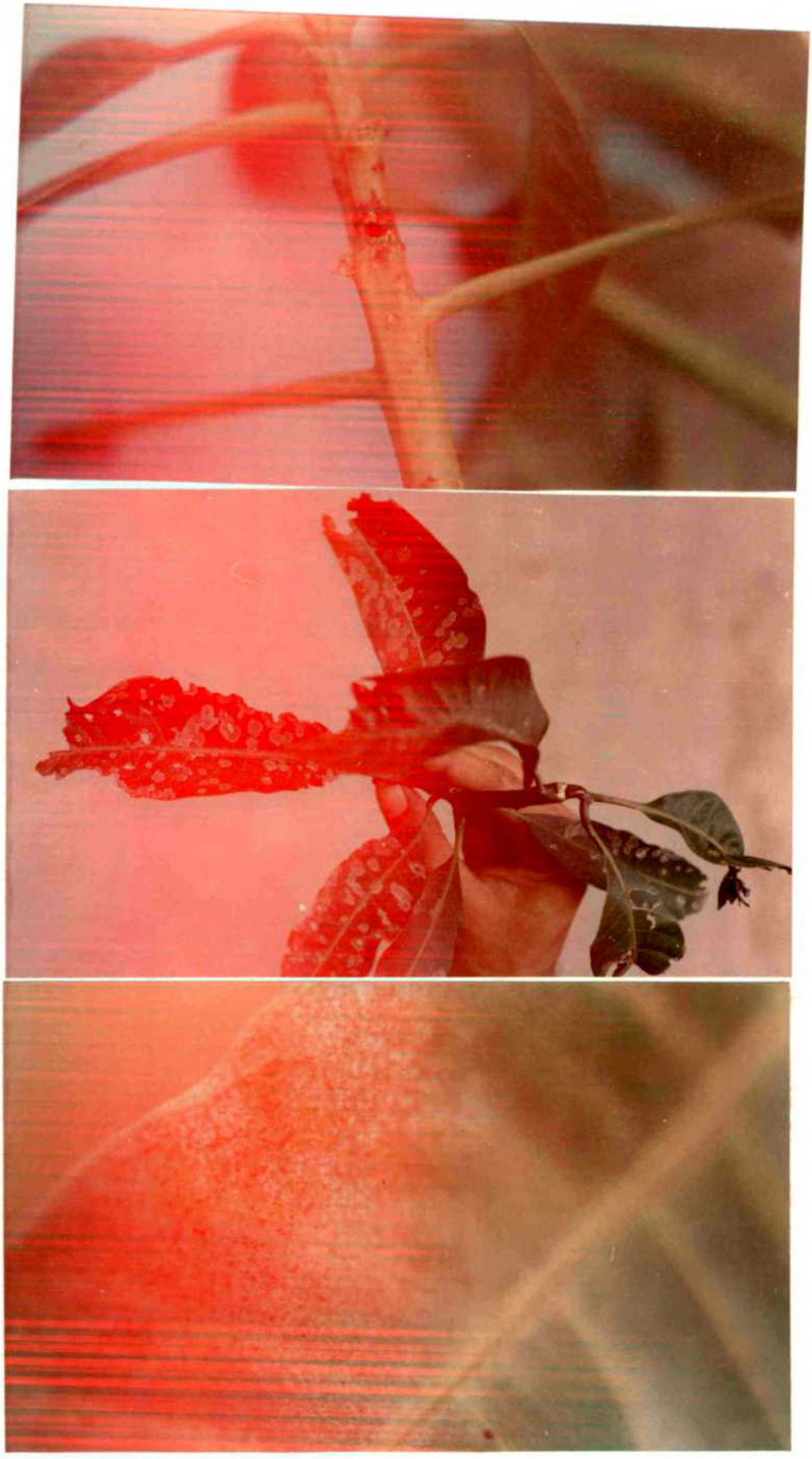


Plate 6 DAMAGE PARTS OF SOME PESTS OF MANGO SAPLINGS
Top : Shoot damaged by Metachrostis sp.
Middle : Leaf damaged by hard scale
Bottom : Leaf damaged by Oligonychus mangiferus(Rah. & Sap.)

colonies on tender parts of the plants.

Thrips

Belonging to this group *Scirtothrips dorsalis* (Hood) was recorded to cause damage by sucking sap along the midrib of the leaf lamina. The nymphs and adults were found congregated on ventral leaf surfaces resulting browning of leaf tips and curling of leaves.

Mite

Oligonychus mangiferus (Rah.& Sap.) is recorded to be one of the limiting agents in successful cultivation of nursery plants. Due to feeding on liberated cell sap caused by laceration the infestation showed minute pale spots on the green leaves (Plate 6).

4.1.3 Incidence of six different pest species

Altogether 23 insect species and one species of mite were observed to be distributed in different periods causing damage to different parts of nursery plants (Table 2). Of the total insect species recorded following six species were considered for taking detailed accounts on the indcidence in order of their first appearance and subsequent population build up as they attack the crop.

Fort nightly observations on the incidence of leaf cutting weevil, *Eugnamptus marginellus*Fst. and grey weevil, *Myllocerus discolor* Boh. (Curculionidae: Coleoptera) during 1993-

1995; thrips, *Scirtothrips dorsalis* Hood (Thripidae: Thysonoptera) during 1993-1994 and weekly observations on the shoot borer, *Metachrostis sp.* (Noctuidae: Lepidoptera) during 1993-1995; bagworm (unidentified) and a mite, *Oligonychus mangiferus*(Rah. & Sap.) (Tetranychidae : Acari) during 1993-1994 revealed that owing to climatic variations in different seasons there existed no consistency with respcet to occurrences and build up of populations of the said pest species under field conditions during the course of investigation.The activities of those pest species are presented below:

4.1.3.1 Leaf cutting weevil, *E.marginellus*

This was usually found to appear in the field on second fortnight of February of 1993,1994 and 1995.

During 1993, its occurrence was recorded under field condition from first fortnight of March. It is seen from Table 3 and Fig.2 that the leaf damage caused by the insect species was recorded to be 3.34 per cent during first fortnight of March, 1993. But no damage was recorded from second fortnight of March to second fortnight of April indicating no adult activities including feeding and breeding on the tender newly emerged leaves available during that period. Then its damage was found to increase gradually from first fortnight of May and the peak of abundance was found during second fortnight of July (76.01 per cent) and then the damage gradually declined from first fortnight of August (57.50 per cent) and quite insignificant damage was

noticed on first fortnight of November (3.84 per cent) following no adult activity during second fortnight of November.

Similar trend was noticed during 1994 that the initial activity by causing leaf damage of 6.90 per cent (Table 3 and Fig.2) was found on first fortnight of March as recorded in previous year. It is to note that from second fortnight of March to second fortnight of April no leaf damage was recorded in the field. It was observed that from first fortnight of May onwards the adults reappeared and gradually the activity increased with the peak (69.34 per cent) during second fortnight of July following gradual decline in the adult activities onwards as has been seen in previous year.

As regards the abundance of leaf cutting weevil, *E.marginellus* analysis of meteorological data revealed that the activities of the insect species was found initiated primarily during first fortnight of March both in 1993 and 1994 when tempetature, relative humidity and rain fall were in the range of 25.04°C ± 7.24°C,65.83% ± 24.49% and zero mm, respectively. But during 1995, the activity of the weevil was not noticed during first fortnight of March when the temperature, relative humidity and rainfall were in the range of 23.51°C±6.64°, 64.77%±24.77% and zero to 0.20mm, respectively.

Results as observed during 1993,1994 and 1995 indicate that the awakening of the activity of *E.marginellus* is related with ideal climatic conditions of environment particularly moder-

Table 3 Incidence of leaf cutting weevil, *E.marginellus* on nursery plants of mango during 1993-1995 (Mean of three replications)

Time of observation	Per cent leaf damage		
	1993	1994	1995
March I	10.99*	15.77	4.05
	(3.34)**	(6.90)	(0.00)
March II	4.05	4.05	4.05
	(0.00)	(0.00)	(0.00)
April I	4.05	4.05	4.05
	(0.00)	(0.00)	(0.00)
April II	4.05	4.05	4.05
	(0.00)	(0.00)	(0.00)
May I	22.03	18.09	4.05
	(13.65)	(9.22)	(0.00)
May II	29.66	22.97	13.90
	(24.13)	(14.74)	(5.38)
June I	35.93	30.48	25.83
	(33.96)	(25.32)	(18.72)
June II	45.47	34.69	31.11
	(50.32)	(31.90)	(26.20)
July I	55.68	52.79	44.05
	(67.69)	(62.90)	(47.86)
July II	61.02	56.78	62.86
	(76.01)	(69.34)	(78.68)
August I	49.64	47.25	51.25
	(57.50)	(53.77)	(60.31)
August II	38.22	37.58	45.50
	(37.78)	(36.72)	(50.37)
September I	30.96	32.21	38.63
	(26.04)	(27.94)	(38.48)
September II	29.15	27.86	28.98
	(23.26)	(21.34)	(22.98)
October I	24.55	22.31	24.31
	(16.79)	(13.99)	(16.49)
October II	17.55	17.81	19.06
	(8.63)	(8.86)	(10.20)
November I	11.99	11.58	13.41
	(3.84)	(3.57)	(5.06)
November II	4.05	4.05	4.89
	(0.00)	(0.00)	(0.27)
December I	4.05	4.05	4.05
	(0.00)	(0.00)	(0.00)
S.Em ±	1.27	1.03	1.49
C.D at 5%	3.648	2.958	4.344

* Angular transformed value
** Figures in the parentheses indicate original mean values
I Indicates first fortnight
II Indicates second fortnight

ate temperature coupled with moderate humidity as prevailed during 1993 and 1994.

It is interesting to note that after primary build up of population during both 1993 and 1994 the pest species disappeared suddenly upto the end of April which may be due to occurrence of premonsoon rain coupled with high temperature during that period.

The general trend in the activity of weevil was not at par with that observed in the two earlier years i.e., 1993 and 1994. Only during second fortnight of May,1995,the weevils began its primary activity causing about 5.38 per cent damage and subsequently it increased reaching the peak during second fortnight of July then the adult activity gradually diminished leading to zero during second fortnight of November. Such build up of population of *E.marginellus* was found similar as has been recorded during two previous years.

From the same Table 3 and Fig.2 it is evident that build up of the population was found started during first fortnight of May,1993,1994 and second fortnight of May,1995 when the temperature, relative humidity and rain fall were in the range of 31.58°C±5.06°C, 71.89%±17.19% and 0-44.0 mm, respectively.

It was further observed that the peak of the activity of the pest species was found during the same period i.e. second fortnight of July in 1993,1994 and 1995 when the temperature,

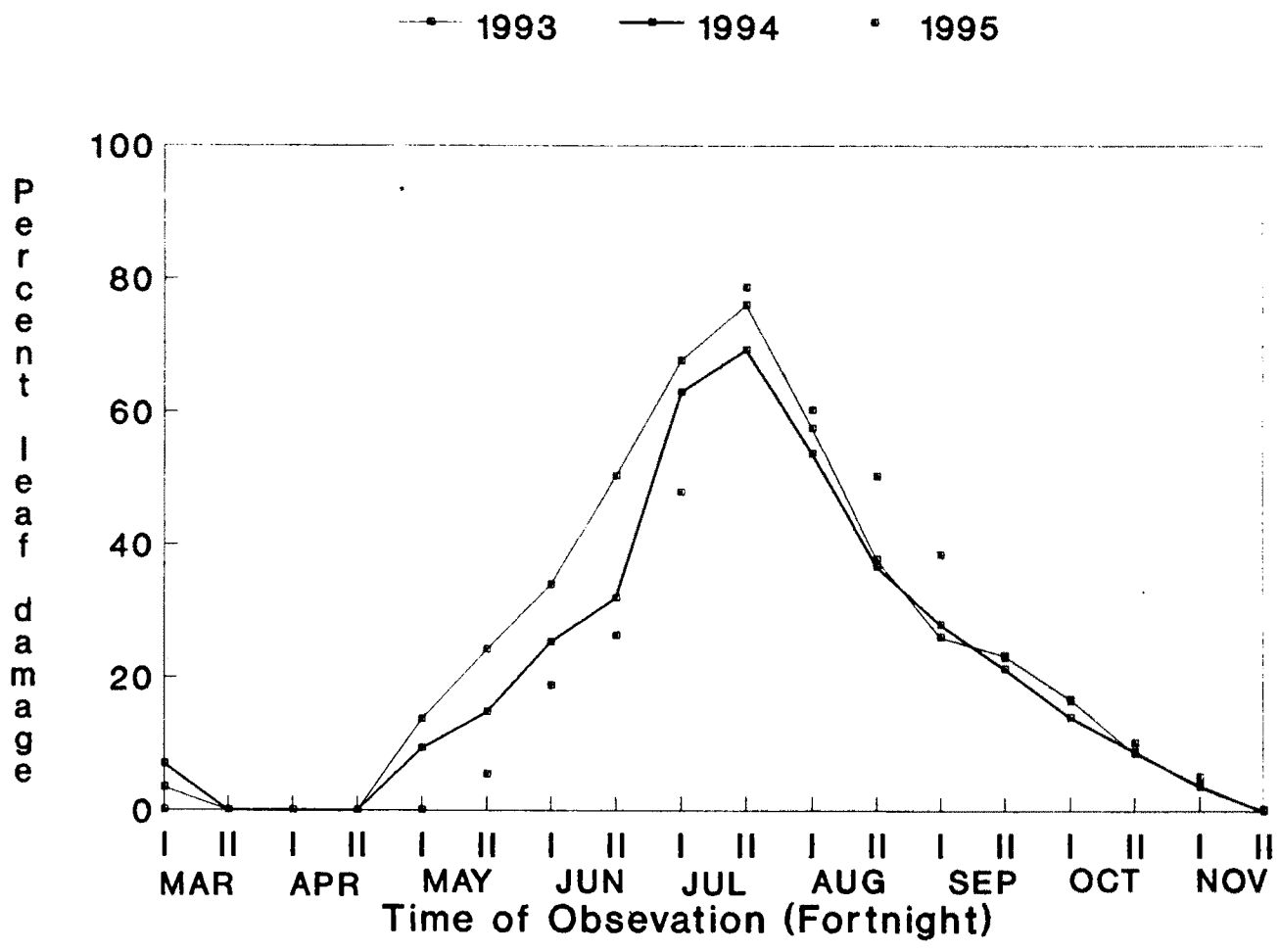


FIG.2 INCIDENCE OF E.marginellus ON NUSERY PLANTS OF MANGO

relative humidity and rain fall were in the range of 29.41°C± 2.86°C, 86.84%±8.48% and 0-37.0 mm, respectively.

Results obtained in the dynamics of *E.marginellus* revealed that the intiation of the activities of the insect species was primarily observed in the early part of March both during 1993 and 1994 when weather is warm and dry. But in the following year i.e. 1995 the pest appeared late i.e. in May. From Fig.2 and Table 3 it is seen that after remaining dormant during winter months it started its biological activity from May and continued to November. In all the three years the general trend of incidence as recorded revealed that after establishing its primary phase of activities under warm and dry weather during May it increased in an exponential fashion reaching the peak during July and declined gradually reaching very low activity during November followed by absence of any feeding or breeding activity from December onward till advent of favourable temperature of about 26°C during warmer months. From the trial conducted during 1993-1995 it was observed that the population of the insect species in terms of damage caused by the adult weevil was found to carry on its activity usually from May onwards in all the three years,although in 1993 and 1994 it appeared quite earlier i.e. in early March in small numbers due to sudden change of climatic condition favourable for initiation in the growth of the population, which crashed down subsequently. From graphical presentation (Fig.2) it is seen that being active for longer riod i.e. May to November the adults caused vital loss to the

crop by significant defoliation of tender apical growth restricting desirable and acceptable height of the nursery plants, thus resulting bare apical shoot and fetching very low market price particularly during July-August when the nursery growers are to sale out the produce for plantation and the plants may not give desired reproductive flush in the following season if infested in post monsoon period i.e. during July-November.

The cloudy condition during June-September coupled with moderate temperature of 27°C±2°C and high humidity was found favourable for increased activity of the leaf cutting weevil, *E.marginellus* as has been confirmed by the data collected during the years 1993-1995 under South Bengal condition.

The leaf cutting weevil once observed to be the minor pest of mango now established itself as one of the major constraints in improving mango cultivation through intensification of dwarf and regular bearing cultivars particularly in the nursery growth in West Bengal. From the investivation carried out for the year,1993-1995 revealed that warm and humid condition prevailing during May to October favours not the growth of crop only but the potentiality to build huge population of the pest species is also greatly influenced.

4.1.3.2 Grey weevil: *M. discolor* Boheman

In nursery mango the weevil is one of the potential pest species causing considerable damage as has been observed

Table 4 Incidence of grey weevil,*M.discolor* on nursery plants of mango during 1993-1995 (mean of three replications)

Time of observation	Per cent leaf damage		
	1993	1994	1995
January I	4.05 *	4.05	4.05
	(0.00)**	(0.00)	(0.00)
January II	4.05	4.05	4.05
	(0.00)	(0.00)	(0.00)
February I	25.10	4.05	8.13
	(17.55)	(0.00)	(1.53)
February II	30.82	7.26	11.40
	(25.76)	(1.10)	(3.42)
March I	24.47	9.65	11.82
	(16.71)	(2.46)	(3.59)
March II	26.13	10.38	12.15
	(19.05)	(2.76)	(3.93)
April I	18.35	13.64	9.37
	(9.42)	(5.43)	(2.15)
April II	17.01	16.47	10.21
	(8.06)	(7.56)	(2.67)
May I	16.45	17.23	10.73
	(7.53)	(8.10)	(2.97)
May II	16.51	23.21	10.25
	(7.64)	(8.33)	(3.26)
June I	25.21	19.66	10.48
	(17.67)	(10.83)	(2.82)
June II	23.98	20.50	14.65
	(16.13)	(11.78)	(6.20)
July I	17.63	20.38	20.23
	(8.70)	(11.63)	(11.46)
July II	19.39	18.55	19.05
	(10.52)	(9.63)	(10.15)
August I	15.93	13.06	17.10
	(7.05)	(4.62)	(8.15)
August II	8.88	6.12	16.34
	(2.23)	(0.71)	(7.42)
September I	4.05	4.05	16.07
	(0.00)	(0.00)	(7.19)
September II	4.05	4.05	14.09
	(0.00)	(0.00)	(5.48)
October I	4.86	4.05	14.85
	(0.26)	(0.00)	(6.14)
October II	6.31	9.25	10.86
	(0.79)	(2.09)	(3.07)
November I	8.74	9.51	11.03
	(1.81)	(2.24)	(3.23)
November II	8.15	9.42	10.47
	(1.53)	(2.19)	(2.81)

Table 4 (Contd.)

Time of observation	Per cent leaf damage		
	1993	1994	1995
December I	5.54	7.05	9.16
	(0.48)	(1.01)	(2.05)
December II	4.05	4.05	4.05
	(0.00)	(0.00)	(0.00)
S.Em±	0.9788	0.8275	0.9457
C.D.at 5%	2.7919	2.3626	2.6973

* Angular transformed value
**Figures in the parentheses indicate original mean values

from the field studies for three years i.e. 1993,1994 and 1995. It is seen from Table 4 that the insect species present in the field throughout excepting in the winter month of December and January. From the investigation carried out for three years it revealed that the occurrence of the pest species determined in terms of damage caused, showed no consistency. In 1993 it started its activity during February (17.55 to 25.76 per cent) when the temperature, relative humidity and rain fall were in the range of 23.29°C±7.29°C, 69.85%±21.37% and zero mm, respectively and remained active during March (16.71 to 19.05 per cent) when the temperatur,relative humidity and rainfall were in the range of 25.45°C±7.31°C, 65.48%±19.94% and 0-39.8 mm, respectively, then it gradually slowed down its activity from April-May(9.42 to 7.64 per cent), at that time the temperature, relative humidity and rainfall were in the range of 29.78°C±5.34°C, 73.04%±12.59% and 0-30.10 mm, respectively.

In the following month i.e. in June the activity was considerably increased (17.67 per cent) with gradual decrease in July (8.70 to 10.52 per cent) and August (7.05 to 2.23 per cent) and again sharp fall leading to zero damage in September. After restoring its very insignificant activity during October-November (0.26 to 1.53 per cent) and early part of December (0.48 percent) the insect dis appeared from mid December.

In 1994, the pest species began its primary activity causing insignificant damage during second fortnight of February

and remained active upto first fortnight of July (1.10 to 11.63 per cent) when the temperature , relative humidity and rainfall were in the range of 28.78°C±4.85°C,75.48%±16.18% and 0-53.50 mm, respectively, then it gradually slowed down its activity from second fortnight of July to August (9.63 to 0.71 per cent) when the temperature, relative humidity and rain fall were in the range of 28.77°C±3.42°C,88.84%±7.03% and 0-24.0 mm and again there was sharp fall leading to zero damage in September and early part of October. After restoring its very insignificant activity during mid October to early part of December (2.09 to 1.01 per cent) the insects were found to disappear from mid December.

In 1995 the insect started its activity during February with a very insignificant damage (1.53 to 3.42 per cent) when temperature, relative humidity and rain fall were in the range of 21.26°C±6.74°C,72.88%±22.39% and 0-31.10 mm,respectively and remained active during March (3.59 to 3.93 per cent) when the temperature, relative humidity and rainfall were in the range of 26.10°C± 6.8°C,67.41%±17.72% an 0-6.4 mm, respectively. Then it gradually slowed down its activity from April to early part of June (2.15 to 2.82 per cent) with sharp increase from mid June to early part of July (6.20 to 10.15 per cent), when the temperature, relative humidity and rainfall were in the range of 31.62°C±6.28°C,71.88%±10.53% and 0-80.40 mm, respectively. The activity of the insect was found to decrease from mid July to early part of December (10.15 to 2.05 per cent) and the insect

disappeared from mid December.

The three years data on the maximum population build up of *Myllocerus* indicate that ideal climatic conditions responsible for the higher incidence of this pest were comparatively moderate temperature , adequate relative humidity and low rain fall.

4.1.3.3 Thrips: *S.dorsalis*

It is seen from Table 5 that in 1993, the pest appeared first during first fortnight of February (9.83 thrips/plant) when the temperature, relative humidity and rainfall were in the range of 21.88°C±7.11°C, 69.89% ± 23.56% and zero mm, respectively and remained in the field upto first fortnight of July. Highest population was found during first fortnight of March (24.22 thrips/plant) when the temperature, relative humidity and rainfall were in the range of 24.56°C±7.77°C, 64.9%± 27.9% and zero mm, respectively and the lowest (0.29 thrips/plant) during first fortnight of July when the temperature,relative humidity and rainfall were in the range of 29.64°C±3.29°C, 88.80±6.0% and 0-45.0 mm, respectively.

In 1994, the population was noted during second fortnight of February (12.19 thrips/plant) as depicted in Table 5 when temperature, relative humidity and rainfall were in the range of 22.47°C±5.82°C,70.93%±22.85% and 0-22.6 mm, respectively. Highest population was noted during first fortnight of March hen the temperature, relative humidity and rainfall were in the

Table 5 Incidence of thrips,*S.dorsalis* on nursery plants of mango during 1993-1994 (mean of three replication)

Time of observation	Number of thrips per plant	
	1993	1994
February I	1.03* (9.83)**	0.00 (0.00)
February II	1.16 (13.49)	1.12 (12.19)
March I	1.40 (24.22)	1.28 (18.09)
March II	1.30 (19.05)	0.96 (9.04)
April I	1.14 (12.83)	0.66 (8.07)
April II	1.04 (9.97)	0.86 (6.33)
May I	0.67 (8.32)	0.68 (3.85)
May II	0.90 (6.89)	0.42 (2.28)
June I	0.78 (5.12)	0.27 (0.85)
June II	0.32 (1.08)	0.09 (0.23)
July I	0.10 (0.29)	0.00 (0.00)
S.Em±	0.0927	0.1138
C.D.at 5%	0.2721	0.3386

* Log transformed value
**Figures in the parentheses indicate original mean values

range of 25.53°C±8.72°C, 64.90%±27.9% and zero mm, respectively as observed during earlier year and the lowest (0.23 thrips/ plant) during second fortnight of June when the temperature, relative humidity and rainfall were in the range of 28.97°C±2.71°C,90.0%±5.93% and 0-16.20 mm, respectively.

Results of the studies showed that *Scirtothrips dorsalis* Hood was very sensitive to climatic conditions for their first appearance as well as high population build up. Moderate temperature coupled with adequate humidity during February and March was observed to be conducive for maximum multiplication while continuous rain during monsoon period was found unfavourable for population growth of the thrips.

4.1.3.4 Shoot borer: *Metachrostis sp.*

As regards incidence of the shoot borer in terms of population and shoot damage it was noted that the larval population was found scatterly distributed in nursery plants causing moderate shoot damage. During the course of investigation weekly observation on larval population and shoot damage were taken in 1993-1995.

It is seen from Table 6 that the initial population in 1993 was recorded during fourth week of June (0.066 per plant) with a peak population during third week of July (0.466 per plant) when temperature, relative humidity and rainfall were in the range of 29.41°C±2.66°C, 87.10%±6.77% and 0-118.40 mm, re-

Table 6 Incidence of shoot borer, *Metachrostis sp.* on nursery plants of mango during 1993-1995 (mean of three replications)

Time of observation (week)	Number of larva per plant			Per cent shoot damage		
	1993	1994	1995	1993	1994	1995
June III	0.00*	0.117	0.04	4.05♦	8.03	9.59
	(0.00)**	(0.04)	(0.107)	(0.00)♦♦	(1.70)	(2.84)
June IV	0.026	0.143	0.10	8.05	11.92	14.48
	(0.066)	(0.106)	(0.267)	(1.70)	(3.77)	(5.83)
July I	0.107	0.16	0.137	13.89	14.61	17.94
	(0.280)	(0.16)	(0.373)	(5.29)	(5.87)	(9.03)
July II	0.143	0.145	0.117	16.95	16.94	18.66
	(0.413)	(0.386)	(0.32)	(8.03)	(7.99)	(9.73)
July III	0.167	0.157	0.107	18.16	19.06	19.92
	(0.466)	(0.440)	(0.293)	(9.23)	(10.16)	(11.11)
July IV	0.11	0.103	0.16	14.57	16.14	17.87
	(0.293)	(0.280)	(0.453)	(5.86)	(7.26)	(9.03)
August I	0.06	0.18	0.11	12.26	13.12	14.35
	(0.146)	(0.213)	(0.293)	(4.24)	(4.68)	(5.65)
August II	0.083	0.16	0.123	11.89	13.51	12.24
	(0.213)	(0.16)	(0.333)	(3.75)	(4.99)	(3.99)
August III	0.037	0.167	0.08	11.67	11.91	11.92
	(0.093)	(0.04)	(0.2)	(3.63)	(3.78)	(3.81)
August IV	0.007	0.057	0.047	8.59	10.87	10.23
	(0.013)	(0.013)	(0.12)	(1.75)	(3.05)	(2.66)
September I	0.05	0.00	0.037	8.03	8.76	9.09
	(0.12)	(0.00)	(0.093)	(1.62)	(1.86)	(2.02)
September II	0.017	0.00	0.037	5.78	5.34	6.91
	(0.04)	(0.00)	(0.093)	(0.57)	(0.40)	(0.96)
September III	0.00	0.00	0.017	4.05	4.05	6.20
	(0.00)	(0.00)	(0.04)	(0.00)	(0.00)	(0.68)
September IV	0.00	0.00	0.037	4.05	4.05	8.35
	(0.00)	(0.00)	(0.093)	(0.00)	(0.00)	(1.65)
October I	0.00	0.00	0.023	4.05	4.05	7.47
	(0.00)	(0.00)	(0.053)	(0.00)	(0.00)	(1.23)
October II	0.00	0.00	0.01	4.05	4.05	5.18
	(0.00)	(0.00)	(0.027)	(0.00)	(0.00)	(0.39)
S.Em±	0.0209	0.0736	0.0202	0.9807	0.7919	1.0853
C.D.at 5%	0.0613	N.S.	0.0582	2.8764	2.3115	3.1278

* Log transformed value
** Figures in the parentheses indicate original mean values
♦ Angular transformed value
♦♦ Figures in the parentheses indicate original mean value

spectively where as their activities were noted during third week of June both in 1993 and 1994 (0.04 and 0.107 per plant) with peak population (0.440 per plant) during third week of July in 1994 as recorded in 1993 and in 1995 it peak population was observed to 0.453 per plant during fourth week of July. The temperature, relative humidity and rainfall were in the range of 29.09°C±2.81°C, 92.46% ±3.26% and 0-48.0 mm in 1994, 29.88°C± 2.62°C, 93.21%±4.62% and 0-80 mm in 1995, respcetively.

The population of the insect species were found to decrease from fourth week of July-second week of September (0.293-0.04 per plant) leading to zero population from third week of September in 1993 when temperature, relative humidity and rainfall were in the range of 28.40°C±2.65°C,82.65%±10.45% and 0-120.0 mm, respectively where as in 1994 the population was found to decrease from fourth week of July-fourth week of August and the insect disappeared from first week of September when the temperature, relative humidity and rainfall were in the range of 30.21°C±3.81°C, 93.20± 4.03% and 0-22.40 mm, respectively.

In 1995, lower population was recorded from first week of August but their activity was remained in the field for longer period i.e. upto second week of October (Table 6) when the temperature, relative humidity and rainfall were in the range of 27.94°C±3.39°C,88.91%±7.35% and 0-105.40 mm, respectively, after that it disappeared.

It is seen from Table 6 and Fig 3 that their population

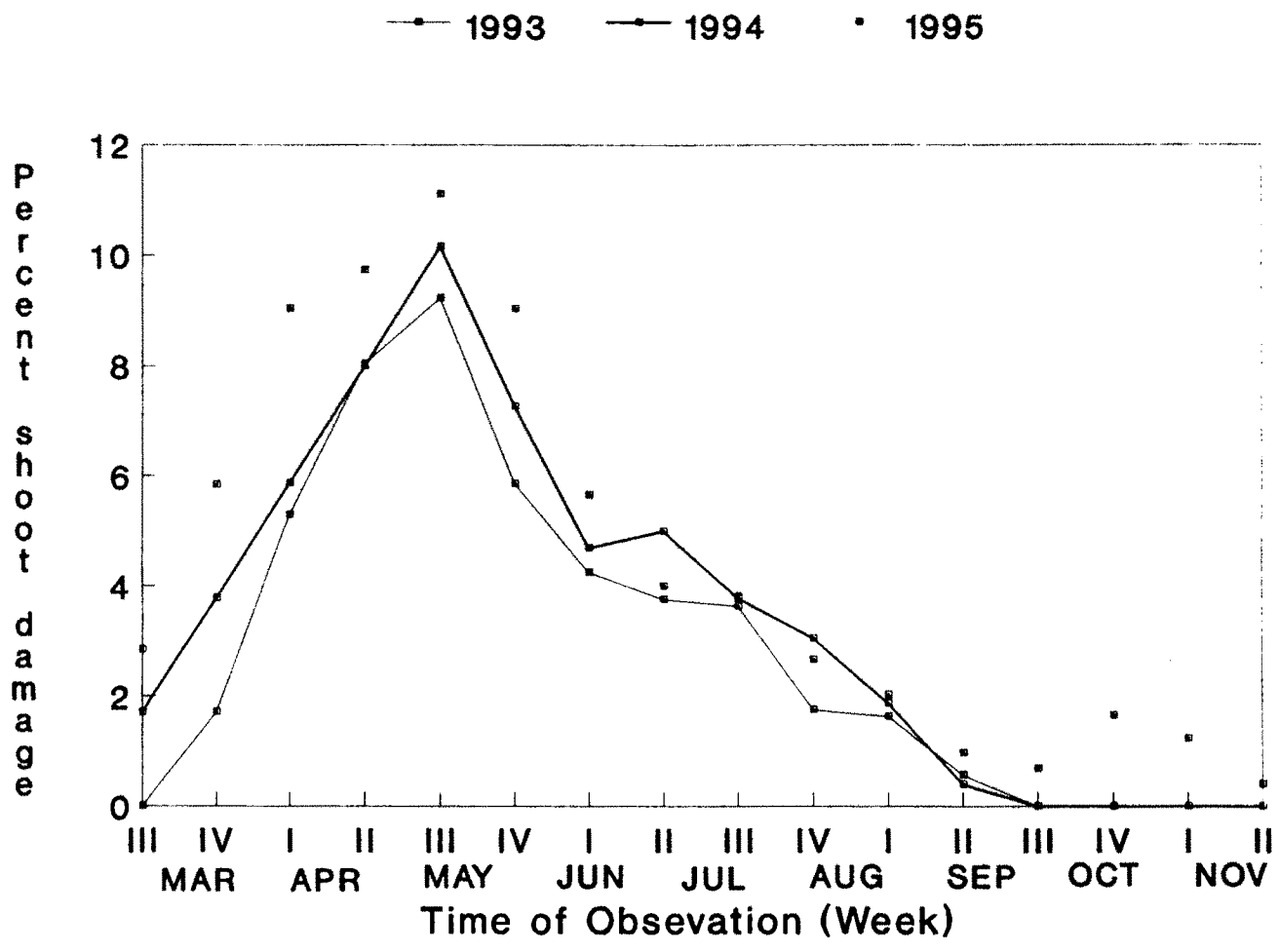


FIG.3 INCIDENCE OF Metachrostis sp. ON NUSERY PLANTS OF MANGO

interms of shoot damage was recorded from fourth week of June 1993,third week of June 1994 and 1995 (1.70,1.70 and 2.84 per cent) as its population was recorded during the same period as mentioned earlier. Highest shoot damage was recorded 9.23 per cent, 11.11 per cent and 10.16 per cent respectively during third week of July during 1993,1994 and 1995. The three years data in terms of population build up and shoot damage, it revealed that favourable climatic conditions responsible for the pest species were cloudy condition during July coupled with moderate temperature and high relative humidity.

4.1.3.5 Bagworm

As regards incidence of the bagworm it was found scatterly distributed in the nursery plants causing moderate damage. During three years study it was recorded only during 1993 and 1994 as shown in Table 7 which in 1995,the activity of insect was almost nil i.e. the number ranging from 2-4 larvae were found distributed during whole of the period in the investigating field.

Results as depicted in Table 7 revealed that the activity of the bagworm was found only for a short period from the end of August to November, 1993 and 1994 i.e. in the post monsoon period when the temperature, relative humidity and rainfall were in the range of 27.91°C±4.10°C,82.36%±11.15% and 0-120.0 mm in 1993 and 28.03°C±5.91°C,79.88%±11.88% and 0-105.40 mm in 1994, respectively. It may be concluded that moderate temperature

Table 7 Incidence of bagworm on nursery plants of mango during 1993-1994 (mean of three replications)

Time of observation (week)	Number of larva per plant	
	1993	1994
August III	0.00*	0.00
	(0.00)**	(0.00)
August IV	0.00	0.26
	(0.00)	(0.81)
September I	0.30	0.33
	(0.99)	(1.13)
September II	0.35	0.34
	(1.24)	(1.20)
September III	0.32	0.32
	(1.17)	(1.13)
September IV	0.36	0.34
	(1.29)	(1.19)
October I	0.32	0.30
	(1.16)	(1.07)
October II	0.21	0.26
	(0.77)	(0.85)
October III	0.20	0.15
	(0.63)	(0.44)
October IV	0.15	0.14
	(0.47)	(0.40)
November I	0.13	0.09
	(0.35)	(0.24)
November II	0.10	0.04
	(0.28)	(0.09)
November III	0.06	0.05
	(0.15)	(0.12)
November IV	0.00	0.00
	(0.00)	(0.00)
S.Em±	0.0636	0.0388
C.D.at 5%	0.1865	0.1133

* Log transformed value
** Figures in the parentheses indicate original mean values

coupled with high humidity and low rainfall are favourable for incidence of the bagworm.

4.1.3.6 Red mite, *O. mangiferus*

Two years (1993-1994) observation on incidence of red mite in relation with the major abiotic factors were investigated in nursery plants of mango and the data as obtained are presented in Table 8 and Table 9.

It is seen from Table 8 that the significant 't' value of the correlation coefficient during 1993, temperature has a positive influence on the mite population. Moderate climatic conditions prevailed during 4th May- 15th June resulted higher rate of mite population.

The non-significant 't' value of the correlation coefficient of relative humidity showed no relationship with the population of mite. While, the amount of rain fall indicated a positive correlation with the mite population. The total amount of rainfall was more from 22nd June-3rd August and it resulted lower incidence of mites. On the contrary the total amount of rainfall was low from 27th April-15th June and it resulted higher incidence of mites. The present investigation revealed that the registered abiotic factors had a cumulative effect on the population dynamics of red mite as indicated in significant 'F' value.

In 1994, it is seen from Table 9 that the regression of

Table 8 Influence of major abiotic factor on relative abundance of mite on nursery plants of mango during 1993

Date of observation	Mean population of mite per leaf	Temperature (°C)			Relative himidity (%)			Total rainfall (mm)
		Max.	Min.	Mean	Max.	Min.	Mean	
13.04.93	0.53	35.91	21.96	28.94	78.71	53.00	65.86	50.60
20.04.93	2.84	35.73	24.60	30.17	81.57	58.57	70.07	0.80
27.04.93	10.20	34.47	24.47	29.47	90.43	62.14	76.29	5.70
04.05.93	29.81	35.35	25.31	30.33	88.42	60.42	74.12	5.80
11.05.93	36.52	35.86	26.76	31.31	86.29	60.14	73.22	26.90
18.05.93	43.32	34.67	25.23	29.95	82.29	52.86	67.58	2.80
25.05.93	52.47	34.80	25.17	29.99	93.29	74.00	83.65	22.80
01.06.93	39.73	33.95	25.34	29.65	92.29	77.14	84.72	39.30
08.06.93	36.67	34.73	26.00	30.37	87.43	59.00	73.22	50.40
15.06.93	37.16	34.23	26.07	30.15	85.71	66.57	76.14	7.60
22.06.93	27.47	31.69	25.56	28.63	95.43	79.57	87.50	57.60
29.06.93	12.75	31.71	27.14	29.43	93.29	77.14	85.22	206.00
06.07.93	14.79	33.56	26.34	29.95	93.86	79.71	86.79	39.20
13.07.93	7.48	32.47	26.39	29.43	93.29	80.43	86.86	98.80
20.07.93	2.19	32.31	27.26	29.79	94.29	82.14	88.22	50.50
27.07.93	1.27	31.83	26.63	29.23	96.00	74.57	85.29	67.60
03.08.93	0.99	32.99	27.20	30.10	92.86	75.43	84.15	23.00

Factors	Values of 'r' (correlation coefficient)	Regression coefficient	values of 't'	Remarks
1. Mite population & temperature (°C)	0.3913*	11.15062	1.6468	Sig.*
2. Mite population & relative humidity (%)	-0.0190	-0.03427	-0.073359	N.S.
3. Mite population & total rainfall (mm)	-0.3885	-0.69043	-2.032	Sig.*

Multiple correlation coefficient (R) = 0.886007706 Sig.*

Multiple regression F-test value = 5.09367 Sig.*

* Significant at 1 % level.

Table 9 Influence of major abiotic factor on relative abundance of mite on nursery plants of mango during 1994

Date of observation	Mean population of mite per leaf	Temperature(°C)			Relative humidity (%)			Total rainfall (mm)
		Max.	Min.	Mean	Max.	Min.	Mean	
29.04.94	3.64	34.41	24.59	29.50	92.43	60.29	76.36	53.50
06.05.94	21.39	37.41	26.06	31.74	88.57	46.14	67.36	2.80
13.05.94	34.69	37.90	26.41	32.16	91.00	50.43	70.72	7.10
20.05.94	23.28	36.13	24.92	30.53	92.29	60.14	76.22	122.00
27.05.94	46.72	32.84	26.34	29.59	93.57	69.86	81.72	17.00
03.06.94	53.61	35.90	27.47	31.69	84.14	61.57	72.86	0.00
10.06.94	31.53	35.26	26.80	31.03	90.86	72.14	81.50	134.40
17.06.94	19.81	31.91	26.29	29.10	97.71	84.43	91.07	43.00
24.06.94	12.66	32.17	26.20	29.19	94.57	81.00	87.79	56.80
01.07.94	8.11	31.51	26.63	29.07	95.71	86.00	90.86	71.80
08.07.94	7.39	32.00	26.36	29.18	95.14	81.71	88.43	90.80
15.07.94	7.94	32.14	26.57	29.36	95.14	83.29	89.22	30.10
22.07.94	4.43	32.01	26.60	29.31	95.14	80.14	87.64	67.00
29.07.94	3.82	33.44	26.90	30.17	95.43	76.29	85.86	12.10
05.08.94	1.39	31.99	26.40	29.20	95.43	85.43	90.43	55.80

Factors	Values of 'r' (Correlation coefficient)	Regression coefficient	Values of 't'	Remarks
1.Mite population and temperature(°C)	0.6372**	9.580299	2.980	Sig.*
2.Mite population and relative humidity(%)	-0.5693**	-1.17458	-2.4967	Sig.*
3.Mite population and total rainfall (mm)	-3.896*	-0.63096	-2.028	Sig.*
	Multiple correlation coefficient (R)= 0.9486775			Sig.*
	Multiple regression 'Ftest' value = 5.09128			Sig.*

* Significant at 1% level
** Significant at 5% level

temperature, relative humidity and rainfall has a positive correlation with the mite population. The maximum population was recorded in 3rd June(53.61/leaf) and 27 th May(46.72/leaf) when the mean temperatures were 31.69°C and 29.59°C, respectively.

It is also noted that the high level of relative humidity and continuous rainfall were prevalent from 10th June-15th August resulting lower rate of incidence of mites. It may be concluded that high relative humidity and high rain fall affect the mite population. The significant 'F' value clearly indicates that these abiotic factors had a cumulative effect on the population dynamics of the mite.

Though over 175 pest species were recorded from mango as reported by Fletcher,1917; Wadhi and Batra, 1964; Vevai, 1969 and Nayar *et al.*,1976. Only a few species namely *D.mendosa basivitta (Syn:D.mendosa*,Butani,1979;Nair 1986 and Mukherjii,1929), *L.ampla* (Butani,1979),*E.scintillans and T.veraria*(Nair,1986), *M.discolor* (Butani,1979;Nair,1986;Marshall,1916 and Hussain *et al.*,1987) *R.iceryoides* (Nair,1986; Ayyar,1924; Mishra,1924 and Singh,1960), *T.aurantii* (Butani,1979), *S.dorsalis* and *O.mangiferus* (Butani,1979), *Metachrostis sp.*(Anonymous, 1903; Hampson, 1912; Palo,1932; Voute,1935;Palo and Garcia,1936; Beeson,1941; Singh, 1957; Gangoli *et al.*,1957;Sen Gupta and Behura,1957; Kushwaha *et al.*, 1964; Ramakrishna and Srivastaba, 1967; Chahal and Singh, 1977 and Nair,1986) and *E.marginellus (Syn; D.marginatus)* (Fletcher,1914;1917; Hutson and Alwis,1934; Butani,1979; Zou,

1982; Yong *et al.*, 1982; Stebbing,1914; Gupta and Singh, 1986; singh, 1978; Bholė *et al.*,1987; Bhole and Dumbre,1989; Nair,1986; Ahmad and Hossain,1979; Dan *et al.*,,1992; Singh and Pandey,1972; Siddiqui and Mathur,1980; Soh and Khoo,1983) were reported associated with mango causing damage on leaves/ shoots. Amongst them *E. marginellus (Syn; D.marginatus)* (Bhole *et al.*, 1987; Bhole and Dumbre, 1989 and Siddiqui and Mathur,1980), *Metachrostis sp.* (Singh,1957; Chahal and Sing,1977 and Butani, 1979) and scales (Singh, 1960 and Butani,1979) were reported associated with the seedlings/nursery stage of mango only. The perusal of literatures available indicates that no detailed work on entomology in the nursery stage of mango has been done so far excepting some causal reports of those mentioned above. Investigation carried out by the present author during the period from 1993 to 1995 under West Bengal condition revealed occurrence of 23 insect species and one mite species in nursery plants of mango as depicted in Table 2. It is of great importance to report that out of the regular pests which appeared during 1993,1994 and 1995 successively, only *E.marginellus* attained major status causing significant reduction in net return. Other regular pests including *M.discolor, Metachrostis sp., S.dorsalis* and *O.mangiferus* and the sporadic like *A.lateralis, A.melanophthalma,D.pallens, Monolepta sp., D.mendosa basivitta, E.scintillans,L. ampla* and *T.veraria* and some unidentified insect species like leaf miner, leaf webber, leaf folder and bagworm were of minor importance as observed during the course of investigation. Another group of pests including *T.*

semihyalina, Coptosoma sp. T. aurantii, R.iceryoides and an unidentified scale insect were recorded in stray instances only. It may be inferred from the investigation that the check list of pests occuring in nursery plants of mango are very scarce and practically no attention has been paid earlier to ascertain the pest spectrum of nursery plant of mango before the present author took the initiative to carry out the programme. It is further mentioned here, that the pests like *A.lateralis, Monolepta sp., A.melanophthalma, D.pallens* and *T.semihyalina* which were recorded infesting mango from West Bengal have not been reported earlier from mango but were reported occurring in crops other than mango (Stebbing,1914; Nair,1986 and Butani, 1979). The evidence as reported by Gupta and Singh,1986 from India that the adults of *D.marginatus(Syn:E.marginellus)* were found to feed on new flushes of leaves both on young and older trees of mango and litchi simultaneously i.e. during June to september. Holecova (1993) from Slovakia reported it in hazel (*Corylus avellana*) during May-June. While the present author recorded *E.marginellus* feeding only on mango from West Bengal region. Bhole *et.al.*, 1987; Singh and Pandey, 1972; Ahmad and Hossain, 1979 and Holecova,1993 reported that *D.marginatus (Syn:E.marginellus)* occured during June -October with peak in July-October.The appearance of *D.marginatus* as reported earlier was found from May (Holecova, 1993) and June (Gupta and Singh,1986;Bhole *et.al.*, 1987; Singh and Pandey,1972 and Ahmad and Hossain,1979) which is in variance with the present observation. Under West Bengal condition the

first appearance of the insect species was recorded immediately after winter months *i.e.*.during end of February as observed in three successive years *i.e.*1993-1995. The persistent of incidence of this pest species as reported by various authors (Gupta and Singh,1986; Bhole *et.al.*,1987 and Holecova, 1993) was under field condition upto October with peak of incidence in July-October (Bhole *et.al.*, 1987) and May-June (Holecova,1993). The present author during the course of investigation recorded the activity of the insect species on nursery plants of mango upto first fortnight of November with peak in July-August which are more or less in agreement with the earlier observation made by Bhole *et.al.*,1987. Regarding damage caused by *E. marginellus* to the new flushes, the present author observed that it was to the extent of about 79 per cent including both leaves cut after deposition of eggs and scrapping of green matter from the leaves of nursery plants of mango. The results which are more or less at par with the data furnished by Gupta and Singh (1986) who reported 90 per cent damage on leaves of new flushes of mango.

M.discolor observed by the present author to be one of regular pests in nursery mango caused damage to the extent of about 26 percent during 1993. The activity of the pest which existed from Februry - early part of December under West Bengal condition is almost similar with the observation made by Singh (1960) who reported the pest found active throughout the year except winter.

Regarding the incidence of shoot borer *Chlumetia transversa* , Butani (1979) reported that the insect was usually found active from August-October on young grafted seedlings and Singh (1957) reported it being active during earlier part of April attacking young saplings of nursery. The present author while studying on the pest species recorded that the pest was found to cause significant shoot damage to the extent of about 11 percent with average of 0.453 larva per plant and observed to be active from end of June to September-October during the course of investigation. The finding as indicated in the present investigation differs from the observations made by the earlier authors mentioned above.

The incidence of thrips was economically important as revealed from the observation (Table 5) recorded from mango saplings under West Bengal condition. No detailed reports on the indicence of bagworm (unidentified), thrips and mite are available excepting the host records from the literatures consulted.

4.2 BIOECOLOGY OF *Eugnamptus marginellus* Fst.(Syn:*Deporus marginatus* Pascoe)

Excepting fragmentary notes practically no work has been done on this weevil, though a common pest in nursery mangoes. The present investigation provides information on the bionomics of the pest species.

4.2.1 Description of different stages and life history

4.2.1.1 Egg and developmental period

Freshly laid egg creamy white and nearly transparent (Plate 7), cylindrical, smooth, both ends rounded and without any distinct markings; dull yellow at the time of hatching, length and width of the eggs ranged from 0.585 to 0.725 mm and 0.260 to 0.320 mm with an average of 0.653 and 0.290 mm, respectively. The developmental period of eggs ranged from 45.00 to 48.00 hours with an average of 46.40 hours under laboratory condition (Table 10 and Table 11).

4.2.1.2 Larva and larval period

As observed in the laboratory rearing *E.marginellus* underwent three larval instar (Plate 7). There were not much differences in the general charcters of the three instars except for the size of the body and head capsule.

The larva on hatching, feed on the dead tissues of cut leaves fallen on the ground by making serpentine mines (Plate 6). The larva made mine and completed its larval stage on the same

Table 10 Developmental period of immature stages of *E.marginellus* under laboratory condition

Stage of insect	Developmental period (hrs)		
	Minimum	Maximum	$(\bar{X})^*$
Egg	45.00	48.00	46.40
Larva			
I	27.00	47.00	32.36
II	25.00	47.00	33.08
III	102.00	120.00	108.80
Prepupa	98.00	137.00	111.24
Pupa	140.00	214.00	169.48

* Mean of 50 observations

Table 11 Measurement of immature stages of *E.marginellus* under laboratory condition

Stage of insect	Length(mm)			Width(mm)		
	Minimum	Maximum	$(\bar{X})^*$	Minimum	Maximum	$(\bar{X})^*$
Egg	0.585	0.725	0.653	0.260	0.320	0.290
Larva						
I	1.69	2.14	1.91	0.74	1.04	0.87
II	3.05	3.26	3.16	1.07	1.26	1.17
III	4.68	5.20	4.90	1.62	1.95	1.75
Pupa	4.03	5.46	4.81	1.04	1.82	1.44

* Mean of 50 observations

laminal side of leaf on which side the egg was deposited.

Full grown larva apodous (Fig.4), moderately stout, thin and pliable, subcylindrical, flat, weakly curved; head exerted, retracted into the prothorax, depressed, lightly pigmented, flat, box-like epicranial suture distinct; antennae one segmented, arise from head capsule near the base of the mandibles; mouth prognathous (Fig.5), labrum light pigmented, mandibles tridentate and concave on their mesal aspect maxillae located immediately ventrad of mandible and laterad to the labium, each maxilla consists of cardo, stipes, two segmented palpus and blunt setigerous mala, labium small with spoon like ligula and two segmented palpi near its base; thorax three segmented with sclerotised pigmented prothorax somewhat longer than the subequal meso and metathorax; spiracles not distinct, body hairs fine; abdomen ten segmented, exhibits transverse folds with two dorsal plicae per segment; one pair distinct elevations or protuberances in each segment; subanal spines arising from tubercules exist on the lateral aspect of caudal segment.

Length and width of the first, second and third instar larvae varied from 1.69 to 2.14 mm, 3.05 to 3.26 mm and 4.68 to 5.20 mm in length and 0.74 to 1.04 mm, 1.07 to 1.26 mm and 1.62 to 1.95 mm in width with average of 1.91 mm, 3.16 mm and 4.90 mm in length and 0.87 mm, 1.17 mm and 1.75 mm in width, respectively.The developmental period of first, second and third instar larvae ranged from 27.00 to 47.00 hours, 25.00 to 47.00 hours and

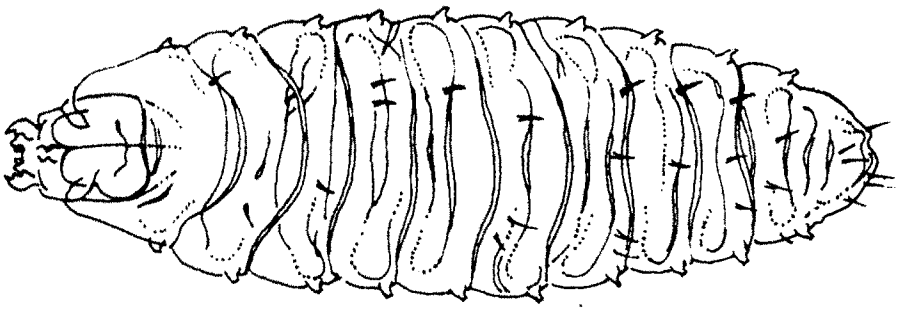


FIG.4 FULL GROWN LARVA OF
E.marginellus

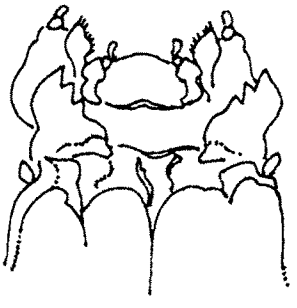


FIG.5 MOUTH PARTS OF FULL GROWN LARVA OF
E.marginellus

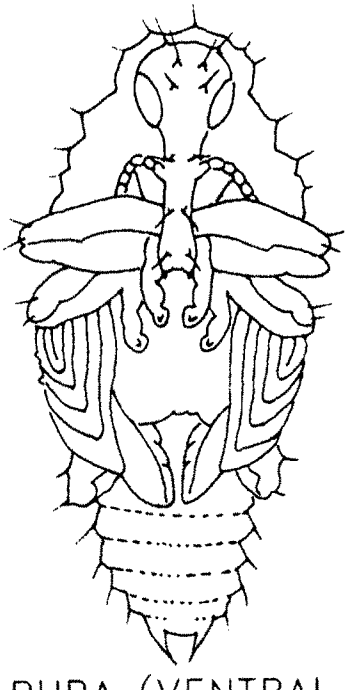


FIG.6 PUPA (VENTRAL VIEW) OF
E.marginellus

102.00 to 120.00 hours with average of 32.36 hours, 33.08 hours and 108.80 hours, respectively as depicted in Table 10 and Table 11.

4.2.1.3 Pupa and Pupation

Newly emerged pupae uniformly whitish yellow (Plate 7). Length and width of the pupa ranged from 4.03 to 5.46 mm, and 1.04 to 1.82 mm with average of 4.81 mm in length and 1.44 mm in width, respcetively (Table 11)

Body one and half times longer than broad, soft with minute sitae; head little longer than broad bearing two pairs of divergent sitae, one pair above eyes, one pair at rear edge of eyes; rostrum with four pairs of sitae, one pair at the juncture of beak and head,one pair at one fourth towards the apex, one pair at half towards the apex and one pair near the apex, beak reaches second tarsal segment of front legs; abdomen with one pair of sitae on each of last two segments near lateral margin (Fig.6).

Before entering into pupal stage, the prepupal larva came out from leaves by boring the mined leaves and entered into soil. On finding a suitable location with loose soil the larva secreted a thin clear fluid from the anus by wriggling and turning about and moistened a layer of soil particle around it. The fluid having gummy held these particles together. The gummy soil formed around the larva a uniform crust thus forming the cocoon

or soil shell. This process of forming shell took few hours and on completion the larva remained inactive for a period ranged from 98.00 to 137.00 hours with average of 111.24 hours (Table 10) as prepupal stage, after that it transformed into pupa.

Under field condition the shells were found normally at a depth of 3 to 5 to cm in soil. These were hemispherical in shape (Plate 7) and measured 8 to 11 mm with an average of 9.88 mm dia.

The pupal period varied from 140.00 to 214.00 hours with an average of 169.48 hours (Table 10). The total life cycle of the weevil from egg stage to time of emergence of adult varied from 437.00 to 613.00 hours with an average of 501.36 hours as shown in Table 10.

4.2.1.4 Adult and adult feeding

General colour of adult including rostrum (anterior to antennal insertion), antennae, tibiae and tarsi shiny dark brown; head, prothorax (above and below) and femora reddish orange(Fig 7); under part showing dilute red; rostrum slender, strongly curved, as long as prothorax gradually dilated towards apex, moderately punctate; antennae elongate slender, inserted well below middle of rostrum, densely clothed with hairs,last funicular segment slender, longer than wide with distinct club; head about as wide as long, sides rounded, elevated along margin of eyes; eyes large, black, highly protuberant; prothorax longitudi-

Table 12 Morphological details of male and female adults of *E.marginellus*

Characters	Male(mm)			Female(mm)		
	Minimum	Maximum	$(\bar{X})^*$	Minimum	Maximum	$(\bar{X})^*$
Body length from head to abdominal tip	4.09	4.35	4.24	4.42	4.55	4.48
Body length from head to elytra	3.90	4.12	4.05	4.16	4.29	4.20
Width of body	1.49	1.75	1.64	1.88	1.98	1.92
Length of snout (immediately above compound eye)	0.85	1.04	0.97	1.17	1.20	1.16
Width of snout	0.26	0.33	0.30	0.33	0.39	0.36
Length of antenna	2.27	2.27	2.27	2.27	2.27	2.27
Length of elytra	2.14	2.37	2.29	2.34	2.53	2.47
Width of elytra	1.49	1.62	1.53	1.62	1.75	1.69
Length of pronotum	0.78	1.00	0.93	0.98	1.10	1.06
Body length from tip of the snout to tip of the abdomen	4.94	5.39	5.21	5.59	5.75	5.64
Number of segement of antenna	11	11	11	11	11	11

* Mean of 50 observations

nally oval, sides smoothly rounded from base to apex, impunctate, little broader than long, narrowest in front and broadest posteriorly, upper surface convex; femora thickened, elytra reddish brown with dark longitudinal stripes(Fig 9), broadest at the shoulder than the prothorax, striae shallow and punctures distinct, not reaching the last abdomenal segment; abdomen light brown,pygidium exposed.

Males are similar in general characters but little shorter in size (Plate 7) . In male the rostrum is shorter and densely punctate throughout with fine short hairs (Fig.8). The adults are active fliers and highly mobile. They are usually in the habit of death feigning i.e. when disturbed they fell down and remained concealed . Measurements of different parts of adult male and female are depicted in Table 12.

Both male and female adults of *E. marginellus* attack the new flushes of leaves of nursery plants of mango. They damage the new leaves by scrapping the leaf tissues (Plate 6). Due to feeding by the weevils irregular short holes are formed on the leaves and such holes coalace to result irregular patch of feeding on the leaves. Due to scrapping of green matter from the tender portions, the leaves become crumpled and curled in wardly causing shedding of attacked leaves. As a result vital functioning in the growth of nursery plants is considerabley affected.

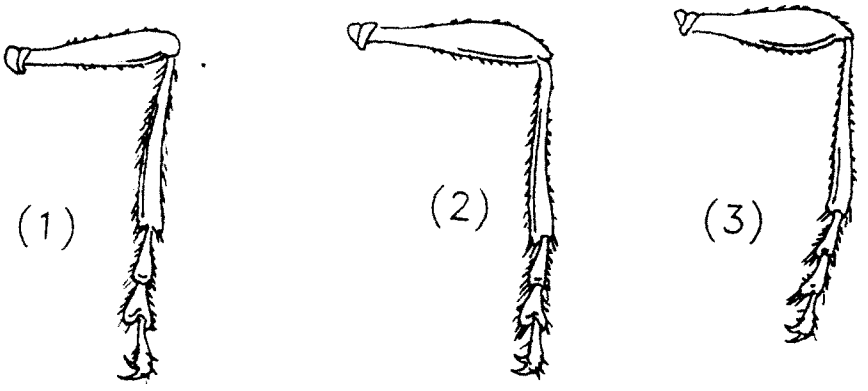


FIG.7 FORE (1),MIDDLE (2) & HIND (3) LEGS OF *E.marginellus*

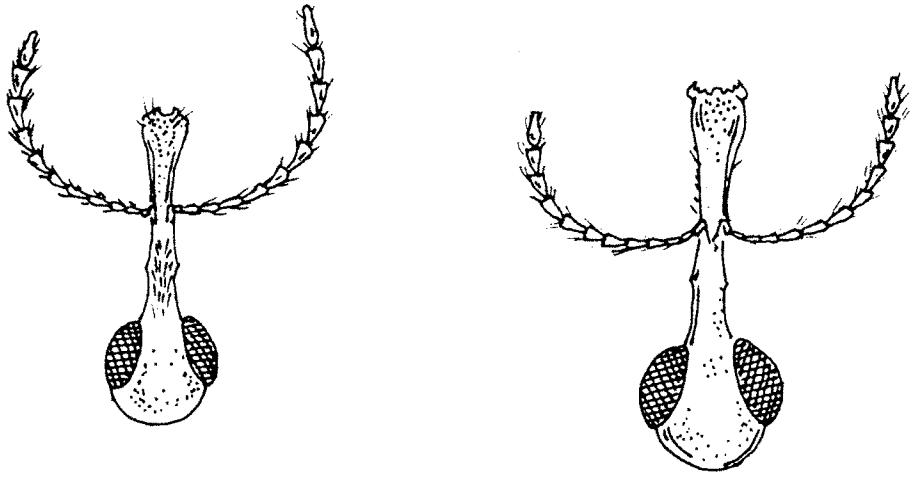


FIG.8 ROSTRUM OF MALE (LEFT) AND FEMALE (RIGHT) OF *E.marginellus*

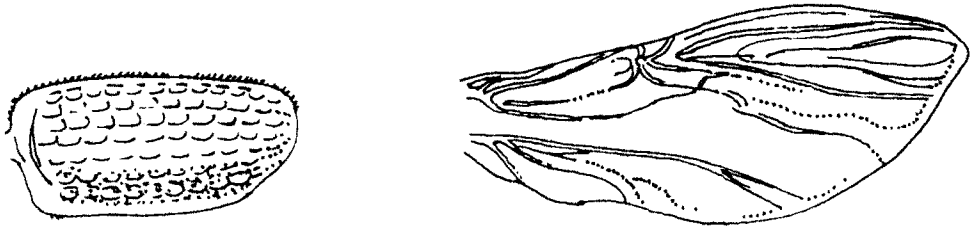


FIG.9 FORE (LEFT) & HIND (RIGHT) WING OF *E.marginellus*

4.2.1.5 Sexual dimorphism of *E.marginellus*

Observation on the morphological variation amongst the adult males and females within the population of *E.marginellus* indicated differences in width of the tip of snout as well as the length of snout suggesting thereby existence of sexual dimorphism. On the basis of this differences particularly the difference in the width of the tip of snouts of the adults within the population were placed under two distinct groups,

i> adults with wide rostral tip

ii> adults with uniformly narrow rostral tip

For confirmation of sexes on the basis of their reproductive organs, fifty such adults of each categories were dissected and it was observed that adult with wider rostral tip were females where as adults with narrow rostral tip were turned out to be males. Cause of the difference in the wideness of the rostral tip of female was assumed to be due to effectively developed slightly protruding mandibles required for making pouch to deposit egg along the midrib and cutting leaf base particularly in case of female and the size of the width was recorded to be 20.00 per cent increased over males.

It was further observed that the rostrum, body length, width of the body, length and width of elytra were 19.59 per cent, 5.66 per cent, 17.07 per cent, 7.86 per cent and 10.46 per cent larger over males, respectively.

It was also observed under binocular microscope that the rostral punctàtion in case of males are more per linear unit than that of females giving the rostral surface a smooth appearance.

4.2.2 Adult behaviour

4.2.2.1 Mating

The leaf cutting weevils, *E.marginellus* freely mate both in the field and in the captivity. Mating usually takes place 2-3 days after adult emergence. During mating, the male mounted over the female keeping its body towards the head of the female (Plate 8) and hooked the claws of the fore and hind legs by the side of the female elytra. While the hind legs of the male were on the substratum to make her immovable in case the female is disturbed. The time taken for mating as observed under field condition ranged from 15 to 40 minutes. Frequent mating usually took place depending upon the willingness of the female. During mating fighting between single male and mating male was also common.

4.2.2.2 Place and mode of egg laying

The gravid female wondered for sometime on the dorsal surface of the tender leaf and finally came to rest at the midrib towards the laminal base leaving a space of about 1.3 cm to 8.0 cm from petiole. With the help of sharp cutting mouth parts located at the tip of the snout the female made a small 'C'

shaped pouch by inserting full length of rostrum (Plate 8) to an average depth of about 1.16 mm at the side of the midrib and later with drew snout and turned about bringing the ovipositor over the puncture (Plate 8). The cylindrical genital capsule was then pushed through the pouch upto the depth previously made by the rostrum and deposited egg singly in each pouch. Soon after deposition of egg, it again turned round and repaired the opening of the ovipositional slit with the help of exudation coming out of the pouch. The sticky oozed fluid dried up quickly to form covering at the mouth of the pouch, so that the egg got full protection against hazards. This appeared as brownish spot.

It was also noted that the female had the habit of deposition of eggs right or left alternately alongside the midrib starting from base of leaf towards tip. At times the female was also found to deposit eggs on the midrib at the ventral aspect.

Immediately after completion of egg laying, the female adult made an inscision first on the midrib of the same leaf about 1.3 to 8.0 cm above the petiole as mentioned earlier and then cut the laminal part along that particular point of inscision on either side (Plate 8), resulting scissor like cutting (Plate 6). This characteristic damage symptom ususally confirmed the incidence of *E.marginellus* under field condition. In rare occasion, the female cut the leaf ventrally and also it made an inscision on the midrib only before deposition of eggs. The egg deposited leaf then fell on the ground facilitating the newly

Plate 6 DAMAGE PARTS OF SOME PESTS OF MANGO SAPLINGS

Top :(From left) Leaf damaged due to scrapping of green matter by Eugnamptus marginellus Fst. and leaves mined by grubs of E.marginellus.

Bottom :Scissor like cutting of leaves by E.marginellus

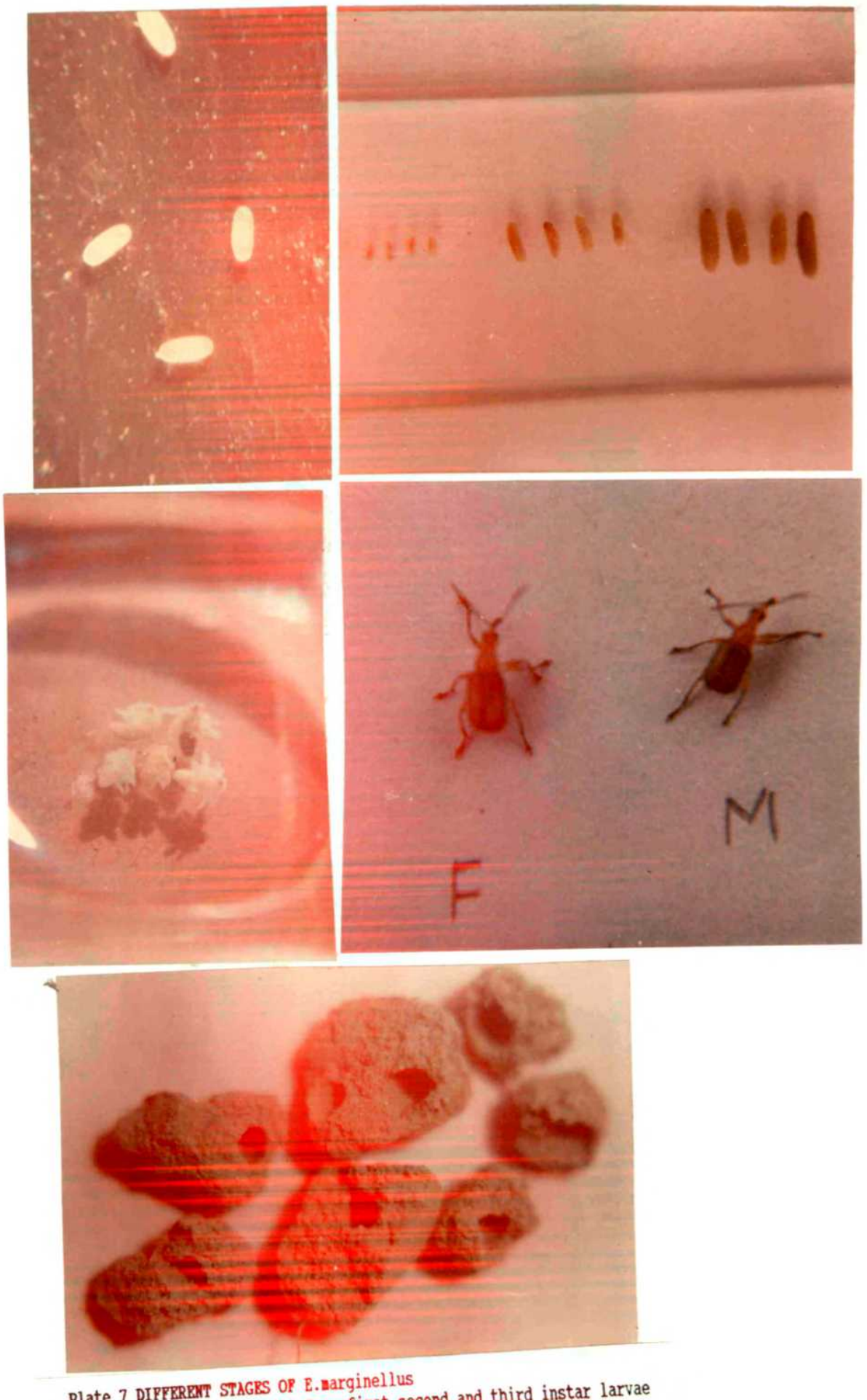


Plate 7 DIFFERENT STAGES OF E.marginellus
Top :(From left) Eggs;first,second and third instar larvae
Middle :(From left) Pupae; female and male adults
Bottom :Pupae within earthen shell

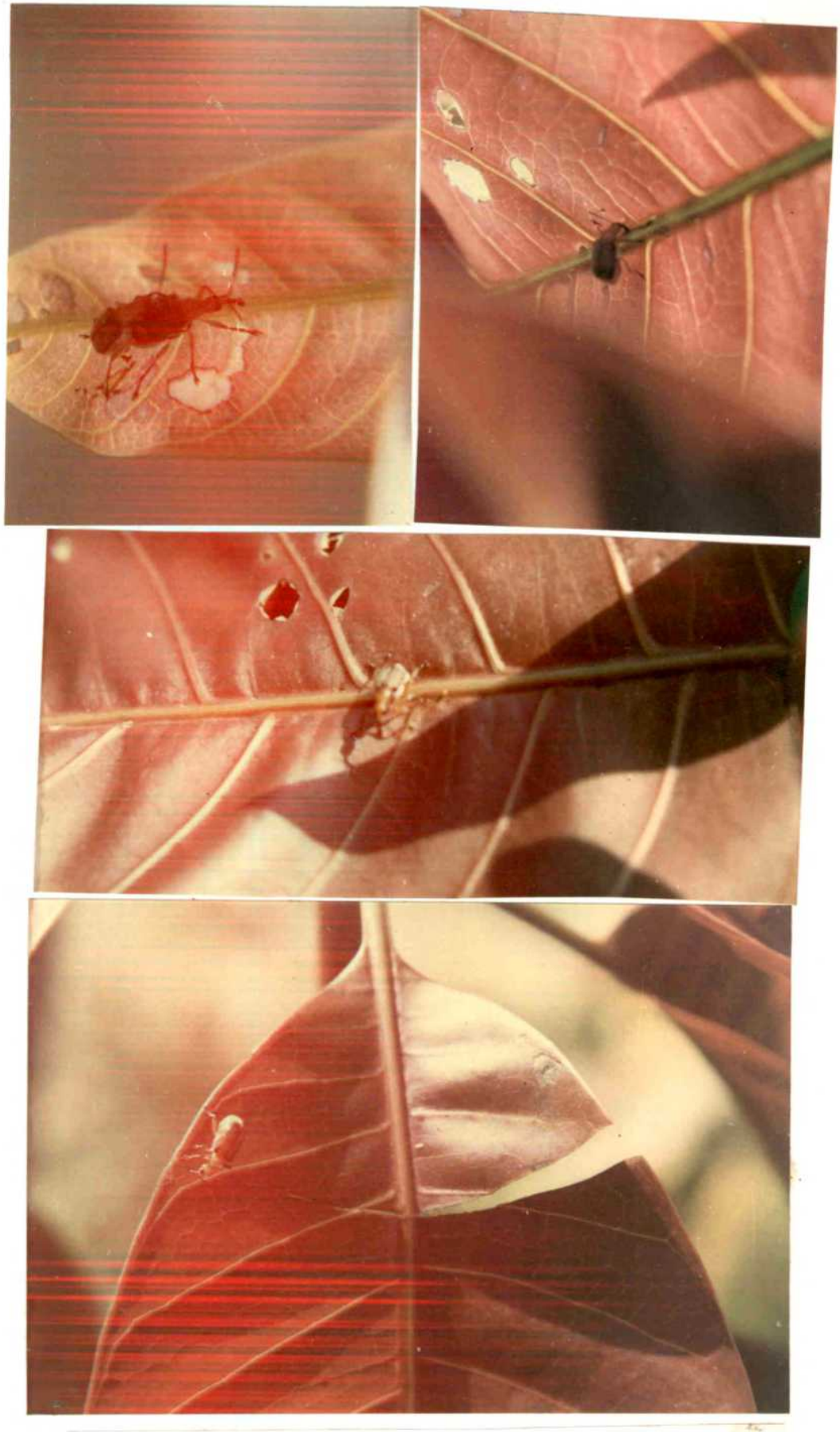


Plate 8 MATING POSTITION & OVIPOSITIONAL OPERATION OF E.marginellus
Top :(From left) Mating position, excavation of 'c'shaped pouch for egg deposition along midrib
Middle :Laying of egg on pouch
Bottom :Cutting laminal part after oviposition

hatched larvae to feed on the dead leaf by making mines freely. Morning hours of the day seemed to be favourable for egg deposition.

The data as recorded during ovipositional operation under field condition revealed that the time taken for making pouch, depositing egg and repairing of pouch were 35.00 to 90.00 seconds, 10.00 to 25.00 seconds and 7.00 to 15.00 seocnds with an average of 59.44, 14.48 and 10.04 seconds,respectively.

Similarly the time taken for cutting the leaf after oviposition at right, left and midrib was 35.00 to 180.00 seconds, 30.00 to 120.00 seconds and 90.00 to 250.00 seconds with average of 85.72, 69.56 and 164.44 seconds as observed in 25 individuals (Table 13). From freshly cut leaves collected from the field, it was recorded that all the ovipositional slits made for depositing eggs by the female were not found effective i.e. all the ovipositional chambers were not having eggs as observed under bionocular microscope. The data as recorded in this respect showed that number of effective eggs per leaf ranged from 1 to 21 with an average of 7.74 and the number of the cavities made by the female varied from 1 to 25 with average of 8.88 as depicted in Table 13.

Regarding distribution of eggs deposited in the midrib, it was observed that the eggs were usually placed keeping a space not less than 1 mm to the extent of 3 mm between one pouch to another.

Table 13 Details of ovipositional operation

Operations	Time(seconds)		
	Minimum	Maximum	$(\bar{X})^*$
Along the midrib			
To make a pouch	35.00	90.00	59.44
To deposit an egg	10.00	25.00	14.48
To repair the pouch	7.00	15.00	10.04
To cut the leaves			
At right side	35.00	180.00	85.72
At left side	30.00	120.00	69.56
At midrib	90.00	250.00	164.44
Number of egg cavity /leaf	Number		
	Minimum	Maximum	$(\bar{X})^*$
At right side	1.00	25.00	8.88
At left side	2.00	18.00	8.48
Number of effective egg/leaf	1.00	21.00	7.74
	Measurement of ovipositional cavity(mm)		
	Minimum	Maximum	$(\bar{X})^*$
i>distance from one egg cavity to another			
At right side	3.00	21.00	10.96
At left side	1.00	25.00	11.40
ii>Distance of cavity from base of cut end of leaves	1.00	17.00	4.28
Tip of cut leaves	28.00	110.00	47.44

* Mean of 25 observations

It was also noted that the eggs of *E.marginellus* were deposited leaving the space about 28.00 to 110.00 mm and 1.00 to 17.00 mm with an average of 47.44 and 4.28 mm (Table 13) at the tip and cut end of the leaf, respectively. The size of the pouch as made by the female rostrum was varied from 0.32 to 0.65 mm with an average of 0.52 mm dia as observed from 58 egg cavities of 10 leaves.

Morphology of different stages of *E.marginellus (Syn:D.marginatus)* was carried out during its active phase. Observations on the external morphological chracters of the insect species except colouration and size of different stages are mostly agree with those of Bhole and Dumbre (1989), Butani (1979) and Nair(1986). With respect to colouration, the present author observed that the general body colour of adults including rostrum (anterior to antennal insertion), antennae, tibiae and tarsi were shiny dark brown and the abdomen being light brown which differ slightly those of the authors mentioned earlier who reported that the adults exhibited differences in colour such as reddish brown with yellowish abdomen and uniform black, greysigh brown having long brown snout and shining black elytra and black and brown weevil with a long snout,respectively.

With respect to size of adult, different larval instars, pupa and snout, the present author noted that the average length x width of male and female were 5.21 mmx 1.64 mm and 5.64 mm x 1.92 mm, respectively. Similarly average length x width of

first, second and third instar larvae were 1.91 mmx 0.87 mm, 3.16 mm x1.87 mm and 4.90mm x 1.75 mm and the pupa was 4.81 mm x 1.44 mm and the average length of snout was observed to be 0.97 mm in male and 1.16 mm in female, respectively. These differ with the findings made by Bhole and Dumbre (1989) who observed that the average length x width of male and female, different larval instars and pupa were 5.12 mm x 1.22 mm and 5.77 mm x 1.46 mm; 1.30 mm x 0.68 mm, 2.25 mm x 0.99 mm and 3.49 mm x 1.03 mm; 3.02 mm x 1.49 mm, respectively. The average length of snout was 1.18 mm in male and 1.43 mm in female, respectively. While the length of the grubs as recorded by Butani (1979) to be about 5 mm approximates with the present observation. The mean incubation period, prepupal and pupal period were observed to be 46.40 hours (1.93 days), 111.24 hours (4.64 days) and 169.48 hours (7.06 days), respectively by the present author during the course of investigation which are in variance with the observations made by Bhole and Dumbre (1989) who reported the mean incubation period, prepupal and pupal period were 2.5, 3.5 and 5 days, respectively. The mean larval period was 174.24 hours (7.26 days) and mating took place 2-3 days after emergence as recorded by present author which contradict with the observations recorded by Tigvattnanont (1988) who noted that the average larval period was 11.13 days and mating began on 5th and 7th days after emergence. The mode of deposition of eggs on either side of midrib of leaves as observed by the present author mostly tallies with those of Bhole and Dumbre, 1989; Tigvattnanont, 1988 and Singh, 1960 who

reported that the females excavated small cavities on either side of midribs on dorsal side of leaves only and deposited one egg in each egg cavity. The present author noted that the female in rare occassion laid eggs on ventral side of leaves. Von (1930), Hossain(1989), Butani(1979) and Nair (1986) reported that the females laid eggs only underside of leaves which is not at par with the observations made by the present author. It was further noted that the distance between two pouches, time taken to make a pouch and to lay an egg and to repair the pouch were 11.40 mm, 59.44 seconds, 14.48 seconds and 10.04 seconds, respectively including 83.96 seconds (1.4 minutes) for the whole process. These differ with the observations made by Bhole and Dumbre (1989) who observed that the distance between two pouches, time taken to lay an egg and for the whole process including making a pouch, to lay an egg and to repair the pouch were 1.89 cm, 2 minutes and about 4 minutes.

4.2.3 Biometrical analysis of larval growth of *E.marginellus*

To find out the relationship between growth characters in the larval instars of *E.marginellus*, observations were made on the length and width of the body and width of head capsule of each individual larva. For the purpose measurements of the above mentioned characters on twenty five individuals were taken separately at the end of each stadium and the data thus obtained were utilized for biometrical analysis.

4.2.3.1 Correlation between larval length, larval width and width of the head capsule

Correlation studies on larval length,larval width and width of the head capsule were carried out separately and data on larval length, larval width prior to shedding of head capsule as well as the width of the head capsule in different instars have been presented in Table 14. Multiple correlation coefficient has been calculated and found to be 0.937 and the regression was a good fit because of high value of the multiple correlation. It may be seen from Table 14 that the larval length, width and width of the head capsule increase gradually from first instar to third instar.

4.2.3.2 Progression factor in respect of width of the head capsule

For assigning the individual larva to its particular instar twenty five newly hatched larvae were reared seperately and regular observations were made to collect head capsule immediately after moulting in all the three instars of respective individual.

Measurement on the width of the head capsules of successive instars along with standard error of mean and calculated values of the width of the head capsules along with progression factors were taken and the data thus obtained for each instar were analysed. Relative larval growth of different instars and the calculated and observed values of head capsules

Table I4 Correlation between larval length, width and width of head capsule of *E.marginellus*

Instar	Serial number of larvae	Larval length prior to shedding of head capsule (mm)	Larval width prior to shedding of head capsule (mm)	Observed width of larval head capsule (mm)	Calculated value of the width (mm)	Coefficient o multiple corr lation head capsule (mm)
	1	1.75	0.78	0.195	0.275	
	2	1.82	0.84	0.260	0.279	
	3	1.88	0.84	0.292	0.286	
	4	1.85	0.87	0.260	0.281	
	5	1.82	0.84	0.260	0.279	
	6	1.88	0.87	0.292	0.284	
	7	1.88	0.84	0.292	0.286	
	8	1.88	0.84	0.292	0.286	
	9	1.98	0.91	0.292	0.293	
	10	2.01	0.94	0.325	0.294	
1st	11	1.95	0.87	0.260	0.292	
	12	1.95	0.91	0.292	0.289	
	13	1.88	0.84	0.292	0.286	
	14	1.88	0.84	0.292	0.286	
	15	1.91	0.84	0.292	0.289	
	16	1.85	0.87	0.260	0.281	
	17	1.95	0.87	0.292	0.292	
	18	2.01	0.87	0.292	0.299	
	19	1.95	0.91	0.292	0.289	
	20	1.88	0.84	0.260	0.286	
	21	1.88	0.91	0.260	0.281	
	22	1.85	0.87	0.195	0.281	
	23	1.95	0.91	0.292	0.289	
	24	1.88	0.84	0.260	0.286	
	25	1.88	0.84	0.260	0.286	
	1	3.08	1.10	0.390	0.407	
	2	3.12	1.17	0.455	0.408	
	3	3.08	1.10	0.390	0.407	
	4	3.05	1.07	0.390	0.406	
	5	3.12	1.17	0.390	0.408	
	6	3.15	1.13	0.422	0.414	
	7	3.15	1.17	0.455	0.411	
	8	3.15	1.17	0.455	0.411	
	9	3.18	1.17	0.455	0.414	
	10	3.12	1.17	0.455	0.408	
2nd	11	3.15	1.20	0.422	0.409	
	12	3.15	1.20	0.422	0.409	
	13	3.18	1.20	0.455	0.413	
	14	3.12	1.10	0.455	0.412	
	15	3.05	1.10	0.390	0.404	
	16	3.18	1.23	0.455	0.411	
	17	3.25	1.30	0.455	0.414	

Table 14 (contd.)

Instar	Serial number of larvae	Larval length prior to shedding of head capsule (mm)	Larval width prior shedding of head capsule (mm)	Observed width of larval head capsule (mm)	Calculated value of the width of head capsule (mm)	Coefficien multiple correlatio (mm)
	18	3.12	1.10	0.390	0.412	
	19	3.15	1.17	0.455	0.411	
	20	3.08	1.10	0.390	0.407	
	21	3.15	1.17	0.455	0.411	
	22	3.12	1.17	0.455	0.408	
	23	3.25	1.23	0.455	0.419	
	24	3.15	1.17	0.455	0.411	
	25	3.15	1.17	0.455	0.411	
	1	4.22	1.62	0.520	0.505	
	2	4.68	1.69	0.520	0.554	
	3	4.94	1.75	0.585	0.580	
	4	5.07	1.75	0.585	0.595	
	5	5.07	1.75	0.585	0.595	
	6	4.94	1.75	0.585	0.580	
	7	5.20	1.88	0.618	0.602	
	8	5.20	1.88	0.618	0.602	
	9	5.07	1.75	0.585	0.595	
	10	5.07	1.75	0.585	0.595	
	11	5.20	1.88	0.585	0.602	
3rd	12	5.20	1.88	0.618	0.602	
	13	4.94	1.75	0.585	0.580	
	14	4.94	1.75	0.585	0.580	
	15	4.94	1.75	0.585	0.580	
	16	4.94	1.88	0.585	0.572	
	17	5.20	1.82	0.585	0.605	
	18	5.07	1.75	0.520	0.595	
	19	4.97	1.75	0.520	0.583	
	20	4.87	1.75	0.520	0.572	
	21	5.13	1.82	0.585	0.597	
	22	5.07	1.75	0.520	0.595	
	23	5.20	1.95	0.650	0.597	
	24	4.94	1.75	0.585	0.580	
	25	4.94	1.75	0.585	0.580	
						0.937

Table 15 Observed and calculated values of head capsule of larvae along with progression factor (mean of 25 observations)

	Mean width of head capsule(mm) ± S.E. during 1st instar	Mean width of head capsule(mm) ± S.E.during 2nd instar	Mean width of head capsule(mm) ± S.E. during 3rd instar	Progression factor
Observed	0.274±0.005	0.433±0.005	0.576±0.007	
Calculated	0.286	0.410	0.585	1.43
Difference	-0.012	0.023	-0.009	

have been presented in Fig. 10 and Table 15 shows mean observed and calculated values of the width of the head capsules of different instars along with the progression factor. In case of *E. marginellus*, a curculionid, the growth of the larva was estimated with the increase of the width of the head capsule by a ratio of 1.43 in successive instars which is in agreement of the Dyar's law as has been illustrated by the regression line (Fig.11).

No earlier authors have worked critically either on multiple correlation on larval length, width and width of the head capsule of *E.marginellus*(Syn:*D.marginatus*) or on the applicability of Dyar's law in respect of progression factor of 1.4. Only Bhole and Dumbre (1989) determined the larval instars by applying Dyar's law giving no details of the same. The Dyar's law in respect of progression factor applicable in non-lepidopterous insects has also been reported in case of soyabean girdler *Obereopsis(=Oberea) brevis* (Pal,1983) and banana pseudostem weevil, *Odoiporus longicollis* (Dutt and Maiti,1972) under the Coleopterous family, curculionidae. Progression factor in respect of the width of the head capsule of the larvae of *E.marginellus* was estimated to be 1.43 and it was in agreement with the postulation of Dyar(1890).

4.2.4 Effect of constant temperature on the developmental period of immature stages of *E marginellus*.

Ecological requirement like temperature plays the key role on the development and survival of immature stages of

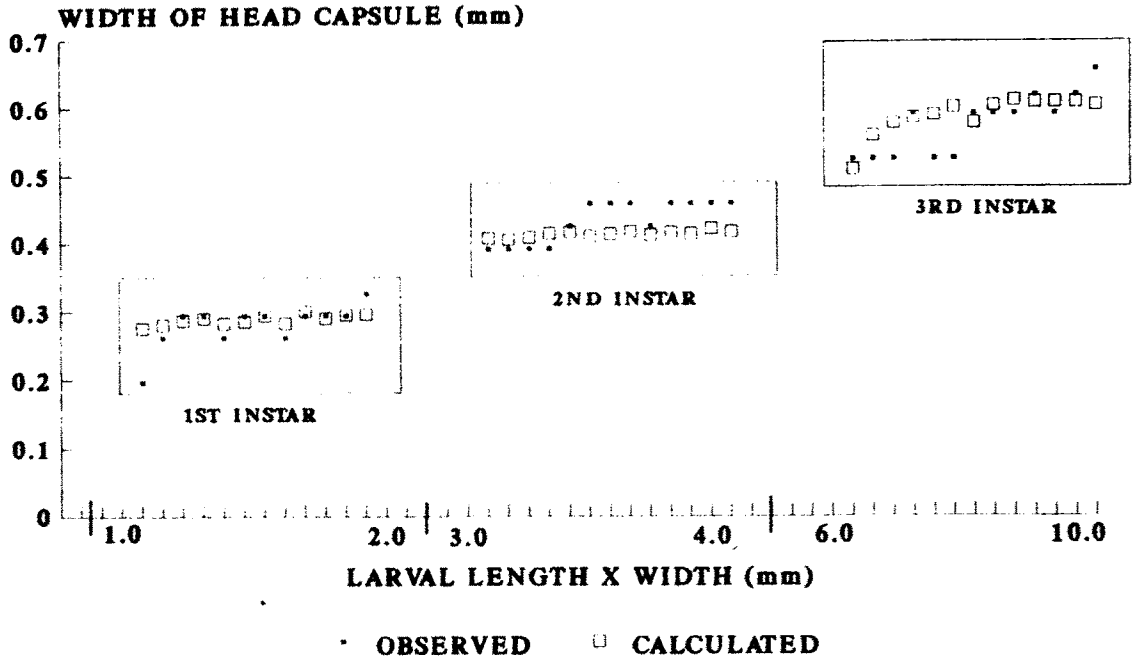


FIG10OBSERVED AND CALCULATED VALUES OF THE WIDTH OF LARVAL HEAD CAPSULES OF *E.marginellus*

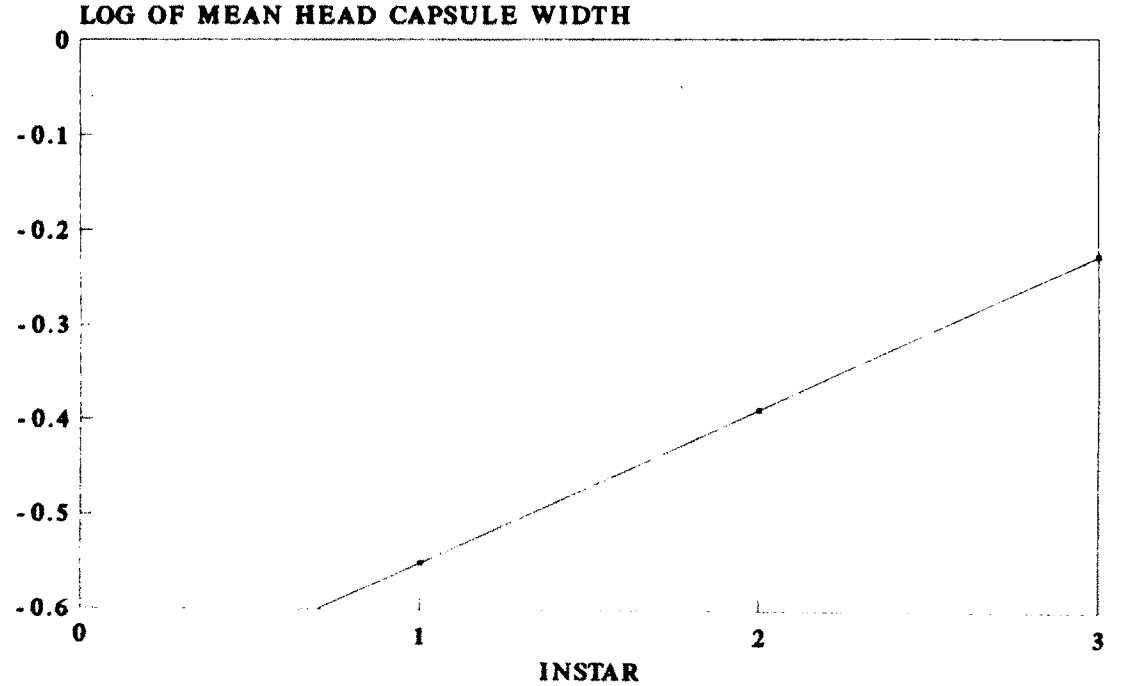


FIG11REGRESSION GRAPH OF INSTAR ON MEAN HEAD CAPSULE WIDTH OF *E.marginellus*

E.marginellus. To evaluate the effect of the important factors studies were taken up at different constant temperatures. This study may provide informations with the objective to assess the utility in the application under field condition.Freshly laid eggs were exposed to different constant temperatures till the emergence of adult *vis-a-vis* a portion of leaves containing fresh eggs were also kept constantly at room temperature ranged from 28 to 31°C till adult emergence and it was served as control.

4.2.4.1 Incubation period

The data as depicted in Table 16 and Fig. 12 showed that there was decrease in the incubation period with the increase of temperature from 15±1°C to 35±1°C indicating negative correlation between temperature and incubation period.It was also observed that with increase of temperature from 15±1°C to 30±1°C,there was increase in the hatching percentage indicating positive correlation between temperature and hatching percentage but hatching percentage was found to decrease at 35±1°C temperature. From observations carried out at different constant temperatures, it was found that the developmental period of egg varied considerably with the prevailing temperature. The mean egg periods were 123.12,93.36,47.28,46.08 and 45.81, hours and the hatching percentage was observed 45.25,69.39,82.41,80.66 and 41.22 respectively when the eggs were kept constantly at 15±1°C,20±1°C, 25±1°C, 30±11°C and 35±1°C temperatures and in room temperature mean egg period and hatching percentage were 46.80 hours and

Table 16 Effect of constant temperature on developmental period of immature stages of E.marginellus

Stage of insect	Developmental period (hrs)																							
	14±1°C			15±1°C			20±1°C			25±1°C			30±1°C			35±1°C			36±1°C			Room temperature (28-31°C)		
	Min.	Max.	(X̄)*	Min.	Max.	(X̄)*	Min.	Max.	(X̄)*	Min.	Max.	(X̄)*	Min.	Max.	(X̄)*	Min.	Max.	(X̄)*	Min.	Max.	(X̄)*	Min.	Max.	(X̄)*
Egg	-	-	-	121.00	125.00	123.12	92.00	94.00	93.36	46.00	48.00	47.28	45.00	47.00	46.08	45.00	46.00	45.81	-	-	-	45.00	48.00	46.80
% hatching of egg		-			45.25			69.39			82.41			80.66			41.22			-			80.71	
Larva																								
I	-	-	-	50.00	53.00	51.12	45.00	47.00	45.84	26.00	36.00	34.65	26.00	32.00	31.25	NR	NR	NR	-	-	-	27.00	47.00	32.66
II	-	-	-	48.00	50.00	48.48	46.00	47.00	46.32	27.00	36.00	34.95	26.00	32.00	31.53	NR	NR	NR	-	-	-	25.00	47.00	33.12
III	-	-	-	144.00	146.00	144.48	125.00	131.00	127.44	98.00	116.00	110.35	96.00	109.00	105.12	NR	NR	NR	-	-	-	102.00	120.00	107.95
Prepupa	-	-	-	-	-	-	-	-	-	144.00	186.00	172.55	110.00	118.00	115.61	NR	NR	NR	-	-	-	98.00	137.00	110.85
Pupa	-	-	-	-	-	-	-	-	-	204.00	240.00	215.44	132.00	190.00	152.25	NR	NR	NR	-	-	-	140.00	214.00	168.17

NR = Data not recorded
* = Mean of 25 observations

80.71,respectively.

It may also be seen from Table 16 and Fig. 12 that there was a significant variation in egg period. It was observed that the eggs exposed to 15±1°C and 20±1°C temperature took more period than that eggs exposed to 25±1°C,30±1°C,35±1°C and at room temperature. It was also noticed that there was no significant variation in egg period when the eggs were exposed from 25±1°C to 35±1°C temperature as compared to the eggs kept at room temperature.

4.2.4.2 Threshold of development

To ascertain the effect of low temperature on the development of eggs of *E.marginellus*, an experiment in the laboratory was carried out. For the purpose a set of leaves containing freshly laid eggs were kept in an incubator maintaining a temperature of 14±1°C and observations on time of hatching were recorded. From the data as recorded in the Table 16 it was revealed that none of the eggs did hatch at temperature 14±1°C even after a lapse of more than two weeks.They were then transferred to room temperature to determine their viability and it was found that all the eggs were dead. The findings indicate clearly that there is practically no development below 15±1°c, which therefore marks that 14±1°C temperature was the lower vital limit for the egg stage of *E.marginellus*.

From the experiments carried out to establish the index

of development of eggs of *E.marginellus* it was noted that the period of growth of eggs sharply decreased with the increase of temperature from threshold upto a temperature of 25±1°C, there after showed more or less straight and at 36±1°c no development took place as revealed in Table 16. To determine the viability of the eggs exposed at 36±1°C,they were shifted to room temperature and were recorded dead even after observing for 10 days. The results as obtained from the experiments indicate that the temperatures for optimum development of eggs lie in the range of temperature nearing 25°±1C to temperature nearing 35±1°C and that the upper vital limit remains at 36±1°C.

4.2.4.3 Larval period

The data as presented in the Table 16 and Fig.12 revealed that there was decrease in the larval period of three instars with the increase of temperature from 15±1°C to 30±1°c showing negative correlation between teperature and larval period. The mean periods of first, second and third instar larvae were 51.12,48.48 and 144.48 hours at 15±1°C,45.84,46.32 and 127.44 hours at 20±1°C; 34.65,34.95 and 110.35 hours at 25±1°C;31.25, 31.53 and 105.12 hours at 30±1°C temperature and 32.66,33.12 and 107.95 hours at room temperature respectivley. At 35±1°C data on larval periods were not recorded. It may be seen from Table 16 and Fig.12 that there was variation in mean larval period with respect to different temperatures. It was further observed that the growth periods of three different instars

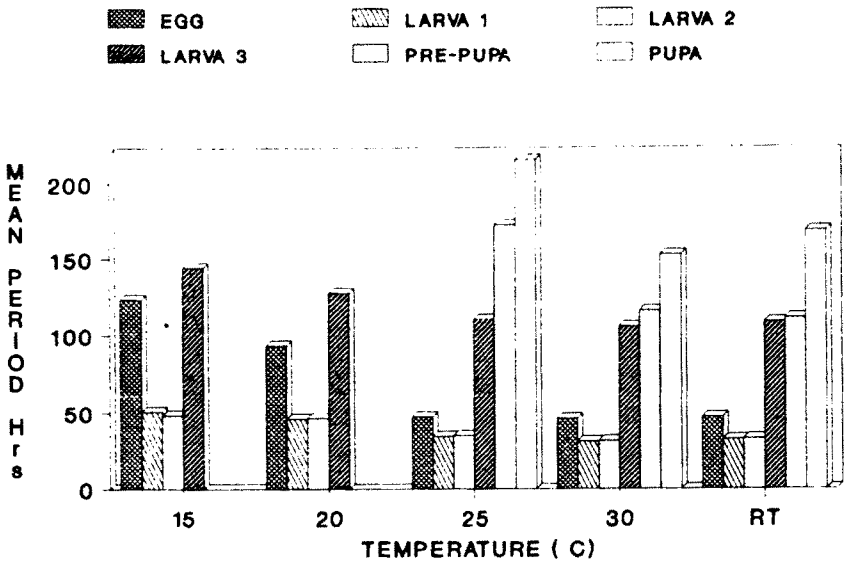


FIG.12 Developmental period of immature stages of *E.marginellus* exposed to different constant temperatures

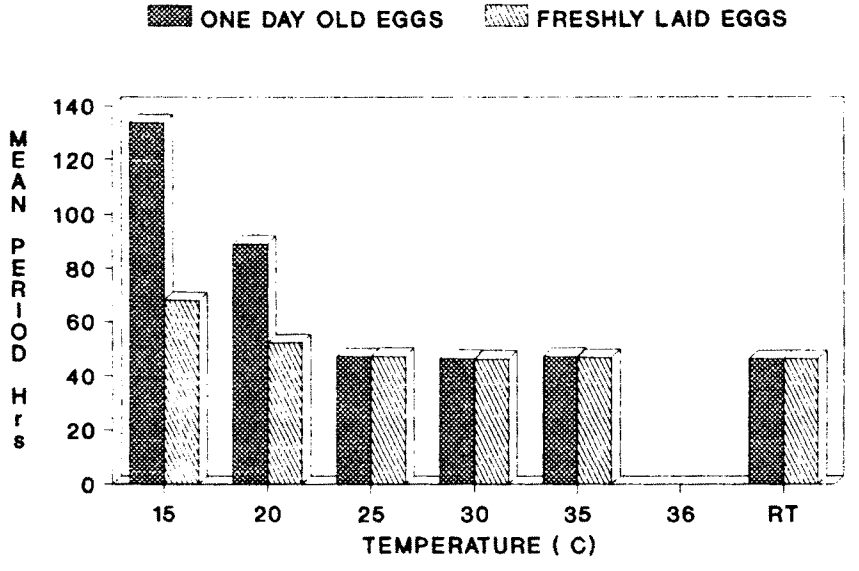


FIG.13 Developmental period of eggs of *E.marginellus* kept at alternate temperatures

varied considerably when the data as obtained from effect of different temperatures were compared, in which case the growth period was less in temperatures ranging from 25±1°C to 30±1°C where as growth periods were prolonged in low temperature of 15±1°c and 20±1°C. Results of the experiments may indicate that the optimum temperature for larval development also lie in the same range of temperature as in case of egg development.

4.2.4.4 Pre-pupal period

The results of observations on pre-pupal period kept at various constant temperatures (Table 16) showed that there was decrease in pre-pupal periods with the increase of temperature from 15±1°C to 30±1°C indicating negative correlation between the temperature and prepupal period.The mean prepupal period was observed 172.55, 115.61 hours when they were kept constantly at 25±1°C and 30±1°C and was 110.85 hours at room temperature.

It was interesting to note that the index of development showed uniform accelaration to a temperature ranged from 25±1°C to 30±1°C. At lower this a change was noticed, which is however, not as marked as that in the case of egg or larval development. The prepupal larvae were able to complete development at a constant temperature of 25±1°C and 30±1°c respectively but were unable to do so at 15±1°C and 20±1°C. In this case, prepupal larvae were kept as 15±1°C and 20±1°c for a period of about one month. All of them remained as prepupae without reaching the pupal stage.They were then shifted from incubator and

kept at room temperature to determine their viability. It was found that within week the prepupal larvae changed into pupal stage. It was noted that 95 percent prepupae tested, emerged as pupae. This study interestingly gave an idea that during winter months of December-January when temperatures were low, *E.marginellus* remained only in the prepupal stage undergoing hibernating stage under field condition.

4.2.4.5 Pupal period

Similar trend was also noted as observed earlier i.e. with the increase of temperature, thre was a decrease in pupal period indicating negative correlation between pupal period and temperatures. It may be seen from Table 16 that the mean pupal period was prolonged (215.44 hours) when the prepupal larvae were kept at 25±1°C. But the period of the same was significantly low (152.25 hours) when kept at 30±1°C. The period when prepupal larvae kept at room temperature took more time (168.17 hours) than those kept at 30±1°C but less than at 25±1°C. It was also found from the results that no pupation took place when the prepupal larvae kept at 15±1°C and 20±1°C for a period of about one month as mentioned earlier.

4.2.5 Effect of alternate temperature on development of eggs of *E.marginellus*

4.2.5.1 Freshly laid eggs:

The eggs were first incubated at different temperature viz. 15±1°C,20±1°C,25±1°C,30±1°C,35±1°C and 36±1°C for one day in

BOD incubator and then shifted and allowed to hatch at room temperature (27 to 31°C). It may be seen from Table 17 and Fig.13 that the mean incubation period of these eggs were observed to be 68.12,52.24,47.36,46.40 and 46.91 hours, respectively and their hatching percentages being 37.50,54.07,76.68,78.29 and 36.36, respectively. But in case of eggs when incubated at 36±1°C temperature and allowed to hatch at room temperature, no eggs were found to hatch. In case of control, mean incubation period was observed to be 46.52 hours with hatching percentage of 82.22 as depicted in Table 17 and Fig.13.

4.2.5.2 One day old eggs:

The freshly laid eggs were kept at room temperature for one day and then allowed to hatch at different temperatures viz. 15±1°C,20±1°C,25±1°C,30±1°C,35±1°C, and 36±1°C with control treatment. The mean incubation periods were noted at different temperatures 133.68 hours (at15±1°C), 89.00 hours (at20±1°C) 47.16 hours (at 25±1°C),46.66 hours (at 30±1°C), 47.31 hours (at 35±1°C) and 46.52 hours (at room temperature)and their hatching percentages were 35.81,43.64,69.40,73.45,31.85 and for control it was 82.22,respectively as depicted in Table 18 and Fig.13, but in case of temperature of 36±1°C, similar trend was noticed as observed in case of freshly laid eggs. From the data on the incubation period of freshly laid eggs and one day old eggs it was revealed that with the decrease of temperature there was an increase in incubation period as compared with control growth period. It was further noted that the egg periods were signifi-

Table 17 Development of freshly laid eggs of *E.marginellus* kept at alternate temperature

Temperature employed (±1°C)	Period of exposure (day)	% hatching of egg	Incubation period (hours)		
			Min.	Max.	$(\bar{X})^*$
15	1	37.5	60.00	74.00	68.12
20	1	54.07	51.00	56.00	52.24
25	1	76.68	47.00	48.00	47.36
30	1	78.29	46.00	48.00	46.40
35	1	36.36	46.00	48.00	46.91
36	1	-	-	-	-
Control (RT)		82.22	46.00	48.00	46.52

* Mean of 25 observations

Table 18 Development of one day old eggs of *E.marginellus* kept at alternate temperatures

Temperature employed (±1°C)	Initially egg kept at room temperature (day)	% hatching of egg	Incubation period (hours)		
			Min.	Max.	$(\bar{X})^*$
15	1	35.81	131.00	140.00	133.68
20	1	43.64	88.00	91.00	89.00
25	1	69.40	47.00	48.00	47.16
30	1	73.45	46.00	48.00	46.66
35	1	31.85	46.00	47.00	47.31
36	1	-	-	-	-
Control(RT)		82.22	46.00	48.00	46.52

* Mean of 25 observations

cantly prolonged when the eggs were treated at 15°±1C and 20±1°C after keeping them twenty four hours at room temperature before treatment with mean growth periods of 133.68 hours and 89.00 hours as shown in Tables 17 & 18 and Fig.13. This varied significantly in case of freshly laid eggs kept for twenty four hours at 15±1°C (68.12 hours) and 20±1°C (52.24 hours) and for other temperatures viz. 25°±1C,30±1°C and 35±1°C in both the cases the growth periods were more or less at par including control.

4.2.6 Effect of different short exposure of temperature on development of eggs of *E.marginellus*

While the temperature plays a decisive role in population build of *E.marginellus* the impact of temperature on the development of eggs was investigated. In previous experiment the eggs were not hatched at a lower threshold temperature of 14±1°C and upper limit of 36±1°C,however, eggs are able to withstand short exposures to temperature at 14±1°C and even above 36±1°C temperature. The incubation periods of each treatment including control are given in Tables 19 & 20. It is evident that the eggs kept at different temperatures with a short exposure are able to withstand and the eggs were found to hatch both incase of freshly laid and one day old eggs but there was no significant variation in incubation period.

The biology of *E.marginellus(D.marginatus)* has been studied only at oridinary temperature by Tigvattnanont (1988), Bhole and Dumbre(1989), Hutson and Alwis(1934), Khanna(1952) and

Table 19 Development of freshly laid eggs of *E.marginellus* kept at short exposure of alternate temperature

Temperature employed (±1°C)	Period of exposure (hrs)	Incubation period (hrs)		
		Min.	Max.	$(\bar{X})^*$
14	1	45.00	47.00	46.33
	2	46.00	47.00	47.05
	3	47.00	48.00	47.92
15	1	45.00	47.00	46.31
	2	46.00	47.00	46.88
	3	47.00	48.00	47.66
20	1	45.00	46.00	45.69
	2	45.00	46.00	45.44
	3	46.00	48.00	47.14
25	1	45.00	46.00	45.42
	2	45.00	46.00	45.22
	3	46.00	47.00	46.34
30	1	45.00	46.00	45.18
	2	45.00	47.00	45.10
	3	44.00	47.00	46.12
35	1	46.00	47.00	46.13
	2	45.00	46.00	45.28
	3	45.00	47.00	45.69
36	1	45.00	46.00	45.26
	2	44.00	46.00	44.72
	3	44.00	47.00	44.63
37	1	45.00	47.00	45.11
	2	44.00	47.00	44.53
	3	43.00	46.00	44.24
38	1	45.00	46.00	45.10
	2	44.00	46.00	44.44
	3	44.00	47.00	44.29
Control (RT)		46.00	48.00	47.25

* Mean of 25 observation

Table 20 Development of one day old eggs of *E.marginellus* kept at short exposure of alternate temperature

Temperature employed (±1°C)	Initially egg kept at room temperature (day)	Period of exposure (hrs)	Incubation period (hrs)		
			Min.	Max.	$(\bar{X})^*$
	1	1	46.00	47.00	46.81
14		2	46.00	48.00	47.77
		3	47.00	48.00	47.93
	1	1	46.00	47.00	46.63
15		2	46.00	47.00	46.92
		3	47.00	48.00	47.88
	1	1	45.00	46.00	45.73
20		2	45.00	46.00	45.22
		3	46.00	47.00	46.69
	1	1	45.00	46.00	45.39
25		2	45.00	46.00	45.29
		3	45.00	47.00	45.99
	1	1	45.00	46.00	45.10
30		2	44.00	46.00	44.85
		3	44.00	46.00	45.13
	1	1	45.00	46.00	45.69
35		2	44.00	46.00	44.35
		3	44.00	45.00	44.19
	1	1	44.00	46.00	45.33
36		2	44.00	46.00	44.25
		3	44.00	47.00	44.11
	1	1	43.00	45.00	44.14
37		2	43.00	45.00	44.19
		3	43.00	46.00	44.10
	1	1	43.00	46.00	44.22
38		2	43.00	45.00	43.89
		3	43.00	46.00	43.72
Control(RT)			46.00	48.00	47.25

* Mean of 25 observations

Hussain (1989). The present author have studied the same under constant, alternate and different short exposures of temperatures. Studies on the egg biology and relationship with meteorological parameters have been highlighted by several workers. Exposure of eggs to low temperature (10°C) for some periods is known to retard the development in some orthopteran eggs (Bodine,1925;Iqbal and Aziz,1973; Majeed and Aziz,1980). In *Tetranychus telarius,* Harrison and Smith (1961) found that the length of the incubation period of eggs varied inversely with temperature. While Katiyar and Mukharji (1974) observed that the egg stage of *Leucinodes orbonalis* seemed to be sensitive to temperature fluctuations and the egg period was much prolonged at 15°C than at 27°C and eggs did not hatch below 15°C. Pugalenthi and Livingston (1993) noted that the higher temperature reduced the incubation period of *Eurybracys tomentosa* but increased at lower temperature. Atwal and Verma (1972) observed acceleration in the rate of development in the egg of *L.orbonalis* owing to the rise in temperature more between 20°C and 25°C than between 25°C and 30°C. Sang Ock Park (1988) reported that in *Gerris paludum insularis* the eggs hatched at 15°C-35°C, whereas they failed to hatch at 10°C and 40°C. The same author further observed that the rate of hatching of eggs was higher at 25°Cand 30°C. The findings as noted by above mentioned workers are agreed with the present author who noted that the eggs of *E.marginellus* hatched at 15±1°C-35±1°C and the developmental period was much prolonged at 15±1°C-20±1°C and was found to decrease with the increase of

temperature from 25±1°-35±1°C. The present author further noted that the eggs did not hatch below 15±1°C and rate of hatching of eggs were more at 25±1°C and 30±1°C. Ahmad and Ullah(1939) found that the eggs of *Earias fabia* did not hatch even at 13°C in twenty eight days and they were then transferred to 16°C to determine their viability and all the eggs were found dead indicating lower threshold level and the eggs failed to hatch at 40°C. The said authors further noted that the eggs were able to withstand short exposure to temperature much below the threshold and even above 40°C. The present author also observed similar trend and noted that the eggs of *E.marginellus* failed to hatch at 14±1°C after keeping them more than two weeks and they were then shifted to room temperature and all the eggs were found dead indicating lower threshold level for the egg stage *vis-a-vis* the eggs did not hatch at 36±1°C indicating upper threshold level but the eggs were able to withstand short exposure to temperature even below 15±1°C and above 36±1°C. The larval and pupal periods of *L.orbonalis* were found to decrease with the increase of temperature from 20°C-35°C (Atwal and Verma,1972) while Katiyar and Mukharji (1974) noted the same that the pupal period of *L.orbonalis* increased as the temperature was lowered. The findings as made by above mentioned authors tallies with those of the present author who observed that there was decrease in larval and pupal period with the increase of temperature from 15±1°C to 30±1°C.

4.3 LARVAL BEHAVIOUR UNDER DIFFERENT ECOLOGICAL CONDITION AND DORMANCY OF *E.marginellus*

The present author observed during the course of investigation that the normal life activities including egg deposition followed by leaf cutting by female and scrapping of green matter from newly formed tender leaves by the adults of *E.marginellus* remained operative in the new vegetative flushes of mango nurseries from late February to early November with decrease activitiesduring April as has been mentioned under chapter 4.1. During winter period from early December to mid February no such adult activities were recorded even in case there was new tender leaves available for breeding and feeding. Observations as recorded in two successive years, 1994 and 1995 were also more or less similar trend at par with the observations recorded during 1993.

The disappearance of this pest species from November-January gave an indication that probably low temperature prevailing during winter might be causing detrimental effect on the multiplication of *E.marginellus* in eastern India. Keeping this idea in view a series of experiments were carried out to investigate the cause of disappearance during winter months. At the advent of winter the insect after completing its larval stage stopped feeding by mining in the dead cut leaves fallen on the ground and remained inactive in prepupal stage by forming chamber in soil without going into transformation to pupa atall till favourable effective temperature was restored. Such behaviour of the larva during low temperature condition led to the assumption

that the insect species overwintered or hibernated in the prepupal stage. This phenomenon of dormancy is obligatory as it terminated only with the onset of favourable high temperature during post winter months.

4.3.1 Induction of hibernation under laboratory condition

To ascertain the factors influencing induction of larval hibernation of *E.marginellus*, room temperature, one of the physical components of environment was taken into account for experimentation under laboratory condition. From the experiment it was revealed that the fortnight maximum temperature ranging from 24.15°C-26.62°C and minimum temperature ranging from 23.77°C - 26.10C° during 1993 and the maximum temperature ranging from 24.53°C- 26.59°C and minimum temperature ranging from 23.82°C - 26.10°C during 1994 for the period, November and December were found effective for the induction of dormant phase of the insect species (Table 21). Investigation was carried out fortnightly with different number of larvae starting from October and they were kept under laboratory conditions till induction of the dormancy. Laboratory temperature and relative humidity were recorded fortnightly and the data are presented in Table 21 and Fig.14 and Fig.15. Other details of the experiment are mentioned under materials and methods.

It may be seen from Table 21 and Figs.14 & 15 that during first and second fortnight of October (October I and October II), 1993 and 1994, no larvae were found entering into

Table 21 Induction of hibernation in larvae of E.marginellus under laboratory condition during 1993-1994

Time of larval collection (fortnight)	Average temperature(°c)				Relative humidity(%) ranged		No.of larvae observed		Per cent larvae pupated		Per cent larvae hibernated	
	Max.	Min.	Max.	Min.								
	1993		1994		1993	1994	1993	1994	1993	1994	1993	1994
October I	29.22	28.51	27.94	26.99	91-96	88-96	51	53	100.00	100.00	-	-
October II	29.11	28.41	27.62	26.73	92-96	82-94	45	58	100.00	100.00	-	-
November I	26.62	26.08	26.59	26.10	73-96	87-94	55	51	61.82	39.22	38.18	60.78
November II	26.12	25.03	24.53	23.82	77-96	81-96	49	54	8.16	0.00	91.84	100.00
December I	24.15	23.77			69-86		25	-	0.00	-	100.00	-

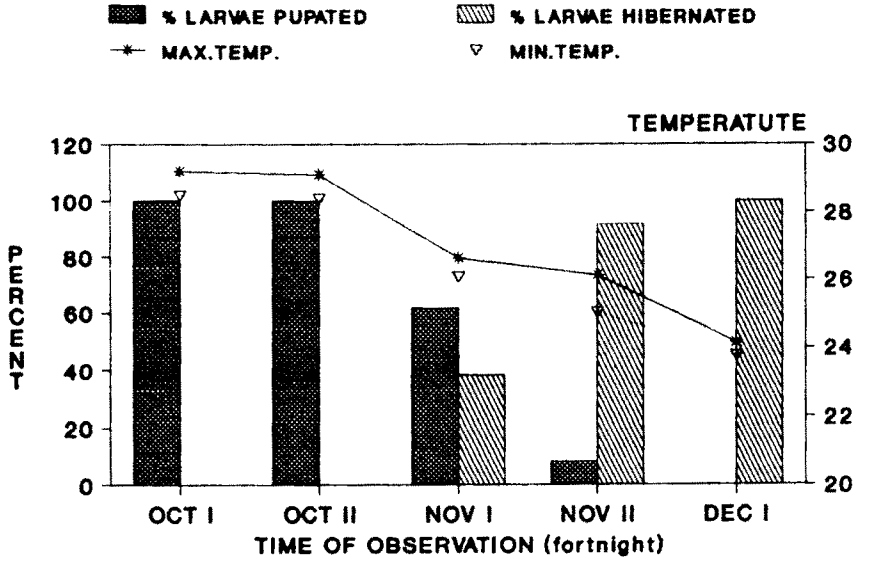


FIG.14 INDUCTION OF LARVAL HIBERNATION OF *E.marginellus* IN RELATION TO TEMP.UNDER LAB.CONDITION DURING 1993

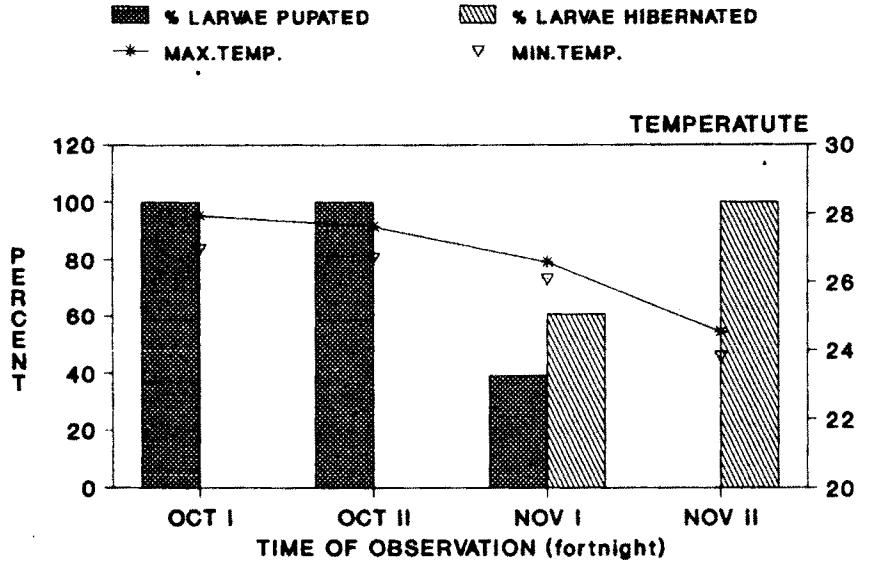


FIG.15 INDUCTION OF LARVAL HIBERNATION OF *E.marginellus* IN RELATION TO TEMP.UNDER LAB.CONDITION DURING 1994

the stage of dormancy when the temperature and relative humidity were in the range of 28.41°C - 29.22°C and 26.73°C - 27.94°C; 91-96% and 82-96 % respectively *i.e.* 100% larvae transformed into pupae after completing their prepupal stage. From the same table it was interestingly observed that 38.18% 91.84% and 100% larvae during November I,November II and December I, 1993 when the temperature and relative humidity were in the range of 23.77°C -26.62°C and 69-86%; 60.78% and 100% larvae during November I and November II, 1994 were found entering into dormant stage respectively (Temperature and relative humidity during that period were in the range of 23.82°C-26.59°C and 81-96% respectively)

It may be inferred from the investigation carried out during 1993 and 1994 that the arrest of development of *E.marginellus* is initiated in the prepupal larval stage at a temperature of about 24°C and below.

An investgation was carried out subsequently to study the loss of body weight of the larvae of *E.marginellus* at the advent of winter prior to their entering into hibernation and results are presented in Table 22 below. Loss of body weight to the extent of 26.69% from November,1995 onwards indicated that the larvae were entering into a state of inactivity or kind of dormancy. The loss of body weight was regained during post winter period as shown in Table 23.

Table 22 Loss of body weight of the larvae of *E.marginellus* entering into hibernation (Mean of 10 larvae)

Time of observation	Average body weight (mg)	Loss in body weight (%)
November'95		
First week	69.70	0.00
Second week	68.22	2.12
Third week	67.02	3.85
Fourth week	66.50	4.59
December'95		
First week	64.80	7.03
Second week	63.07	9.51
Third week	61.00	12.48
Fourth week	58.93	15.45
January'96		
First week	56.83	18.32
Second week	55.30	20.66
Third week	51.37	26.30
Fourth week	51.10	26.69

Table 23 Regain of body weight of larvae during termination of hibernation

Time of observation	Average body weight (mg)	Gain in weight (%)
February'96		
First week	57.00	0.00
Second week	61.00	7.02
Third week	70.00	22.81
Fourth week	73.00	28.07

4.3.2 Termination of hibernation under laboratory condition

It is seen from Tables 24 & 25 that under laboratory condition maximum, temperatures ranging from 25.72°C - 28.88°C and minimum temperature ranging from 25.05°C-27.79°C during first week of February to fourth week of February, 1994 and 25.98°C-27.89°C and 25.10°C-26.80°C during first week of February to third week of February,1995 respectively were found effective for termination of overwintering phase of the hibernated larvae observed. Maximum termination was observed during third week of February ,1994 *i.e.*59.37% larvae transformed into pupae (Table 24 and Fig.16) when the temperature and relative humidity were in the range of 26.13°C -27.32°C and 61-89%, respectively.

It is also seen from Table 24 & Fig.16 that 43.75% adults emerged from pupae during first week of March, 1994 when temperature and relative humidity were in the range of 28.72°C - 30.16°C and 67-85%, respectively.

During 1995,54.54% larvae became pupated on second week of February when the temperature was in the range of 26.59°C-27.75°C with humidity percent 59-88% and 54.54% adults emerged from pupae during fourth week of February,1995 when temperature and relative humidity were in the range of 27.86°C-29.15°C and 65-91%,respectively (Table 25 and Fig.17).

It may be evident from the experimentation that the break of larva dormancy of *E.marginellus* is effected with the on-

Table 24 Termination of larval hibernation of *E.marginellus* under laboratory condition durring 1994 *

Time of observation	Number of hibernated larvae observed	Average temperature (°C) Max.	Min.	Relative humidity ranged (%)	Per cent pupae emerged	Per cent adult emerged	Remark
January '94							
Fourth week		24.66	22.83	64-77	-	-	
February'94							
First week		25.72	25.05	71-79	9.38	-	
Second week		26.35	25.65	69-86	21.87	9.38	
Third week		27.32	26.13	61-89	59.37	-	
Fourth week	35	28.88	27.79	70-78	9.38	21.87	Three larvae died on
March '94							
First week		30.16	28.72	67-85	-	43.75	second week of
Second week		30.22	28.65	67-91	-	25.00	January

* Experiment conducted on first week of December '93 and continued till termination

Table 25 Termination of larval hibernation of *E.marginellus* under laboratory condition during 1995 *

Time of observation	Number of hibernated larvae observed	Average temperature (°C) Max.	Min.	Relative humidity ranged (%)	Per cent pupae emerged	Per cent adult emerged	Remark
January '95							
Fourth week		23.82	22.10	60-79	-	-	
February'95							
First week		25.98	25.10	63-82	31.81	-	
Second week		27.75	26.59	59-88	54.54	13.64	
Third week		27.89	26.80	60-87	13.64	54.54	Eight larvae
Fourth week	30	29.15	27.86	65-91	-	27.27	died on
March '95							first
First week		30.72	28.85	55-80	-	4.55	week of January

* Experiment conducted on first week of December '94 and continued till termination

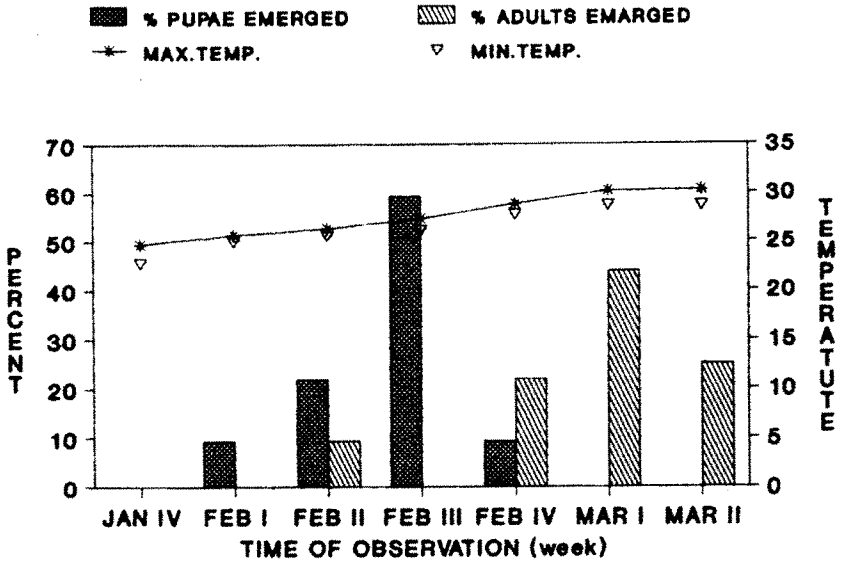


FIG.16 PUPAL AND ADULT EMERGENCE FROM LARVAL HIBERNATION IN RELATION TO TEMP. UNDER LAB.CONDITION DURING 1994

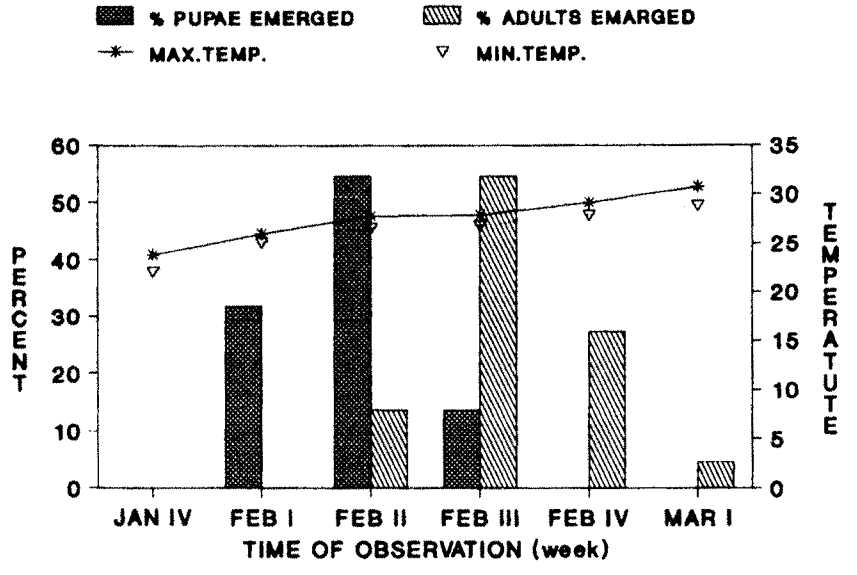


FIG.17 PUPAL AND ADULT EMERGENCE FROM LARVAL HIBERNATION IN RELATION TO TEMP. UNDER LAB.CONDITION DURING 1995

set of favourable temperature of about 26°C and above.

4.3.3 Effect of relative humidity on termination of hibernation under room temperature and a constant temperature of 30°C±1°c

Of the various physical factors known to influence the life activities of insects only temperature and relative humidity could act incombination to modify the usual phenomenon. Keeping the view in objective a preliminary trial on the termination of hibernation of the larvae of *E.marginellus* was conducted with different levels of humidity under laboratory room temperature and a constant temperature of 30°C±1°C. Results as obstained are presented in Table 26 and Table 27.

Of the different level of humidities taken into consideration for carrying out the experiment, maximum termination of larval dormancy *i.e* more number of hibernated larvae transformed into pupae was found in relative humidity ranging 40-60% during fourth week of January 1995 as seen in Table 26.

Data as revealed in Table 27 indicate that maximum amount of termination of larval dormancy (50-60%) was in relative humidity ranging from 50-60% at constant temperature of 30°C±1°C.

It is noteworthy that the hibernated larvae exposed to 40% relative humidity under room temperature condition were found transformed into pupae after breaking dormancy within a period of about four weeks followed by adult emergence after three to five weeks where as at same humidity level under constant temperature

Table 26 Effect of relative humidity on termination of larval hibernation of E.marginellus under room temperature *

Treatment (% RH)	Number of hibernated larvae observed	Time of observation(week)																							
		January '95												February'95											
		1st			2nd			3rd			4th			1st			2nd			3rd			4th		
		a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
40	10	20	30	-	-	-	-	-	-	-	-	50	50	-	-	-	-	-	30	-	-	-	-	-	-
50	10	-	60	-	20	-	-	-	-	-	-	20	60	-	-	-	-	-	20	-	-	-	-	-	-
60	10	-	-	-	-	-	-	-	-	-	10	20	20	-	-	-	10	30	-	-	20	-	10	-	50
70	10	-	-	-	10	-	-	-	-	-	-	-	-	-	20	-	10	60	20	-	-	-	-	-	60
80	10	-	-	-	-	-	-	-	-	-	20	60	-	-	-	60	20	-	-	-	-	-	-	-	-
90	10	10	-	-	-	-	-	-	70	-	20	-	70	-	-	-	-	-	-	-	-	-	-	-	-
100	10	40	-	-	-	10	-	20	30	-	-	-	40	-	-	-	-	-	-	-	-	-	-	-	-
Average temperature (°C)	Max.	19.75			20.12			22.05			23.82			25.98			27.75			27.89			29.15		
	Min.	18.08			19.66			21.12			22.10			25.10			26.59			26.80			27.86		

* Experiment conducted on second week of December '94 and continued till termination
'a' Indicates per cent larvae dead
'b' Indicates per cent pupae emerged
'c' Indicates per cent adults emerged

Table 27 Effect of relative humidity on termination of larval hibernation of E.marginellus at a constant temperature of 30°C±1°C *

Treatment (% RH)	Number of hibernated larvae observed	Time of observation(week)											
		January '95											
		1st			2nd			3rd			4th		
		a	b	c	a	b	c	a	b	c	a	b	c
40	10	-	30	-	20	20	30	30	-	20	-	-	-
50	10	20	50	-	-	10	40	-	20	20	-	-	20
60	10	20	60	-	-	-	-	-	20	60	-	-	20
70	10	40	-	-	-	60	40	-	-	20	-	-	-
80	10	10	30	-	-	-	30	-	60	-	-	-	60
90	10	30	-	-	30	40	-	-	-	40	-	-	-
100	10	20	-	-	60	20	-	-	-	20	-	-	-

* Experiment conducted on second week of January '95 and continued till termination
'a' Indicates per cent larvae dead
'b' Indicates per cent pupae emerged
'c' Indicates per cent adults emerged

of 301°C±1°C condition the said larvae transformed into pupae within one week followed by adult emergence after one week as seen in Table 26 and Table 27. On the basis of results obtained during the course of investigation on the termination of hibernation of the larvae of *E.marginellus* as presented in Table 26 and 27 that the insect species eliminated its state of inactivity with the onset of favorable temperature mostly prevailing during February.

4.3.4 Effect of depth of soil on dormancy under field condition

During winter months the larvae of *E.marginellus* after completing their larval feeding enter into dormant state without transforming into pupae and remain under ground in soil shell at certain depth of soil till adult emergence. To ascertain whether the different depths of soil have any effect on transformation, or dormancy or survivality of the larvae, an experiment was conducted under field condition placing the dormant larvae at different depths of soil as per lay out mentioned under materials and methods.

Data as obtained from the experiment revealed that chances of survival of dormant larvae placed at zero and 1 cm depth of soil were comparatively less than those placed at lower soil depths. In the cases almost 100 per cent larvae were found dead due to dessication after a lapse of certain period (Table 28). Where as all the larvae placed at depth ranging from 2-5 cm were found transformed into pupae during February after a lapse

Table 28 Effect of depth of soil on dormant larvae of E.marginellus under field condition*

Depth of soil(cm)	Number of hibernated larvae observed	Time of observation(week)																							
		January '95												February'95											
		1st			2nd			3rd			4th			1st			2nd			3rd			4th		
		a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
0	10	60	-	-	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	90	-	10
2	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	-	-	80	20	-	-	80
3	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	-	-	80	-	-	20
4	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	-	-	80	-	-	20
5	10	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	90	-	-	-	100	-	-	-	-

Average temperature (°C)	Max.	25.26	26.39	28.53	28.93	27.78
	Min.	8.27	12.0	14.13	15.68	17.52
Average relative humidity(%)	Max.	94.10	93.29	95.0	94.71	97.71
	Min.	34.30	44.86	47.29	45.0	65.0

* Experiment conducted on fourth week of December '94 and continued till termination
'a' Indicates per cent larvae dead
'b' Indicates per cent pupae emerged
'c' Indicates per cent adults emerged

of period ranging from six to seven weeks and subsequently emergence of the adults took place after about one week showing 100 per cent survivality (Table 28 and Fig.18 & Fig19). The temperature, relative humidity during that period are shown in Table 28.

The present author noted that the evidence of no record of feeding and /or adult breeding, loss of body weight of larva, arrest of transformation of larva to pupa of *E.marginellus* remaining under ground during winter months of December,January and early February clearly indicated the occurrence of hibernation in the larval stage under West Bengal condition. No earlier authors have studied critically on dormancy of *E.marginellus (D.marginatus)* except Bhole and Dumbre (1989) who reported simply the larval dormancy as hibernation during winter. Dutt and Dalapati (1977) reported that the loss of body weight in adults of both sexes of *Raphidopalpa foveicollis* occured prior to their entering into hibernation phase in winter and regained their body weight in following summer. Such type of phenomenon was also found existed in the larve of *E.marginellus*.

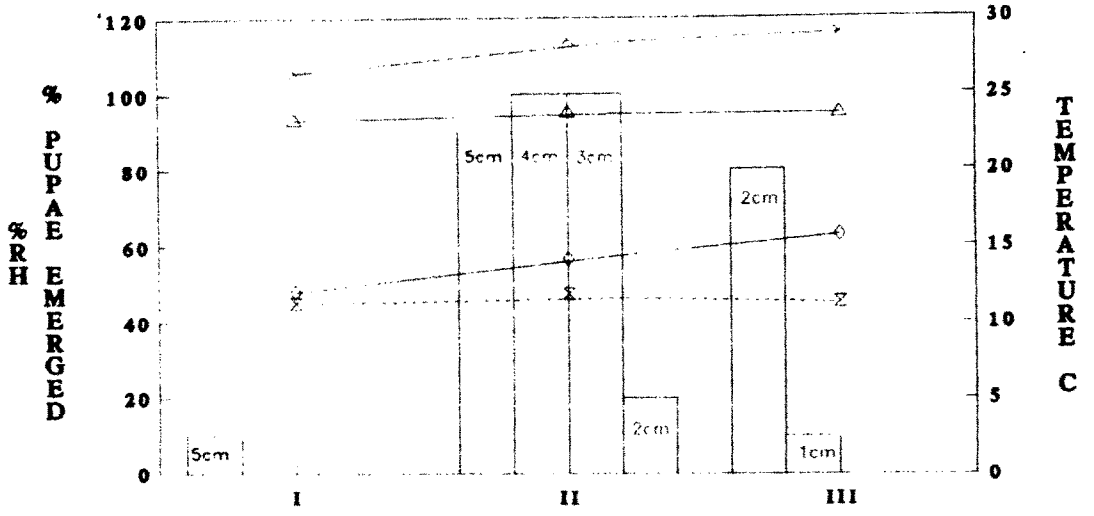


FIG18PUPAL EMERGENCE FROM LARVAL HIBERNATION KEPT AT DIFFERENT DEPTH OF SOIL EXPOSED TO FIELD CONDITIONS

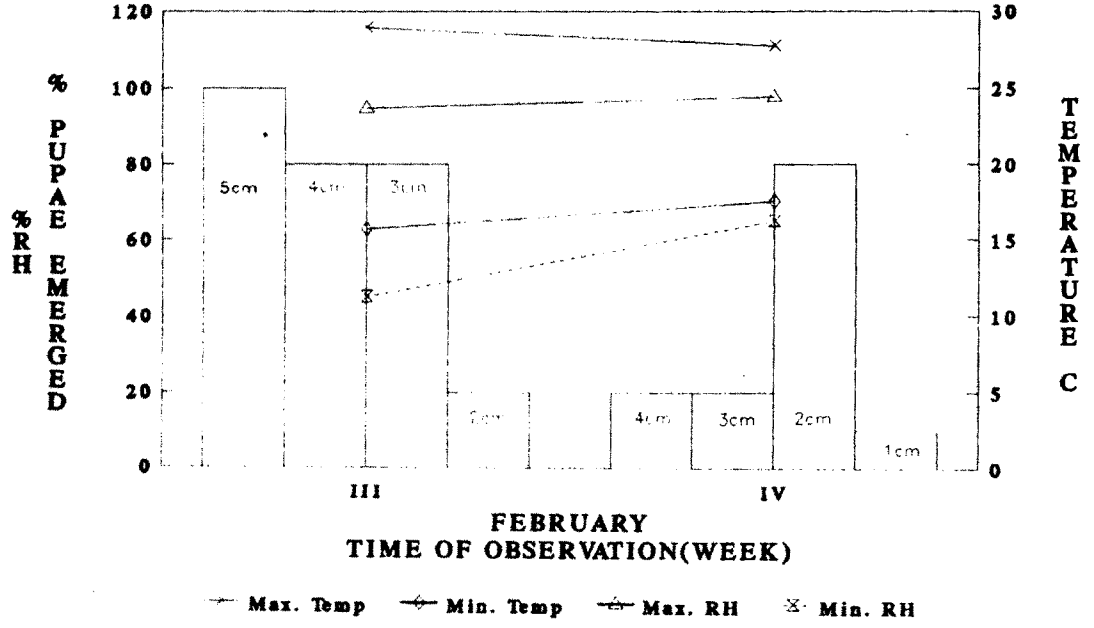


FIG19ADULT EMERGENCE FROM LARVAL HIBERNATION KEPT AT DIFFERENT DEPTH OF SOIL EXPOSED TO FIELD CONDITIONS

4.4 CONTROL OF *E.marginellus(Syn:D.marginatus)*

Control of leaf cutting weevil ,*E.marginellus* by application of insecticides is rather difficult since eggs are inserted along the midrib of tender leaf; the larvae which are miners remain in the fallen leaves on the ground till their development and enter into the soil where pupation takes place. Both the adult males and females remain on the leaves feeding on green matter by scrapping. Obviously an integrated approach for control of the pest species becomes necessary. The methods to be proposed for controlling *E.marginellus* are integration of suitable agrotechniques as suggested alongwith chemicals based on results obtained during the course of the present investigation as mentioned below:

Agrotechniques:

Collection and destruction of fallen cut leaves on the ground containing freshly laid eggs

It has been mentioned earlier that the females before ovpositional operation, prepared 'c' shaped pouch on either side of the midrib of tender leaves of new vegetative flush for placing eggs. After completion of egg laying, females cut the egg deposited leaves which fall on the ground. Collection of fallen leaves from the field containing eggs and subsequently their destruction are recommended for limiting the population of *E.marginellus*. This can prove to be effective during initial build of pest population.

Raking followed by burning of dry leaves

Since the immature stages including prepupae and pupae remain underground as mentioned earlier, raking of soil around mursery plants followed by burning of dry leaves is effective for reducing the pest population and this may be carried out immediately after uprooting of saplings for selling and/or before planting the seedling for grafting.

Destruction of hibernated larvae during winter months

It has been stated earlier that larva goes into hibernation during winter months inside the soil upto a certain depth. Raking around the base of the plant to expose the hibernated larvae for sun drying, predation, parasitasation etc. at frequent intervals is recommended for limiting the pest population.

Flooding the field for a reasonable period may also be effective against the immature stages of *E.marginellus* remaining underground.

4.4.1 Relative toxicity of few insectidides against adults

For the purpose of control of the adults, contact toxicity of four different insectidides were tested under laboratory condition. The techniques employed and other details of the experiment have been mentioned under materials and methods.

Based on the LC_{50} value the order of efficacy of four insecticides tested against the adults of *E.marginellus* after twenty four hours (Table 29 & Fig.20) was in the descending

Table 29 Relative toxicity of few insecticides used against E.marginellus after twenty four hours

Insecticide	Heterogenity	Regression equation	LC_{50}	Fiducial limit	Relative toxicity
Cypermethrin	$X^2(3)=0.31$	Y=3.98 + 0.47x	0.0015	0.0094 0.0431	6.13
Quinalphos	$X^2(3)=0.064$	Y=3.74 + 0.515x	0.0026	0.0197 0.028	3.54
Carbaryl Flowable	$X^2(3)=0.43$	Y=4.078 + 0.512x	0.0067	0.00014 0.003	1.37
Dichlorvos	$X^2(3)=1.29$	Y=3.794 + 0.479x	0.0092	0.0855 0.0097	1.00

In none of these cases the data were found to be significantly heterogeneous at P=0.05, Y=probit kill; x=log (concentration x 10^{-5});LC_{50}= concentration calculated to give 50.0 per cent mortality.

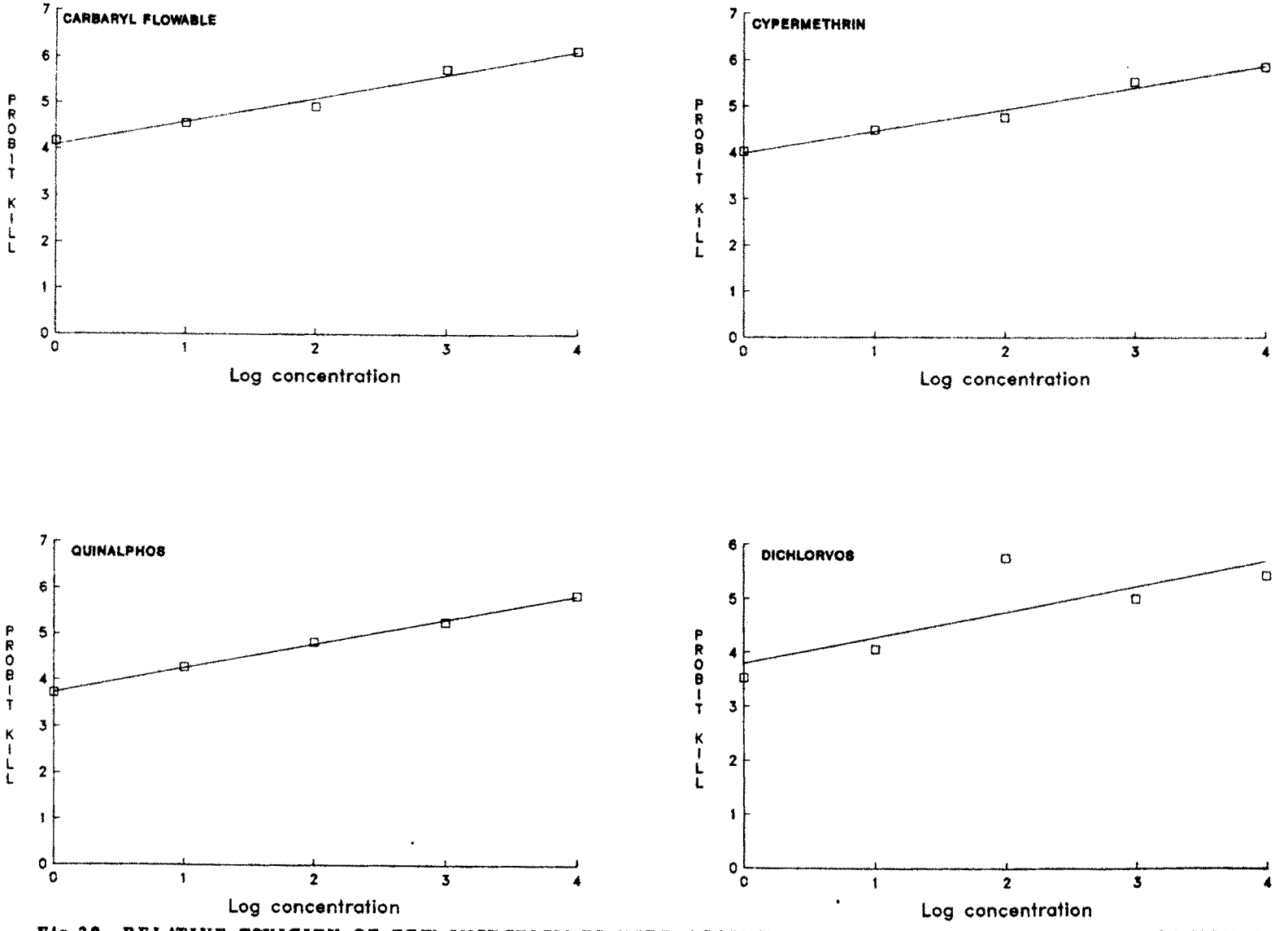


Fig.20 RELATIVE TOXICITY OF FEW INSECTICIDES USED AGAINST ADULTS OF *E marginellus* AFTER 24 HOURS

order:

Cypermethrin > quinalphos > carbaryl flowable > dichlorvos.

4.4.2 Effect of soil insectidies to prepupae and pupae

The leaf cutting weevil,*E.marginellus* after completing its active larval stage over ground enters in the prepual stage for pupation inside the soil. With the objective to control the vulnerable stages of the pest species i.e. prepupal and pupal stages which would effectively be killed in case of their coming in contact with soil treated with insecticides, two soil chemicals viz. chlorphyriphos and aldrin were selected for carrying out tests under laboratory conditon at temperature and relative humidity 24°C to 29°C and 67 to 89% respectively. Details of the experiments are mentioned under materials and methods. Data obtained from the experiments are analysed and presented in Tables 30 and 31.

As regards the efficacy of two soil insecticides viz. chlorphyriphos and aldrin each having two concentrations against prepupae and pupae it is seen that they are capable of giving excellent control of *E.marginellus* only with a contact period of one hour. From Table 30 and Table 31 it is seen that chlorphyriphos at 0.08% caused a rapid kill of the prepupae and pupae, all of them dying within 120 hours and 96 hours respectively. Aldrin at 0.05% also killed the prepupae and pupae rapidly and caused 76.67%, and 100%, kill within 120hrs following treatment.

Table 30 Effect of insecticides in soil on prepupal stage of *E.marginellus*(mean of three replications)

Insecticides	Concentration (%)	Mean per cent mortality after				
		24hrs	48hrs	72hrs	96hrs	120hrs
Chlorphyriphos	0.08	26.45* (20.00)**	31.32 (26.67)	51.15 (60.00)	74.32 (86.67)	85.95 (100.00)
	0.06	9.00 (3.33)	13.96 (6.67)	39.44 (40.00)	51.46 (60.00)	54.21 (63.33)
Aldrin	0.05	4.05 (0.00)	4.05 (0.00)	41.37 (43.33)	51.24 (60.00)	65.01 (76.67)
	0.03	4.05 (0.00)	4.05 (0.00)	21.50 (16.67)	31.59 (33.33)	31.59 (33.33)
Control	0.00	4.05 (0.00)	4.05 (0.00)	4.05 (0.00)	4.05 (0.00)	4.05 (0.00)
S.Em±		2.91	2.42	4.86	10.21	10.31
C.D.at 5%		9.18	7.63	15.33	32.20	32.51

* Angular transformed value
**Figures in the parentheses indicate original mean values

Table 31 Effect of insecticides in soil on pupal stage of *E.marginellus*(mean of three replications)

Insecticides	Concentration (%)	Mean per cent mortality after 24hrs	48hrs	72hrs	96hrs	120hrs
Chlorpyriphos	0.08	41.37* (43.33)**	51.47 (60.00)	71.18 (86.67)	85.95 (100.00)	-
	0.06	24.25 (16.67)	39.17 (40.00)	43.38 (46.67)	48.36 (53.33)	53.00 (56.67)
Aldrin	0.05	27.34 (26.67)	49.53 (56.67)	55.30 (66.67)	59.55 (73.33)	85.95 (100.00)
	0.03	9.00 (3.33)	21.50 (16.67)	23.50 (20.00)	33.32 (30.00)	35.24 (33.33)
Control	0.00	4.05 (0.00)	4.05 (0.00)	4.05 (0.00)	4.05 (0.00)	4.05 (0.00)
S.Em±		6.80	7.30	6.79	5.91	7.79
C.D.at 5%		N.S.	23.02	21.41	18.64	24.57

* Angular transformed value
**Figures in the parentheses indicate original mean values

The kill obtained with chlorpyriphos at 0.06% was comparatively less than either of the first two mentioned earlier but it still caused 63.33% incase of prepuae and 56.67% in case of pupae, at the end of 120 hours. The soil treated with aldrin at 0.03% though failed to control prepupae, 48 hours following treatment afforded 33.33% mortality in both the stages of pest species tested at the end of 120 hours. Results as obtained from the experiments indicated that aldrin,chlorinated hydrocarbon group of pesticide was the least and that chlorpyriphos, organophosphorus group of pesticide was more toxic against both prepupae and pupae of *E.marginellus* inhabiting underground.

4.4.3 Field evaluation of some insecticides as surface application

To ascertain the effect of insecticides on the incidence of *E.marginellus*, a two factor design trial was conducted under field condition. For the purpose of the test 13 different insecticides with two different dosages were selected for foliar application. The insecticides were applied on the nursery plant at an interval of 10 days and the experiment was carried for about five months starting from 8th May to 22nd October both during 1994 and 1995. The methods employed for carrying out the experiment including other details are mentioned under materials and methods. Data obtained from the experiments are analysed and presented in the Tables 32 and 33 separately for 1994 and 1995.

During 1994 results on treatment effect as depicted in

Table 32 Means for stage x treatment effect on per cent reduction of leaf damage of E.marginellus during 1994

Stage / Treatment	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	S_{12}	S_{13}	S_{14}	S_{15}	S_{16}	S_{17}	
T_1(phosphamidon 0.043%)	2.570	2.253	6.942	4.657	5.820	11.557	12.990	10.203	12.673	11.453	10.660	9.423	8.573	11.380	11.663	10.413	9.137	8.963
T_2(phosphamidon 0.034%)	0.463	1.500	2.837	1.370	2.757	3.760	3.683	2.363	3.037	7.060	6.973	4.083	5.140	5.183	6.470	5.877	7.887	4.144
T_3[monocrotophos (sufos) 0.054%]	1.880	1.857	3.107	4.113	5.303	6.107	12.597	10.010	13.377	7.963	8.163	5.673	8.433	7.220	7.597	6.653	7.830	6.934
T_4[monocrotophos (Sufos) 0.036%]	0.753	0.180	0.953	0.693	2.330	2.407	2.307	2.427	3.180	5.470	7.147	3.240	5.800	4.253	6.977	5.873	7.160	3.597
T_5[monocrotophos (Lufos) 0.054%]	2.430	2.157	3.170	3.743	3.847	4.173	10.813	6.260	11.813	10.993	5.300	9.153	8.235	6.887	8.010	5.023	7.167	6.422
T_6[monocrotophos (Lufos) 0.036%]	2.833	1.080	1.230	1.197	1.633	2.660	1.747	2.713	2.863	3.637	2.747	3.943	3.710	4.743	5.010	4.563	7.923	3.190
T_7[dichlorvos (DIVAP) 0.076%]	3.510	2.043	9.170	6.680	10.750	15.253	17.983	16.463	15.157	17.490	17.650	11.217	12.563	13.853	10.420	9.500	8.560	11.663
T_8[dichlorvos (DIVAP) 0.053%]	1.073	0.660	5.200	1.750	1.803	4.297	3.273	1.617	4.883	9.060	8.673	5.163	4.287	6.180	8.183	7.063	7.933	4.771
T_9[dichlorovos (Luvon) 0.076%]	7.253	3.990	3.013	3.223	3.610	9.747	5.843	5.063	4.507	6.507	3.387	4.703	5.860	4.530	5.033	3.960	6.483	5.101
T_{10}[dichlorovos(Luvon) 0.053%]	1.223	1.140	1.583	0.740	1.923	6.667	1.183	1.803	1.657	1.463	8.137	3.497	4.653	3.747	4.280	3.530	7.347	3.210
T_{11}(quinalphos 0.038%)	2.633	3.030	4.187	3.883	5.110	13.183	10.657	5.837	9.703	7.210	7.703	7.510	8.367	14.897	14.170	6.643	8.697	7.848
T_{12}(quinalphos 0.025%)	3.190	1.537	1.527	1.610	2.067	1.760	1.970	1.813	2.533	3.393	5.467	4.390	3.950	4.557	6.277	5.753	7.173	3.469
T_{13}(chlorphyriphos 0.08%)	1.847	0.397	4.720	1.330	1.243	1.873	0.930	3.470	2.897	3.727	1.673	5.017	4.483	3.603	4.000	2.590	7.00	2.988
T_{14}(chlorphyriphos 0.07%)	1.067	0.603	-0.133	0.757	1.450	0.803	0.473	0.773	1.207	1.787	1.183	4.373	4.157	2.677	2.217	5.773	7.590	2.162
T_{15}(oxydemetonmethyl 0.025%)	1.900	0.523	0.530	0.490	2.080	0.703	1.760	3.037	3.217	2.943	3.523	4.017	4.883	3.330	4.357	2.983	7.350	2.802
T_{16}(oxydemetonmethyl 0.018%)	0.637	0.210	0.487	-0.333	0.260	0.380	0.673	0.943	1.217	1.287	1.387	3.130	2.787	1.727	3.170	2.640	6.527	1.596
T_{17}(fenvalerate 0.01%)	1.523	0.823	1.653	3.087	2.570	6.993	4.777	12.067	4.683	6.107	3.887	5.667	4.363	4.570	6.653	4.607	7.610	4.802
T_{18}(fenvalerate 0.006%)	0.427	1.430	1.487	1.330	2.113	5.227	1.530	2.673	1.140	2.880	2.243	3.413	3.653	3.213	3.307	4.133	7.220	2.789
T_{19}(cypermethrin 0.005%)	5.060	2.783	8.223	5.297	8.777	5.550	14.727	12.220	14.077	13.977	15.083	12.803	10.767	12.087	13.173	10.117	8.400	10.184
T_{20}(cypermethrin 0.003%)	2.017	0.663	2.693	2.590	2.273	2.693	6.470	1.853	5.680	10.247	7.263	4.393	3.877	5.590	7.210	6.680	7.310	4.677
T_{21}(azadirachtin-iodine 0.024%)	5.510	0.507	1.780	5.247	4.187	1.777	0.870	2.930	3.733	4.463	2.363	4.067	4.963	4.167	4.243	2.590	6.630	3.531
T_{22}(azarirachtin-iodine 0.021%)	0.577	1.487	0.317	1.643	0.777	0.880	0.313	1.637	2.277	0.903	0.833	3.513	4.397	2.640	2.870	3.123	6.067	2.015
T_{23}(carbaryl flowable 0.126%)	5.993	8.773	12.752	11.577	17.110	24.757	20.583	26.460	21.977	20.463	23.000	12.760	17.143	13.290	14.117	10.877	15.663	16.312
T_{24}(carbaryl folwable 0.015%)	2.537	1.657	2.813	2.720	2.827	4.223	7.217	4.483	6.800	6.007	8.937	5.910	5.827	6.653	6.777	6.853	8.980	5.366
T_{25}(carbaryl 0.2%)	2.573	1.827	4.063	5.150	5.130	7.847	15.883	13.720	12.107	10.617	13.040	7.023	8.873	8.550	8.087	7.970	9.573	8.355
T_{26}(carbaryl 0.1%)	1.063	1.313	2.743	2.497	2.090	2.920	1.320	1.507	3.293	2.723	8.257	3.433	3.930	5.530	6.173	5.420	7.697	3.642
T_{27}(control)	0.547	-2.003	-5.047	-2.890	-4.760	-4.670	-4.350	-5.457	-0.627	1.853	8.153	2.843	2.327	2.317	2.930	1.527	3.283	-0.237
	2.337	1.571	3.037	2.746	3.521	5.316	5.860	5.514	6.261	6.729	7.142	5.717	6.148	6.199	6.792	5.657	7.785	

	Stage	Treatment	Stage x Treatment
S.Em±	0.2160	0.1714	0.8905
C.D.at 5%	0.6018	0.4775	2.4809

Duration of stages

S_1 = May8-May15 S_4 = June7-June14 S_7 = July7-July14 S_{10}= August6-August13 S_{13} = September5-September12 S_{16} = October5-October12
S_2 = May18-May25 S_5 = June17-June24 S_8 = July17-July24 S_{11}= August16-August23 S_{14} = September15-September22 S_{17}= October15-October22
S3 = May28-June4 S6 = June27-July4 S9 = July27-August3 S12=August26-September2 S15 = September25-October2

Table 33 Means for stage x treatment effect on per cent reduction of leaf damage of E.marginellus during 1995

Stage / Treatment	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	S_{12}	S_{13}	S_{14}	S_{15}	S_{16}	S_{17}	
T_1(phosphamidon 0.043%)	1.820	3.695	7.728	5.598	7.025	13.035	13.810	10.881	13.519	14.009	9.720	11.025	9.366	13.026	12.402	12.025	8.271	10.022
T_2(phosphamidon 0.034%)	1.721	2.632	3.920	2.521	3.569	4.562	5.021	3.210	3.860	7.820	7.829	4.792	5.920	5.625	6.021	5.123	8.771	4.929
T_3[monocrotophos (sufos) 0.054%]	3.201	3.061	4.021	4.978	6.305	6.932	14.052	10.961	14.101	8.816	9.025	6.381	9.221	7.882	8.305	7.729	8.902	7.882
T_4[monocrotophos (Sufos) 0.036%]	1.580	1.772	2.053	1.370	3.292	3.521	3.202	3.510	4.029	6.293	7.903	3.872	6.422	5.021	7.620	6.705	7.919	4.282
T_5[monocrotophos (Lufos) 0.054%]	3.529	2.901	3.982	4.051	5.210	4.839	11.725	6.810	12.711	12.021	6.169	9.856	8.812	7.779	8.829	5.888	7.736	7.290
T_6[monocrotophos (Lufos) 0.036%]	3.880	2.042	1.880	2.102	2.961	3.569	3.210	3.559	3.902	4.422	3.552	4.712	4.520	5.525	6.029	5.126	8.625	3.880
T_7[dichlorvos (DIVAP) 0.076%]	4.391	2.761	11.025	7.823	11.662	16.025	18.569	17.253	15.930	18.366	19.007	11.825	13.312	15.025	11.228	10.329	9.325	13.025
T_8[dichlorvos (DIVAP) 0.053%]	1.951	2.021	6.021	2.913	3.022	4.821	3.862	2.512	5.702	9.902	9.421	6.023	4.625	5.922	8.921	7.739	8.811	5.590
T_9[dichlorovos (Luvon) 0.076%]	7.643	4.810	3.826	3.032	4.561	10.721	6.621	5.832	5.880	7.382	4.221	5.615	6.722	4.702	4.920	4.620	7.361	5.701
T_{10}[dichlorovos(Luvon) 0.053%]	1.881	2.013	2.592	2.112	2.756	7.581	1.920	2.776	3.021	2.339	8.965	4.258	5.592	4.552	4.829	4.302	8.129	3.883
T_{11}(quinalphos 0.038%)	3.602	3.963	5.063	4.712	6.012	14.021	11.710	6.719	10.511	7.862	8.513	8.710	9.126	15.820	14.622	7.302	9.770	9.062
T_{12}(quinalphos 0.025%)	3.962	1.609	2.420	2.512	3.112	2.620	2.620	2.811	4.002	4.302	6.257	5.291	4.708	5.329	6.829	6.502	6.920	4.383
T_{13}(chlorphyriphos 0.08%)	2.705	2.210	5.329	2.962	1.621	2.720	1.910	4.509	3.717	3.601	2.410	4.602	5.226	3.102	4.092	3.325	6.119	3.820
T_{14}(chlorphyriphos 0.07%)	1.872	2.823	-0.962	1.911	2.830	1.708	1.810	1.525	1.862	3.025	3.092	4.829	4.725	4.029	3.035	6.622	8.396	2.669
T_{15}(oxydemetonmethyl 0.025%)	2.816	1.633	1.630	1.761	3.012	1.621	2.210	3.938	3.809	3.879	4.312	4.021	5.816	4.205	5.122	3.621	8.221	3.866
T_{16}(oxydemetonmethyl 0.018%)	1.553	1.829	2.392	-1.525	1.882	1.250	1.510	1.772	1.869	2.035	2.282	3.512	3.610	2.502	3.829	3.925	6.205	2.239
T_{17}(fenvalerate 0.01%)	2.592	3.021	3.082	4.035	3.412	7.812	5.621	13.025	5.426	7.019	4.679	5.369	5.125	5.320	7.305	6.025	6.022	5.629
T_{18}(fenvalerate 0.006%)	2.720	1.812	2.663	2.662	3.102	5.833	2.410	3.910	1.902	3.622	2.621	4.412	4.402	3.821	4.203	4.929	8.109	3.558
T_{19}(cypermethrin 0.005%)	5.936	3.569	10.102	5.891	9.921	6.510	16.013	13.829	14.826	14.829	14.192	11.662	11.512	12.692	13.929	12.025	9.332	11.102
T_{20}(cypermethrin 0.003%)	3.021	1.821	3.539	3.510	3.711	3.410	7.292	2.625	6.613	12.039	7.767	4.426	4.902	6.720	7.820	7.728	8.212	5.336
T_{21}(azadirachtin-iodine 0.024%)	6.703	2.022	2.692	6.120	4.932	2.559	1.692	3.811	3.902	5.511	3.256	5.611	5.602	4.720	4.625	3.820	7.309	4.200
T_{22}(azadirachtin-iodine021%)	1.381	2.396	2.022	2.921	2.021	2.021	1.229	2.521	2.772	1.819	1.912	4.921	5.166	3.325	3.620	3.729	6.883	2.625
T_{23}(carbaryl flowable 0.126%)	6.822	10.021	14.821	12.920	17.883	25.921	22.012	27.662	23.001	19.092	24.029	14.029	17.775	15.003	14.925	11.723	16.712	18.082
T_{24}(carbaryl folwable 0.015%)	3.591	2.525	4.032	3.810	3.805	4.831	7.512	5.328	7.295	7.022	9.021	5.626	6.620	5.290	7.556	7.720	9.720	5.922
T_{25}(carbaryl 0.2%)	4.023	2.712	4.961	5.912	6.021	9.021	16.356	14.612	12.961	8.969	12.162	7.725	9.602	8.219	8.925	8.370	10.311	9.161
T_{26}(carbaryl 0.1%)	1.881	2.290	3.825	2.834	2.810	3.520	2.390	2.510	4.032	3.619	8.711	4.332	4.221	6.203	6.773	6.338	8.021	4.420
T_{27}(control)	1.362	-4.012	-7.029	-3.792	-5.725	-6.012	-5.569	-7.025	-2.039	3.069	9.025	4.008	3.108	4.026	3.920	3.022	3.823	-1.029
	4.022	2.582	3.869	3.506	4.292	5.992	6.802	6.428	6.993	7.772	7.920	6.501	6.941	6.862	7.619	6.382	9.025	

	Stage	Treatment	Stage x Treatment
S.Em±	0.8120	0.5631	1.0250
C.D.at 5%	2.2622	1.5688	2.8556

Duration of stages

S_1 = May8-May15 S_4 = June7-June14 S_7 = July7-July14 S_{10}= August6-August13 S_{13} = September5-September12 S_{16} = October5-October12
S_2 = May18-May25 S_5 = June17-June24 S_8 = July17-July24 S_{11}= August16-August23 S_{14} = September15-September22 S_{17}= October15-October22
S3 = May28-June4 S6 = June27-July4 S9 = July27-August3 S12=August26-September2 S15 = September25-October2

Table 32 showed that all the treatments were found to reduce leaf damage over control (T_{27}) where as T_{23} (Carbaryl flowable 0.126%) was observed to be the best amongst all other treatments, the order of other treatments with respect to effectiveness is as follows, T_7 [dichlorvos(DIVAP) 0.076%)], T_{19}(cypermethrin 0.05%), T_1 (phosphamidon 0.043%), T_{25}(Carbaryl 0.2%), T_{11} (quinalphos 0.038%),T_5 [monocrotophos(Luphos) 0.04%] and T_9 [dichlorvos (Luvon) 0.076%]. It is also seen that T_{16} (oxydemetonmethyl 0.018%] gave least effect.

In case of stage effect as shown in Table 32, the best stage effect was observed in S_{17}(Oct.15-Oct.22) followed by S_{11}(Aug.16-Aug.23) and S_{15}(Sept.25-Oct.2)and S_{10}(Aug.6-Aug.13) and least effect was noticed in S_2 (May 18- May 25)

Results on interaction effect of stage and treatment as represented in Table 32 showed that the best interaction effect was noted in T_{23} (carbaryl flowable 0.126%) with all successive stages followed by T_7 S_5-T_7S_{17} (DIVAP 0.076% during Jun.17-Jun.24), $T_{19}S_7$- $T_{19}S_{17}$ (cypermethrin 0.005% during Jul.7-Jul.14 and Oct.15-Oct.22), T_1S_6-T_1S_{17} (phosphamidan 0.043% during Jun.27-Jul.4 and Oct.15-Oct.22), $T_{25}S_7$-$T_{25}S_{11}$ (carbaryl 0.2% during Jul.7-Jul.14 and Aug.16-Aug.23), $T_{11}S_6$-$T_{11}S_7$ (quinalphos 0.038% during Jun.27-Jul.4 and Jul.7-Jul.14), $T_{11}S_9$ (quinalphos 0.038% during Jul.27-Aug.13),$T_{11}S_{14}$-$T_{11}S_{15}$ (quinalphos 0.038% during Sep.15-Sep.22 and Sep.25-Oct.2) and T_3S_7-T_3S_9 [monocrotophos (Sufos) 0.054% during Jul.7-Jul.14 and Jul.27-Aug.13),

respectively with least result obtained in T_{16} (oxidemetonmethyl 0.018%).

To verify the results as obtained during 1994 the experiment was repeated with same methods and materials. It is evident from the Table 33 that more or less similar trend in the effect of the insecticides on the incidence of the pest species was found during 1995 with little variation in the damage caused by the pest in comparison with previous year as shown in Table 33.

4.4.4 Field evaluation of grannular insecticides as soil application

As egg, larval and pupal stages of *E.marginellus* are on or inside the soil a three factor replicated trial was conducted under field condition. For the purpose three different grannular insecticides with dosages one each of phorate 10 G and carbofuran 3 G and two of carbaryl 4% + lindane 4% G were selected for soil application. At an interval of one month the gra nules were applied in the soil around the base of plant followed by proper mixing with the soil and sufficient watering and the experiment was continued from 29th May to 30 the October both 1994 and 1995. Details of the experiment are mentioned under materials and methods.

Results as indicated in Table 34 that all the treatments were significantly superior to the control (T_5) in reducing the percent leaf damage during 1994. T_4 (carbaryl 4% + lindane 4%

Table 34 Means for treatment x week effect on per cent reduction of leaf damage during 1994

Week / Treatment	W_1 (June-October)	W_2 (June-October)	W_3 (June-October)	W_4 (June-October)	
T_1(phorate @ 5g/plant)	7.386	11.164	14.042	14.541	11.783
T_2(carbofuran @ 5g/plant)	4.016	5.145	8.093	8.486	6.435
T_3(carbaryl+lindane @ 5g/ plant)	5.899	9.582	11.962	12.107	9.887
T_4(carbaryl+lindane @ 7.5g/ plant)	8.692	14.881	17.512	17.664	14.393
T_5(control)	0.442	0.265	1.936	2.928	1.393
	5.287	8.207	10.709	11.145	

Table 35 Means for treatment x month effect on per cent reduction of leaf damage during 1994

Month / Treatment	M_1 (June)	M_2 (July)	M_3 (August)	M_4 (September)	M_5 (October)
T_1	5.658	8.969	20.204	13.789	10.298
T_2	2.081	3.124	15.781	5.874	5.315
T_3	4.342	7.487	17.907	11.085	8.615
T_4	7.924	11.391	22.271	18.486	13.364
T_5	-5.896	-9.125	15.149	1.879	4.958
	2.822	4.369	18.263	10.223	8.510

Table 36 Means for week x month effect on per cent reduction of leaf damage during 1994

	M_1	M_2	M_3	M_4	M_5
W_1 (1st week)	0.083	2.243	12.206	6.332	5.571
W_2 (2nd week)	5.231	5.910	14.239	8.990	6.667
W_3 (3rd week)	5.332	7.423	20.471	10.750	9.569
W_4 (4th week)	0.641	1.901	26.134	14.818	12.232

Table 37 Means for treatment x month x week effect on per cent reduction of leaf damage during 1994

Week / Treatment	M_1 (June)				M_2 (July)				M_3 (August)				M_4 (September)				M_5 (October)			
	W_1	W_2	W_3	W_4	W_1	W_2	W_3	W_4	W_1	W_2	W_3	W_4	W_1	W_2	W_3	W_4	W_1	W_2	W_3	W_4
T_1	1.805	8.655	9.555	2.615	5.100	10.480	13.725	6.570	13.785	16.185	21.870	28.975	8.565	12.130	14.345	20.115	7.675	8.370	10.715	14.430
T_2	0.470	3.395	3.665	0.795	1.615	3.490	5.115	2.275	10.850	10.395	19.200	22.680	3.615	5.565	6.065	8.250	3.530	2.880	6.420	8.430
T_3	0.505	7.050	7.775	2.040	3.545	9.395	11.655	5.355	10.945	14.495	19.860	26.330	7.660	9.640	11.455	15.585	6.840	7.330	9.065	11.225
T_4	2.665	12.175	12.475	4.380	5.315	14.470	17.795	7.985	15.055	19.370	23.325	31.335	12.390	16.605	19.100	25.850	8.035	11.785	14.865	18.770
T_5	-5.030	-5.120	-6.810	-6.625	-4.360	-8.285	-11.175	-12.680	10.395	10.750	18.100	21.350	-0.570	1.010	2.785	4.290	1.775	2.970	6.780	8.305

	Treatment	Week	Month	Treatment x Week	Treatment x Month	Week x Month	Treatment x Week x Month
S.Em±	0.2055	0.1838	0.2055	0.4111	0.4596	0.4111	0.9192
C.D.at 5%	0.5754	0.5147	0.5754	1.1511	1.2869	1.1511	2.5739

G @ 7.5g/plant) proved to be the best amongst all other treatments. It is also seen from the result (Table 34) that first week (W_1 i.e.June to October) had the least effect in reducing the damage. The effect in reducing damage categorically increased in successive weeks and it was best in fourth week (W_4 i.e. June to October) and third week(W_3 i.e. June to October).

Results on interaction effect of treatments and weeks as depicted in Table 34 showed that T_4W_4 (carbaryl + lindane @ 7.5g/plant during fourth week of June to October) gave the best result and this interaction effect were at par with T_4W_3 (carbaryl + lindane @ 7.5g/plant during third week of June to October). However, all the interaction effect of treatments and weeks were found to good over the successive weeks of T_5(control).

Results as depicted in Table 35 showed significant reduction in damage in M_3 (August). The interaction effect between treatment and month was the best in T_4M_3 (carbaryl + lindane @ 7.5g/plant durign August) and least in T_5M_2 (control treatment during July).

The results as presented in Table 36 also showed that irrespective of treatments, the interaction effect of W_4M_3 (fourth week of August) was found to reduce significant leaf damage amongst all other interaction effects and W_1M_1 (first week of June) was observed to be the lowest reduction of leaf damage.

Among the combined effect of three factors i.e. treat-

Table 38 Means for treatment x week effect on per cent reduction of leaf damage during 1995

Week / Treatment	W_1 (June-October)	W_2 (June-October)	W_3 (June-October)	W_4 (June-October)	
T_1(phorate @ 5g/plant)	8.279	11.962	14.931	15.366	12.491
T_2(carbofuran @ 5g/plant)	4.652	5.933	8.864	9.369	7.812
T_3(carbaryl+lindane @ 5g/plant)	6.979	10.390	12.753	12.922	10.832
T_4(carbaryl+lindane @ 7.5g/plant)	9.461	15.588	18.543	19.469	15.552
T_5(control)	1.253	0.858	2.722	3.813	2.922
	5.899	8.726	11.679	11.936	

Table 39 Means for treatment x month effect on per cent reduction of leaf damage during 1995

Month / Treatment	M_1 (June)	M_2 (July)	M_3 (August)	M_4 (September)	M_5 (October)
T_1	6.478	9.753	20.856	14.577	11.355
T_2	2.961	3.762	16.562	6.688	5.863
T_3	5.155	8.369	18.722	11.926	9.436
T_4	8.569	13.235	22.880	20.326	14.255
T_5	-7.688	-9.552	15.965	3.671	5.728
	4.677	5.158	18.955	10.845	9.326

Table 40 Means for week x month effect on per cent reduction of leaf damage during 1995

	M_1	M_2	M_3	M_4	M_5
W_1 (1st week)	0.862	3.856	12.825	7.881	7.352
W_2 (2nd week)	5.852	7.555	15.865	9.563	7.425
W_3 (3rd week)	7.250	8.345	22.263	11.521	11.371
W_4 (4th week)	1.281	2.733	26.855	16.631	12.859

Table 41 Means for treatment x month x week effect on per cent reduction of leaf damage during 1995

Week / Treatment	M_1 (June)				M_2 (July)				M_3 (August)				M_4 (September)				M_5 (October)			
	W_1	W_2	W_3	W_4	W_1	W_2	W_3	W_4	W_1	W_2	W_3	W_4	W_1	W_2	W_3	W_4	W_1	W_2	W_3	
T_1	2.629	9.405	11.285	3.385	6.835	12.372	14.561	8.130	14.834	16.934	23.320	29.808	10.346	14.750	15.225	20.921	8.455	9.162	12.012	15.262
T_2	1.390	4.062	5.011	2.217	3.202	4.338	5.961	2.878	11.613	12.012	19.989	24.731	6.120	6.391	6.988	9.691	4.514	4.119	4.911	9.372
T_3	2.279	7.961	8.661	4.102	2.952	10.305	12.678	5.833	12.489	16.366	21.320	27.112	8.801	11.721	11.983	17.026	7.330	8.662	10.736	12.105
T_4	3.511	14.026	12.601	4.880	4.921	14.839	19.669	8.800	15.992	20.761	25.022	32.391	13.690	18.736	17.279	27.933	9.839	12.803	15.766	20.021
T_5	-5.991	-7.001	-6.110	-7.591	-5.021	-9.110	-12.013	-14.113	11.029	11.677	20.322	22.022	-1.888	1.961	4.022	3.920	2.669	3.770	8.711	9.692

	Treatment	Week	Month	Treatment x Week	Treatment x Month	Week x Month	Treatment x Week x Month
S.Em±	0.3432	0.2979	0.3432	0.5325	0.4978	0.5325	0.9873
C.D.at 5%	0.9610	0.8342	0.9610	1.4911	1.3939	1.4911	2.7646

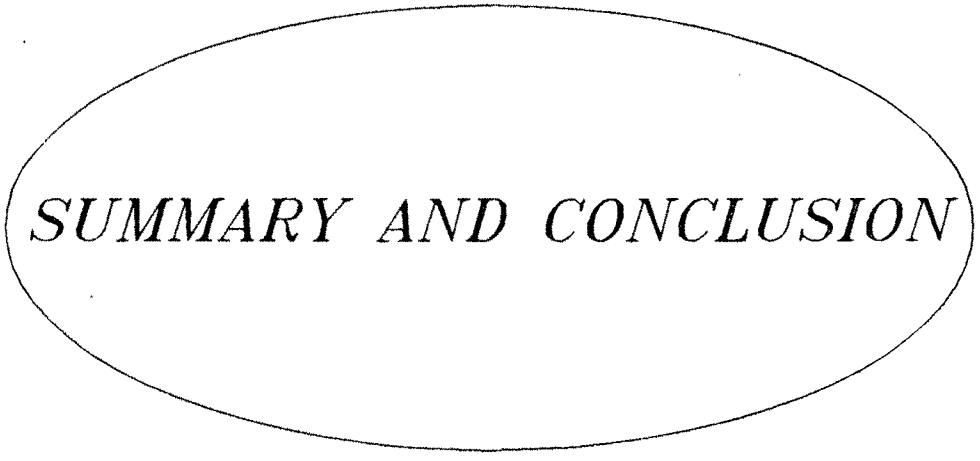
ment, month and week as shown in Table 37, the combined effect of T_4M_1 - T_4M_5 (carbaryl + lindane @7.5g/plant during June - October) with all successive weeks were found to reduce significant leaf damage followed by T_1M_1-T_1M_5 (phorate @ 5g/plant during June - October) and T_3M_1-T_3M_5 (carbaryl + lindane @ 5g/plant during June - October) with all successive weeks.

More or less similar trend in the effect of grannular insecticides on the incidence of *E.merginellus* were noted during 1995 as depicted in Tables 38-41.

As regards control of *E.marginellus* (Syn:*D.marginatus)* by use of chemicals, the sprays of DDT at 0.25% (Singh and Pandey,1972 and Siddiqui and Mathur,1980), dichlorvos at 0.05% (Singh and Pandey,1972) , monocrotophos at 0.03% (Butani,1975), deltamethrin at 0.0022% (Soh and Khoo,1983) and cypermethrin at 0.05% (Bhole *et al.*,1987) were found most consistent in controlling the pest species. The present author during his trial with thirteen different insecticides having two different dosages of each, had observed that some treatments including carbaryl flowable at 0.126 % followed by dichlorvos (DIVAP) at 0.076%,cypermethrin at 0.005%,phosphamidon at 0.043%, carbaryl at 0.2%, quinalphos at 0.038% and monocrotophos (Sufos and Lufos) at 0.054% were considerably effective in controlling the same insect species. These findings are more or less in agreement with the results reported by various authors mentioned above. While in case of oxydemoton methyl which was recorded least effective as

obtained from the present investigation was not at par with that as reported by Siddiqui and Mathur (1980) who found it significantly effective.

CHAPTER - 5



SUMMARY AND CONCLUSION

Survey of insect pest complex of nursery plants of mango has been carried out during 1993-1995 at Horticultural Nursery Farm, B.C.K.V., Kalyani Nadia,W B. A total number of twenty three insect species and one mite species has been recorded from mango saplings during the present course of investigation which are as follow:

Order :Coleoptera

Family:Curculionidae

Leaf Cutting Weevil, *Eugnamptus marginellus*Fst.(Syn:*Deporaus marginatus* Pascoe)

Grey Weevil, *Myllocerus discolor* Boh.

Leaf Weevil, *Astycus lateralis* Fabr.

Family : Chrysomelidae

Leaf beetle, *Aspidolopha melanophthalma* Lacord and *Diapromorpha pallens*(F.)

Flea beetle, *Monolepta sp.*

Order : Lepidoptera
Family : Noctuidae

Shoot borer, *Metachrostis sp.*

Family : Lymantriidae

Hairy caterpillar, *Dasychira mendosa basivitta*(walker)
Euproctis scintillans(Walk.)
Lymantria ampla Walk.

Family : Geomtridae

Looper, *Thalassodes veraria* Guenee.

Family : Zygaenidae

Slug caterpillar,	*Trypenophora semihyalina* Koll.
	Family : Aphididae
Aphid,	*Toxoptera aurantii* Bd.F
	Family : Pentatomidae
Stink bug,	*Coptosoma sp.* Family : Coccidae
Mealy bug,	*Rastrococcus iceryoides*(Green)
	Family : Thripidae
Thrips,	*Scirtothrips dorsalis* Hood
	Order : Acarina Family : Tetranychidae
Mite	*Oligonychus mangiferus* (Rah.& Sap.).

Some unidentified insect species were also recorded during the course of investigation and these are bag worm, leaf webber, leaf folder, leaf miner and scale insect.

Out of the regular pests which appeared during 1993-1995 only *E.marginellus* attained major status causing significant reduction in net return. The other regular pests including *M.discolor, Metachrostis sp.,S.dorsalis* and a mite ,*O.mangiferus* and the sporadic like *A.lateralis, A.melanophthalma, D. mendosa basivitta, E.scintillans, L.ampla and T.veraria* and some unidentified insect species including bag worm, leaf webber, leaf folder, leaf miner were of minor importance as observed during the course of investigation. Another group of pests like *T.semihyalina. Coptosoma sp., T. aurantii, R.iceryoides* and unidentified scale insect were in stray instances only. Out of all the

above mentioned pest species, following were recorded for the first time from mango saplings including *A.lateralis, A.melanophthalma,D.pallens* and *T.semihyalina*.

The morphology and feeding habits of the above mentioned species were investigated.

The first appearance of *E.marginellus* was observed immediately after winter months *i.e.* during end of February in three successive years from 1993-'95 under West Bengal condition. The activity of the pest species on mango saplings was upto early part of November with peak in July-August and caused damage to the extent of about 79 per cent including both tender leaves cut after deposition of eggs and scrapping of green matter.

M.discolor observed to be one of regular pests in mango saplings caused damage to the extent of about 26 per cent during 1993. The activity of the pest existed from February- early part of December.

Metachrostis sp. was found causing shoot damage to the extent of about 11 per cent and observed to be active from end of June to September - October.

S.dorsalis appeared first during early part of February and remained in the field upto early part of July,1993. In 1994 the activity of the pest species was from late February-June with peak during early March both during 1993 and 1994.

The activity of bagworm was found only for a short

period from the end of August to November, 1993 and 1994.

Moderate climatic conditions prevailed from 4th May-15th June favoured higher rate of mite population but more rainfall showed lower incidence during 1993 and 1994.

The leaf cutting weevil *E.marginellus* freely mate both in the field and in the captivity and usually mating took place 2-3 days after adult emergence and lasted for 15-40 minutes under field condition. A female laid 1-21 eggs per leaf singly in 'C' shaped pouch usually at the dorsal side of leaves prepared by it on either side of midrib. Freshly laid eggs were creamy white, cylindrical and rounded at both the ends. Average length x width of eggs were 0.653 x 0.290 mm and developmental period was 46.40 hours. Larvae developed on fallen cut leaves by passing through three larval instars and average duration of which was 32.36, 33.08 and 108.80 hours, respectively. The average length x width of three instar larvae were 1.91 x 0.87 mm, 3.16 x 1.17 mm and 4.90 x 1.75 mm, respectively. The average prepupal stage lasted for 111.24 hours. Pupation took place in an earthen soil shell at a depth ranging 3-5 cm and lasted for an average of 169.48 hours. The length x width of pupae was 4.81 x 1.44 mm. Life cycle from egg to adult was completed in 501.36 hours. Adults were shiny dark brown and abdomen being light brown, average length x width of male and female being 5.21 x 1.64mm and 5.64 x 1.92mm. respectively. The average length of snout in male and female was 0.97mm and 1.16mm, respectively.

Per cent increase of different body parts of female including length of rostrum and body, width of the body, length and width of elytra were found larger over males.

Correlation studies of *E.marginellus* between larval length,larval width and width of the head capsule were made and a high value of correlation coefficient, (0.937) was found. Progression factor in respect of width of head capsule of the larvae of *E.marginellus* was estimated to be 1.43 and it was in agreement with the postulation of Dyar (1890).

There was decrease in incubation period of eggs of *E.marginellus* with the increase of temperature from 15±1°C-35±1°C and with the increase of temperature from 15±1°C-30±1°C there was increase in hatching percentage but the rate of hatching was lowered at 35±1°C. None of the eggs did hatch at lower temperatures below 15±1°C indicating threshold level for egg development and upper temperatures above 35±1°C.The larval, prepupal and pupal period were found to decrease with the increase of temperature from 15±1°C-30±1°C.

Similarly with the decrease of temperature there was an increase of incubation period of *E.marginellus* and it was significantly prolonged when eggs were exposed at 15±1°C and 20±1°C after keeping the freshly laid eggs one day at room temperature before treatment as compared to the freshly laid eggs exposed to the same temperature treatments. None of the eggs of freshly laid and one day old did hatch when incubated at 36±1°C. But the eggs

of both freshly laid and one day old kept at different short exposures (one, two and three hours) of constant temperature were found to withstand but there was no significant variation on growth period of eggs.

The larvae of *E.marginellus* entered into dormant stage during November 1993 and 1994 in earthen soil shell under laboratory condition. The loss of body weight of the larvae of *E.marginellus* to the extent of 26.69% from November, 1995 onwards indicated the larvae were entering into a state of inactivity or hibernation type of dormancy and regaining of body weight started during spring (February). The break of larval dormancy of *E.marginellus* under laboratory condition was effected with the onset of favourable temperature of about 26°C and above mostly prevailing during February.

Of the various factors tested under laboratory condition, it was observed that the dormancy of the said species was mostly terminated in relative humidity ranging from 40-60%. Similarly 50-60% termination was in relative humidity ranging 50-60% at a constant temperature of 30°±1°C. It was noteworthy that about four weeks were required for termination when larvae exposed to 40% relative humidity under room temperature but at the same humidity level under constant temperature of 30°±1°C, the said larval hibernation terminated within one week.

The chances of dormant larvae placed at zero and 1 cm depth of soil were comparatively less than those placed at more

lower soil depth.Almost 100% larvae were found dead after a lapse of certain period when exposed to zero and 1 cm soil depth. All the dormant larvae exposed to a depth ranging from 2-5cm were transformed into pupae during February and subsequently emergence of adults took place showing 100% survivality.

For control of the Pest, *E.marginellus* an integration of suitable agrotechniques were found necessary. Since after oviposition,the female cut the leaf near its base and the leaves contining eggs fell down to the ground and on hatching the larvae which are miners remained in the fallen leaves and after completing its larval stage, the prepupal larvae came out from the leaves and entered into soil upto a certain depth of soil for pupation. Accordingly collection and destruction of fallen leaves containing eggs, raking of soil around plants followed by burning of dry leaves, flooding etc. were useful. Similarly, destruction of hibernated larvae during winter by raking around the base of the plants to expose the hibernated larvae to the sun,parasites,predators etc. was helpful in reducing the pest population.

Relative contact toxicity of four insecticides to the adults of *E.marginellus* were tested under laboratory condition. Based on the $^{LC}_{50}$ value, the order of efficacy of four insecticides against adults was in the descending order: cypermethrin > quinalphos > carbaryl flowable > dichlorvos.

As regards the efficacy of two soil insecticides *viz.* chlorphyriphos and aldrin against prepupae and pupae of *E.margin-*

ellus, it was observed that they are capable of giving excellent control only with a contact period of one hour and chlorphyriphos at 0.08% concentration caused a rapid kill of the prepupae and pupae within 120 hours and 96 hours, respectivley. Aldrin at 0.05% also killed the prepupae and pupae rapidly as caused 76.67% and 100% kill in 120 hours following treatment.

Thirteen insecticides, each of two concentrations were applied as surface application at an interval of ten days in a two factor replicated field trial for five months both during 1994 and 1995. Observation on per cent reduction of leaf damage from treated plant vis-a-vis control treatments were evaluated at seven days interval. All the treatments were found effective over control. Sevin Flo (Carbaryl Flowable 0.126%) was observed to be the best amongst all other treatments follow ed by DIVAP (Dichlorvos 0.076%), Bilcyp (Cypermethrin 0.005%), Sumidon (Phosphamidon 0.043%), Sufos and Luphos (Monocrotophos 0.054%) and Luvon (Dichlorvos 0.075%). With respect to stage effect, the best result was in the stage seventeen (S_{17}) *i.e.* during October. In case of interaction effect between stage and treatment, Sevin Flo (Carbaryl Flowable 0.126%) with all successive stages were found best.

Three grannular insecticides were selected as soil application and applied at an interval of one month in a three factor replicated field trial from 29th May- 30th October, 1994 and 1995 and observations on the same were evaluated at seven

days interval. All the treatments were significantly superior over control while Sevidol(Carbaryl 4% + Lindane 4% g @7.5 g/plant) proved to be the best treatment effect. In case of week effect, it was found equally best in fourth and third week. While the interaction effect between treatments and weeks, the best result noted in fourth week with Sevidol (@ 7.5 g/plant) and it was at par with third week.

As regards the effect of month, interaction effect between treatments and months and months and weeks, the best result was observed during August (M_3), T_4 M_3, fourth week of August. Among the combined effect of three factor *i.e.* treatment, month and week, the best combined effect was noted from June-October with Sevidol (@ 7.5 g/plant) in all successive weeks followed by Anumet (Phorate 10 G @ 5g/plant) and Sevidol (@ 5g/plant).

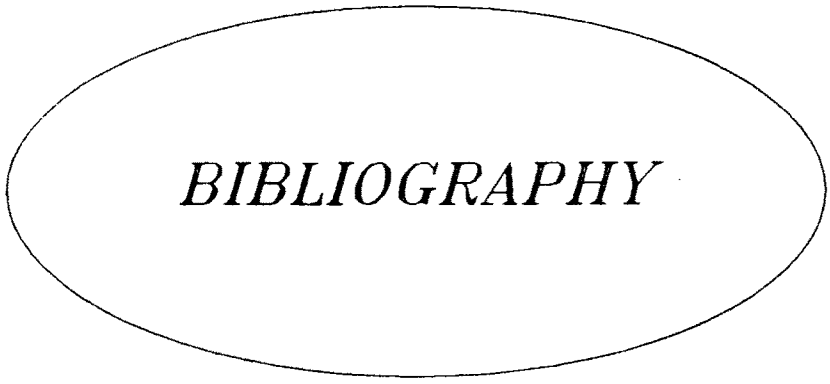
CHAPTER - 6

FUTURE SCOPE OF RESEARCH

Nursery mango is a highly profitable cash crop, particularly suited to small holdings.The cultivation of the crop requires special expertise. Previously it had remained a specialised job amongst small section of people who had this expertise traditionally. Now it has extended to non-traditionals.

Increase of land under nursery cultivation of high yielding mango varieties has resulted multifaceted problems particularly insect damage. As ascertained through investigation the grafted mango saplings which are nursed in conditions favouring quick growth with adequate supply of food materials for the purpose of ready market in a limited period, are prone to the attack of insect pests, there by causing reduced price of the crop. The net return of the cultivation can be enhanced if proper management practices against insect pests are under taken. The pre-requisites of the programme include assessment of pest spectrum through intensive studies under different agroclimatic conditions to formulate appropriate pest management system with emphasis on biology, habit and natural enemy complex of potential pests. By exploiting the weaknesses in the life system of the pest species damage they cause may be prevented.

CHAPTER - 7



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