BIOLOGY AND CHEMICAL CONTROL OF SEMI-LOOPER, *Achaea mercatoria* Fabricius (Noctuidae : Catocalinae [M. Honey (NHM) det.] : Lepidoptera) ON SAPOTA, *Manilkara achras* (Mill.) Fosberg

A

THESIS

SUBMITTED TO THE

GUJARAT AGRICULTURAL UNIVERSITY

SARDAR KRUSHINAGAR

IN PARTIAL FULFILMENT OF THE REQUIREMENTS

FOR

THE AWARD OF THE DEGREE

OF

MASTER OF SCIENCE

(AGRICULTURE)

IN

AGRICULTURAL ENTOMOLOGY

BY

NILESHKUMAR VITTHALBHAI PATEL

B. Sc. (Agri.)

DEPARTMENT OF AGRICULTURAL ENTOMOLOGY

N. M. COLLEGE OF AGRICULTURE

GUJARAT AGRICULTURAL UNIVERSITY

NAVSARI CAMPUS, NAVSARI - 396 450

GUJARAT STATE

DECEMBER-2000

Registration No. **04 - 04109 - 98**

ABSTRACT

BIOLOGY AND CHEMICAL CONTROL OF SEMI-LOOPER, *Achaea mercatoria* Fabricius (Noctuidae : Catocalinae [M. Honey (NHM) det.] : Lepidoptera) ON SAPOTA, *Manilkara achras* (Mill.) Fosberg

---

Name of Student	Major Advisor
Shri N. V. Patel	Dr. M. B. Patel

DEPARTMENT OF AGRICULTURAL ENTOMOLOGY

N. M. COLLEGE OF AGRICULTURE

GUJARAT AGRICULTURAL UNIVERSITY

NAVSARI CAMPUS, NAVSARI-396 450

A B S T R A C T

In the study of biology of *Achaea mercatoria* Fabricius on sapota, the eggs were found to be laying singly on the lower as well as on the upper surface of leaves. Freshly laid eggs were bluish grey in colour which changed to light brown after one day and became dark brown prior to hatching. Eggs were hemispherical with upper surface convex and lower surface concave with numerous ridges and furrows running from one polar end to another. Average length and breadth of egg was 0.39 $\pm$ 0.027 mm and 0.68 $\pm$ 0.057 mm, respectively. Average incubation period and hatching percentage were 2.27 $\pm$ 0.46 days and 90.48 $\pm$ 2.42 per cent, respectively. The larval stage passed through six instars. The average developmental period of first, second, third, fourth, fifth and sixth larval instar was 2.96 $\pm$ 0.20, 2.04 $\pm$ 0.20, 2.08 $\pm$ 0.28, 2.16 $\pm$ 0.37, 2.64 $\pm$ 0.49 and 5.32 $\pm$ 0.48 days, respectively. Total

larval developmental period was on an average 17.20 ± 0.71 days. Average duration of prepupal and pupal period were 2.12 ± 0.33 and 10.48 ± 0.59 days, respectively.

The female and male adults measured on an average 22.0 ± 0.87 mm and 25.60 ± 1.15 mm in length and 50.26 ± 1.03 mm and 54.52 ± 1.40 mm in breadth across the expanded wings, respectively. The average pre-oviposition, oviposition and post-oviposition period was 2.22 ± 0.46, 5.00 ± 0.76 and 3.04 ± 0.89 days, respectively. Average egg laying capacity of female was 272.55 ± 40.34 eggs. The average longevity of female and male was 10.32 ± 1.03 and 9.0 ± 0.82 days, respectively. Total life cycle occupied 39 to 45 days (Average 42.40 ± 1.50 days) in case of female and 38 to 44 days (Average 41.08 ± 1.38 days) in case of male.

The pest remained active from last week of March to second week of June and first week of April to third week of May during 1999-2000 and 2000-2001, respectively. The result on per cent damage leaves showed that the maximum per cent damage leaves were recorded in third week of May during 1999-2000, while during 2000-2001 it was maximum in the fourth week of May and thereafter it declined.

Evaluation of various insecticides, indicated that nurelle D_{505} 0.055 per cent, profenofos 0.075 per cent, carbosulfan 0.05 per cent, lambda-cyhalothrin 0.005 per cent, spark 0.036 per cent, endosulfan 0.075 per cent, fenobucarb 0.1 per cent, polytrin-C_{404} 0.044 per cent were found to be the most effective in control of the larva, *A. mercatoria* in field conditions. The various insecticides were evaluated on the basis of per cent damage leaves, it was indicated that

profenofos 0.075 per cent, carbosulfan 0.05 per cent, nurelle D_{505} 0.055 per cent, spark 0.036 per cent, endosulfan 0.075 per cent, lambda-cyhalothrin 0.005 per cent, fenobucarb 0.1 per cent and polytrin-C_{404} 0.044 per cent were found to be the most effective treatments in recording minimum per cent of damage leaves.

The result of laboratory trial on bio-efficacy of different insecticides against larvae of *A. mercatoria* revealed that profenofos 0.075 per cent, carbosulfan 0.05 per cent, endosulfan 0.075 per cent, spark 0.036 per cent and fenobucarb 0.1 per cent were found to be the best in giving higher larval mortality. Polytrin-C_{404} 0.044 per cent and nurelle D_{505} 0.055 per cent were at par with each other and stood next to above mentioned treatments.

Among plant leaves extracts, kadvi mahendi leaves (*C. inerme*) extract 5 per cent suspension and naffatia leaves (*I. fistulosa*) extract 5 per cent suspension were found to be the best treatment giving higher larval mortality.

Dr. M. B. Patel
Associate Professor (Entomology),
N. M. College of Agriculture,
Gujarat Agricultural University,
Navsari Campus, Navsari-396 450.

CERTIFICATE

This is to certify that the thesis entitled **"Biology and Chemical Control of Semi-looper, *Achaea mercatoria* Fabricius (Noctuidae : Catocalinae [M. Honey (NHM) det.] : Lepidoptera) on Sapota, *Manilkara achras* (Mill.) Fosberg"** submitted by **Shri N. V. Patel** in partial fulfilment of the requirements for the award of the degree of **Master of Science (Agriculture)** in the subject of **Agricultural Entomology** of the Gujarat Agricultural University is a record of bonafide research work carried out by him under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma or other similar title.

Place : Navsari
Date : December 17th, 2000

(M. B. Patel)
Major Advisor

DECLARATION

This is to declare that the whole of the research work reported in this thesis in partial fulfilment of the requirements for the degree of **Master of Science (Agriculture)** in **Agricultural Entomology** by the undersigned is the results of investigation carried out by him under the direct guidance and supervision of **Dr. M. B. Patel**, Associate Professor (Entomology), N. M. College of Agriculture, Gujarat Agricultural University, Navsari Campus, Navsari and that no part of the work has been submitted for any other degree so far.

Place : Navsari

Date : December 27th, 2000

(N. V. Patel)

COUNTERSIGNED BY

(M. B. Patel)

Associate Professor (Entomology),
N. M. College of Agriculture,
Gujarat Agricultural University,
Navsari Campus, Navsari-396 450

ACKNOWLEDGEMENT

Every author owes a debt to his teacher. Therefore, I seize this opportunity to express my deep sense of indebtedness and profound gratitude to my major advisor Dr. M. B. Patel, Associate Professor, Department of Entomology, N. M. College of Agriculture, Navsari for his distinct and valuable guidance given with sustained interest and constructive criticism during the period of investigation and the preparation of this manuscript.

The revelation of concealed facts in an investigation needs a co-operative approach. Hence, I acknowledge with gratitude and appreciation, the ready assistance, involvement and critical suggestion of the members of my advisory committee Dr. K. U. Solanky, Associate Professor, Department of Plant Pathology, Dr. J. R. Patel, Senior Acarologis, Department of Entomology, Dr. M. S. Purohit, Training Associate, T & V Scheme, Dr. J. D. Awadaria, Assistant Research Scientist (Statistics), Soil and Water Management Project at various stages of the present study.

I wish to express my profound sense of gratitude to Dr. H. N. Vyas, Principal, N. M. College of Agriculture, Navsari for providing necessary facilities to carry out the investigation.

I am sincerely thankful to Mr. John Maxen, CABI, Bio-science, International Institute of Entomology, London, U. K. who have most generously helped in identifying the semi-looper.

In particular, I wish to extend my earnest and heart felt thanks and profound gratitude to Mr. Hiteshbhai Desai and Mr. Purshottambhai Patel for not only granting me the permission to

undertake present investigation at their farms, Kharsad and Khara Abrama but also extending the help and co-operation during the course of investigation.

My sincere thanks to Dr. G. G. Radadia, Dr. Z. P. Patel (Gandevi), Dr. N. B. Rote, Sarwashri S. N. Sarvaiya, A. A. Shah, A. J. Patel, Dr. H. R. Desai and other staff members of the Department of Entomology and Shri J. R. Naik, Department of Agril. Statistics for their direct and indirect help.

I express my cordial thanks to my friends and collegues Sarvashri Bhatt, S. P., Unnithan, Sharma, Jignesh, Chauhan, Girish, Divyesh, Hardik, Devang, Dilip, Uttam, R. K., Deore, S. R. Patel, Dr. Sawant, K. D. Patil, Chattu, Subhash, Vijay, Thakkar for their help, sincere co-operation and encouragement during the study period.

The excellent and untiring efforts made by Shri Rajeshbhai Ardeshna in typing out this manuscript are duly acknowledged.

The credit of being the sole back bone to this work goes to my beloved father Vitthalbhai and mother Shardaben and all my family members without whose love, affection, constant inspiration, encouragement, prayer, support and guidance this achievement would have remained a dream for me.

Place : Navsari

Date : December 27th, 2000

(N. V. Patel)

CONTENTS

Content...(contd.)

Content...(contd.)

Content...(contd.)

Content...(contd._)

LIST OF TABLES

Table...(contd._)

Table...(contd.)

LIST OF FIGURES

LIST OF PLATES

Plates...(contd.)

INTRODUCTION

I INTRODUCTION

Sapota or sapodilla or Chiku [*Manilkara achras* (Mill.) Fosberg.] belongs to family Sapotaceae and is native of Mexico and tropical America. It is slow growing ever green tree, having dark green, shining leathery leaves. The tree develops a smooth central stem with radiating whorl of horizontally disposed branches, produced at more or less regular intervals. These main branches carry an array of short branchlets which bear fruits terminally and also give out vegetative shoots from their sides.

Fully ripen sapota fruits are delicious, sweet in taste with a slight flavour of astringency. The fruits skin can also been eaten since it is richer than the pulp in nutritive value (Bose, 1985). Sugar content in the fruits ranges between 12 and 14 per cent. The pulp is also used to prepare delicious Sharbat and Halwa (Singh *et al.*, 1963). Each 100 g of edible portion of sapota fruit contains 78.7 g moisture, 21.4 g carbohydrate, 0.70 g protein, 1.1 g fat, 28 mg calcium, 2.7 mg phosphorus, 2 mg iron and 6 mg ascorbic acid (Bose, 1985).

The cultivation of sapota is done in the countries like Mexico, Jamaica, south Florida, China, Sri Lanka and India. It is not known when it was introduced into India, but the sapota cultivation was taken up for the first time in Maharashtra in 1898 in a village named Gholwad. Now it is chiefly grown in moist coastal peninsular tracts in India. It is largely grown on commercial scales in the states of Maharashtra, Gujarat, Andhra Pradesh, Karnataka, Tamil Nadu, Kerala, Uttar Pradesh, Haryana, Punjab and West Bengal (Cheema *et al.*, 1954 and Vevai, 1971).

The states of Gujarat and Maharashtra of western India have the maximum acerage under sapota crop. In Gujarat State, sapota occupies an area of 9000 ha of which south Gujarat occupies an area of 7097 hectares in the year 1988-89, area under sapota cultivation increases year after year. While it was 14885 hectares total area of sapota cultivation in Gujarat of which south Gujarat occupies an area of 7368 hectares in Bharuch, Narmada, Surat, Navsari, Valsad (Bulsar) districts in the year 1998-99. In south Gujarat, major sapota cultivation districts are Navsari and Valsad.

Among the various factors affecting the yield and economic value of fruits, damage done by insect pest and mites are very important. More than 25 insect pests have been reported to attack sapota tree (Butani, 1979). In Gujarat the insect pests reported to damage sapota throughout the year are chiku moth, *Nephopteryx eugraphella* Ragonot (Pyralidae: Lepidoptera); bud borer, *Anarsia achrasella* Bradley (Gelechidae: Lepidoptera); leaf miner, *Acrocercops gemoniella* stainton (Gracillariidae: Lepidoptera); leaf folder, *Banisia myrsusalis elearalis* Walker (Thyrididae: Lepidoptera) and fruit fly, *Dacus correctus* Bezzi (Tephritidae: Diptera) (Patel, 1981 and Anonymous, 1982). Besides the insect pests, the mite *Tuckerella kumanonensis* Gupta (Tuckerellidae: Acaria) also damage the fruits of sapota.

Among these pests, semi-looper, *Achaea mercatoria* Fabricius is recorded for the first time damaging tender leaves of sapota tree in Khara Abramma and Kharsad villages of Navsari district during the year 1999. The semi-looper was reported as pest of castor in Sri Lanka by Edward (1978).

The early instar larvae of *A. mercatoria* feed on chlorophyll of the tender leaves and leaves become transparent, papery and dried up. The larvae also feed on inner content of flower bud. The severe damage is done by late instar larvae, which eat away the entire tender leaves by leaving the midrib.

As no work has been done on biology and control measures of *Achaea mercatoria* Fabricius in India and abroad, the studies on these aspects were carried out covering following objectives:

1. Nature of damage caused by larva of *A. mercatoria* Fabricius
2. Biology of semi-looper, *Achaea mercatoria* Fabricius on sapota
3. Bio-efficacy of various insecticides against larvae of *Achaea mercatoria* Fabricius under laboratory conditions as well as field conditions
4. Bio-efficacy of various plant leaves extracts against larvae of *Achaea mercatoria* Fabricius under laboratory conditions.

REVIEW OF LITERATURE

II REVIEW OF LITERATURE

The semi-looper is reported for the first time on sapota crop in Gujarat, India and was identified as *Achaea mercatoria* Fabricius; family Noctuidae; order Lepidoptera, by CABI Bio-science, UK Centre, International Institute of Entomology, London, UK. In past except its record in Australia and Sri Lanka, no research work has been reported on this pest. Hence, the literature on castor semi-looper, *Achaea janata* Linnaeus and *Achaea serva* Fabricius, the species related to this insect has been reviewed and presented here as under.

2.1 Distribution and host range of *A. mercatoria*

Edwards (1978) reported that *A. mercatoria* was recorded from Australia for the first time. He further added that the species was also recorded on castor in Sri Lanka.

2.2 Nature of damage

Pandey *et al.* (1969) reported that first instar larvae of *A. janata* fed on epidermis by scrapping, second instar by making holes and later instars by completely skeletonising the leaves. Tahiliani (1985) reported that the newly hatched larvae fed gregariously on the leaves of castor plants and the older larvae segregate and fed voraciously by devastating the entire leaf lamina. Ismail and Salim (1982) reported an outbreak of *A. janata* occurred on wild euphorbiceae *Excoecaria agallocha.*

2.3 Biology

Not a single report is available on biology of *A. mercatoria* damaging sapota leaves. However, some information available on biology of *A. janata* on host plant other than sapota are presented here under.

2.3.1 Egg

The review pertaining to eggs of *A. janata* is presented under following heads.

2.3.1.1 Site and pattern of egg laying

Tahiliani (1985) reported that eggs were laid singly on under side of the leaves. Ismail and Salim (1982) reported that eggs were laid singly or in clusters on the leaves and stem. Whereas Karmawati and Tobing (1988) observed that the females deposited eggs singly. Nafus and Schreiner (1991) reported that *A. serva* laid 80.90 per cent of the eggs on new leaves of sapota. Vyas (1994) studied the biology of A. janata and observed that eggs were laid singly on either surfaces of the leaf and tender parts of the rose, *Rosa indica* plants.

2.3.1.2 Colour, shape and size

Karmawati and Tobing (1988) reported that the eggs of *A. janata* were subspherical with flattened base and measured 0.75 mm in diameter. John and Muraleedharan (1989) found that eggs were 1.064 mm in diameter, spherical in shape with a greenish colour, convex on the dorsal side with concentric rings and concave on the

ventral side. Similar observations on colour and shape were described by Vyas (1994).

2.3.1.3 Incubation period

Karmawati and Tobing (1988) and John and Muraleedharan (1989) reported that the incubation period of *A. janata* was 2 or 3 and 3 days, respectively. Byale and Bilapate (1990) reported that average incubation period was 2.02 $\pm$ 0.13 days on castor. While Vyas (1994) reported it to be 5 to 7 days on rose.

2.3.2 Larva

According to Karmawati and Tobing (1988) and Byale and Bilapate (1990), the larvae of *A. janata* passed through six instars when reared on castor and pomegranate, whereas John and Muraleedharan (1989) and Byale and Bilapate (1990) reported that the larvae of *A. janata* passed through five instars on castor. While Vyas (1994) reported that *A. janata* passed through four instars on rose.

Karmawati and Tobing (1988) reported that newly emerged larvae of *A. janata* were translucent yellowish green in colour and measured 3.0 to 3.5 mm in length and 0.3 to 0.4 mm in width of head capsule. According to John and Muraleedharan (1989), the first instar larvae of *A. janata* was thread like, brown in colour and the head capsule was slightly bigger than the body. Larva measured 3.61 $\pm$ 0.004 mm in length, 0.38 $\pm$ 0.004 mm in breadth and head capsule was 0.456 $\pm$ 0.004 mm in breadth. Vyas (1994) observed that the head of first instar larva was slightly brown and the rest of the body was light green in colour, but after few hours of feeding, it was changed to light copper. The duration of first instar larva was 1 to 2, 2, 2.40 and 2 to 3

days as reported by Karmawati and Tobing (1988), John and Muraleedharan (1989) on castor, Byale and Bilapate (1990) on pomegranate and Vyas (1994) on rose, respectively.

The second instar larva of *A. janata* was dark green or greyish green in colour as reported by Karmawati and Tobing (1988). Whereas John and Muraleedharan (1989) observed that the larva was more spongy and its colour slowly changed to grey. Vyas (1994) reported that second instar larva of *A. janata* had a black head with white patches on it and body region was light green to brick red in colour. The second instar larva measured 5.0 to 6.0 mm in length with 0.4 to 0.5 mm width of head capsule (Karmawati and Tobing, 1988). John and Muraleedharan (1989) measured the larva of *A. janata* as 7.0 $\pm$ 0.058 mm in length and 0.99 $\pm$ 0.004 mm in breadth with 0.836 $\pm$ 0.004 mm width of head capsule. The similar observations on length was reported by Vyas (1994). The duration of second instar larva was 1 to 2 and 2 days on castor as reported by Karmawati and Tobing (1988) and Johna and Muraleedharan (1989), respectively. Whereas Byale and Bilapate (1990) reported that the duration was 2.15 days on pomegranate. Vyas (1994) reported it to be 2 to 3 days on rose.

John and Muraleedharan (1989) reported that third instar larva of *A. janata* became conspicuously longer with a dark grey colour. While Vyas (1994) found that the third instar larva was more prominent in colouration and became darker green in colour. As reported by Karmawati and Tobing (1988), the third instar larva of *A. janata* measured about 11.0 to 12.0 mm in length and 0.5 to 0.6 mm in width of head capsule. According to John and Muraleedharan (1989), the average length, breadth and width of the head capsule of the larva

was 13.5 ± 0.051 mm, 1.63 ± 0.011 and 1.44 ± 0.004 mm, respectively. The duration of third instar larva was 1 to 2 and 2 days on castor, 2.14 days on pomegranate and 3 to 4 days on rose as reported by Karmawati and Tobing (1988), John and Muraleedharan (1989), Byale and Bilapate (1990) and Vyas (1994), respectively.

The fourth instar larva of *A. janata* became much larger in size with a black streak running in the mid-line of the body. Two white conspicuous spots became evident between fourth and fifth body segment on dorsal side reported by John and Muraleedharan (1989). While, Vyas (1994) reported that fourth instar larva was dark green in colour with white spot on body. The larva of *A. janata* measured about 15.0 to 17.0 mm in length and 1.0 to 1.2 mm in head capsule width as reported by Karmawati and Tobing (1988). While John and Muraleedharan (1989) measured the larva as 26.0 ± 0.108 mm in length, 2.81± 0.012 mm in breadth and 2.47 ± 0.004 mm in width of head capsule. The duration of fourth instar larva was 1 to 2 days and 2 days on castor, 2.37 days on pomegranate and 8 to 9 days on rose as reported by Karmawati and Tobing (1988), John and Muraleedharan (1989), Byale and Bilapate (1990) and Vyas (1994), respectively.

The fifth instar larva of *A. janata* was dark green or greyish green in colour as reported by Karmawati and Tobing (1988). The fifth instar larva measured as 35.0 to 36.0 mm in length and 1.8 to 2.0 mm in width of head capsule as reported by Karmawati and Tobing (1988). Whereas John and Muraleedharan (1989) measured the larva as 42.15 ± 0.216 mm in length, 4.76 ± 0.011 mm in breadth and 3.72 ± 0.008 mm in width of head capsule. The duration of fifth instar larva was 2 to 3 days and 4 days on castor and 3.27 days on pomegranate as reported

by Karmawati and Tobing (1988), John and Muraleedharan (1989) and Byale and Bilapate (1990), respectively.

The sixth instar larva of *A. janata* was grey in colour with spotted head, an orange, red or white coloured lateral stripe and a white and black patch on hump. The body measured as 40.00 to 52.00 mm in length and 2.0 to 2.5 mm in head capsule width as reported by Karmawati and Tobing (1988). The duration of sixth instar larva was 3 to 4 days on castor and 6.80 days on pomegranate as reported by Karmawati and Tobing (1988) and Byale and Bilapate (1990), respectively.

Total larval period reported by Karmawati and Tobing as 9 to 13 days. While John and Muraleedharan (1989) reported it to be 12 to 13 days. Byale and Bilapate (1990) reported average larval period to be 12.38 $\pm$ 1.06 days on castor. While Vyas (1994) reported that it was 15 to 19 days on rose.

2.3.3 Prepupa

John and Muraleedharan (1989) and Vyas (1994) observed that the full grown larva stop feeding before going under pupation. Larva in this stage was sluggish and almost in rolled or spiral form. It started spinning the cocoon between the folds of a leaf, or in the clods of the soil with the help of fluid from mouth. The duration of this stage was 1 to 2 days.

2.3.4 Pupa

Karmawati and Tobing (1988) reported that pupa of *A. janata* was reddish brown in colour. While John and Murleedharan (1989) observed that soon after pupal moult, the pupa appeared whitish

green in colour and the body was very soft. Gradually, it turned into dark brown colour. The pupa measured 23.5 ± 0.065 mm in length and 6.5 ± 0.05 mm in breadth. Similar observation was made by Vyas (1994). According to Byale and Bilapate (1990), male pupa measured 22.31 ± 0.67 mm in length and 7.16 ± 0.26 mm in breadth, while female pupa measured 22.14 ± 0.78 mm in length and 7.15 ± 0.24 mm in breadth. The pupal duration was 8 to 10 days as reported by Karmawati and Tobing (1988) and John and Muraleedharan (1989). Whereas Byale and Bilapate (1990) recorded average pupal duration of *A. janata* as 8.30 ± 1.12 days on castor. While Vyas (1994) reported it to be 12 to 13 days on rose.

2.3.5 Adult

The adult moth of *A. janata* was stout and pale reddish brown in colour. Fore wings had conspicuous transverse wavy lines while hind wings were black having a medial white bands and three large white spot on outer margins (Tahiliani, 1985). Karmawati and Tobing (1988) reported that the colour of the fore wing was brownish grey and hind wing was grey with brighten colour of black and white near the tips. Whereas John and Muraleedharan (1989) reported that adult moth was brown in colour with characteristic black and white patterns in the hind wings. Male show sexual dimorphism and have narrow apex with a tuft of hair in the anal segment. Females had a broad abdomen.

The adult of *A. janata* had a wing span from 50.00 to 65.00 mm as reported by Tahiliani (1985). According to Karmawati and

Tobing (1988) the wing expanse of male was 54.00 to 56.00 mm whereas in female it was 47.0 to 49.00 mm.

Samee (1962) reported that pre-oviposition period of *A. janata* was 4 to 10 days. While Karmawati and Tobing (1988) and John and Muraleedharan (1989) observed the pre-oviposition period as 1 to 4 days and 2 to 3 days, respectively. According to Vyas (1994), it was 4 to 5 days on rose.

Female of *A. janata* laid on an average 1305 eggs on castor (Karmawati and Tobing, 1988). While Vyas (1994) reported that females laid 600 to 650 eggs on rose.

The longevity of male and female of *A. janata* was 16 days as reported by Karmawati and Tobing (1988). Whereas Vyas (1994) reported the longevity of female and male was 5 days and 3 days on rose, respectively.

2.3.6 Total life cycle

Byale and Bilapate (1990) reported total life cycle of *A. janata* on castor to be 22.60 $\pm$ 1.41 days. The average life cycle of male and female was 23.14 $\pm$ 1.24 days and 22.24 $\pm$ 1.42 days, respectively. Vyas (1994) reported total developmental period as 33 to 41 days on rose.

2.3.7 Sex identification

Dani *et al.* (1980) studied the morphometric difference in male and female pupa of *A. janata* and reported that male and female pupa could be easily distinguished on the basis of position of genital opening. The female had a slit like genital opening in the centre of a leaf like pad structure at mid ventral region of the abdominal sternum,

whereas male pupa had the pad like structure on the ninth abdominal sternum, while anal aperture at tenth abdominal sternum with a small slit like structure in both the sexes.

According to John and Muraleedharan (1989), the genital opening is more rounded pore and lies on an elevated tubercle bisecting ninth abdominal segment whereas in females it lies near the anterior margin of the eighth abdominal segment and lacks an elevated pad. They further reported that intersegmental lines of ninth and tenth abdominal segment do not meet. Vyas (1994) observed that females were bigger in size than that of the males.

2.4 Chemical control

Kushwaha and Pal (1978) studied the effectiveness of different insecticides for the control of *A. janata* and showed that carbaryl 0.25 per cent was the best treatment. Rai and Jayaramaiah (1978) tested five insecticidal dusts against semilooper in field conditions and reported that carbaryl 10 per cent and Parathion 2 per cent dusts gave 89.75 per cent larval mortality after 24 hrs of application. Deshmukh *et al.* (1979) tested eight insecticides in field against *A. janata* and reported that treatments of phosalone, leptophos and phenthoate were more effective in reducing the larval population of *A. janata*. Pal (1979) tested the effectiveness of carbaryl and dicrotophos against *A. janata* on castor and found that carbaryl 0.20 per cent gave 75 per cent and 100 per cent reduction after 1 day and 2 days of treatment. Singh (1982) tested eight insecticides against larvae of *A. janata* under laboratory conditions. He reported that quinalphos 0.05

per cent and fenitrothion 0.05 per cent were proved to be most effective.

Ismail and Salim (1982) compared the efficacy of different insecticides and found that permethrin and deltamethrin gave quick knock down of the larvae of *A. janata*. Dalaya *et al.* (1983) evaluated eight different insecticides against *A. janata* and concluded that effective control was obtained with decamethrin @ 10 gm, indothrin @ 60 gm, AC 222 705 @ 40 gm, cyfloxylate @ 20 gm, permathrin @ 60 gm, fenvalerate @ 50 gm and cyprmethrin @ 40 gm a.i. per hectare. Singh *et al.* (1985) conducted a laboratory experiment to evaluate the relative efficacy of different insecticides and reported that cypermethrin, deltamethrin, permethrin, fenvalerate and phoxim were highly toxic to the larvae of *A. janata*. Gerewal *et al.* (1988) conducted an experiment in the laboratory to test the efficacy of nine insecticides *viz.*, deltamethrin, fenvalerate, permethrin and cypermethrin each at 0.01 per cent and endosulfan, chlorpyriphos and fenitrothion each at 0.05 per cent against *A. janata* and reported that chlorpyriphos, fenvalerate, quinalphos and deltamethrin gave quick knock down effect causing 70.3, 64.3, 63.4 and 56.6 per cent mortality, respectively.

Parthasarthy and Rao (1989) reported that fenvalerate 0.02 per cent and mixture of fenvalerate 0.0125 per cent + diflubenzuron 0.01 per cent were found most effective against larvae of *A. janata* and gave 69.72 per cent and 67.26 per cent mortality, respectively. Senapati and Dash (1989) conducted an experiment to evaluate different twelve insecticides and found that the best control of the noctuid, *A. janata* was achieved by three spray application of endosulfan @ 0.5 kg a.i. per hectare at an interval of 21 days. Ahuja *et al.* (1995) conducted field

and field-cum-laboratory experiments to evaluate different insecticides against larvae of *A. janata*. They reported that quinalphos 0.025, monocrotophos 0.036, fenalverate 0.01 and cypermethrin 0.005 per cent were equally effective against the larvae of *A. janata* under field conditions. While quinalphos, monocrotophos, fenalverate and methyl parathion 0.05 per cent had quicker knock down effect as compared to endosulfan 0.07, cypermethrin 0.005, phosalone 0.007 and fenitrothion 0.05 per cent in field-cum-laboratory experiment. Dhingra (1998) evaluated relative toxicity of pyrethroids and non-pyrethroid insecticides against larvae of *A. janata* in the laboratory. The different insecticides on the basis of their LC50 values lambda-cyhalothrin, cypermethrin, deltamethrin, fenpropathrin, fenvalerate, methyl parathion and pyrethrin were 240.4, 64.7, 51.4, 23.9, 17.6, 7.5 and 4.1 times more toxic, respectively than endosulfan. Chakravarthy (1999) conducted a study and proved the effectiveness of acephate 75 SP against the *A. janata* and reported that acephate @ 750 and 1000 gm per hectare were effective in controlling larvae.

2.5 Plant extracts

Singh and Pant (1978) reported the antifeedant property of the plants sub-family Amarylloidoidae *Crinum asiaticum* 0.1, *Zephyranthus grandiflora* 0.15, and *Hymenocallis littoralis* 0.05 per cent all possessed different properties and inhibited feeding of the locust completely and the sap of *H. littoralis* also prevented feeding by *A. janata*. Chari and Muraleedharan (1985) suggested that neem seed suspension 2 per cent or neem leaf extract 1 per cent would be an effective and economical treatments for the control of *A. janata*. Rao

and Subrahmanyam (1989) studied on the effect of injected azadirachtin @ 4.1 µg per gm body weight and reported that larval and pupal periods were unaffected but the fecundity of *A. janata* was reduced to half.

Ramchandran and Mukherjee (1989) reported that the azadirachtin solution 0.1 to 10.0 ppm affected the food deprivation by *A. janata*. Sharma *et al.* (1992) tested the bioactivity of Lamiaceae plants against different insects and reported that extracts of *Leucas celiata*, *L. cephalotus*, *Pogostemon parviflorus*, *P. plectranthoides*, *P. purpurascens* and *Salvia plebia* showed antifeedant activity against *A. janata*. Arivudainambi and Nachiappan (1993) evaluated the antifeedant property of various extracts (stem, matured leaves, tender leaves and flowers) of *Ipomoea carnea* Jacq. at three different concentrations *viz.*, 1, 2 and 3 per cent and found that 3 per cent concentration was very effective and gave 88.04 per cent protection of leaf area. According to Muthukrishnan and Ananthagowri (1994), extracts of three plants *Glycosmis pentaphylla*, *Vitex nugendo* and *Nerium oleander* tested at 0.01 to 0.5 per cent and the LD_{50s} were 62.4, 53.5 and 107.1 per cent, respectively and the corresponding ED_{50s} 0.526, 0.231 and 0.526 µg per cm^2 were studied on the bioenergetics against of treated larvae and reported that active ingredients significantly reduced food energy consumption and utilization despite extending the duration of larval stage of *A. janata*. Dodia *et al.* (1995) showed antifeedant properties of indigenous plant extracts. Among all the tested plant extracts, neem seed kernel 5 per cent, tumba fruits 10 per cent and datura leaves 10 per cent were found to be the most promising in protecting the leaf against *A. janata*.

Rao *et al.* (1996) showed that the botanical pesticides from neem and custard apple acted as effective phagodeterrents at 0.1 per cent and retained their antifeedancy upto seven days on field grown castor plants against *A. janata*. Jayani *et al.* (1996) tested the bio-efficacy of neem based formulations against *A. janata* and reported that all botanical pesticides reduced the oviposition by the female. Azadirachtin 0.4 and 0.6 per cent, neemark 1.0 per cent and neem seed kernel suspension 5.0 per cent prevented feeding and showed highest repellence against *A. janata*. Bhatnagar and Agarwal (1997) tested six commercial neem formulations under laboratory conditions against *A. janata* and showed that the neem gold 2 per cent (2 ml per litre) exhibited strong antifeedant activity.

MATERIALS AND METHODS

III MATERIALS AND METHODS

The materials and the methods used for present investigation on various aspects of semi-looper, *Achea mercatoria* Fabricius are presented below.

3.1 Nature of damage

The nature of damage caused by *A. mercatoria* larvae was studied critically by observing infested trees of sapota in the field.

3.2 Biology

The biology of *A. mercatoria* was studied in the laboratory of Department of Entomology, N. M. College of Agriculture, Gujarat Agricultural University, Navsari Campus, Navsari during June to September 1999. Minimum-Maximum temperature and relative humidity in the laboratory were recorded daily.

3.2.1 Rearing technique

To raise the initial culture of *A. mercatoria* in the laboratory, large number of larvae were collected from the farmers' sapota orchard at Khara Abrama, Navsari.

The field collected larvae were reared in a round galvanized tray (35 cm x 11.5 cm) containing fresh tender sapota leaves. Every day sufficient amount of fresh leaves were provided to *A. mercatoria* larvae after removing excreta and partially eaten leaves from the tray, till the larvae turned to prepupal form. Top of the tray was covered with fine muslin cloth held in position by rubber band. Such tray along with larvae inside was secured in wooden cage (60 cm

x 60 cm x 75 cm). Before formation of prepupal stage, larvae fold the leaves and pupate in the folded leaves. The pupae formed in the folded leaves were collected and transferred to glass jar for emergence of the adults.

A pair of newly emerged male and female moths was confined in a glass jar (20.0 cm hieght x 16.0 cm diameter) and fresh twigs of sapota were provided to the moths inside the glass jar for resting and egg laying. A small hook containing cotton swab dipped in five per cent honey solution was placed in rearing jar for food to the moths. The open end of glass jar was covered with fine muslin cloth, secured in a position with the help of rubber band. The twigs were replaced with fresh one daily and the eggs laid on the leaves removed from the jar were collected with fine camel hair brush for further study.

3.2.2 Egg

For the morphological study, freshly laid eggs were observed under the microscope. Size of the eggs were measured under microscope using stage and occular micrometers.

To study the incubation period, counted number of freshly laid eggs were observed daily till hatching. Incubation period was calculated from the date of egg laying to the date of hatching. Hatching percentage was calculated from the data on number of eggs hatched out of total number of eggs kept for hatching.

3.2.3 Larva

With a view to determine the number and duration of different larval instars and total larval period, the newly emerged larvae

were transferred individually with the help of fine camel hair brush to plastic culture tubes (4.0 cm diameter x 7.5 cm height) containing fresh leaves of sapota as food (Plate-I). Fresh food was provided to the larvae every day in the morning.

In order to determine the number of larval instars individual larva was observed daily. Moulting was confirmed by the presence of casted off head capsule and exuviae. Observations for the colour and size of the larvae were recorded in each instar. The breadth of the body and head capsule during different instars and length and breadth of first and second instar larvae were measured with the help of stage and occular micrometers under microscope. While length of larvae, third instars onwards was measured directly using millimeter scale. The total larval period was calculated on the basis of the date of egg hatching and date of formation of prepupa.

3.2.4 Prepupa

When fully grown larvae stopped feeding and contracted, they were considered as prepupae. The prepupal period was considered from the date of stopping of feeding to the date of formation of pupa. The length of prepupa was measured using millimeter scale while, breadth was measured under microscope.

3.2.5 Pupa

The pupae collected from the tubes were measured for their length and breadth using millimeter scale and micrometer respectively. The male and female pupae were separated by examining them under microscope for the distance between genital slit and anal

Plate-I: Rearing of larvae in plastic culture tubes individually for the study of larval instars

slit. The length of genital slit and anal slit was measured with the help of micrometer. Pupal period was calculated on the basis of date of formation of pupa to the date of adult emergence.

3.2.6 Adult

Adults emerged from the pupae were critically observed under microscope for their colour, shape . size and sex. The length and breadth with their expanded wings were measured directly with the help of standard scale.

3.2.6.1 Pre-oviposition, oviposition, and post-oviposition periods, fecundity and longevity

Freshly emerged male and female moths were paired and confined in a glass jar (20 cm height x 16.0 cm diameter) for egg laying (Plate-II). They were provided with five per cent honey solution as food and fresh sapota twig for resting and oviposition. The material provided for resting and egg laying was replaced daily with fresh one. Pre-oviposition period was calculated from the date of emergence of female to the date of starting egg laying. Oviposition period was calculated from the date of starting egg laying to the date of stopping of egg laying for the female. Post-oviposition period was calculated from the date of stopping of egg laying to the date of death of female. To determine the fecundity, the eggs laid by the single female were collected daily in the morning and counted till the death of the female. Longevity of female and male was also calculated separately from the date of emergence to the date of death of adult.

Plate-II: Moths confined in glass jar for egg laying

3.3 Natural enemy

With a view to study the per cent parasitism in nature, the larvae of *A. mercatoria* were collected from the field at weekly interval and reared individually in the laboratory upto emergence of adult. Healthy and parasitised individual pupae were observed till the emergence of adults of *A. mercatoria* or parasites. Per cent parasitism was calculated on the basis of total number of individuals parasitised out of total number of larvae observed.

3.4 Seasonal incidence

The seasonal incidence of semi-looper, *A. mercatoria* on sapota based on leaf damage and number of larvae present on randomly selected twenty twigs from each three selected trees were studied. For the purpose, sapota orchards were selected at Khara Abramma and Kharsad villages of Navsari district. The observation on leaf damage and number of larvae present were recorded at weekly interval commencing from fourth week of March to third week of June during the year 1999-2000 and 2000-2001. The leaf damage recorded as per cent leaf damage calculated by counting the number of damaged leaves out of total number of leaves from twenty twigs.

The per cent leaf damage and number of larvae were correlated with weather parameters *viz.*, temperature (^{0}C), relative humidity (%), sunshine hours, rainfall (mm) and rainy days and also multiple/simple regression were worked out. Weekly meteorological observations recorded at meteorological observatory to study the instanteneous effects of weather parameters on seasonal incidence of semi-looper, *A. mercatoria*.

3.5 Chemical control

3.5.1 Evaluation of insecticides against larvae of *A. mercatoria* in field conditions

With a view to evaluate the relative efficacy of different insecticides (Table 1) against larvae of *A. mercatoria*, the field experiments were conducted at farmer's field at Khara Abramma and Kharsad villages during summer season of 1999-2000 and 2000-2001, respectively.

3.5.1.1 Details of the experiment

The details of the experiment was as under:

a)	Soil type	:	Heavy black
b)	Statistical design	:	CRD
c)	Number of replication	:	3 (three) (one tree was considered as one replication)
d)	Spacing	:	10 m x 10 m
e)	Number of treatments	:	11 (eleven)
f)	Crop	:	Sapota
g)	Variety	:	Kalipatti
h)	Age of tree	:	Approximately 15 years
i)	Dates of application of the treatments	:	1st year - 30th April, 1999 2nd year - 12th May, 2000

3.5.1.2 Method of application of insecticides

The spray fluid was prepared by mixing measured quantity of water and insecticides, and thoroughly mixed before application.

Table 1: Details of chemicals tested against larvae of *A. mercatoria*

Sr. No.	Treatment	Commercial name	Formulation	Chemical name*	Source
1.	Imidacloprid 0.005 %	Confidor	17.8 SL	(1-(6-Chloro-3-pyridyl methyl)-N-nitrol-midazolidin-Z-ylideneamine	Bayer India Ltd.
2.	Profenfos 0.095 %	Curacron	50 EC	O-4-bromo-2-chloro-phenyl-O-ethyl S-propyl phosphorothioate	Novartis India Ltd.
3.	Deltamethrin 0.001 % + Triazophos 0.044 %	Spark	36 EC Deltamethrin 1 % + Triazophos 35 %	(S)-α-cyano-3-phenoxybenzyl (1R, 3R)-3-(2,2-dibromovinyl) - 2, 2-dimethyl cyclopropan-1-carboxylate + O, O-diethyl O-1-phenyl-1H-1, 2, 4-triazol-3-yl phosphorothioate	Hoechst Schering Agro Evo Ltd.
4.	Chlorpyriphos 0.05 % + Cypermethrin 0.009 %	Nurelle D_{505}	505 Chlorpyriphos 50 % + Cypermethrin 5 %	O, O diethyl O-3, 5, 6-trichloro-2-pyridyl phosphorothioate + (Rs)-alpha-cyano-3-phenoxy benzyl-2m, 2-dimethyl-3-(2, 2-dichlorovinyl cyclopropane carboxylate)	De Nocil

Table 1 contd...

Table 1 contd...

Sr. No.	Treatment	Commercial name	Formulation	Chemical name*	Source
5.	Profenofos 0.075 % + Cypermethrin 0.009 %	Polytrin-C_{404}	404 Profenofos 40 % + Cypermethrin 4 %	O-4-bromo-2-chloro-phenyl-O-ethyl S-propyl phosphorothioate + (Rs)-alpha-cyano-3-phenoxy benzyl-2m, 2-dimethyl-3-(2, 2-dichlorovinyl cyclopropane carboxylate)	Novartis India Ltd.
6.	Fenobucarb/BPMC 0.1 %	Bipvin	50 EC	2-sec-butylphenyl-N-methylcarbamate	Rhone-Poulenc
7.	Carbosulfan 0.05 %	Marshal	25 EC	2, 3-dihydro-2, 2-dimethyl-7-ben-zofuranyl [(dibutyl aminothio) methyl carbamate]	Rallis India Ltd.
8.	Endosulfan 0.075 %	Endocel	35 EC	6, 7, 8, 9, 10, 10-hexachloro 1, 5, 5a, 6, 9, 9a-hexahydro-6, 9-methano-2, 4, 3 - = benzodioxathiepine 3 oxide	Excel Industries Ltd.

Table 1 contd...

Table 1 contd...

Sr. No.	Treatment	Commercial name	Formulation	Chemical name*	Source
9.	Lambda-cyhalothrin 0.005 %	Karate	5 % EC	α-cyano-3-phenoxyl benzyl 3-(2-chloro-3, 3, 3 trifluoropropenyl)-2, 2 dimethyl cyclopropane carboxylate , a 1 : 1 mixture of the (2)-(1R, 3R), S-ester and (2)- (1S, 3S), R-ester	ZENECA
10.	Alphamethrin 0.003 %	Alphagaurd	10 EC	(1R cis S) and (1S cis R) enantiomeric isomer pair of α cyano-3-phenoxybenzyl-3-(2, 2-dichlorovinyl)-2, 2-dimethyl cyclopanecarboxylate	Gharda Chemicals Ltd.
11.	Control	–	–	–	–

* Chemical name according to IUPAC nomenclature

Source: The Agrochemicals Handbook (1987). Pub. by Royal society of chemistry, University, Nottingham, NG 7 2RD, England.

Spraying was done with the help of Rocking sprayer. Only one spray was given when the pest population was noticed. The average population per twig was 0.97 larvae.

3.5.1.3 Method of recording observations

To evaluate relative efficacy of different insecticides, twenty twigs were randomly selected from each tree and observed thoroughly and recorded total number of larvae before spraying and at 24, 72, hrs, 7 and 14 days after spraying and per cent mortality was calculated. Healthy and damaged leaves per twig were counted before spraying and at 7 and 14 days after spraying and per cent damaged leaves were calculated on the basis of total number of damaged leaves out of total number of leaves per twig.

3.5.2 Evaluation of insecticides against larvae of *A. mercatoria* under laboratory conditions

With a view to evaluate the bio-efficacy of various insecticides (Table 1) against larva of *A. mercatoria*, experiments were conducted in the laboratory of the Department of Entomology, N. M. College of Agriculture, Gujarat Agricultural University, Navsari Campus during 1999-2000.

The insecticides were tested against third instar larvae of *A. mercatoria*. The experiment was carried out following Completely Randomized Design (CRD) with eleven treatments of insecticides including control. Each treatments repeated three times. The details of treatments are given in Table 1.

The required concentration of various insecticides were prepared in 1 liter water. Two ml solution of each treatment was applied with the help of Potter's Tower on tender leaves of sapota placed in petridishes (15 cm diameter). Treated leaves were transferred to the glass jar (15 cm height x 10 cm diameter). Ten, third instar larvae were released in each glass jar and they were allowed to feed on treated food material for 24 hrs. Fresh tender leaves of sapota were provided daily after 24 hrs of the treatment. Mortality counts were recorded at 24, 48, 72 hrs and 7 days after treatment. The mortality percentage of the larvae was calculated.

3.6 Bio-efficacy of various plant leaves extracts against larvae of *A. mercatoria* under laboratory conditions

With a view to evaluate the bio-efficacy of various locally available plant materials (Plate-III) against *A. mercatoria*, statistically designed experiment was conducted in the laboratory of the Department of Entomology, N. M. College of Agriculture, Gujarat Agricultural University, Navsari Campus, Navsari.

3.6.1 Preparation of plant leaves extracts

Some of the locally availabe plants (Table 2) were collected from the field of College Farm, Gujarat Agricultural University, Navsari Campus. The required quantity of the green plant material was weighed using a top pan balance. Fifty gram green plant *Leaves* of each of the treatments was taken separately and ground in a electrical grinder adding 100 ml water, for 2 minutes at high (18,000 rpm) speed. Ground material was then filtered with fine muslin cloth and remnant from the cloth was again ground by adding

Plate-III: Plant material tested against larvae of *A. mercatoria*

1	Neem	6	Lantana
2	Spider lily	7	Fudina (Mint)
3	Ardusa	8	Chrysanthemum
4	Tulsi (Holy basil)	9	Aank
5	Naffatia	10	Kadvi mahendi (Clerodendrum)

Table 2: Plant leaves extracts studied for their bio-efficacy against larvae of *A. mercatoria*

Sr. No.	Common name	Scientific name	Family	Plant parts used	Concentration	g/lit
1.	Neem	*Azadirachta indica* A. Juss.	Meliaceae	Leaves	5 %	50
2.	Spider lily	*Hymenocallis littoralis* L.	Amaryllidaceae	Leaves	5 %	50
3.	Ardusa	*Alianthus excelsa* Roxb.	Rutaceae	Leaves	5 %	50
4.	Tulsi (Holy basil)	*Ocimum sanctum* L.	Labiatae	Leaves	5 %	50
5.	Naffatia	*Ipomoea fistulosa* Mart. ex choisy	Convolvulaceae	Leaves	5 %	50
6.	Lantana	*Lantana camara* L.	Verbanaceae	Leaves	5 %	50
7.	Fudina (Mint)	*Mentha piperata* L.	Labiatae	Leaves	5 %	50
8.	Chrysanthemum	*Chrysanthemum indicum* L.	Compositae	Leaves	5 %	50
9.	Aank	*Calotropis gigantea* R. Br.	Asclepiadaceae	Leaves	5 %	50
10.	Kadvi mahendi	*Clerodendrum inerme* (L.F.) Gaerph	Verbenaceae	Leaves	5 %	50
11.	Control	–	–	–	–	–

100 ml water and finally 1 litre volume was made by adding required quantity of water. The suspension of each botanical material was prepared individually as procedure described above and used individually to study the bio-efficacy against third instar larvae of *A. mercatoria*.

This experiment was carried out with eleven treatments including control. Each treatment was replicated three times. The details of treatments are given in Table 2.

Suspension of respective treatment was uniformly sprayed on tender sapota leaves with continuous automizer to give uniform coverage. Sprayed leaves were kept under ceiling fan in the laboratory to evaporate excess of water on the leaf. After complete evaporation of the excess of water on the sapota leaves, they were transferred to the glass jar (15 cm height x 10 cm diameter), treatment wise separately. Ten, third instar larvae of *A. mercatoria* starved for 12 hrs were released into each glass jar, and they were allowed to feed on treated food material for 24 hrs. Fresh leaves were provided daily after 24 hrs of the treatment. Mortality counts were recorded at 24, 48, 72 hrs and 7 days after treatment.

3.7 Statistical analysis

The data obtained from laboratory experiments, the mortality of *A. mercatoria* larvae in relation to the initial population was worked out in terms of percentage larval mortality. The data obtained from field experiment was transferred into corrected per cent mortality with the help of formula given by Henderson and Tilton (1955) as under:

$$\text{Per cent mortality} = 100\left(1-\frac{\text{Ta x Cb}}{\text{Tb x Ca}}\right)$$

where,

Ta = Number of larvae on treated tree after treatment

Tb = Number of larvae on treated tree before treatment

Ca = Number of larvae on untreated check after treatment

Cb = Number of larvae on untreated check before treatment

The data of laboratory and field experiments in percentage values were transformed to arcsine scale and statistically analysed following Completely Randomized Design (CRD). The pooled data of laboratory and field experiments are summerised, so as to have an idea on overall performance of different treatments.

RESULTS AND DISCUSSION

IV RESULTS AND DISCUSSION

The results of present investigation of semi-looper *Achaea mercatoria* Fabricius are presented and discussed as below.

4.1 Nature of damage

The nature of damage caused by the larvae of *A. mercatoria* was studied by extensive observations in the field of sapota orchard. The first and second instar larvae were found feeding on chlorophyll of the leaves to which the leaves became transparent-papery and dry (Plate-IV). They also found feeding on inner content of flower buds (Plate-V). The severe damage was done by later instar larvae by eating tender leaves (Plate-VI A and B) and some times flower buds. Similar observations had been reported by Pandey *et al.* (1979) and Tahiliani (1985) on castor.

4.2 Biology of semi-looper, *Achaea mercatoria* Fabricius on sapota

Study on the biology of insect pests provides information on various life stages through which they pass. It also helps in planning the plant protection programme. By knowing the activity of different stages one can decide the strategy of management practices. Having found no reports on study of biology of *Achaea mercatoria* Fabricius, it was considered necessary to study the biology of the pest. The study on biology of semi-looper, *Achaea mercatoria* Fabricius was carried out in the laboratory of Department of Entomology, N. M. College of Agriculture, Navsari during June 1999 to October 1999. The temperature during the study was varied from 27.0 to 30.9^{0}C with an

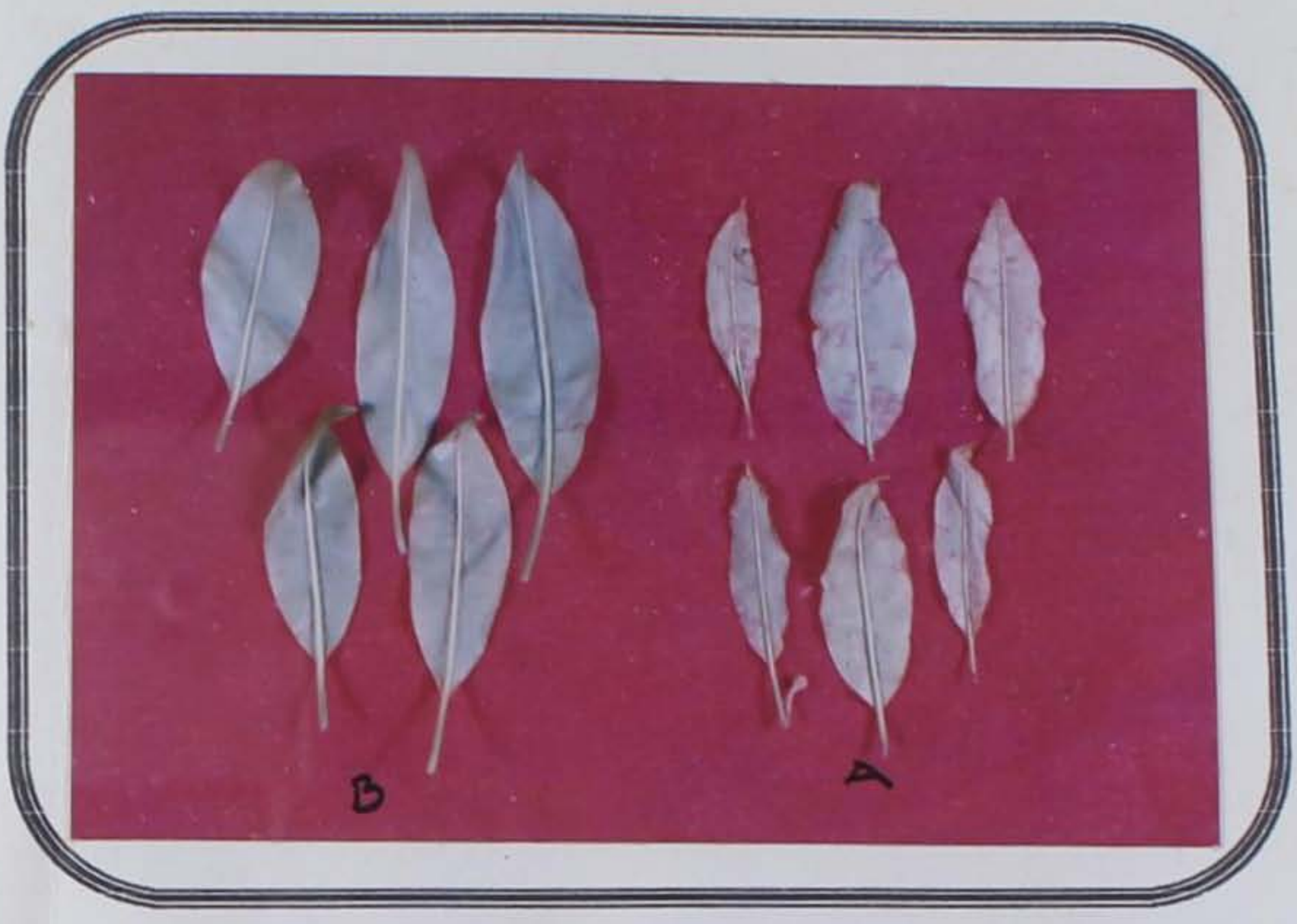


Plate-IV: A. Leaf damaged by first instar larvae of *A. mercatoria*
B. Healthy leaves

Plate-V A: Flower buds damaged by larvae of *A. mercatoria* under field conditions
B: Healthy

A

B

Plate-VI a: Leavesdamaged by larvae of *A. mercatoria* under field conditions

b: Healthy leaves

average of 29.0 ± 0.70°C, while relative humidity ranged from 78.0 to 93.0 per cent with an average of 90.6 ± 3.9 per cent. The results obtained are presented and discussed as under.

4.2.1 Egg

4.2.1.1 Site of egg laying

In laboratory as well as in field conditions, the female of *A. mercatoria* laid eggs singly on the lower or upper surface of leaves (Plate-VII). Occasionally the eggs were also laid on the wall of glass jar as well as on muslin cloth covered on the top of the glass jar in which the adults were confined for egg laying in laboratory. Similar observation was reported by Tahiliani (1985) and Karmawati and Tobing (1988) in case of *A. janata* on castor.

4.2.1.2 Colour, shape and size

The freshly laid eggs were bluish grey in colour which changed to light brown in colour after one day (Plate-VIII), and became dark brown prior to hatching. The prominent black head of the pre-emerged larva was visible through the egg shell. Eggs were hemispherical with upper surface convex and lower surface concave and prominently sculptured with numerous ridges and furrows running from one polar end to another. The outer appearance of the eggs of *A. mercatoria* is similar to that of *A. janata* as described by John and Muraleedharan (1989) on castor and Vyas (1994) on rose.

The length and breadth of eggs were measured under microscope. The data obtained are presented in Table 3.

Plate-VII: Eggs of *A. mercatoria* laid on sapota leaf

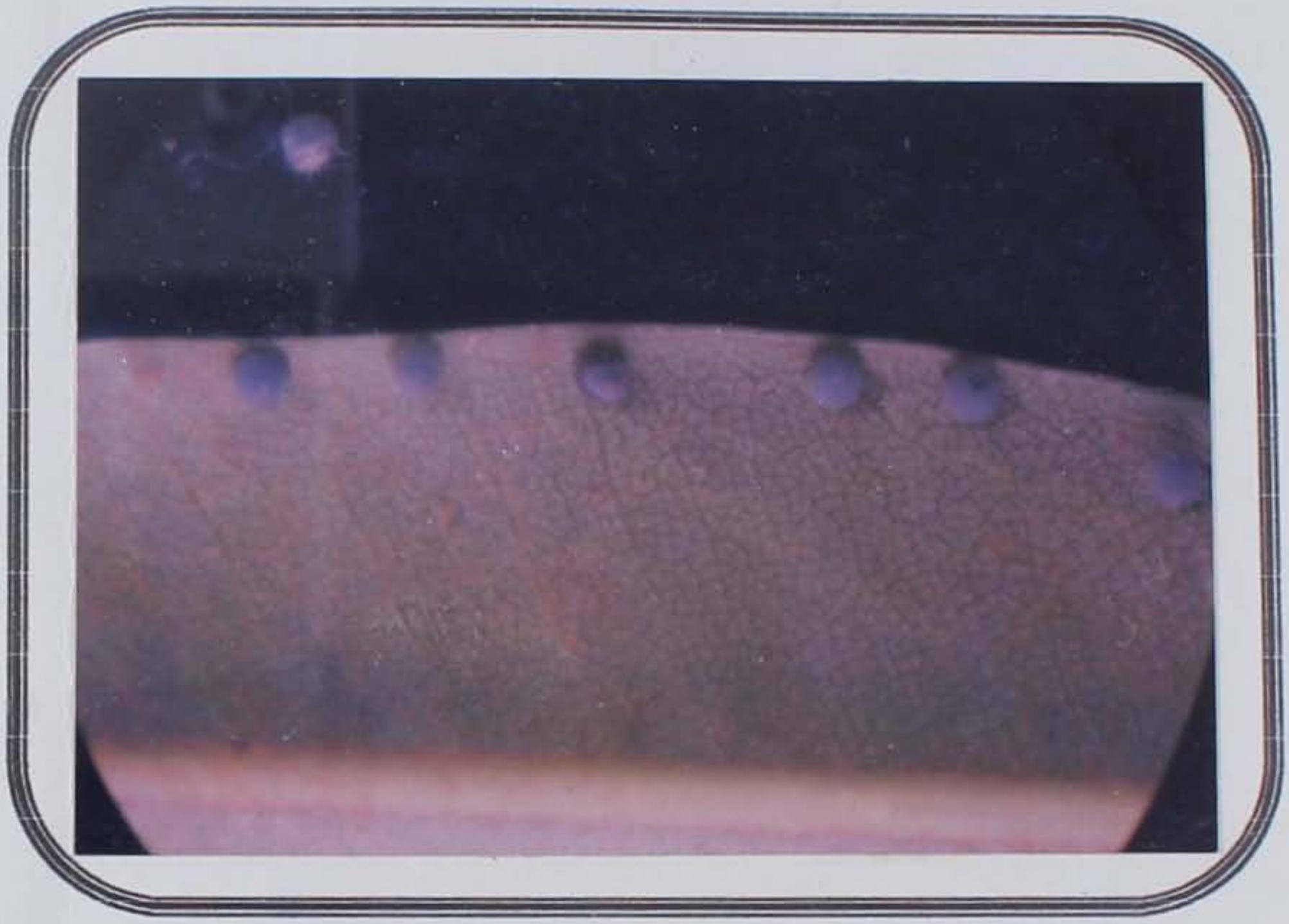


Plate-VIII: Eggs of *A. mercatoria*

Table 3: Measurement of eggs of *A. mercatoria*

Sr. No.	Length (mm)	Breadth (mm)
1.	0.45	0.65
2.	0.43	0.76
3.	0.41	0.70
4.	0.42	0.65
5.	0.37	0.59
6.	0.46	0.59
7.	0.37	0.76
8.	0.39	0.73
9.	0.38	0.70
10.	0.43	0.65
11.	0.45	0.68
12.	0.42	0.73
13.	0.41	0.68
14.	0.41	0.60
15.	0.41	0.62
16.	0.37	0.68
17.	0.37	0.60
18.	0.37	0.60
19.	0.37	0.60
20.	0.39	0.68
21.	0.39	0.62
22.	0.39	0.73
23.	0.37	0.76
24.	0.37	0.76
25.	0.42	0.73
26.	0.38	0.70
27.	0.38	0.73
28.	0.41	0.62
29.	0.39	0.70
30.	0.39	0.70
Mini.	0.37	0.59
Maxi.	0.46	0.76
Ave.	0.39 ± 0.027	0.68 ± 0.057

The data on measurement of eggs revealed that the length of eggs varied from 0.37 to 0.46 mm, with an average of 0.39 $\pm$ 0.027 mm and breadth varied from 0.59 to 0.76 mm with an average of 0.68 $\pm$ 0.057 mm.

4.2.1.3 Incubation period

It is clear from the Table 4 that the incubation period varied from 2 to 3 days with an average of 2.27 $\pm$ 0.46 days. Byale and Bilapate (1990) reported incubation period to be 2.02 $\pm$ 0.13 days in *A. janata* on castor. Thus, the present findings on incubation period is in close agreement with those reported in past.

4.2.1.4 Hatching percentage

It can be seen from Table 4 that hatching per cent of eggs of *A. mercatoria* varied from 86.23 to 94.33 per cent with an average of 90.48 $\pm$ 2.42 per cent. The present findings on hatching per cent is more or less in agreement with the findings of Byale and Bilapate (1990) who also reported it to be 92.00 per cent in *A. janata* on castor.

4.2.2 Larva

In order to study the various larval instars of *A. mercatoria*, newly hatched larvae were reared individually on tender leaves of sapota till they pupated. The data obtained on duration of different instars are presented in Table 5.

4.2.2.1 Number of instars

During the present studies, *A. mercatoria* was observed to pass through six larval instars. To confirm the correctness of the number of instars observed during the present study, Dyar's law was

Table 4: Incubation period and hatching percentage of eggs of *A. mercatoria*

Sr. No.	Period of study	No. of eggs observed	No. of eggs hatched	Hatching percentage	Incubation period (days)
1.	17.8.99 to 19.8.99	205	185	90.24	2
2.	18.8.99 to 20.8.99	266	250	93.98	2
3.	21.8.99 to 24.8.99	200	173	86.50	3
4.	21.8.99 to 23.8.99	280	260	92.86	2
5.	22.8.99 to 24.8.99	300	264	88.00	2
6.	23.8.99 to 25.8.99	215	195	90.70	2
7.	25.8.99 to 28.8.99	300	283	94.33	3
8.	27.8.99 to 29.8.99	276	238	86.23	2
9.	28.8.99 to 30.8.99	291	266	91.41	2
10.	30.8.99 to 01.9.99	300	273	91.00	2
11.	08.9.99 to 11.9.99	330	304	92.12	3
12.	10.9.99 to 12.9.99	290	259	89.31	2
13.	11.9.99 to 13.9.99	279	252	90.32	2
14.	14.9.99 to 17.9.99	350	319	91.14	3
15.	16.9.99 to 18.9.99	249	221	88.76	2
	Min.	200	173	86.23	2
	Max.	350	319	94.33	3
	Ave.	275.40 ± 42.97	248.20 ± 40.83	90.48 ± 2.42	2.27 ± 0.46

Table 5: Duration of different larval instars of *A. mercatoria*

Sr. No.	I instar	II instar	III instar	IV instar	V instar	VI instar	Total
1.	3	2	2	2	3	6	18
2.	3	2	2	2	2	6	17
3.	3	2	2	3	2	5	17
4.	3	2	2	2	3	6	18
5.	3	2	3	2	3	5	18
6.	2	3	3	3	2	6	17
7.	3	2	2	2	2	5	16
8.	3	2	2	2	3	6	18
9.	3	2	2	2	3	5	17
10.	3	2	2	2	3	5	17
11.	3	2	2	2	3	5	17
12.	3	2	2	3	3	5	18
13.	3	2	2	2	2	5	16
14.	3	2	2	2	2	5	16
15.	3	2	3	2	3	5	18
16.	3	2	2	2	3	5	17
17.	3	2	2	2	3	6	18
18.	3	2	2	2	3	6	18
19.	3	2	2	2	2	6	17
20.	3	2	2	3	2	5	17
21.	3	2	2	2	3	5	16
22.	3	2	2	2	3	5	17
23.	3	2	2	2	3	5	17
24.	3	2	2	2	3	5	18
25.	3	2	2	2	3	5	17
Min.	2	2	2	2	2	5	16
Max.	3	3	3	3	3	6	18
Ave.	2.96 ± 0.20	2.04 ± 0.20	2.08 ± 0.28	2.16 ± 0.37	2.64 ± 0.49	5.32 ± 0.48	17.20 ± 0.71

applied to the data collected for the head width of different instars. As per Dyar's law (1890) the head capsule increases in a regular geometrical progression in successive instars by a ratio of 1.4.

The ratio calculated from the data recorded during the study are given below.

Larval instar	Width of the head capsule (mm)	Ratio
I	0.34	-
II	0.64	1.88
III	1.14	1.78
IV	1.81	1.59
V	2.59	1.43
VI	3.52	1.36
Min.		1.36
Max		1.88
Aver		1.61 ± 0.22

It can be seen from the above calculations that the ratio of two successive instars varied from 1.36 to 1.88 with an average of 1.61 ± 0.22 which is nearer to 1.4 as stated by Dyar (1890). Thus, it was confirmed that there were six larval instars of *A. mercatoria*. However, Karmawati and Tobing (1988) and Byale and Bilapate (1990) had reported six larval instars of *A. janata* on castor and pomegranate, respectively which is in accordance with the present findings. While John and Muraleedharan (1989) observed five larval instars of *A. janata* on castor whereas Vyas (1994) reported that there were four larval instars of *A. janata* on rose. The variation found in larval instars

Plate-IX: First instar larvae of *A. mercatoria*

Table 6: Measurement of first instar larvae of *A. mercatoria*

Sr. No.	Body		Breadth of head capsule (mm)
	Length (mm)	Breadth (mm)	
1.	3.24	0.23	0.31
2.	3.33	0.20	0.36
3.	2.71	0.22	0.42
4.	2.44	0.22	0.37
5.	2.67	0.27	0.35
6.	2.45	0.20	0.35
7.	3.11	0.24	0.35
8.	2.31	0.21	0.32
9.	2.44	0.23	0.37
10.	3.24	0.23	0.31
11.	2.35	0.19	0.40
12.	2.40	0.19	0.30
13.	2.49	0.24	0.31
14.	2.67	0.27	0.30
15.	2.80	0.20	0.32
16.	3.20	0.22	0.29
17.	2.76	0.23	0.35
18.	3.24	0.24	0.31
19.	3.20	0.22	0.35
20.	3.33	0.26	0.40
21.	2.76	0.23	0.31
22.	3.11	0.26	0.35
23.	2.67	0.21	0.29
24.	2.80	0.24	0.42
25.	2.45	0.22	0.36
Min.	2.31	0.19	0.29
Max.	3.33	0.27	0.42
Ave.	2.80 ± 0.35	0.23 ± 0.023	0.34 ± 0.039

duration of first instar larva is almost the same as reported by Vyas (1994) as 2 to 3 days in *A. janata* on rose.

4.2.2.3 Second instar larva

The second instar larva (Plate-X) was light brown in colour. The head capsule turned from black brown to dark brown in colour. The distinctive feature was the presence of prominent brown spot on each side of abdominal segment.

The second instar larva measured 4.22 to 5.75 mm with an average of 5.22 $\pm$ 0.344 mm in length and 0.46 to 0.56 mm with an average of 0.51 $\pm$ 0.033 mm in breadth. The breadth of head capsule varied from 0.57 to 0.70 mm with an average of 0.64 $\pm$ 0.039 mm (Table 7). Karmawati and Tobing (1988) reported length and width of head capsule of second instar larva of *A. janata* as 5.0 to 6.0 mm and 0.4 to 0.5 mm, respectively.

The duration of second instar larva varied from 2 to 3 days with an average of 2.04 $\pm$ 0.20 days (Table 5). The present findings on duration of second instar larva is fully in accordance with that of Vyas (1994) who reported the duration of second instar larva of *A. janata* to be 2 to 3 days on rose.

4.2.2.4 Third instar larva

The third instar larva (Plate-XI) had greenish grey colour with brownish black spot on throracic and abdominal region on lateral side. The colour of the head capsule was dark greenish brown with two light whitish line on head. Similar observations were reported by Karmawati and Tobing (1988) and Vyas (1994) in *A. janata* on castor and rose, respectively.

Plate-X: Second instar larva of *A. mercatoria*

Table 7: Measurement of second instar larvae of *A. mercatoria*

Sr. No.	Body		Breadth of head capsule (mm)
	Length (mm)	Breadth (mm)	
1.	4.22	0.53	0.57
2.	5.51	0.55	0.66
3.	5.57	0.53	0.66
4.	5.55	0.48	0.70
5.	4.88	0.46	0.57
6.	5.55	0.56	0.66
7.	5.20	0.48	0.66
8.	5.50	0.55	0.70
9.	5.11	0.53	0.66
10.	4.75	0.46	0.61
11.	5.75	0.56	0.68
12.	5.45	0.55	0.61
13.	5.45	0.51	0.66
14.	5.33	0.48	0.61
15.	5.28	0.48	0.64
16.	4.66	0.48	0.59
17.	4.88	0.53	0.61
18.	5.51	0.48	0.59
19.	5.33	0.51	0.68
20.	5.11	0.51	0.66
21.	5.29	0.52	0.66
22.	5.20	0.48	0.68
23.	5.06	0.50	0.70
24.	5.15	0.55	0.66
25.	5.29	0.56	0.64
Min.	4.22	0.46	0.57
Max.	5.75	0.56	0.70
Ave.	5.22 ± 0.344	0.51 ± 0.033	0.64 ± 0.039

Plate-XI: Third instar larva of *A. mercatoria*

It can be seen from the Table 8 that the length of third instar larva varied from 14.0 to 18.0 mm with an average of 16.06 ± 1.37 mm while, the breadth varied from 2.50 to 3.02 mm with an average of 2.75 ± 0.18 mm. The breadth of head capsule ranged from 1.08 to 1.22 mm with an average of 1.14 ± 0.04 mm.

The duration of third instar larva was 2 to 3 days with an average of 2.08 ± 0.28 days (Table 5). Byale and Bilapate (1990) reported the duration of third instar of *A. janata* on pomegranate to be 2.14 days, which is in confirmation with present findings.

4.2.2.5 Fourth instar larva

The fourth instar larva (Plate-XII) had dark greenish grey with blackish brown head capsule with two white lines on head. The brownish black spots were present on dorso lateral side of each abdominal segment and they were more prominent on first abdominal segment. Three whitish stripes run parallel from first to the last abdominal segments on the dorsal side of the body. The scoli became more prominent with brown colour tips on eighth abdominal segment. The above description was somewhat in line with the description given by Karmawati and Tobing (1988) in regards of colour of *A. janata*.

The fourth instar larva was measured 22.0 to 26.0 mm with an average of 23.90 ± 1.37 mm in length, while breadth was varied from 3.25 to 4.00 mm with an average of 3.62 ± 0.22 mm. The breadth of head capsule varied from 1.71 to 1.95 mm with an average of 1.81 ± 0.07 mm (Table 9). John and Muraleedharan (1989) reported the length of fourth instar larva of *A. janata* as 26.0 ± 0.108 mm which is more or less in confirmation with present findings.

Table 8: Measurement of third instar larvae of *A. mercatoria*

Sr. No.	Body		Breadth of head capsule (mm)
	Length (mm)	Breadth (mm)	
1.	14.50	2.59	1.17
2.	15.00	2.50	1.09
3.	16.50	2.59	1.08
4.	18.00	2.93	1.20
5.	14.00	2.84	1.17
6.	15.50	2.55	1.22
7.	16.00	2.88	1.12
8.	15.50	3.02	1.09
9.	16.50	2.76	1.12
10.	17.50	2.82	1.14
11.	17.00	3.02	1.12
12.	16.00	2.93	1.09
13.	14.00	2.66	1.14
14.	17.50	2.84	1.16
15.	18.00	2.50	1.16
16.	18.00	2.56	1.18
17.	14.50	2.59	1.18
18.	15.50	2.50	1.20
19.	17.50	2.55	1.22
20.	14.00	3.00	1.09
21.	17.00	2.76	1.17
22.	14.50	2.89	1.10
23.	17.50	3.00	1.14
24.	15.00	2.84	1.17
25.	16.50	2.66	1.10
Min.	14.00	2.50	1.08
Max.	18.00	3.02	1.22
Ave.	16.06 $\pm$ 1.37	2.75 $\pm$ 0.18	1.14 $\pm$ 0.04

Plate-XII: Fourth instar larva of *A. mercatoria*

Table 9: Measurement of fourth instar larvae of *A. mercatoria*

Sr. No.	Body		Breadth of head capsule (mm)
	Length (mm)	Breadth (mm)	
1.	23.50	3.56	1.76
2.	25.00	4.00	1.87
3.	23.00	3.75	1.81
4.	26.00	3.25	1.76
5.	26.00	3.75	1.84
6.	25.50	3.68	1.95
7.	23.50	3.55	1.89
8.	23.00	3.48	1.95
9.	23.50	3.46	1.92
10.	22.00	3.40	1.76
11.	23.50	3.70	1.79
12.	22.00	3.68	1.73
13.	23.50	3.84	1.87
14.	23.50	3.35	1.81
15.	26.00	3.85	1.84
16.	22.50	4.00	1.75
17.	22.50	3.75	1.79
18.	24.50	3.45	1.81
19.	24.00	3.58	1.79
20.	22.00	4.00	1.71
21.	23.50	3.68	1.73
22.	26.00	3.45	1.79
23.	22.50	3.35	1.81
24.	25.00	3.40	1.73
25.	25.50	3.46	1.75
Min.	22.00	3.25	1.71
Max.	26.00	4.00	1.95
Ave.	23.90 $\pm$ 1.37	3.62 $\pm$ 0.22	1.81 $\pm$ 0.07

The duration of fourth instar larva varied from 2 to 3 days with an average of 2.16 ± 0.37 days (Table 5). The present finding is more or less in accordance with that of John and Muraleedharan (1989) who also reported the duration of fourth instar larva of *A. janata* to be 2 days.

4.2.2.6 Fifth instar larva

The fifth instar larva (Plate-XIII) had greyish green with pinkish tinge on abdominal region. The spot on first abdominal segment became more prominent. The scoli became more prominent. The head capsule was dark brown in colour with whitish stripes on head.

It can be seen from the Table 10 that the length of fifth instar larva varied from 31.0 to 36.0 mm with an average of 33.68 ± 1.51 mm while, the breadth varied from 3.73 to 4.00 mm with an average of 3.84 ± 0.09 mm. The breadth of head capsule varied from 2.48 to 2.67 mm with an average of 2.59 ± 0.68 mm. Karmawati and Tobing (1988) reported the length of fifth instar larva of *A. janata* as 35.0 to 36.0 mm which is in close confirmation with the present finding.

The duration of fifth instar larva ranged from 2 to 3 days with an average of 2.64 ± 0.49 days (Table 5) which is in accordance with the report of Karmawati and Tobing (1988) who reported the duration of fifth instar larva of *A. janata* to be 2 to 3 days.

4.2.2.7 Sixth instar larva

The sixth instar larva (Plate-XIV) was stout, smooth and plumpy. Body colour was greyish blue with light brownish stripes on dorsal region of the body.

Plate-XIII: Fifth instar larva of *A. mercatoria*

Table 10: Measurement of fifth instar larvae of *A. mercatoria*

Sr. No.	Body		Breadth of head capsule (mm)
	Length (mm)	Breadth (mm)	
1.	32.50	3.80	2.61
2.	34.50	4.00	2.53
3.	34.50	3.85	2.48
4.	33.50	3.75	2.59
5.	36.00	3.89	2.61
6.	33.50	3.75	2.59
7.	35.00	4.00	2.64
8.	34.00	4.00	2.67
9.	32.00	3.88	2.64
10.	36.00	3.73	2.67
11.	35.00	3.73	2.53
12.	32.50	3.74	2.61
13.	34.00	3.80	2.45
14.	34.50	3.76	2.61
15.	35.50	3.78	2.56
16.	31.50	3.75	2.53
17.	33.00	3.90	2.56
18.	36.00	3.96	2.48
19.	31.00	3.90	2.67
20.	32.00	3.75	2.67
21.	33.50	3.75	2.53
22.	31.00	3.90	2.67
23.	33.50	3.88	2.59
24.	34.50	3.78	2.67
25.	33.50	3.95	2.67
Min.	31.00	3.73	2.48
Max.	36.00	4.00	2.67
Ave.	33.68 $\pm$ 1.51	3.84 $\pm$ 0.09	2.59 $\pm$ 0.68

Plate-XIV: Sixth instar larva of *A. mercatoria*

It can be seen from the Table 11 that the body length of sixth instar larva varied from 42.0 to 47.50 mm with an average of 44.98 ± 1.89 mm while, breadth of body varied from 4.94 to 5.56 mm with an average of 5.26 ± 0.25 mm. The breadth of head capsule varied from 3.37 to 3.68 mm with an average of 3.52 ± 0.09 mm.

The duration of sixth instar larva varied from 5 to 6 days with an average of 5.32 ± 0.48 days (Table 5).

4.2.2.8 Larval period

The data on total larval period (Table 5) indicated that the larval period varied from 16 to 18 days with an average of 17.2 ± 0.71 days. Vyas (1994) reported total larval period of *A. janata* on rose was 15 to 19 days which is nearer to present finding.

4.2.2.9 Colour variation in larva

In the present investigation colour variation was observed in the later instars larva of *A. mercatoria*. Two varieties of colour pattern had been observed in the sixth instar larva. The first type of colour pattern in larva was greyish blue with light brownish stripes on the dorsal region of the body (Plate-XV). While another colour pattern was dark brown with black spot on first abdominal region. The head capsule was brownish in colour with two whitish stripes (Plate-XVI).

4.2.3 Prepupa

When the larva completed its development, it stopped feeding and reached for suitable site for pupation. The colour of the full grown larva was light brownish grey. The larva stopped feeding for about two days before pupation. The larva web the leaves together and

Table 11: Measurement of sixth instar larvae of *A. mercatoria*

Sr. No.	Body		Breadth of head capsule (mm)
	Length (mm)	Breadth (mm)	
1.	45.00	5.54	3.55
2.	47.50	5.54	3.42
3.	42.00	5.00	3.46
4.	46.00	5.56	3.55
5.	43.50	5.00	3.68
6.	43.00	4.96	3.51
7.	44.50	5.00	3.66
8.	42.50	5.25	3.48
9.	42.00	4.96	3.51
10.	47.50	5.35	3.55
11.	46.50	5.25	3.62
12.	45.00	4.96	3.51
13.	46.00	4.96	3.64
14.	43.00	5.25	3.57
15.	46.50	5.45	3.64
16.	43.00	5.20	3.45
17.	44.50	5.49	3.51
18.	43.50	4.94	3.40
19.	47.50	5.25	3.42
20.	45.50	5.20	3.40
21.	47.50	5.35	3.68
22.	47.00	5.30	3.44
23.	45.50	5.00	3.37
24.	43.00	5.48	3.51
25.	47.00	5.30	3.60
Min.	42.00	4.94	3.37
Max.	47.50	5.56	3.68
Ave.	44.98 ± 1.89	5.26 ± 0.25	3.52 ± 0.09

Plate-XV: Colour variation in larva : First type of colour pattern

Plate-XVI: Colour variation in larva : Second type of colour pattern

formed a silken cocoon (Plate-XVII). After cocoon formation, the larva contracted its length and appendages and became quiescent (Plate-XVIII). Similar observations were reported by John and Muraleedharan (1989) and Vyas (1994) on *A. janata*.

The length of prepupa varied from 33.50 to 39.00 mm with an average of 35.78 ± 1.59 mm while breadth of the body varied from 6.28 to 7.04 mm with an average of 6.63 ± 0.16 mm (Table 12).

The duration of prepupa ranged from 2 to 3 days with an average of 2.12 ± 0.33 days (Table 12).

4.2.4 Pupa

Pupation took place in folded leaves. The newly formed pupa was light green in colour but the colour changed to brown (Plate-XIX) and finally to dark brown before adult emergence. Similar observation on *A. janata* was made by John and Muraleedharan (1989) and Vyas (1994).

The pupae were also studied for their morphometric differences in male and female. Male pupae had a slit on ventral posterior margin of ninth sternum representing genital aperture while female pupae had a genital aperture on the posterior margin of the eighth sternum. There was an anal slit on the caudal region of the tenth abdominal segment of pupa in both the sexes (Plate-XX).

It can be seen from the Table 13 that in case of female pupa length ranged from 21.0 to 25.0 mm with an average of 23.41 ± 1.29 mm and breadth varied from 5.20 to 6.35 mm with an average of 5.63 ± 0.32 mm, whereas distance between genital and anal slit ranged from 1.35 to 2.10 mm with an average of 1.74 ± 0.21 mm. While in case of

Plate-XVII: Silken cocoon

Plate-XIX: Pupae of *A. mercatoria*

Table 12: Measurement and duration of prepupa and pupal duration of *A. mercatoria*

Sr. No.	Body		Prepupal duration (days)	Pupal duration (days)
	Length (mm)	Breadth (mm)		
1.	36.00	6.35	2	10
2.	38.00	6.43	2	11
3.	35.50	6.62	2	10
4.	34.00	6.57	2	11
5.	34.00	6.57	2	11
6.	33.50	6.28	2	11
7.	39.00	7.04	2	10
8.	34.50	6.62	2	10
9.	35.00	6.62	2	10
10.	35.50	6.64	2	10
11.	36.00	6.35	2	10
12.	38.50	6.79	2	10
13.	35.50	6.62	2	10
14.	37.50	6.71	2	11
15.	37.50	6.71	3	11
16.	37.00	6.80	2	11
17.	34.50	6.63	3	10
18.	38.50	6.78	3	11
19.	36.00	6.70	2	10
20.	34.50	6.69	2	11
21.	35.00	6.62	2	10
22.	34.00	6.62	2	12
23.	34.50	6.69	2	11
24.	35.00	6.69	2	10
25.	35.50	6.70	2	10
Min.	33.50	6.28	2	10
Max.	39.00	7.04	3	11
Ave.	35.78 $\pm$ 1.59	6.63 $\pm$ 0.16	2.12 $\pm$ 0.33	10.48 $\pm$ 0.59

Plate-XX: Morphometric difference in pupae of *A. mercatoria*

a. Male pupa with shorter distance between genital and anal aperture

b. Female pupa with greater distance between genital and anal aperture

Table 13: Measurement of female and male pupae of *A. mercatoria*

Sr. No.	Female		Male	
	Length (mm)	Breadth (mm)	Length (mm)	Breadth (mm)
1.	24.00	5.95	24.50	6.70
2.	23.00	5.60	27.00	6.90
3.	25.00	6.35	26.50	6.75
4.	21.50	5.40	26.00	6.75
5.	23.00	5.70	24.50	6.65
6.	24.00	5.95	25.00	6.70
7.	23.50	5.95	25.50	6.79
8.	24.50	5.80	26.00	6.80
9.	24.50	5.80	26.50	6.85
10.	21.50	5.40	27.00	7.10
11.	24.50	5.63	27.00	7.02
12.	24.00	5.63	25.00	6.70
13.	21.00	5.20	25.50	6.75
14.	23.50	5.70	26.50	6.80
15.	24.50	5.63	27.00	6.20
16.	22.50	5.45	27.00	6.25
17.	21.50	5.20	26.00	6.80
18.	21.00	5.20	24.50	6.70
19.	22.00	5.40	24.50	6.60
20.	22.50	5.45	25.00	6.70
21.	23.00	5.70	26.00	6.85
22.	24.50	6.00	26.50	6.85
23.	25.00	6.20	27.00	7.10
24.	22.00	5.20	27.00	7.02
25.	22.50	5.30	26.50	7.10
Min.	21.00	5.20	24.50	6.20
Max.	25.00	6.35	27.00	7.10
Ave.	23.41 $\pm$ 1.29	5.63 $\pm$ 0.32	25.98 $\pm$ 0.93	6.78 $\pm$ 0.22

male pupa, the length ranged from 24.50 to 27.0 mm with an average of 25.98 ± 0.93 mm and breadth varied from 6.20 to 7.10 mm with an average of 6.78 ± 0.22 mm whereas, distance between genital and anal slit ranged from 0.46 to 0.80 mm with an average of 0.69 ± 0.09 mm. The length of genital slit of the female varied from 0.27 to 0.42 mm with an average of 0.36 ± 0.05 mm while, length of anal slit ranged from 0.27 to 0.43 mm with an average of 0.33 ± 0.05 mm. The length of genital slit of male varied from 0.29 to 0.48 mm with an average of 0.40 ± 0.07 mm while, length of anal slit varied from 0.22 to 0.48 mm with an average of 0.31 ± 0.07 mm (Table 14). Thus, the length, breadth and length of genital slit in male was more than that of the female pupa. Thus, these characters were helpful in separating the sexes in pupal stage.

The duration of pupal stage varied from 10 to 11 days with an average of 10.48 ± 0.59 days (Table 12). The present finding is more or less in confirmation with the finding of Vyas (1994) who reported the pupal period of *A. janata* to be 12 to 13 days on rose.

4.2.5 Adult

The moth of *A. mercatoria* was stout bodied and the thoracic dorsum was thickly covered with brown hair. The brown coloured forewings were provided with ante medial and post medial wavy lines which were ashy grey in colour cheifly at its apical end. Its apical margin was fringed with the short whitish yellow hairs. The hind wings were brown in colour. Bright brown and white coloured spots were present near the tip of hind wing. The outer margin of hind wing was also fringed with short whitish yellow hairs. Abdomen was grey in

Table 14: Length and distance between genital slit and anal slit of female and male pupae of *A. mercatoria*

Sr. No.	Female		Male		Distance between genital and anal aperture (mm)	
	Length (mm)		Length (mm)			
	Genital slit	Anal slit	Genital slit	Anal slit	Female	Male
1.	0.27	0.28	0.30	0.35	2.10	0.46
2.	0.29	0.28	0.32	0.27	1.35	0.75
3.	0.40	0.35	0.40	0.28	1.75	0.46
4.	0.30	0.32	0.30	0.27	1.35	0.56
5.	0.38	0.27	0.30	0.27	1.76	0.62
6.	0.30	0.27	0.37	0.30	1.89	0.69
7.	0.32	0.30	0.41	0.22	1.91	0.76
8.	0.32	0.27	0.41	0.27	1.84	0.76
9.	0.32	0.30	0.43	0.32	1.94	0.68
10.	0.40	0.32	0.46	0.27	1.84	0.73
11.	0.33	0.30	0.32	0.48	1.78	0.73
12.	0.40	0.43	0.29	0.35	1.83	0.70
13.	0.38	0.38	0.45	0.24	1.86	0.54
14.	0.35	0.27	0.46	0.22	1.89	0.80
15.	0.32	0.30	0.48	0.41	1.84	0.68
16.	0.37	0.32	0.48	0.48	1.81	0.78
17.	0.37	0.36	0.47	0.27	1.73	0.80
18.	0.40	0.39	0.44	0.32	1.49	0.77
19.	0.32	0.37	0.44	0.31	1.76	0.66
20.	0.40	0.39	0.47	0.31	1.84	0.65
21.	0.42	0.32	0.38	0.41	1.35	0.70
22.	0.42	0.40	0.34	0.27	1.89	0.73
23.	0.40	0.38	0.47	0.22	1.35	0.69
24.	0.42	0.40	0.41	0.30	1.89	0.69
25.	0.30	0.38	0.29	0.32	1.57	0.77
Min.	0.27	0.27	0.48	0.22	1.35	0.46
Max.	0.42	0.43	0.48	0.48	2.10	0.80
Ave.	0.36 ± 0.05	0.33 ± 0.05	0.40 ± 0.07	0.31 ± 0.07	1.74 ± 0.21	0.69 ± 0.09

colour and its apical portion was provided with a tuft of brownish hairs and abdomen was thicker in case of female than the male. The posterior part of abdomen was longer and tappering posteriorly in case of male (Plate-XXI). Similar characters of adult of *A. janata* were described by Karmawati and Tobing (1988) and John and Muraleedharan (1989).

The measurement of body length (from head to end of abdomen) and breadth across the expanded wings of female and male of *A. mercatoria* are presented in Table 15.

Measurements of females revealed that the length varied from 20.5 to 23.5 mm with an average of 22.0 $\pm$ 0.87 mm while, breadth varied from 48.50 to 52.00 mm with an average of 50.26 $\pm$ 1.03 mm. In case of male, the length varied from 24.00 to 27.50 mm with an average of 25.60 $\pm$ 1.15 mm while, the breadth varied from 52.50 to 57.00 mm with an average of 54.52 $\pm$ 1.40 mm. Thus, the male moth was slightly bigger in size than the female. The observation on breadth was similar to that of observed by Karmawati and Tobing (1988) who measured wing span of male as 54.0 to 56.0 and female as 47.0 to 49.0 mm in case of *A. janata*.

4.2.5.1 Pre-oviposition period

Pre-oviposition period varied from 2 to 3 days with an average of 2.28 $\pm$ 0.46 days (Table 16).

4.2.5.2 Oviposition period

The oviposition period was found to be varying from 4 to 6 days with an average of 5.00 $\pm$ 0.76 days (Table 16).

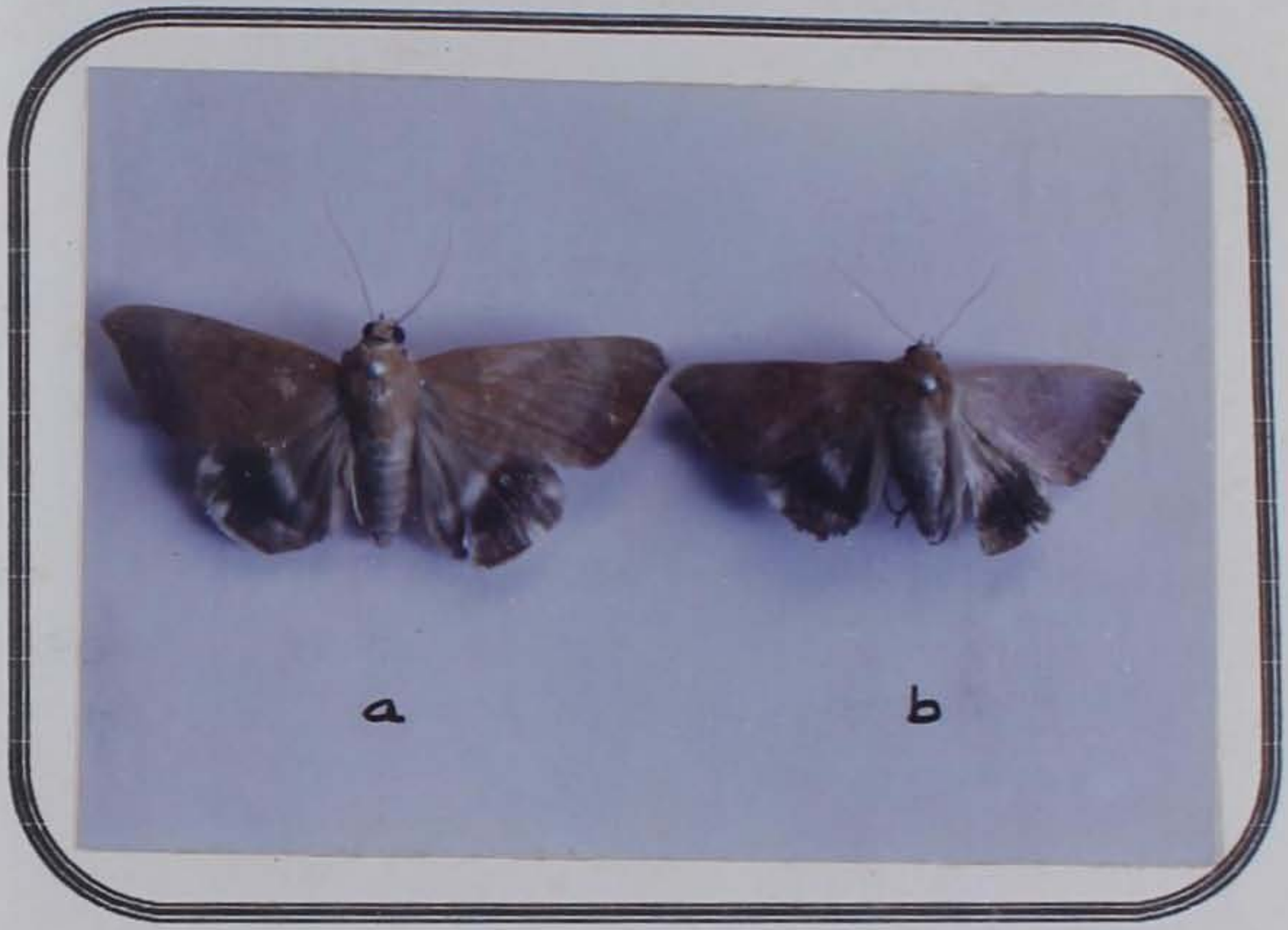


Plate-XXI: Adults of *A. mercatoria*

a. Male

b. Female

Table 15: Measurement of adults of *A. mercatoria*

Sr. No.	Female		Male	
	Length (mm)	Breadth (mm)	Length (mm)	Breadth (mm)
1.	23.5	50.5	25.0	53.50
2.	22.0	50.0	24.5	52.50
3.	21.5	49.5	24.0	53.00
4.	22.0	49.5	27.5	54.00
5.	21.0	48.5	24.5	53.50
6.	22.5	49.5	26.5	55.50
7.	23.0	52.0	27.5	55.00
8.	22.5	51.0	27.0	56.00
9.	22.0	49.0	27.0	56.00
10.	21.0	48.5	27.5	54.50
11.	21.0	51.0	24.5	53.50
12.	21.5	50.5	25.5	57.00
13.	23.0	51.0	24.0	55.00
14.	22.0	51.5	24.5	56.00
15.	22.5	51.0	24.5	56.00
16.	23.0	51.5	26.0	56.00
17.	23.5	51.5	25.5	53.00
18.	21.5	50.5	25.0	56.00
19.	21.5	49.5	26.5	54.50
20.	21.0	50.5	26.5	52.50
21.	21.0	48.5	24.5	56.50
22.	20.5	51.5	25.5	52.50
23.	23.0	50.5	24.5	53.50
24.	22.5	49.5	26.0	54.00
25.	21.5	50.0	26.0	53.50
Min.	20.5	48.50	24.00	52.50
Max.	23.5	52.00	27.50	57.00
Ave.	22.0 $\pm$ 0.87	50.26 $\pm$ 1.03	25.60 $\pm$ 1.15	54.52 $\pm$ 1.40

* With expanded wings

Table 16: Pre-oviposition, oviposition and post-oviposition period and longevity of *A. mercatoria*

Sr. No.	Pre-oviposition period (days)	Oviposition period (days)	Post-oviposition period (days)	Longevity (days)	
				Female	Male
1.	2.00	5.00	3.00	10.00	09.00
2.	2.00	5.00	3.00	10.00	09.00
3.	2.00	4.00	4.00	10.00	10.00
4.	2.00	6.00	4.00	12.00	10.00
5.	3.00	5.00	2.00	10.00	08.00
6.	2.00	5.00	3.00	10.00	08.00
7.	2.00	5.00	4.00	11.00	09.00
8.	2.00	5.00	3.00	10.00	09.00
9.	2.00	6.00	2.00	10.00	09.00
10.	3.00	4.00	4.00	11.00	10.00
11.	3.00	6.00	3.00	12.00	10.00
12.	2.00	6.00	4.00	12.00	08.00
13.	2.00	5.00	2.00	09.00	08.00
14.	2.00	4.00	3.00	09.00	08.00
15.	3.00	5.00	3.00	11.00	10.00
16.	2.00	4.00	4.00	10.00	10.00
17.	2.00	6.00	3.00	11.00	09.00
18.	2.00	5.00	2.00	09.00	09.00
19.	3.00	6.00	2.00	11.00	08.00
20.	2.00	4.00	3.00	09.00	10.00
21.	2.00	4.00	5.00	11.00	10.00
22.	3.00	5.00	4.00	12.00	09.00
23.	3.00	4.00	2.00	09.00	08.00
24.	2.00	5.00	2.00	09.00	08.00
25.	2.00	6.00	2.00	10.00	09.00
Min.	2.00	4.00	2.00	09.00	08.00
Max.	3.00	6.00	5.00	12.00	10.00
Avg.	2.28 $\pm$ 0.46	5.00 $\pm$ 0.76	3.04 $\pm$ 0.89	10.32 $\pm$ 1.03	9 $\pm$ 0.82

4.2.5.3 Post-oviposition

The post-oviposition period was found to be varying from 2 to 5 days with an average of 3.04 $\pm$ 0.89 days (Table 16).

Karmawati and Tobing (1988) reported that pre-oviposition period in *A. janata* was of 1 to 4 days, which is in confirmation with the present findings.

4.2.5.4 Fecundity

The results on fecundity (Table 17) revealed that the egg laying capacity of the female varied from 200 to 350 with an average of 272.55 $\pm$ 40.34 eggs. Karmawati and Tobing (1988) reported fecundity of *A. janata* as 1305 eggs on castor, while Vyas (1994) also reported it to be 600 to 650 eggs on rose. The present finding is not in accordance with the findings of above workers. The variation in fecundity might be due to different host plants under study and different ecological conditions at different locations.

4.2.5.5 Longevity

The data presented in Table 16 showed that the longevity of female varied from 9 to 12 days with an average of 10.32 $\pm$ 1.03 days, while longevity of male varied from 8 to 10 days with an average of 9.0 $\pm$ 0.82 days. Thus, the males lived shorter than the females.

4.2.6 Total life cycle

Total life cycle occupied 39 to 45 days with an average of 42.40 $\pm$ 1.50 days in case of female, while in case of male it occupied 38 to 44 days with an average of 41.08 $\pm$ 1.38 days (Table 18). While Byale and Bilapate reported average life cycle of male 23.14 $\pm$ 1.24 and

Table 17: Fecundity of *A. mercatoria*

Sr. No.	No. of eggs laid on indicated days after emergence									Total
	1	2	3	4	5	6	7	8	9	
1.	-	-	22	59	76	35	13	-	-	205
2.	-	-	30	55	75	90	16	-	-	266
3.	-	-	25	88	52	35	-	-	-	200
4.	-	-	08	34	68	98	48	24	-	280
5.	-	-	-	38	62	108	70	22	-	300
6.	-	-	16	36	89	58	16	-	-	215
7.	-	-	34	44	126	72	24	-	-	300
8.	-	-	10	62	86	90	28	-	-	276
9.	-	-	17	68	89	58	43	16	-	291
10.	-	-	-	39	135	86	40	-	-	300
11.	-	-	-	22	50	76	90	64	28	330
12.	-	-	06	58	92	60	40	34	-	290
13.	-	-	28	48	69	82	52	-	-	279
14.	-	-	72	148	86	44	-	-	-	350
15.	-	-	-	10	62	94	56	27	-	249
16.	-	-	20	58	97	62	-	-	-	237
17.	-	-	16	44	72	85	38	22	-	277
18.	-	-	24	63	83	47	11	-	-	228
19.	-	-	-	16	46	73	98	64	15	312
20.	-	-	38	72	95	61	-	-	-	266
			366	1062	1610	1414	683	273	43	5457
									Min.	200
									Max.	350
									Avg.	272.55
										± 40.34

Table 18: Details of life cycle of *A. mercatoria* on sapota

Sr. No.	Particulars	Period (days)		Average
		Minimum	Maximum	
1.	**Egg period**	2	3	2.27 ± 0.46
2.	**Hatching percentage**	86.23	94.33	90.17 ± 2.56
3.	**Larval period**			
	First instar	2	3	2.96 ± 0.20
	Second instar	2	3	2.04 ± 0.20
	Third instar	2	3	2.08 ± 0.28
	Fourth instar	2	3	2.16 ± 0.37
	Fifth instar	2	3	2.64 ± 0.49
	Sixth instar	5	6	5.32 ± 0.48
	Total	16	18	17.20 ± 0.71
4.	**Prepupal period**	2	3	2.12 ± 0.33
5.	**Pupal period**	10	11	10.48 ± 0.59
6.	**Adult period**			
	Pre-oviposition	2	3	2.28 ± 0.46
	Oviposition	4	6	5.00 ± 0.76
	Post-oviposition	2	5	3.04 ± 0.89
	Longevity			
	Female	9	12	10.32 ± 1.03
	Male	8	10	9.00 ± 0.82
7.	**Total life cycle**			
	Female	39	45	42.40 ± 1.50
	Male	38	44	41.08 ± 1.38
8.	**Egg laying capacity (number)**	200	350	272.55 ± 40.34

female 22.24 ± 1.42 days on castor, which is not in confirmation with present findings.

4.3 Natural enemy of *A. mercatoria*

To know the parasitism of *A. mercatoria* field collected larvae were reared till they pupated and observed for emergence of parasites or adults of *A. mercatoria*. The unidentified dipterous parasite was emerged out (Plate-XXII) from the parasitised pupae of *A. mercatoria*.

Table 19: Studies on natural enemy of *A. mercatoria* :. in . field

Area of	No. of larvae collected	No. of larvae pupated	No. of parasite emerged	Per cent parasitism
Navsari				
1) Khara Abramma	130	120	2	1.67
2) Kharsad				

Data presented in Table 19 indicted that per cent parasitism in *A. mercatoria* by unidentified dipterous parasite was 1.67 in Kharsad and Khara Abramma villages of Navsari area.

4.4 Seasonal incidence of *A. mercatoria* on sapota

The present investigations were carried out at farmer's orchard at villages Khara Abramma and Kharsad, Dist. Navsari to study the seasonal incidence of *A. mercatoria* in relation to weather parameters during the period from fourth week of March to third week of June during 1999-2000 and 2000-2001.

Plate-XXII: Dipterous parasite of *A. mercatoria*

4.4.1 Seasonal incidence

4.4.1.1 Incidence based on population count

The periodical data (Table 20, Fig. 1) on incidence of *A. mercatoria* larvae in 1999-2000 revealed that the pest appeared from 13th standard week i.e. fourth week of March reaching at peak (0.98 larvae/twig) in 18th standard week i.e. fourth week of April and thereafter it declined. More or less similar trend had been observed during second year, 2000-2001 (Table 20, Fig. 2). The pest activity was noticed from 13th standard week to 24th standard week i.e. third week of March to second week of June during both the years.

4.4.1.2 Incidence based on mean per cent damage leaves

During both the years, the data on per cent damage leaves were also recorded periodically, which indicated that during 1999-2000 pest activity was noticed during 13th standard week i.e. 4th week of March to 2nd week of June during 1999-2000. The maximum per cent damage leaves were recorded in 21st standard week i.e. 3rd week of May (62.33 % damage leaves). While during second year, maximum per cent damage leaves were recorded in 22nd standard week i.e. 4th week of May (72.67 % damage leaves). Thereafter, it declined gradually in both the years (Table 20).

4.4.2 Correlation studies

4.4.2.1 Correlation between mean number of larvae and mean per cent damage leaves

The correlation between the mean number of larvae and mean per cent damage leaves per twig was also worked out, which

Table 20: Seasonal incidence of *A. mercatoria* on sapota during 1999-2000 and 2000-2001

Month & Year	Std. week	Dependent variable		Independent variable						
		MNL (Y_1)	MPDL (Y_2)	Temperature (^{0}C)		Relative humidity (%)		Sunshine hrs	Rainfall (mm)	Rainy days
				Max (X_1)	Min (X_2)	Max (X_3)	Min (X_4)			
March-99	12	-	-	35.30	16.00	81	25	9.9	0.00	0
	13	0.02	0.00	35.90	21.00	77	31	9.3	0.00	0
April-99	14	0.07	2.82	35.30	23.60	82	40	9.0	0.00	0
	15	0.22	8.87	34.90	23.70	87	46	9.6	0.00	0
	16	0.38	15.79	35.20	22.90	81	42	10.0	0.00	0
	17	0.59	24.52	35.10	25.40	82	58	10.5	0.00	0
	18	0.98	37.82	32.80	26.10	82	61	10.7	0.00	0
May-99	19	0.73	50.48	32.50	25.70	79	58	10.2	0.00	0
	20	0.56	57.47	33.00	26.00	80	61	7.4	0.80	0
	21	0.44	62.33	32.80	27.40	78	59	9.6	0.00	0
	22	0.33	56.13	31.90	26.30	77	60	9.0	37.90	3
June-99	23	0.18	42.09	32.60	28.10	76	64	10.4	0.00	0
	24	0.11	20.72	32.00	27.20	83	71	5.5	2.00	0
	25	0.00	15.24	-	-	-	-	-	-	-
March-2000	12	-	-	34.60	19.40	79	35	9.2	0.00	0
	13	0.00	0.00	38.20	18.80	59	18	9.1	0.00	0
April-2000	14	0.05	2.48	35.40	23.10	85	48	9.2	0.00	0
	15	0.12	9.76	34.50	24.40	85	53	9.4	0.00	0
	16	0.28	17.67	33.60	24.60	91	63	10.3	0.00	0
	17	0.38	28.79	33.40	25.70	85	65	10.8	0.00	0
	18	0.49	39.18	32.60	25.20	86	61	10.7	0.00	0
May-2000	19	0.62	55.32	32.40	25.40	78	60	9.1	0.00	0
	20	0.27	68.47	31.60	25.50	80	66	9.3	8.00	2
	21	0.12	71.94	33.60	26.70	79	61	10.2	0.01	0
	22	0.00	72.67	33.50	27.30	82	66	9.4	12.00	2
June-2000	23	0.00	54.18	31.20	25.90	90	77	2.4	83.00	4
	24	0.00	49.28	31.70	26.50	78	69	7.5	1.80	-
	25	0.00	0.00	-	-	-	-	-	-	-
Mean		0.24	30.86	31.27	22.78	75.07	50.64	8.49	5.20	0.39

Fig. 1 : Seasonal incidence of *A. mercatoria* (1999-2000)

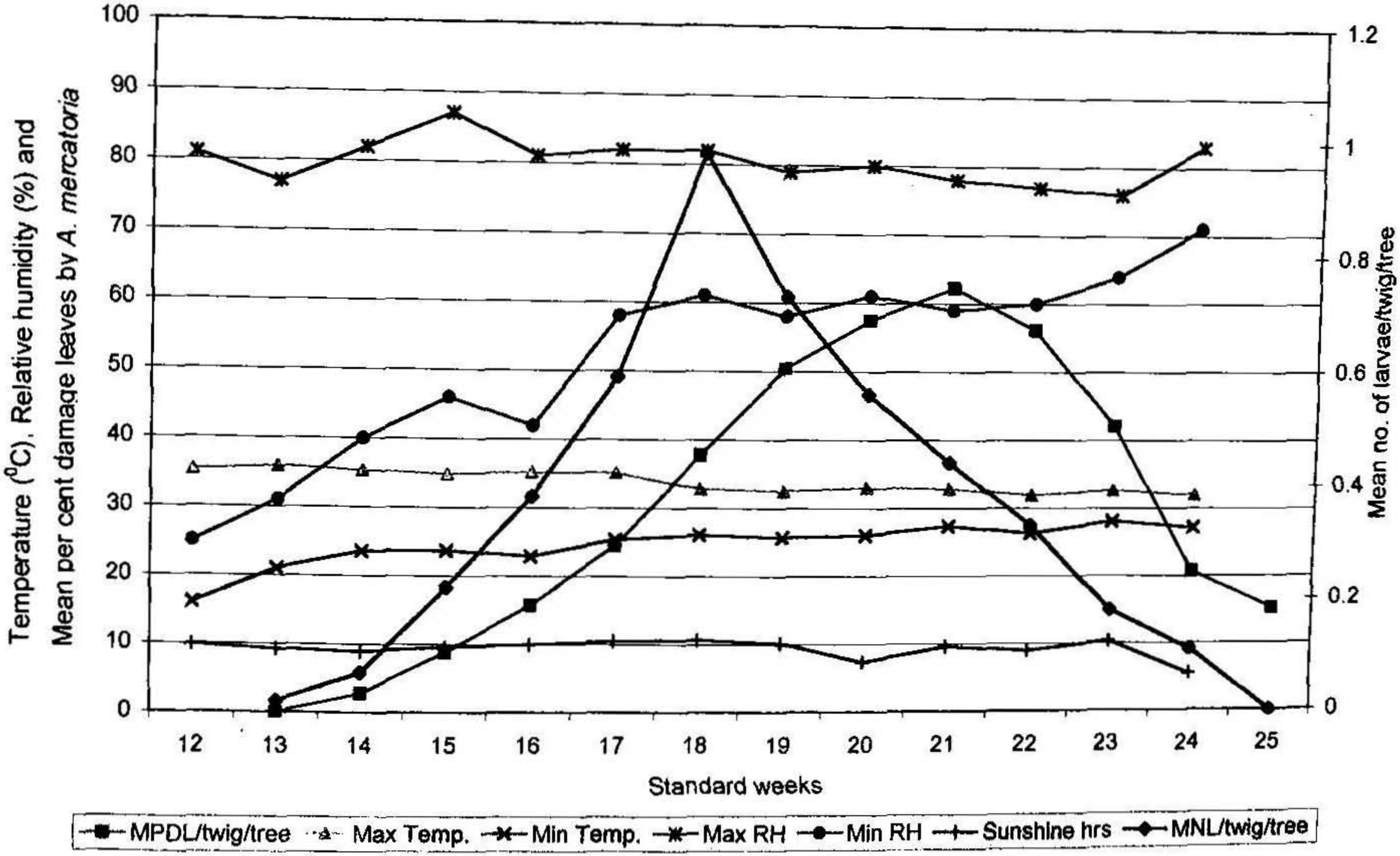
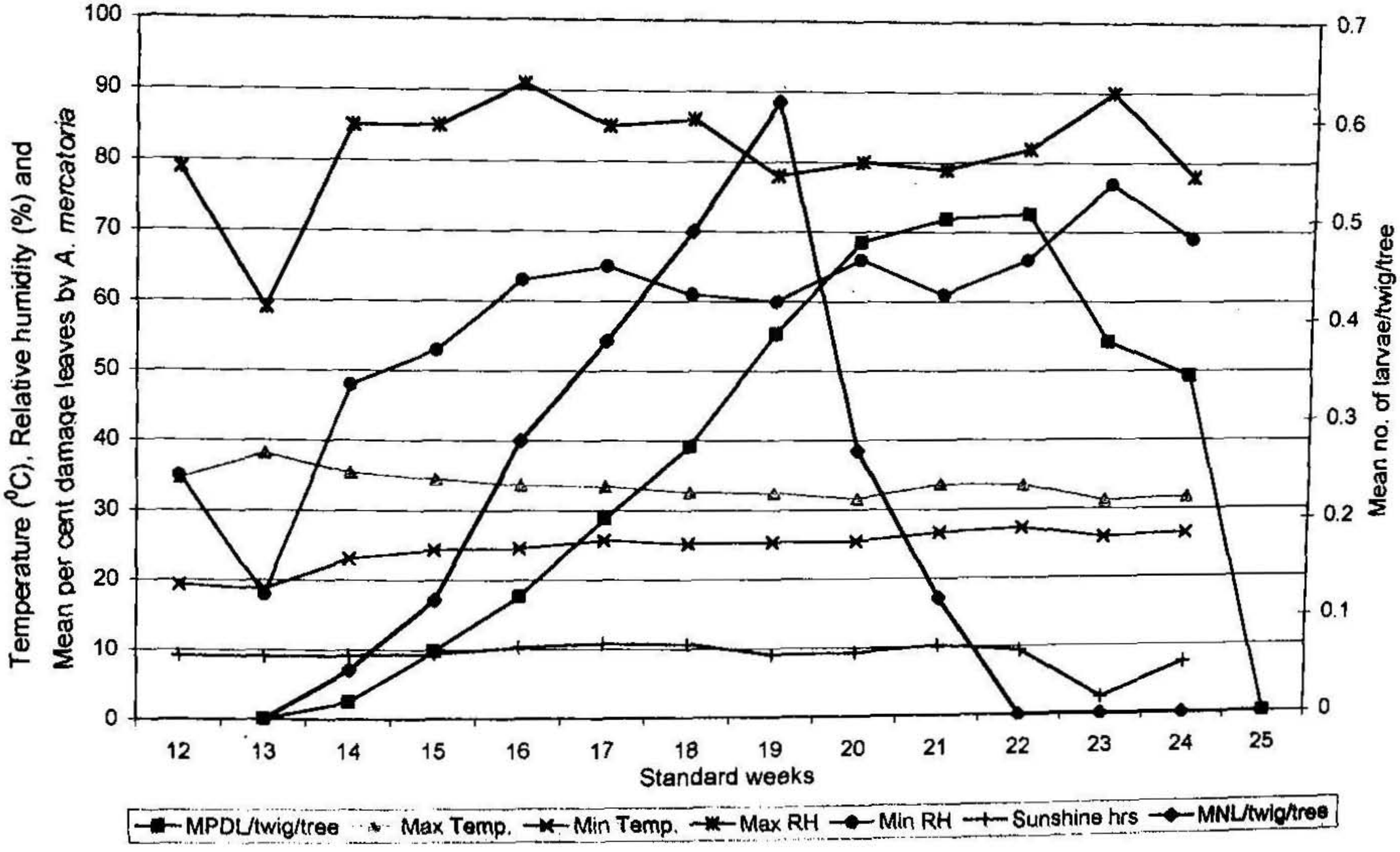


Fig. 2 : Seasonal incidence of *A. mercatoria* (2000-2001)



indicated that positive and significant correlation was observed during 1999-2000 (r = 0.5721). However, in the year 2000-2001 positive but non-significant correlation was observed between mean number of larvae and mean per cent damage leaves per twig (Table 21).

4.4.2.2 Correlation with weather parameters

Correlation of *A. mercatoria* (based on mean number of larvae and per cent damage leaves per twig) were worked out using proceeding week weather parameters *viz.*, maximum temperature (X_1), minimum temperature (X_2), maximum relative humidity (X_3), minimum relative humidity (X_4), sunshine hours (X_5), rainfall (X_6) and rainy days (X_7).

4.4.2.2.1 Based on population count

The correlation was worked out between larval population (Y_1) and weather parameters (X_1 to X_7) during the period from 4th week of March to 3rd week of June. The results obtained are presented in Table 21.

From the Table 21 it is seen that none of the weather parameters showed significant correlation with population count during both the years.

Overall: The correlation matrix (Table 21) indicated that correlation between mean number of larvae and sunshine hours (X_5) was positive and significant indicating that when the sunshine hours increased the larval population was also increased and vice-versa. The correlation between mean number of larvae and maximum and minimum

Table 21: Correlation coefficient values of semi-looper *A. mercatoria* population, per cent damage leaves, on sapota with respect to weather parameters

Values (Y)	Correlation coefficient values						
	Maximum temperature (X_1)	Minimum temperature (X_2)	Maximum relative humidity (X_3)	Minimum relative humidity (X_4)	Sunshine hours (X_5)	Rainfall (mm) (X_6)	Rainy days (X_7)
1999-2000							
Mean no. of larvae (Y_1)	0.0842	0.2471	0.2734	0.2425	0.4747	- 0.1940	- 0.1761
Mean per cent damage leaves (Y_2)	- 0.6181*	0.6257*	- 0.2073	0.6469*	0.0841	0.1608	0.1617
2000-2001							
Mean no. of larvae (Y_1)	- 0.1043	0.1416	0.3817	0.1573	0.4968	- 0.3088	- 0.3741
Mean per cent damage leaves (Y_2)	- 0.5574*	0.6504*	0.2640	0.5769*	0.0523	0.2002	0.3791
Overall							
Y_1	0.1934	0.2005	0.2415	0.1262	0.4584*	- 0.2607	- 0.3019
Y_2	- 0.5835*	0.6157*	0.1574	0.6117*	0.0506	0.1986	0.3188

* Significant at 5 %

temperature (X_1, X_2), maximum and minimum relative humidity (X_3, X_4), rainfall (X_6) and rainy days (X_7) were non-significant.

4.4.2.2.2 Based on mean per cent damage leaves

From the Table 21 it is seen that negative and significant correlation was observed between mean per cent damage leaves and maximum temperature (X_1) ('r' = - 0.6181) while it was positive and significant between per cent damage leaves and minimum temperature (X_2) ('r' = 0.6257) and minimum relative humidity (X_4) ('r' = 0.6469). The correlation between maximum relative humidity (X_3), sunshine hours (X_5), rainfall (X_6) and rainy days (X_7) were found to be positive but non-significant indicating that there was no correlation between per cent damage leaves and maximum relative humidity, sunshine hours, rainfall and rainy days during 1999-2000. The similar trend of correlation was also observed during the year 2000-2001.

Overall: From the Table 21 it is seen that the negative and significant correlation was observed between per cent damage leaves and maximum temperature (X_1) ('r' = - 0.5835), while it was positive and significant between per cent damage leaves and minimum temperature (X_2) ('r' = 0.6157), and minimum relative humidity (X_4) ('r' = 0.6117). The correlation between per cent damage leaves and rest of the weather parameters were found to be positive non-significant indicating that there was no correlation between per cent damage leaves and rest of the weather parameters.

4.4.3 Multiple/simple regression of mean number of larvae and per cent damage leaves (Y) on different weather parameters (X)

The multiple linear regression equation was fitted to the data taking mean number of larvae and per cent damage leaves (Y) as dependent variable and meteorological factors (X) having significant coefficient as independent variables. The results obtained in 1999-2000 and 2000-2001 are presented in Table 22.

4.4.3.1 Mean number of larvae (Y_1)

The multiple linear equation fitted for mean number of larvae (Y_1) was $Y_1 = -0.3576 + 0.0683\ (X_5)$

4.4.3.2 Per cent damage leaves (Y_2)

The data on multiple/simple regression coefficient of per cent damage leaves and weather parameters presented in Table 22 indicated that the multiple linear regression equation fitted to the data taking per cent damage leaves (Y_2) as dependent variable and meteorological factors (X) having significant as independent variable was $Y_2 = 118.9151 - 4.3208\ (X_1) + 1.8875\ (X_2) + 0.2125\ (X_4)$. The multiple regression coefficient ($R^2 = 0.4445$) was statistically non-significant at 5 per cent level. Thus 44.45 per cent variation in the dependent variable has been explained by independent variable. The partial regression coefficient with maximum temperature (X_1), minimum temperature (X_2) and minimum relative humidity (X_4) was significant which indicated that increase in temperature and relative humidity and minimum temperature resulted in increase in per cent damage leaves, during the year 1999-2000.

Table 22: Multiple/simple regression equation to predict mean number of larvae and per cent damage leaves on the basis of weather parameters having significant correlation

	A value	Temperature ^{0}C		Relative humidity (%)		Sunshine hours (X_5)	Rainfall (mm) (X_6)	Rainy days (X_7)	R^2	Multiple R
		Maximum (X_1)	Minimum (X_2)	Maximum (X_3)	Minimum (X_4)					
1999-2000										
Mean no. of larvae (Y_1)	-	-	-	-	-	-	-	-	-	-
Mean per cent damage leaves (Y_2)	118.9151	- 4.3208*	1.8875*	-	0.2025*	-	-	-	0.4445	0.6667
2000-2001										
Mean no. of larvae (Y_1)	-	-	-	-	-	-	-	-	-	-
Mean per cent damage leaves (Y_2)	190.5336	- 10.3036	12.5730	-	- 2.0434	-	-	-	0.4924	0.7017
Overall										
Y_1	- 0.3576	-	-	-	-	0.0683	-	-	-	-
Y_2	101.8643	- 4.5988*	3.7013*	-	- 0.0838*	-	-	-	0.4163	0.6452

* Significant at 5 %

The multiple linear regression equation fitted for per cent damage leaves by *A. mercatoria* (Y_2) was $Y_2 = 190.5336 - 10.3036\ (X_1) + 12.5730\ (X_2) - 2.0434\ (X_4)$. The multiple regression coefficient (R^2) was 0.4924, which explained 49.24 per cent variation in the dependent variable (Y_2) by various independent variables which was statistically non-significant at 5 per cent level of significance. The partial regression coefficient for different independent variables (X_1, X_2 and X_4) was found non-significant (Table 22).

Overall: The data on multiple/simple regression coefficient of mean per cent damage leaves and weather parameters are presented in Table 22 indicated that the multiple linear regression equation fitted by taking mean per cent damage leaves (Y_2) as a dependent variable and meteorological factors (X) having significant correlation as independent variable was $Y_2 = 101.8643 - 4.5988\ (X_1) + 3.7013\ (X_2) - 0.0838\ (X_4)$. The multiple regression coefficient (R^2) was 0.4163 showing thereby that only 41.63 per cent variation in the dependent variable was explained by various independent variables. However, it was statistically non-significant indicating that the factors other than climatic ones were also responsible for contributing to per cent damage leaves of sapota. The partial regression coefficient for different independent variables (X_1, X_2 and X_4) were significant.

4.5 Chemical control

4.5.1 Evaluation of various insecticides against larvae of *A. mercatoria* in field conditions

Field experiments were conducted using Completely Randomized Design with three replications and eleven treatments

during the summer seasons of 1999-2000 and 2000-2001 at farmer's field at Khara Abrama and Kharsad villages, Navsari to evaluate the bio-efficacy of different newer insecticides available in the market (Table 1). The data were summarized as per cent reduction of larvae recorded at 24 hrs, 72 hrs, 7 days and 14 days after the treatment. The insecticides were also evaluated on the basis of per cent damage leaves recorded at 7 and 14 days after the treatment.

4.5.1.1 Summer season of 1999-2000

The result of individual observation and pooled for all the observations in summer 1999-2000 are summarized in Table 23. It is clear from the table that difference in number of larvae before treatments was found to be non-significant and there was significant difference in per cent reduction in larvae among the treatments after the insecticidal application as well as in pooled data.

At 24 hrs after spray, the maximum per cent reduction was recorded in the treatments of profenofos 0.075 per cent and nurelle D_{505} 0.055 per cent and both (99.99 %) were statistically at par with the treatments of lambda-cyhalothrin 0.005 per cent, carbosulfan 0.05 per cent and fenobucarb 0.1 per cent (93.91 to 99.18 %) and was significantly superior to rest of the treatments. However, the treatments of lambda-cyhalothrin 0.005 per cent, carbosulfan 0.05 per cent and fenobucarb 0.1 per cent were equally effective in per cent reduction and at par on one side with nurelle D_{505} 0.055 per cent and profenofos 0.075 per cent and on other side with spark 0.036 per cent and polytrin-C_{404} 0.044 per cent, however, treatments of carbosulfan 0.05 per cent and fenobucarb 0.1 per cent were also at par with the treatment of

Table 23: Reduction of *A. mercatoria* in field conditions (1999-2000)

Sr. No.	Treatments		Mean no. of larvae/ 20 twig	Per cent reduction of larvae after indicated period								
				24 hrs		72 hrs		7 days		14 days		Pooled	
1.	Imidacloprid 0.005 %		20.33	17.95*[d]	(9.50)**	24.47[b]	(17.16)	33.02[b]	(29.70)	37.31[c]	(36.74)	28.19[b]	(22.32)
2.	Profenofos 0.075 %		19.67	89.32[a]	(99.99)	89.32[a]	(99.99)	89.32[a]	(99.99)	89.32[a]	(99.99)	89.32[a]	(99.99)
3.	Spark 0.036 % (deltamethrin + triazophos)		16.00	73.08[a]	(91.53)	89.32[a]	(99.99)	89.32[a]	(99.99)	89.32[a]	(99.99)	85.26[a]	(99.32)
4.	Nurelle D505 0.055 % (chlorpyriphos + cypermethrin)		18.33	89.32[a]	(99.99)	89.32[a]	(99.99)	89.32[a]	(99.99)	89.32[a]	(99.99)	89.32[a]	(99.99)
5.	Polytrin- C_{404} 0.044 % (Profenofos + cypermethrin)		18.00	74.73[a]	(93.06)	89.32[a]	(99.99)	89.32[a]	(99.99)	89.32[a]	(99.99)	85.67[a]	(99.43)
6.	Fenobucarb 0.1 %		22.67	75.71[a]	(93.91)	89.32[a]	(99.99)	89.32[a]	(99.99)	89.32[a]	(99.99)	85.92[a]	(99.49)
7.	Carbosulfan 0.05 %		19.67	76.24[a]	(94.34)	89.32[a]	(99.99)	89.32[a]	(99.99)	89.32[a]	(99.99)	86.05[a]	(99.53)
8.	Endosulfan 0.075 %		20.33	68.76[a]	(86.88)	89.32[a]	(99.99)	89.32[a]	(99.99)	89.32[a]	(99.99)	84.18[a]	(98.97)
9.	Lambda-cyhalothrin 0.005 %		17.00	84.81[a]	(99.18)	89.32[a]	(99.99)	89.32[a]	(99.99)	89.32[a]	(99.99)	88.20[a]	(99.90)
10.	Alphamethrin 0.003 %		21.00	18.38[b]	(9.94)	25.23[b]	(18.29)	29.05[b]	(23.58)	45.17[b]	(50.30)	29.46[b]	(24.19)
11.	Control		19.67	-	-	-	-	-	-	-	-	-	-
	General Mean		19.33	66.83	(84.48)	76.43	(94.49)	77.67	(95.44)	79.71	(96.81)	75.16	(93.44)
	S. Em. ±	P	-	-		-		-		-		-	
		T	1.65	4.73		1.27		1.56		2.51		2.34	
		P x T	-	-		-		-		-		2.86	
	CD at 5 %	P	-	-		-		-		-		-	
		T	NS	13.96		3.75		4.62		7.40		6.79	
		P x T	-	-		-		-		-		8.44	
	CV %		14.82	12.26		2.88		3.49		5.45		6.54	

* Figures out side the parenthesis are arcsine transformed values NS = Non-significant

** Figures inside the parenthesis are retransformed values

endosulfan 0.075 per cent (86.88 %). The treatments of alphamethrin 0.003 per cent and imidacloprid 0.005 per cent were found least effective against larvae of *A. mercatoria*.

At 72 hrs after the treatment, the treatments of profenofos 0.075, spark 0.036 per cent, nurelle D_{505} 0.055 per cent, fenobucarb 0.1 per cent, carbosulfan 0.05 per cent, endosulfan 0.075 per cent and lambda-cyhalothrin 0.005 per cent were equally effective in larval reduction (99.99 %) and they were at par with one another and significantly superior over rest of the treatments. The treatments of alphamethrin 0.003 per cent and imidacloprid 0.005 per cent were at par with each other and gave 18.29 per cent and 17.16 per cent reduction, respectively.

The similar trend of effectiveness of the different insecticides on average per cent reduction of *A. mercatoria* larvae were obtained at 7 and 14 days after the treatment as well as in pooled data.

On the basis of pooled data the order of effectiveness of various insecticides based on per cent reduction was profenofos (99.99 %) = nurelle D_{505} (99.99 %) > lambda-cyhalothrin (99.90 %) > carbosulfan (99.53 %) > fenobucarb (99.49 %) > polytrin-C_{404} (99.43 %) > spark (99.32 %) > endosulfan (98.97 %) > alphamethrin (24.19 %) > imidacloprid (22.32 %). The ANOVA of pooled analysis of data on per cent reduction over periods revealed that the source : interaction (treatment x period) was significant indicating inconsistent performance of different treatments under study over period.

4.5.1.2 Summer season of 2000-2001

The results of the individual observation and pooled for all the observations in summer 2000-2001 are summarized in Table 24. It is clear from the data in the table that before treatment difference in counts of larvae was non-significant and there was significant difference in per cent reduction of the larvae among the treatments after the insecticidal application at each observation as well as in pooled data.

At 24 hrs after treatment, per cent reduction ranged from 93.89 to 99.99 in the treatments of fenobucarb 0.1 per cent, polytrin-C_{404} 0.044 per cent, lambda-cyhalothrin 0.005 per cent, profenofos 0.075 per cent, nurelle D_{505} 0.055 per cent, carbosulfan 0.05 per cent, endosulfan 0.075 per cent and spark 0.036 per cent and all these treatments were at par with one another and significantly superior over the treatments of alphamethrin 0.003 per cent (24.77 %) and imidacloprid 0.005 per cent (10.46 %).

After 72 hrs of the treatment, treatments of profenofos 0.075 per cent, spark 0.036 per cent, nurelle D_{505} 0.055 per cent, polytrin-C_{404} 0.044 per cent, fenobucarb 0.1 per cent, carbosulfan 0.05 per cent, endosulfan 0.075 per cent and lambda-cyhalothrin 0.005 per cent gave 99.99 per cent reduction and significantly superior over rest of the treatments and were statistically at par with one another. The next effective treatment was alphamethrin 0.003 per cent (75.71 %) and was significantly superior over imidacloprid 0.005 per cent (28.55 %).

Table 24: Reduction of *A. mercatoria* in field conditions (2000-2001)

Sr. No.	Treatments	Mean no. of larvae/ 20 twig	Per cent reduction of larvae after indicated period									
			24 hrs		72 hrs		7 days		14 days		Pooled	
1.	Imidacloprid 0.005 %	18.67	18.87[b]*	(10.46)**	32.30[c]	(28.55)	24.88[c]	(17.70)	74.16[c]	(92.55)	37.55[c]	(37.14)
2.	Profenofos 0.075 %	17.67	82.50[a]	(98.30)	89.32[a]	(99.99)	89.32[a]	(99.99)	89.32[a]	(99.99)	87.62[a]	(99.83)
3.	Spark 0.036 % (deltamethrin + triazophos)	18.67	89.32[a]	(99.99)	89.32[a]	(99.99)	89.32[a]	(99.99)	89.32[a]	(99.99)	89.32[a]	(99.99)
4.	Nurelle D505 0.055 % (chlorpyriphos + cypermethrin)	20.33	85.23[a]	(99.99)	89.32[a]	(99.99)	89.32[a]	(99.99)	89.32[a]	(99.99)	88.30[a]	(99.91)
5.	Polytrin- C_{404} 0.044 % (Profenofos + cypermethrin)	23.33	75.69[a]	(93.89)	89.32[a]	(99.99)	89.32[a]	(99.99)	89.32[a]	(99.99)	85.91[a]	(99.49)
6.	Fenobucarb 0.1 %	13.67	75.69[a]	(93.89)	89.32[a]	(99.99)	89.32[a]	(99.99)	89.32[a]	(99.99)	85.91[a]	(99.49)
7.	Carbosulfan 0.05 %	14.33	89.32[a]	(99.99)	89.32[a]	(99.99)	89.32[a]	(99.99)	89.32[a]	(99.99)	89.32[a]	(99.99)
8.	Endosulfan 0.075 %	13.33	89.32[a]	(99.99)	89.32[a]	(99.99)	89.32[a]	(99.99)	89.32[a]	(99.99)	89.32[a]	(99.99)
9.	Lambda-cyhalothrin 0.005 %	18.67	80.22[a]	(97.11)	89.32[a]	(99.99)	89.32[a]	(99.99)	89.32[a]	(99.99)	87.05[a]	(99.83)
10.	Alphamethrin 0.003 %	14.33	29.85[b]	(24.77)	60.34[b]	(75.51)	64.04[b]	(80.84)	80.45[b]	(97.25)	58.67[b]	(72.96)
11.	Control	12.33	-	-	-	-	-	-	-	-	-	-
	General Mean	16.85	71.60	(90.04)	80.72	(97.40)	80.35	(97.20)	86.92	(99.97)	79.90	(96.92)
	S. Em. ± P	-	-		-		-		-		-	
	T	3.39	7.55		6.19		5.19		5.56		4.73	
	P x T	-	-		-		-		-		6.19	
	CD at 5 % P	-	-		-		-		-		-	
	T	NS	22.28		18.26		15.32		5.56		13.71	
	P x T	-	-		-		-		-		17.44	
	CV %	34.87	18.27		13.28		11.19		11.07		13.41	

* Figures out side the parenthesis are arcsine transformed values NS = Non-significant

** Figures inside the parenthesis are retransformed values

The same trend of effectiveness of the different insecticides on average per cent reduction of *A. mercatoria* larvae were obtained at 7 and 14 days after the treatment and in pooled data.

On the basis of pooled data the order of effectiveness of various insecticides based on per cent reduction was endosulfan (99.99 %) = spark (99.99 %) = carbosulfan (99.99 %) > nurelle D_{505} (99.91 %) > profenofos (99.83 %) = lambda-cyhalothrin (99.83 %) > polytrin-C_{404} (99.49 %) = fenobucarb (99.49 %) > alphamethrin (72.96 %) > imidacloprid (37.14 %). The ANOVA of pooled analysis of data on per cent reduction over periods revealed that the source : interaction (treatment x period) was significant indicating inconsistent performance of different treatments under study over period.

4.5.1.3 Overall pooled

The result of both the years were pooled and summarized in Table 25 and graphically depicted in Fig. 3. The data revealed that the differences among the treatments in pooled of individual observation for both the years as well as overall pooled were significant except the observations recorded 14 days after treatment, which was found to be non-significant.

The pooled data of 24 hrs observation revealed that the treatments of nurelle D_{505} 0.055 per cent, profenofos 0.075 per cent, carbosulfan 0.05 per cent, lambda-cyhalothrin 0.005 per cent, spark 0.036 per cent, endosulfan 0.075 per cent, fenobucarb 0.1 per cent and polytrin-C_{404} 0.044 per cent gave 93.48 to 99.77 per cent reduction and were statistically on same bar and significantly superior over

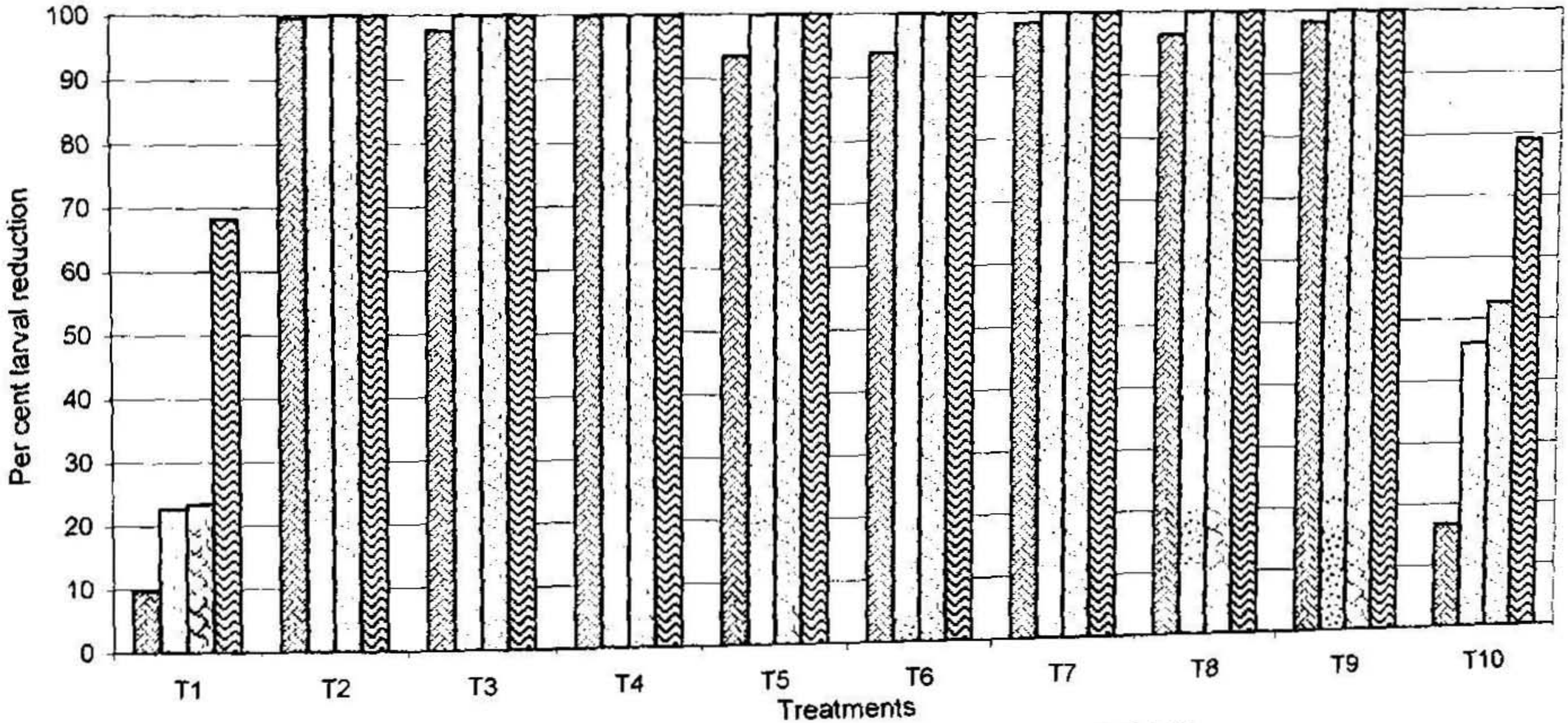
Table 25: Reduction of *A. mercatoria* in field conditions (pooled for 2 years 1999-2000 and 2000-2001)

Sr. No.	Treatments	Per cent reduction of larvae after indicated period									
		24 hrs		72 hrs		7 days		14 days		Over all pooled	
1.	Imidacloprid 0.005 %	18.41 [b]	(9.97)	28.39 [b]	(22.61)	28.95 [b]	(23.43)	55.74	(68.31)	32.87 [c]	(29.46)
2.	Profenofos 0.075 %	85.91 [a]	(99.49)	89.32 [a]	(99.99)	89.32 [a]	(99.99)	89.32	(99.99)	88.47 [a]	(99.93)
3.	Spark 0.036 % (deltamethrin + triazophos)	81.20 [a]	(97.66)	89.32 [a]	(99.99)	89.32 [a]	(99.99)	89.32	(99.99)	87.29 [a]	(99.78)
4.	Nurelle D505 0.055 % (chlorpyriphos + cypermethrin)	87.28 [a]	(99.77)	89.32 [a]	(99.99)	89.32 [a]	(99.99)	89.32	(99.99)	88.21 [a]	(99.96)
5.	Polytrin- C_{404} 0.044 % (Profenofos + cypermethrin)	75.21 [a]	(93.48)	89.32 [a]	(99.99)	89.32 [a]	(99.99)	89.32	(99.99)	85.79 [a]	(99.46)
6.	Fenobucarb 0.1 %	75.70 [a]	(93.90)	89.32 [a]	(99.99)	89.32 [a]	(99.99)	89.32	(99.99)	85.92 [a]	(99.49)
7.	Carbosulfan 0.05 %	82.78 [a]	(98.42)	89.32 [a]	(99.99)	89.32 [a]	(99.99)	89.32	(99.99)	87.69 [a]	(99.84)
8.	Endosulfan 0.075 %	79.04 [a]	(96.39)	89.32 [a]	(99.99)	89.32 [a]	(99.99)	89.32	(99.99)	86.75 [a]	(99.68)
9.	Lambda-cyhalothrin 0.005 %	82.51 [a]	(98.30)	89.32 [a]	(99.99)	89.32 [a]	(99.99)	89.32	(99.99)	87.62 [a]	(99.83)
10.	Alphamethrin 0.003 %	24.12 [b]	(16.70)	42.79 [b]	(46.15)	46.55 [b]	(52.70)	62.81	(79.12)	44.07 [b]	(48.38)
	General Mean	69.22	(87.41)	75.58	(96.08)	79.01	(96.37)	83.31	(98.64)	77.53	(95.34)
	S. Em. ± P	-		-		-		-		-	
	T	4.53		5.55		5.82		7.61		2.44	
	P x T	6.30		4.47		3.83		4.31		2.87	
	CD at 5 % P	-		-		-		-		-	
	T	12.89		17.76		18.61		NS		7.09	
	P x T	NS		13.38		11.31		12.71		8.47	
	CV %	15.77		9.85		8.41		8.96		6.48	

* Figures out side the parenthesis are arcsine transformed values NS = Non-significant

** Figures inside the parenthesis are retransformed values

Fig. 3 : Evaluation of various insecticides against larvae of *A. mercatoria* in field conditions during 1999-2000 and 2000-2001 (pooled)



T_1 = Imidacloprid 0.005 %
T_2 = Profenofos 0.075 %
T_3 = Spark 0.036 %
T_4 = Nurelle D_{505} 0.055 %
T_5 = Polytrin-C_{404} 0.044 %
T_6 = Fenobucarb 0.1 %
T_7 = Carbosulfan 0.05 %
T_8 = Endosulfan 0.075 %
T_9 = Lambda-cyhalothrin 0.005 %
T_{10} = Alphamethrin 0.003 %

alphmethrin 0.003 per cent (16.70 %) and imidacloprid 0.005 per cent (9.97 %).

The same trend of effectiveness of different insecticides on average per cent reduction of *A. mercatoria* larvae were obtained in pooled data of 72 hrs and 7 days after treatment.

The result of overall pooled data (Table 25) indicated that all the tested insecticides gave 99.46 to 99.96 per cent reduction and were at par with one another except the tratments of alphamethrin 0.003 per cent (48.38 %) and imidacloprid 0.005 per cent (29.46 %) which ranked second and third in their effectiveness, respectively.

The order of effectiveness of various insecticides based on average per cent reduction of *A. mercatoria* larva was nurelle D_{505} (99.96 %) > profenofos (99.93 %) > carbosulfan (99.84 %) > lambda-cyhalothrin (99.83 %) > spark (99.78 %) > endosulfan (99.68 %) > fenobucarb (99.49 %) > polytrin-C_{404} (99.46 %) > alphamethrin (48.38 %) > imidacloprid (29.46 %). The ANOVA of overall pooled analysis of data on per cent reduction over periods showed that the source : interaction (treatment x period) was significant indicating inconsistent performance of different treatments under study over period.

Thus, it is concluded that all the tested insecticides were equally effective in controlling the larval population except alphamethrin and imidacloprid which were less effective against the semi-looper *A. mercatoria*. Ismail and Salim (1982) reported that permethrin and deltamethrin gave quick knock down of the larvae of *A. janata*. Thus, the present findings are more or less in accordance with the findings of Senapati and Dash (1989) who reported that best

control of the noctuid *A. janata* was achieved by three spray application of endosulfan @ 0.5 kg a.i. per hectare.

4.5.2 Evaluation of the various insecticides on the basis of per cent damage leaves due to *A. mercatoria*

Twenty twigs were randomly selected in each replicated tree before application and after application at 7 and 14 days of the treatments. Healthy and damaged leaves were counted and per cent damage leaves were calculated on the basis of total number of damaged leaves out of total number of leaves per twig.

4.5.2.1 Summer season of 1999-2000

The results of the individual observation and pooled for both the observations in summer 1999-2000 are summarized in Table 26. It is clear from the data in the Table 26 that before treatment, per cent damage leaves recorded was found to be non-significant and there was significant difference in per cent damage leaves recorded among the treatments after the insecticidal application at each observation as well as in pooled data.

At 7 days after spray, the treatments of lambda-cyhalothrin 0.005 per cent and nurelle D_{505} 0.055 per cent recorded 29.00 per cent and 29.44 per cent damage leaves and were at par on one side with the treatment of profenofos 0.075 per cent, which recorded lower percentage of damage leaves (21.74 %), while on other side with the treatments of carbosulfan 0.05 per cent, fenobucarb 0.1 per cent, polytrin-C_{404} 0.044 per cent, spark 0.036 per cent, endosulfan 0.075 per cent and alphamethrin 0.003 per cent (34.42 to 41.35 % damage

Table 26: Per cent damage leaves due to *A. mercatoria* (1999-2000)

Sr. No.	Treatments	Mean per cent damage recorded before spraying		Mean per cent damage leaves recorded after indicated period of spraying				Pooled	
				7 days		14 days			
1.	Imidacloprid 0.005 %	40.67	(42.27)	41.99^{cd} *	(44.76)**	43.53^{d}	(47.44)	42.76^{c}	(44.36)
2.	Profenofos 0.075 %	28.15	(22.26)	27.79^{a}	(21.74)	23.95^{a}	(16.48)	25.87^{a}	(19.04)
3.	Spark 0.036 % (deltamethrin + triazophos)	39.90	(41.15)	39.36^{bcd}	(40.22)	34.31^{b}	(31.77)	36.84^{cd}	(35.95)
4.	Nurelle D505 0.055 % (chlorpyriphos + cypermethrin)	33.66	(30.72)	32.86^{ab}	(29.44)	27.63^{ab}	(21.51)	30.24^{ab}	(25.36)
5.	Polytrin- C_{404} 0.044 % (Profenofos + cypermethrin)	37.63	(37.28)	36.84^{bc}	(35.95)	33.59^{b}	(30.61)	35.21^{bd}	(33.24)
6.	Fenobucarb 0.1 %	36.45	(35.30)	36.01^{bc}	(34.57)	32.69^{b}	(29.17)	34.35^{bc}	(31.84)
7.	Carbosulfan 0.05 %	36.01	(34.57)	35.92^{bc}	(34.42)	32.11^{b}	(28.25)	34.01^{bc}	(31.29)
8.	Endosulfan 0.075 %	40.18	(41.63)	39.81^{bcd}	(40.99)	34.56^{bc}	(32.18)	37.19^{cd}	(36.54)
9.	Lambda-cyhalothrin 0.005 %	33.11	(29.84)	32.58^{ab}	(29.00)	29.08^{ab}	(23.62)	30.83^{ab}	(26.26)
10.	Alphamethrin 0.003 %	38.69	(39.08)	40.02^{bcd}	(41.35)	41.83^{cd}	(44.48)	40.92^{de}	(42.90)
11.	Control	38.10	(38.07)	45.26^{cd}	(50.45)	49.28^{d}	(57.44)	47.27^{e}	(53.96)
	General Mean	36.59	(35.53)	37.13	(36.44)	34.78	(32.54)	35.95	(34.45)
	S. Em. ± P	-		-		-		-	
	T	2.70		2.63		2.55		1.79	
	P x T	-		-		-		2.59	
	CD at 5 % P	-		-		-		-	
	T	NS		7.71		7.49		5.09	
	P x T	-		-		-		NS	
	CV %	12.76		12.27		12.71		12.48	

* Figures out side the parenthesis are arcsine transformed values NS = Non-significant

** Figures inside the parenthesis are retransformed values

leaves). The treatment of imidacloprid 0.005 per cent recorded 44.76 per cent damage leaves.

At 14 days after the treatments, the treatment nurelle D_{505} 0.055 per cent and lambda-cyhalothrin 0.005 per cent recorded 21.51 and 23.62 per cent damage leaves and were at par on one side with the treatments of profenofos 0.075 per cent which recorded lower percentage of damage leaves (16.48 %) while on the other side with the treatments carbosulfan 0.05 per cent, fenobucarb 0.1 per cent, polytrin-C_{404} 0.044 per cent and endosulfan 0.075 per cent (28.25 to 32.18 %). However, the treatment of endosulfan 0.075 per cent was also at par with the treatments of alphamethrin 0.003 per cent (44.48 %), imidacloprid 0.005 per cent (47.44 %) and control (57.44 %).

The pooled data in Table 26 indicated that all the insecticidal treatments were significantly superior over control the treatment of alphamethrin 0.003 per cent and imidacloprid 0.005 per cent which were at par with control. The treatments of nurelle D_{505} 0.055 per cent and lambda-cyhalothrin 0.005 per cent recorded 25.36 per cent and 26.26 per cent damage leaves and were at par on one side with the treatment of profenofos 0.075 per cent (19.04 %), while on other side with the treatments of carbosulfan 0.05 per cent (31.29 %), fenobucarb 0.1 per cent (31.84 %) and polytrin-C_{404} 0.044 per cent (33.24 %).

On the basis of pooled data the order of effectiveness of various insecticides was profenofos (19.04 %) > nurelle D_{505} (25.36 %) > lambda-cyhalothrin (26.26 %) > carbosulfan (31.29 %) > fenobucarb (31.84 %) > polytrin-C_{404} (33.24 %) > spark (35.95 %) > endosulfan (36.54 %) > alphamethrin (42.90 %) > imidacloprid (44.36 %) >

control (53.96 %). The ANOVA of pooled analysis of data on per cent damage leaves recorded over periods revealed that the source : interaction (treatment x period) was non-significant indicating consistent performance of different treatments under study over period.

4.5.2.2 Summer season of 2000-2001

The results of the individual observation and pooled for both the observations in summer 2000-2001 are summarized in Table 27. It is clear from the table that before treatment, per cent damage leaves recorded was non-significant and there was significant difference in per cent damage larvaes recorded among the treatments after the insecticidal application at each observation as well as in pooled data.

After 7 days of spray, all the insecticidal treatments were significantly superior over control except fenobucarb 0.1 per cent, alphamethrin 0.003 per cent and imidacloprid 0.005 per cent and which were at par with control. The treatment of spark 0.036 per cent recorded 26.88 per cent damage leaves and was at par on one side with the treatment of endosulfan 0.075 per cent (26.10 %), while on other side with the treatments of carbosulfan 0.05 per cent, nurelle D_{505} 0.055 per cent, profenofos 0.075 per cent and lambda-cyhalothrin 0.005 per cent (31.59 to 44.32 %).

After 14 days of the post treatment carbosulfan 0.05 per cent and lambda-cyhalothrin 0.005 per cent recorded 25.33 and 38.75 per cent damage leaves and on side it were at par with spark 0.036 per cent (21.09 %) and endosulfan 0.075 per cent (21.25 %) and on other side with nurelle D_{505} 0.055 per cent (31.17 %), profenofos 0.075 per

Table 27: Per cent damage leaves due to *A. mercatoria* (2000-2001)

Sr. No.	Treatments	Mean per cent damage recorded before spraying		Mean per cent damage leaves recorded after indicated period of spraying				Pooled	
				7 days		14 days			
1.	Imidacloprid 0.005 %	47.17	(53.78)	47.63^{de}*	(54.58)**	47.65^{cd}	(54.62)	47.64^{c}	(54.60)
2.	Profenofos 0.075 %	38.24	(38.31)	38.08^{abcd}	(38.04)	34.19^{ab}	(31.58)	36.14^{ab}	(34.70)
3.	Spark 0.036 % (deltamethrin + triazophos)	32.05	(28.16)	31.23^{ab}	(26.88)	27.34^{a}	(21.09)	29.28^{a}	(23.92)
4.	Nurelle D505 0.055 % (chlorpyriphos + cypermethrin)	37.81	(37.58)	37.53^{abcd}	(37.11)	33.94^{ab}	(31.17)	35.73^{ab}	(34.10)
5.	Polytrin- C_{404} 0.044 % (Profenofos + cypermethrin)	43.30	(47.03)	43.11^{bcd}	(46.70)	41.31^{bc}	(43.58)	42.21^{bc}	(45.14)
6.	Fenobucarb 0.1 %	44.09	(48.41)	43.69^{cde}	(47.71)	40.66^{bc}	(42.45)	42.17^{bc}	(45.07)
7.	Carbosulfan 0.05 %	34.57	(32.20)	34.26^{abc}	(31.69)	30.22^{ab}	(25.33)	32.24^{a}	(28.46)
8.	Endosulfan 0.075 %	30.78	(26.19)	30.72^{a}	(26.10)	27.45^{a}	(21.25)	29.09^{a}	(23.64)
9.	Lambda-cyhalothrin 0.005 %	42.03	(44.83)	41.74^{abcd}	(44.32)	38.50^{abc}	(38.75)	40.12^{bc}	(41.52)
10.	Alphamethrin 0.003 %	45.09	(50.16)	46.42^{cde}	(52.48)	47.04^{cd}	(53.56)	46.73^{c}	(53.02)
11.	Control	48.72	(56.47)	55.82^{de}	(68.44)	58.03^{d}	(71.97)	56.93^{d}	(70.23)
	General Mean	40.35	(41.92)	40.93	(42.92)	38.76	(39.20)	39.84	(41.04)
	S. Em. ± P	-		-		-		-	
	T	4.33		4.18		4.30		2.75	
	P x T	-		-		-		4.24	
	CD at 5 % P	-		-		-		-	
	T	NS		12.27		12.60		7.79	
	P x T	-		-		-		NS	
	CV %	18.59		17.70		19.20		18.43	

* Figures out side the parenthesis are arcsine transformed values NS = Non-significant

** Figures inside the parenthesis are retransformed values

cent (31.58 %), fenobucarb 0.1 per cent (40.66 %) and polytrin-C_{404} 0.044 per cent (41.31 %). The treatments of alphamethrin 0.003 per cent, imidacloprid 0.005 per cent and control recorded 53.56, 54.62 and 71.97 per cent damage leaves, respectively and were at par with one another.

The pooled data in Table 27 indicated that all the insecticidal treatments were significantly superior over control. The treatments of nurelle D_{505} 0.055 per cent and profenofos 0.075 per cent recorded 34.10 and 34.78 per cent damage leaves and were at par on one side with the treatments of endosulfan 0.075 per cent (23.64 %), spark 0.036 per cent (23.92 %) and carbosulfan 0.05 per cent (28.46 %) while on other side with the treatments of lambda-cyhalothrin 0.005 per cent, fenobucarb 0.1 per cent and polytrin-C_{404} 0.044 per cent (41.52 to 45.14 %).

On the basis of pooled data the order of effectiveness of various insecticides was endosulfan (23.64 %) > spark (23.92 %) > carbosulfan (28.46 %) > nurelle D_{505} (34.10 %) > profenofos (34.78 %) > lambda-cyhalothrin (41.52 %) > fenobucarb (45.07 %) > polytrin-C_{404} (45.14 %) > alphamethrin (53.02 %) > imidacloprid (54.60 %) > control (70.23 %). The ANOVA of pooled analysis of data on per cent damage leaves recorded over periods revealed that the source : interaction (treatment x period) was non-significant indicating consistent performance of different treatments under study over period.

4.5.2.3 Overall pooled

The results of both the years were pooled and summarized in Table 28 and graphically depicted in Fig. 4. The data revealed that

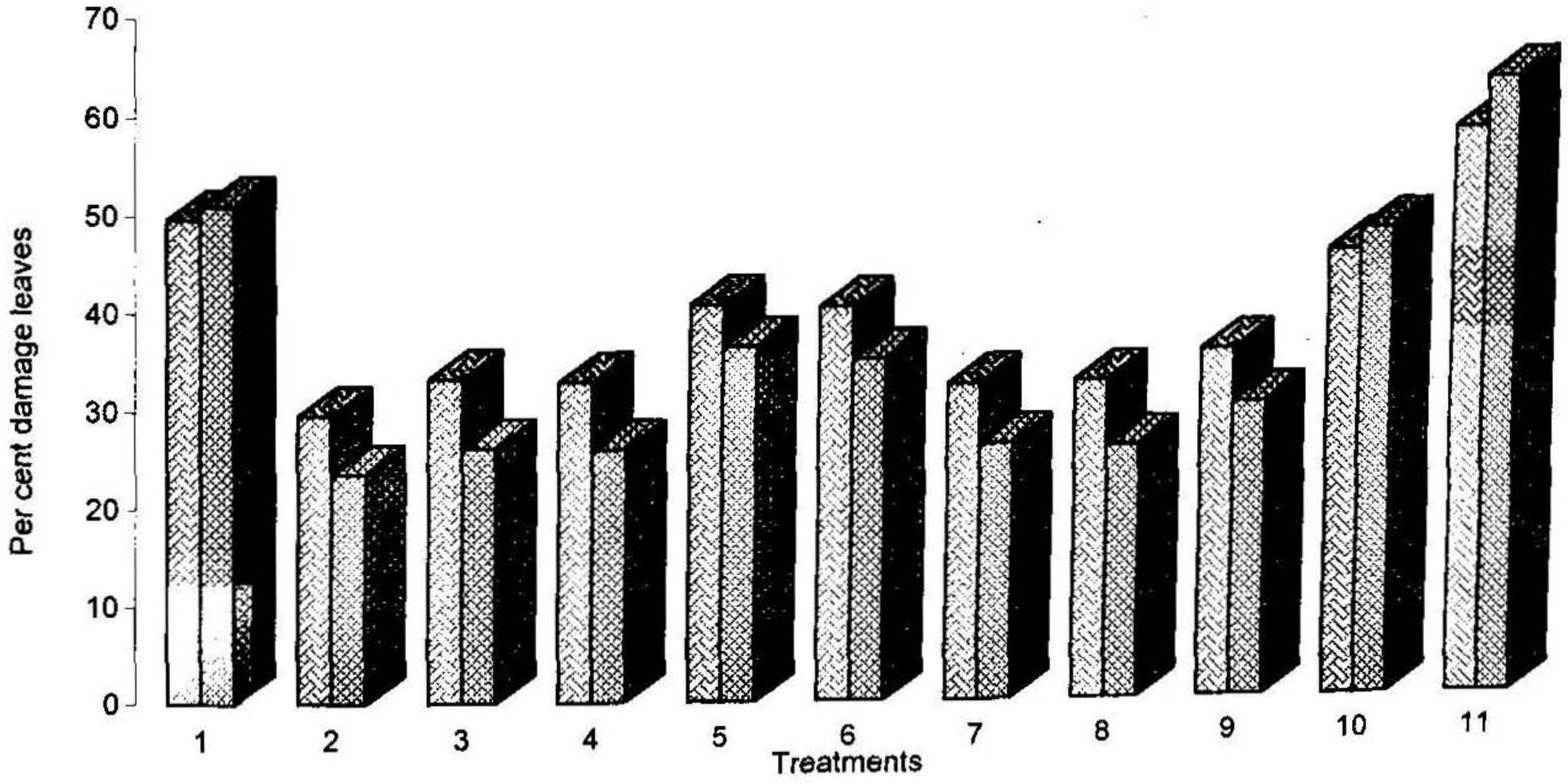
Table 28: Per cent damage leaves due to *A. mercatoria* (Pooled for two years 1999-2000 and 2000-2001)

Sr. No.	Treatments	Mean per cent damage leaves recorded after indicated period of spraying				Overall pooled	
		7 days		14 days			
1.	Imidacloprid 0.005 %	44.81^{cd}	(49.66)	45.59^{d}	(51.03)	45.20^{e}	(50.35)
2.	Profenofos 0.075 %	32.94^{a}	(29.57)	29.07^{a}	(23.61)	31.01^{a}	(26.54)
3.	Spark 0.036 % (deltamethrin + triazophos)	35.30^{a}	(33.39)	30.83^{ab}	(26.26)	33.06^{a}	(29.76)
4.	Nurelle D505 0.055 % (chlorpyriphos + cypermethrin)	35.20^{a}	(33.23)	30.79^{ab}	(26.20)	32.99^{a}	(29.65)
5.	Polytrin- C_{404} 0.044 % (Profenofos + cypermethrin)	39.98^{abc}	(41.28)	37.45^{bc}	(36.97)	38.72^{cd}	(39.13)
6.	Fenobucarb 0.1 %	39.85^{abc}	(41.06)	36.68^{ab}	(35.68)	38.26^{bc}	(38.34)
7.	Carbosulfan 0.05 %	35.09^{a}	(33.05)	31.17^{ab}	(26.79)	31.13^{a}	(26.73)
8.	Endosulfan 0.075 %	35.27^{a}	(33.34)	31.01^{ab}	(26.54)	33.14^{ab}	(29.89)
9.	Lambda-cyhalothrin 0.005 %	37.16^{ab}	(36.49)	33.79^{ab}	(30.93)	35.48^{abc}	(33.69)
10.	Alphamethrin 0.003 %	43.22^{bcd}	(46.90)	44.44^{cd}	(49.02)	43.83^{de}	(47.96)
11.	Control	50.54^{d}	(59.61)	53.66^{e}	(64.89)	52.10^{f}	(62.27)
	General Mean	39.03	(39.66)	36.77	(35.83)	37.90	(37.73)
	S. Em. ± P	-		-		-	
	T	2.65		2.65		1.83	
	P x T	3.49		3.53		3.51	
	CD at 5 % P	-		-		-	
	T	7.52		7.52		5.14	
	P x T	NS		NS		NS	
	CV %	15.50		16.65		16.06	

* Figures out side the parenthesis are arcsine transformed values

** Figures inside the parenthesis are retransformed values

Fig. 4 : Evaluation of the various insecticides on the basis of per cent damage leaves due to *A. mercatoria* (pooled for 2 years)



T_1 = Imidacloprid 0.005 %
T_2 = Profenofos 0.075 %
T_3 = Spark 0.036 %
T_4 = Nurelle D_{505} 0.055 %
T_5 = Polytrin-C_{404} 0.044 %
T_6 = Fenobucarb 0.1 %
T_7 = Carbosulfan 0.05 %
T_8 = Endosulfan 0.075 %
T_9 = Lambda-cyhalothrin 0.005 %
T_{10} = Alphamethrin 0.003 %
T_{11} = Control

7 days
14 days

the differences among the treatments in pooled of individual observation for both the years as well as overall pooled were significant at all the period of observation.

The pooled data of 7 days observation revealed that the treatments of profenofos 0.075 per cent, carbosulfan 0.05 per cent, nurelle D_{505} 0.055 per cent, endosulfan 0.075 per cent and spark 0.036 per cent (29.57 to 33.89 %) were significantly superior over control and which were in turn all these treatments were at par with one another and were also at par with the treatments of lambda-cyhalothrin 0.005 per cent, fenobucarb 0.1 per cent and polytrin-C_{404} 0.044 per cent by recording 36.49 to 41.28 per cent damage leaves. However, the treatments of alphamethrin 0.003 per cent (46.90 %), imidacloprid 0.005 per cent (49.66 %) and control (59.61 %) were also at par with one another.

The results of the pooled data of 14 days observation revealed that all the insecticidal treatments were significantly superior over control. Minimum per cent damage leaves were recorded in the treatment of profenofos 0.075 per cent (23.61 %) and it was at par with the treatments of nurelle D_{505} 0.055 per cent, spark 0.036 per cent, endosulfan 0.075 per cent, carbosulfan 0.075 per cent, carbosulfan 0.05 per cent, lambda-cyhalothrin 0.005 per cent and fenobucarb 0.1 per cent (26.20 to 35.68 %) which were in turn all these insecticides were also at par with one another. The treatments of alphamethrin 0.003 per cent and imidacloprid 0.005 per cent recorded 49.02 and 51.03 per cent damage leaves and were at par with each other and significantly superior over control.

The results of overall pooled data indicated that all the tested insecticides were significantly superior over control. The treatment of endosulfan 0.075 per cent recorded 29.89 per cent damage leaves and was at par on one side with the treatments of profenofos 0.075 per cent, carbosulfan 0.05 per cent, nurelle D_{505} 0.055 per cent and spark 0.036 per cent (26.54 to 29.76 %) which in turn all these insecticides were also at par with one another while on other side with the treatment of lambda-cyhalothrin 0.005 per cent (33.69 %). However, the treatment of polytrin-C_{404} 0.044 per cent (39.13 %) was at par on one side with the treatments of fenobucarb 0.1 per cent (38.34 %) and lambda-cyhalothrin 0.005 per cent (33.69 %) while on other side with the treatment of alphamethrin 0.003 per cent (47.96 %). The treatments of alphamethrin 0.003 per cent and imidacloprid 0.005 per cent were on same bar and recorded 47.96 and 50.35 per cent damage leaves and were significantly superior over control. The chronological order of effectiveness of various insecticides based on per cent damage leaves recorded was profenofos (26.54 %) > carbosulfan (26.73 %) > nurelle D_{505} (29.65 %) > spark (29.76 %) > endosulfan (29.89 %) > lambda-cyhalothrin (33.69 %) > fenobucarb (38.26 %) > polytrin-C_{404} (39.13 %) > alphamethrin (47.96 %) > imidacloprid (50.35 %) > control (62.27 %). The ANOVA of pooled analysis of data on per cent damage leaves recorded over periods revealed that the source : interaction (treatment x period) was non-significant indicating consistent performance of different treatments under study over period.

Thus, it is concluded that the all the tested insecticides were effective in recording minimum percentage of damage leaves

except the treatments of alphamethrin and imidacloprid which were found to be recorded higher percentage of damage leaves.

4.5.3 Evaluation of various insecticides against larvae of *A. mercatoria* under laboratory conditions

The bio-efficacy of various insecticides against larvae of *A. mercatoria* were evaluated under laboratory conditions during 1999. The per cent mortality recorded at 24 hrs, 48 hrs, 72 hrs and 7 days after treatment are presented in Table 29.

The results (Table 29, Fig. 5) revealed that there was significant difference in per cent mortality at all the period of observations. At 24 hrs of the post treatment the per cent mortality ranged from 0.02 to 99.97. All the treatments under test were found significantly superior over control. The treatment of profenofos 0.075 per cent gave 99.97 per cent mortality and it was significantly superior over control, but it remained at par with carbosulfan 0.05 per cent (98.61 %) and endosulfan 0.075 per cent (98.61 %). The treatment of spark 0.036 per cent and fenobucarb 0.01 per cent were at par with each other and recorded 90.41 per cent mortality of *A. mercatoria*. The treatment of nurelle D_{505} 0.055 per cent gave 76.79 per cent mortality, which remained at par with polytrin-C_{404} 0.044 per cent (73.44 %) and lambda-cyhalothrin 0.005 per cent (66.71 %). The treatment of alphamethrin 0.003 per cent gave 29.65 per cent mortality. The treatment of imidacloprid 0.005 per cent gave lowest per cent mortality and did not differ significantly over control.

At 48 hrs of the post treatment, per cent mortality ranged from 0.02 to 99.97. The treatments of profenofos (99.97 %), spark

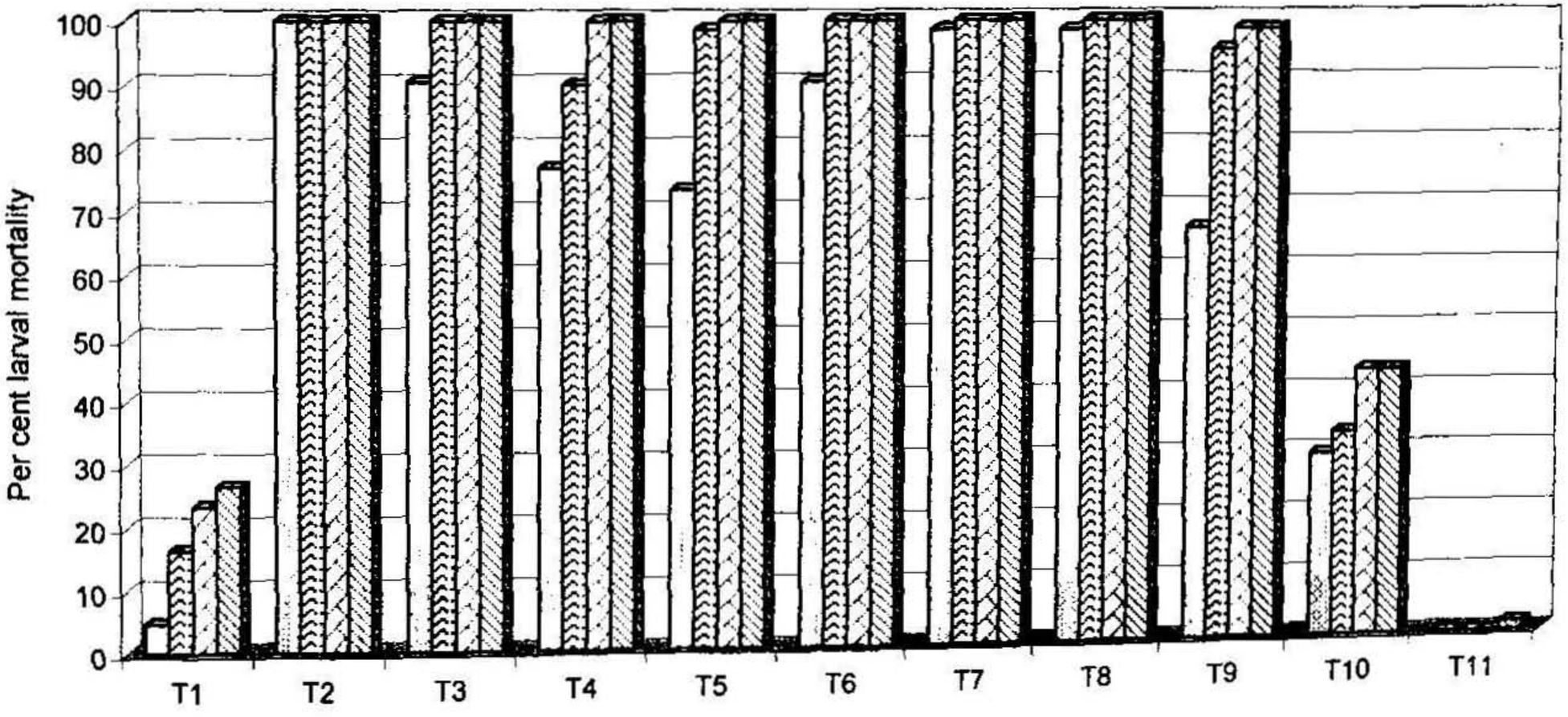
Table 29: Evaluation of various insecticides against larvae of *A. mercatoria* under laboratory conditions during 1999

Sr. No.	Treatments	Cumulative mean per cent mortality after indicated period									
		24 hrs		48 hrs		72 hrs		7 days		Pooled	
1.	Imidacloprid 0.005 %	12.59*de	(4.75)**	23.85e	(16.35)	28.77c	(23.16)	30.98c	(26.50)	24.05f	(16.61)
2.	Profenofos 0.075 %	89.06a	(99.97)	89.06a	(99.97)	89.06a	(99.97)	89.06a	(99.97)	89.06a	(99.97)
3.	Spark 0.036 % (deltamethrin + triazophos)	71.96bc	(90.41)	89.06a	(99.97)	89.06a	(99.97)	89.06a	(99.97)	84.78abc	(99.17)
4.	Nurelle D505 0.055 % (chlorpyriphos + cypermethrin)	61.20c	(76.79)	71.54c	(89.97)	89.06a	(99.97)	89.06a	(99.97)	77.71cd	(95.45)
5.	Polytrin-C_{404} 0.044 % (profenofos + cypermethrin)	58.98c	(73.44)	83.22ab	(98.61)	89.06a	(99.97)	89.06a	(99.97)	80.08bcd	(97.03)
6.	Fenobucarb 0.1 %	71.96bc	(90.41)	89.06a	(99.97)	89.06a	(99.97)	89.06a	(99.97)	84.78abc	(99.17)
7.	Carbosulfan 0.05 %	83.22ab	(98.61)	89.06a	(99.97)	89.06a	(99.97)	89.06a	(99.97)	87.60ab	(99.82)
8.	Endosulfan 0.075 %	83.22ab	(98.61)	89.06a	(99.97)	89.06a	(99.97)	89.06a	(99.97)	87.60ab	(99.82)
9.	Lambda-cyhalothrin 0.005 %	54.76c	(66.71)	77.38bc	(95.23)	83.22a	(98.61)	83.22a	(98.61)	74.64d	(92.98)
10.	Alphamethrin 0.003 %	32.99d	(29.65)	35.20d	(33.23)	41.14b	(43.28)	41.14b	(43.28)	37.62e	(37.26)
11.	Control	0.91e	(0.02)	0.91f	(0.02)	0.91d	(0.02)	6.75d	(1.38)	2.37g	(0.17)
	General Mean	56.44	(69.44)	67.03	(84.77)	70.68	(89.05)	71.41	(89.84)	66.39	(83.96)
	S. Em. ±	P	-	-		-		-		2.86	
		T	5.01	2.69		1.97		2.64		2.79	
		P x T	-	-		-		-		3.29	
	CD at 5 %	P	-	-		-		-		8.05	
		T	14.68	7.89		5.78		7.75		8.04	
		P x T	-	-		-		-		9.64	
	CV %		15.36	6.95		4.83		6.410		8.57	

* Figures out side the parenthesis are arcsine transformed values

** Figures inside the parenthesis are retransformed values

Fig. 5 : Evaluation of various insecticides against larvae of *A. mercatoria* under laboratory conditions during 1999



T_1 = Imidacloprid 0.005 %
T_2 = Profenofos 0.075 %
T_3 = Spark 0.036 %
T_4 = Nurelle D_{505} 0.055 %
T_5 = Polytrin-C_{404} 0.044 %
T_6 = Fenobucarb 0.1 %
T_7 = Carbosulfan 0.05 %
T_8 = Endosulfan 0.075 %
T_9 = Lambda-cyhalothrin 0.005 %
T_{10} = Alphamethrin 0.003 %
T_{11} = Control

(99.97 %), fenobucarb (99.97 %), carbosulfan (99.97 %), endosulfan (99.97 %) and polytrin-C_{404} (98.61 %) were at par with one another and these treatments were significantly superior over rest of the treatments. The treatment of polytrin-C_{404} gave 98.61 per cent mortality and it was at par with lambda-cyhalothrin and nurelle D_{505} (95.23 %). The treatments of lambda-cyhalothrin and nurelle D_{505} were at par with each other and gave 95.23 and 89.97 per cent mortality, respectively.

At 72 hrs of the post treatment, per cent mortality ranged from 0.02 to 99.97. The treatments of profenofos, spark, nurelle D_{505}, polytrin-C_{404}, fenobucarb, carbosulfan, endosulfan and lambda-cyhalothrin gave 98.61 to 99.97 per cent mortality and were at par with one another, and were significantly superior over control and rest of the treatments. The treatments of alphamethrin and imidacloprid gave 43.28 and 23.16 per cent mortality, respectively.

On the 7th day, all the treatments were significantly superior over control and the trend of effectiveness of insecticides remained similar to 72 hrs observation.

The pooled data in Table 29 indicated that all the insecticidal treatments were significantly superior over control. The treatments of profenofos 0.075 per cent showed maximum per cent mortality (99.97 %) and it was at par with the treatments of carbosulfan (99.82 %), endosulfan (99.82 %), spark (99.17 %) and fenobucarb (99.17 %). The treatments of polytrin-C_{404} and nurelle D_{505} remained at par with each other and gave 97.03 and 95.45 per cent mortality, respectively. The treatment of lambda-cyhalothrin gave 92.98 per cent larval mortality and found significantly superior than the treatments of alphamethrin and imidacloprid, which were found least effective

against *A. mercatoria*. The descending chronological order of effectiveness of treatments based on per cent mortality of larva was : profenofos (99.97 %) > carbosulfan (99.82 %) = endosulfan (99.82 %) > spark (99.17 %) = fenobucarb (99.17 %) > polytrin-C_{404} (97.03 %) > nurelle D_{505} (95.45 %) > lambda-cyhalothrin (92.98 %) > alphamethrin (32.26 %) > imidacloprid (16.61 %). The ANOVA of pooled analysis of data on per cent mortality over periods revealed that the source : periods was significant indicating difference in per cent mortality in different periods and also source : interaction (treatment x period) was found significant indicating inconsistent performance of different treatments under study over periods.

Thus, from the above results, it is seen that the treatment profenofos 0.075 per cent, carbosulfan 0.05 per cent, endosulfan 0.075 per cent, spark 0.036 per cent and fenobucarb 0.1 per cent proved to be more effective in giving higher mortality of larvae of *A. merctoria*. Further, it is obvious from the results that almost 100 per cent mortality of larvae of *A. mercatoria* in the laboratory was achieved 24 hrs after the treatments of profenofos 0.075 per cent, carbosulfan 0.05 per cent and endosulfan 0.075 per cent. Thus, it can be taken advantage in quick knock down of the pest in field conditions. Singh (1982) reported that quinalphos 0.05 per cent and fenitrothion 0.05 per cent were proved to be most effective against *A. janata*. While Gerewal *et al.* (1988) who reported chloropyriphos and quinalphos 0.05 per cent, fenvalerate and deltamethrin 0.01 per cent gave quick knock down effect causing 70.3, 63.4, 64.3 and 56.6 per cent mortality of larva of *A. janata*, respectively.

4.6 Bio-efficacy of various plant leaves extracts against larvae of *A. mercatoria* under laboratory conditions

The bio-efficacy of various plant leaves extracts against larvae of *A. mercatoria* were evaluated under laboratory conditions during 1999. The per cent mortality recorded at 24 hrs, 72 hrs and 7 days after treatment are presented in Table 30.

The results (Table 30, Fig. 6) revealed that there was significant difference in per cent mortality at all the periods of observations except 24 hrs, when the difference was found to be non-significant.

After 48 hrs of the post treatment, larval mortality ranged from 0.02 to 26.50 per cent. The treatment of NaLES gave 26.50 per cent mortality and was significantly superior over control and was at par with the treatments of KLES (19.30 %), LLES (16.35 %) and SLES (4.75 %). However, the treatment of SLES (4.75 %) was at par on one side with KLES (19.30 %) and LLES (16.35 %) while on the other side with the rest of the treatments.

The treatment of NaLES gave 35.93 per cent mortality after 72 hrs of the post treatment and was significantly superior over control and was statistically at par with the treatments of KLES (34.77 %), LLES (16.35 %), TLES (15.72 %), AaLES (9.05 %) and SLES (9.05 %). There was no significant difference among the treatments of TLES, AaLES, SLES, ALES, FLES, CLES and NeLES (0.02 to 15.72 % mortality).

After 7 days of the post treatment, the treatment of KLES gave 95.23 per cent mortality and was significantly superior over

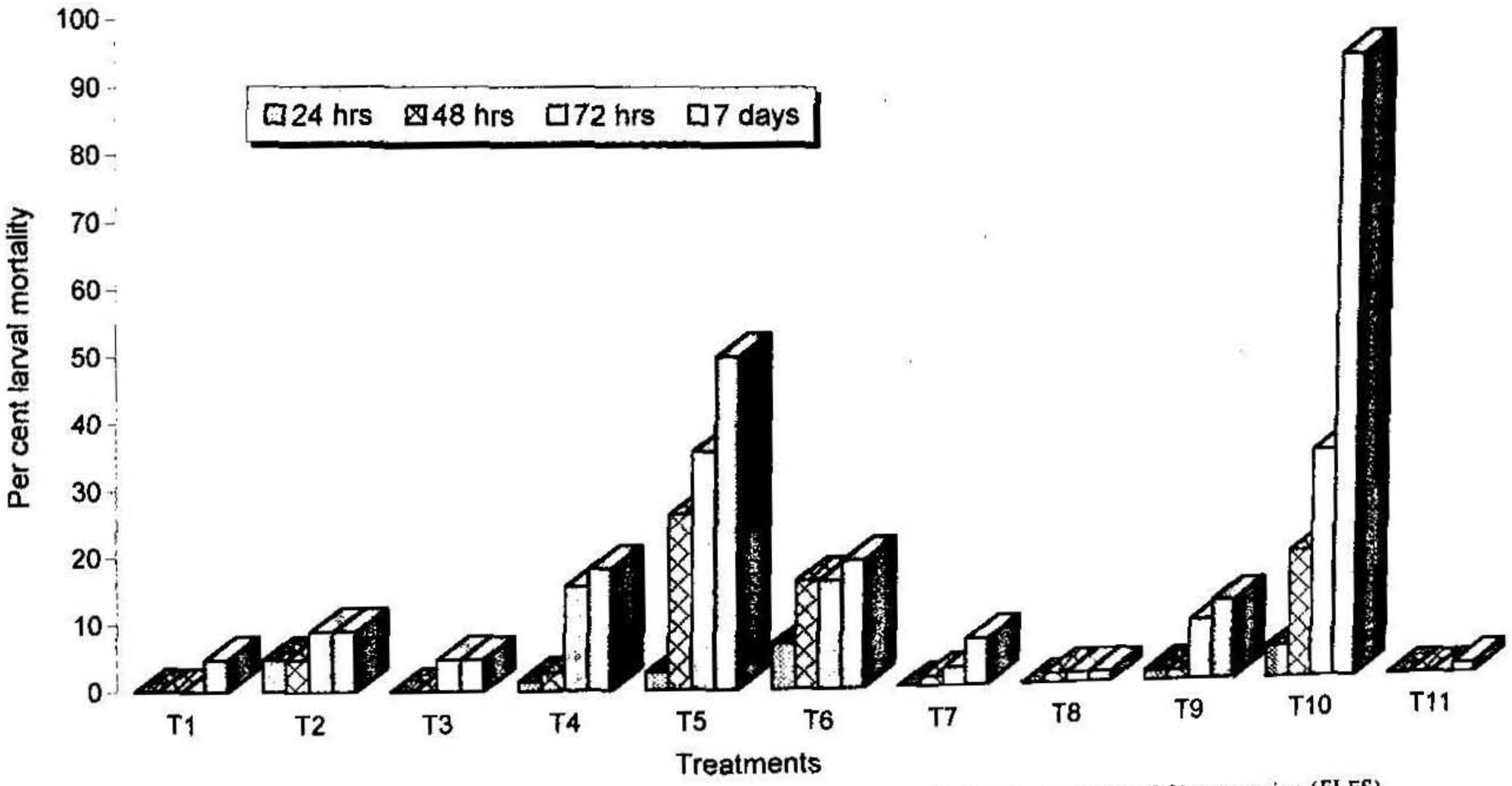
Table 30: Bio-efficacy of various plant leaves extracts against larvae of *A. mercatoria* under laboratory conditions during 1999

Sr. No.	Treatments	Cumulative mean per cent mortality after indicated period									
		24 hrs		48 hrs		72 hrs		7 days		Pooled	
1.	Neem leaves extract 5 % suspension (NeLES)	0.91*	(0.02)**	0.91^{c}	(0.02)	0.91^{d}	(0.02)	12.59^{c}	(4.75)	3.83^{fg}	(0.45)
2.	Spider lily leaves extract 5 % suspension (SLES)	12.59	(4.75)	12.59^{abc}	(4.75)	17.51^{abcd}	(9.05)	17.51^{c}	(9.05)	15.05^{cde}	(6.74)
3.	Ardusa leaves extract 5 % suspension (ALES)	0.91	(0.02)	0.91^{c}	(0.02)	12.59^{cd}	(4.75)	12.59^{c}	(4.75)	6.75^{defg}	(1.38)
4.	Tulsi leaves extract 5 % suspension (TLES)	6.75	(1.38)	9.46^{c}	(2.70)	23.56^{abcd}	(15.72)	25.37^{bc}	(18.36)	16.23^{cd}	(7.81)
5.	Naffatia leaves extract 5 % suspension (NaLES)	9.46	(2.70)	30.98^{a}	(26.50)	36.83^{a}	(35.93)	45.07^{b}	(50.12)	30.58^{ab}	(25.88)
6.	Lantana leaves extract 5 % suspension (LLES)	15.30	(6.96)	23.85^{ab}	(16.35)	23.85^{abc}	(16.35)	26.06^{bc}	(19.30)	22.26^{bc}	(14.35)
7.	Fudina leaves extract 5 % suspension (FLES)	0.91	(0.02)	6.75^{c}	(1.38)	9.46^{cd}	(2.70)	15.30^{c}	(6.96)	8.10^{defg}	(1.99)
8.	Chrysenthemum leaves extract 5 % suspension (CLES)	0.91	(0.02)	6.75^{c}	(1.38)	6.75^{cd}	(1.38)	6.75^{c}	(1.38)	5.29^{efg}	(0.85)
9.	Aankleaves extract 5 % suspension (AaLES)	6.75	(1.38)	6.75^{c}	(1.38)	17.51^{abcd}	(9.05)	20.22^{c}	(11.95)	12.81^{cdef}	(4.92)
10.	Kadvi mahendi leaves extract 5 % suspension (KLES)	12.59	(4.75)	26.06^{ab}	(19.30)	36.13^{ab}	(34.77)	77.38^{a}	(95.23)	38.04^{a}	(37.97)
11.	Control	0.91	(0.02)	0.91^{c}	(0.02)	0.91^{d}	(0.02)	6.75c	(1.38)	2.37g	(0.17)
	General mean	6.18	(1.16)	11.44	(3.93)	16.89	(8.44)	24.14	(16.73)	14.66	(6.41)
	S. Em. ± P	-		-		-		-		2.75	
	T	4.93		4.67		7.78		8.18		3.51	
	P x T	-		-		-		-		6.59	
	CD at 5 % P	-		-		-		-		7.74	
	T	NS		13.70		22.83		24.00		9.84	
	P x T	-		-		-		-		NS	
	CV %	138.10		70.70		79.82		58.70		77.82	

* Figures out side the parenthesis are arcsine transformed values NS = Non-significant

** Figures inside the parenthesis are retransformed values

Fig. 6 : Bio-efficacy of various plant leaves extracts against larvae of *A. mercatoria* under laboratory conditions during 1999



T_1 = Neem leaves extract 5 % suspension (NeLES)
T_2 = Spidor lily leaves extract 5 % suspension (SLES)
T_3 = Ardusa leaves extract 5 % suspension (ALES)
T_4 = Tulsi leaves extract 5 % suspension (TLES)
T_5 = Naffatia leaves extract 5 % suspension (NaLES)
T_6 = Lantana leaves extract 5 % suspension (LLES)
T_7 = Fudina leaves extract 5 % suspension (FLES)
T_8 = Chrysenthemum leaves extract 5 % suspension (CLES)
T_9 = Aankleaves extract 5 % suspension (AaLES)
T_{10} = Kadvi mahendi leaves extract 5 % suspension (KLES)
T_{11} = Control

control and rest of the treatments. The next effective treatment was NaLES, which gave 50.12 per cent mortality and was statistically on same bar with the treatments of LLES (19.30 %) and TuLES (18.36 %). The treatments of LLES, TLES, AaLES, SLES, FLES, ALES, NeLES and CLES did not differ significantly and were found least effective against larva of *A. mercatori* (1.38 to 19.30 per cent mortality).

The pooled data in the Table 30 showed that maximum per cent mortality was recorded in the treatment of KLES (37.97 %) but it was at par with the treatment of NaLES (25.88 %). The treatment of TLES gave 7.81 per cent mortality, which was comparable with LLES (14.35 %), SLES (6.74 %), AaLES (4.92 %), FLES (1.99 %) and ALES (1.38 %). The treatments of CLES and NeLES gave 0.85 and 0.45 per cent mortality did not differ significantly over control and were at par with each other. The descending order of effectiveness of treatments based on per cent mortality of larva was : KLES (37.97 %) > NaLES (25.88 %) > LLES (14.35 %) > TuLES (7.81 %) > SLES (6.74 %) > AaLES (4.92 %) > FLES (1.99 %) > ALES (1.38 %) > CLES (0.85 %) NeLES (0.45 %) > Control (0.17 %). The ANOVA of pooled analysis of data on per cent mortality over periods revealed that the source : period was significant indicating different per cent mortality in different periods while, the source : interaction (treatment x period) was significant indicating inconsistent performance of different treatments under study over periods.

Thus, from the above results, it is seen that the treatment of KLES and NaLES proved to be more effective in giving higher mortality of *A. mercatoria* larvae. Further, it is obvious from the results that 37.97 per cent mortality of larvae of *A. mercatoria* in the

laboratory was achieved by the treatment of KLES. These results are more or less in accordance with findings of Arvudainambi and Nachippan (1993), who reported that 3 per cent concentration of *Ipomoea carnea* Jacq. (stem, matured leaves, tender leaves and flowers) was found effective and gave 88.04 per cent protection of leaf area from *A. janata*.

SUMMARY AND CONCLUSIONS

V SUMMARY AND CONCLUSION

Investigation on biology of semi-looper, *Achaea mercatoria* Fabricius on sapota was carried out at N. M. College of Agriculture, Navsari during the year 1999. The bio-efficacy of various insecticides and plant leaves extracts against larvae of *A. mercatoria* were evaluated under laboratory and field conditions. The important findings derived from these investigations are as under.

5.1 Nature of damage

The study on nature of damage showed that the early instar larvae of semi-looper, *A. mercatoria* found to fed on chlorophyll of the leaves. Attacked leaves rendered transparent-papery and dried up. The severe damage was done by late instar larvae by eating tender leaves. Larvae also fed on inner content of flower bud.

5.2 Biology

Study on biology of *A. mercatoria* was carried out in the Department of Entomology, N. M. College of Agriculture, Navsari during the year 1999. The room temperature during the study was 27.0 to 30.9^{0}C with an average of 29.0 $\pm$ 0.70^{0}C, while relative humidity was 90.6 $\pm$ 3.9 per cent.

It was found that the female of *A. mercatoria* laid eggs singly on the lower surface and some times on upper surface of leaves. The freshly laid eggs were bluish grey in colour, which changed to light brown colour after one day and became dark brown prior to hatching. Eggs were hemispherical with upper surface convex and lower surface concave and prominently sculptured with numerous ridges and furrows

running from one polar end to another. The average length and breadth of egg was 0.39 ± 0.027 mm and 0.68 ± 0.057 mm, respectively. The average hatching percentage was 90.48 ± 2.42.

The larval stage passed through six instars. The newly hatched larva was blackish brown in colour. The second instar larva was light brown in colour. The distinctive feature was the presence of a prominent brown spot on each side of abdominal segment. The head changed brown to dark brown in colour. The body of the third instar larva was greenish grey in colour with brownish black spot on thoracic and abdominal region on lateral side. The head capsule was dark greenish brown with two light whitish lines. The fourth instar larva was greenish grey with blackish brown head. Three whitish stripes run parallel on the dorsal side of the body. The scoli became more prominent with reddish brown tip. The fifth instar larva was greyish green with pinkish tinge on abdominal region. The sixth instar larva was stout, smooth and plumpy. The body colour was greyish blue with light brownish stripes on dorsal region of the body. The colour variation was observed in later instar larva, the another colour pattern of sixth instar larva was dark brown with black spot on first abdominal region. The head capsule was brownish in colour with two whitish yellow stripes. The average length of first, second, third, fourth, fifth and sixth instar larva was 2.80 ± 0.35 mm, 5.22 ± 0.34mm, 16.06 ± 1.37 mm, 23.90 ± 1.37 mm, 33.68 ± 1.51 mm and 44.98 ± 1.89mm, whereas average breadth of body was 0.23 ± 0.023 mm, 0.51 ± 0.03 mm, 2.75 ± 0.18 mm, 3.62 ± 0.22 mm, 3.84 ± 0.09 mm, 5.26 ± 0.25 mm, respectively. The average breadth of head capsule of first, second,

third, fourth, fifth and sixth instar larva was 0.34 ± 0.039 mm, 0.64 ± 0.04 mm, 1.14 ± 0.04 mm, 1.81 ± 0.07 mm, 2.59 ± 0.68 mm, 3.52 ± 0.09 mm, respectively. The average duration of first, second, third, fourth, fifth and sixth instar larva was 2.96 ± 0.20, 2.04 ± 0.20, 2.08 ± 0.28, 2.16 ± 0.37, 2.64 ± 0.49 and 5.32 ± 0.48 days, respectively. Total larval period was on an average 17.20 ± 0.71 days.

During the prepupal stage, the larva looked sluggish, stopped feeding, changed its colour and contracted its body. The average length and breadth of prepupa was 35.78 ± 1.59 mm and 6.63 ± 0.16 mm, respectively. The average prepupal period was 2.12 ± 0.33 days. The newly formed pupa was light greenish in colour but soon changed to reddish brown and finally to dark brown before adult emergence. The average length and breadth of female and male pupa was 23.41 ± 1.20 mm and 25.98 ± 0.93 mm in length and 5.63 ± 0.32 mm and 6.78 ± 0.22 mm in breadth, respectively. Average length of genital aperture in female and male pupa was 0.36 ± 0.05 mm and 0.40 ± 0.07 mm, respectively, whereas length of anal aperture in female and male pupa was 0.33 ± 0.05 mm and 0.31 ± 0.07 mm, respectively. Average distance between genital and anal aperture in female and male pupa was 1.74 ± 0.21 mm and 0.69 ± 0.09 mm, respectively. Thus, the distance between genital and anal aperture was more in case of female pupae as compared to that in male pupae, which can be taken advantage for sex identification. The average duration of pupal stage was 10.48 ± 0.59 days.

The adults were stout bodied and the thoracic dorsum was thickly covered with brown hair. The brown coloured fore wings were

provided with antemedial and postmedial wavy lines which were ashy grey in colour chiefly at its apical end. Its apical margin was fringed with the short whitish yellow hairs. The hind wings were brown in colour, bright brown and white coloured spots were present near the tip of hind wing. The outer margin was also fringed with short whitish yellow hairs. Abdomen was grey in colour and its apical portion was provided with a tuft of brownish hairs and abdomen was thicker in case of female than male. The posterior part of abdomen was longer and tappering posteriorly in case of male.

The female and male adults measured on an average 22.0 $\pm$ 0.87 mm and 25.60 $\pm$ 1.15 mm in length and 50.26 $\pm$ 1.03 mm and 54.52 $\pm$ 1.40 mm in breadth across the expanded wings, respectively. Thus, male moth was slightly bigger in size than male.

The average pre-oviposition, oviposition and post-oviposition periods were recorded as 2.22 $\pm$ 0.46, 5.00 $\pm$ 0.76, 3.04 $\pm$ 0.89 days, respectively. The average egg laying capacity of female was 272.55 $\pm$ 40.34 eggs. The average longevity of female and male was 10.32 $\pm$ 1.03 and 9.0 $\pm$ 0.82 days, respectively. The longevity of male was shorter as compared to female.

Total life cycle occupied 39 to 45 days with an average of 42.40 $\pm$ 1.50 days in case of female, while it occupied 38 to 44 days with an average of 41.08 $\pm$ 1.38 days in case of male.

5.3 Natural enemy

The result of the natural parasitism showed that the per cent parasitism by dipterous parasite was 1.67.

5.4 Seasonal incidence of *A. mercatoria* on sapota

5.4.1 Seasonal incidence

5.4.1.1 Incidence based on population count

The activity of semi-looper larvae was observed from last week of March to second week of June and the pest reached at peak in fifth week of April during 1999-2000. More or less similar trend had been observed during 2000-2001.

5.4.1.2 Incidence based on per cent damage leaves

The result of the per cent damage leaves indicated that during 1999-2000 pest activity was noticed from fourth week of March to second week of June and maximum per cent damage leaves were recorded in third week of May, while during 2000-2001 maximum per cent damage leaves were recorded in fourth week of May and thereafter it declined.

5.4.2 Correlation studies

5.4.2.1 Correlation between mean number of larvae and mean per cent damage leaves

The correlation between mean number of larvae and per cent damage leaves per twig indicated that positive and significant correlation was observed during 1999-2000, however, in the year 2000-2001 it was found to be positive but non-significant.

5.4.2.2 Correlation with weather parameters

The correlation between larval population and weather parameters, none of the parameters showed significant correlation

during both the years. But overall correlation of two years showed that positive and significant correlation was observed with sunshine hours. The correlation with rest of the parameters was non-significant.

The per cent damage leaves had negative and significant correlation with maximum temperature, whereas it was positive and significant with minimum temperature and minimum relative humidity while there was non-significant correlation with other climatic factors during 1999-2000 and the similar trend was also observed during the 2000-2001 and in overall correlation of both the years.

5.4.3 Multiple/simple regression of mean number of larvae and per cent damage leaves (Y) on different weather parameters (X)

The multiple linear regression equation fitted for mean number of larval (Y_1) was $Y_1 = -0.3576 + 0.0683\ (X_1)$. The multiple linear regression equation fitted for per cent damage leaves (Y_2) for the year 1999-2000 was $Y_2 = 118.9151 - 4.3208\ (X_1) + 1.8875\ (X_2) + 0.2125\ (X_4)$. The multiple regression coefficient ($R^2 = 0.4445$) was statistically non-significant, whereas during 2000-2001 multiple linear regression equation for per cent damage leaves (Y_2) was $Y_2 = 190.5336 - 10.3036\ (X_1) + 12.5730\ (X_2) - 2.0434\ (X_4)$. The multiple regression coefficient ($R^2 = 0.4924$) was statistically non-significant, while overall multiple linear regression equation fitted for both the years by taking data on per cent damage leaves (Y_2) was $Y_2 = 101.8643 - 4.5988\ (X_1) + 3.7013\ (X_2) - 0.0838\ (X_4)$. The multiple regression coefficient ($R^2 = 0.4163$) was also statistically non-significant.

5.5 Chemical control

5.5.1 Under field conditions

Various insecticides *viz*., imidacloprid 0.005 per cent, profenofos 0.075 per cent, spark 0.036 per cent, nurelle D_{505} 0.055 per cent, polytrin-C_{404} 0.044 per cent fenobucarb 0.1 per cent, carbosulfan 0.05 per cent, endosulfan 0.075 per cent, lambda-cyhalothrin 0.005 per cent, alphamethrin 0.003 per cent, including untreated control were evaluated against the semi-looper, *A. mercatoria* for their bio-efficacy under field conditions.

The field experiments were conducted during summer, 1999-200 and 2000-2001. Nurelle D_{505} 0.055 per cent, profenofos 0.075 per cent, carbosulfan 0.05 per cent, lambda-cyhalothrin 0.005 per cent, spark 0.036 per cent, endosulfan 0.075 per cent, fenobucarb 0.1 per cent and polytrin-C_{404} 0.044 per cent were found most effective in reducing more than 99.00 per cent larvae of *A. mercatoria*. Similarly, the treatments profenofos 0.075 per cent, carbosulfan 0.05 per cent, nurelle D_{505} 0.055 per cent, spark 0.036 per cent, endosulfan 0.075 per cent, lambda-cyhalothrin 0.005 per cent, fenobucarb 0.1 per cent and polytrin-C_{404} 0.044 per cent were found to be the most effective in recording lower per cent of damage leaves.

5.5.2 Under laboratory conditions

The relative bio-efficacy of different insecticides; which were tested in field conditions were also tested under laboratory conditions. The effectiveness of treatments were concluded on the basis of per cent mortality of larvae of *A. mercatoria*.

All the insecticidal treatments were significantly superior over control. The treatments of profenofos 0.075 per cent, carbosulfan 0.05 per cent, endosulfan 0.075 per cent, spark 0.036 per cent (deltamethrin 0.001 per cent + triazophos 0.044 per cent) and fenobucarb 0.1 per cent were found effective, giving higher mortality of *A. mercatoria*. Further, it was obvious from the results that almost 100 per cent mortality of larvae of *A. mercatoria* was achieved 24 hrs after the treatments of profenofos 0.075 per cent, carbosulfan 0.05 per cent and endosulfan 0.075 per cent. Thus it can be taken advantage in quick knock down of the pest in field condition. The treatments of polytrin C_{404} 0.044 per cent (profenofos 0.075 per cent + cypermethrin 0.009 per cent) and nurelle D_{505} 0.055 per cent (chlorpyriphos 0.05 per cent + cypermethrin 0.009 per cent) were at par with each other. The treatment of lambda-cyhalothrin 0.005 per cent was significantly superior over the treatments of alphamethrin 0.003 per cent and imidacloprid 0.005 per cent, which were found least effective against larvae of *A. mercatoria*.

5.6 Bio-efficacy of various plant leaves extracts against larvae of *A. mercatoria*

The bio-efficacy of various plant leaves extracts against larvae of *A. mercatoria* were evaluated under laboratory conditions during 1999.

All the plant leaves extracts were superior over control, treatments of kadvi mahendi leaves extract 5 per cent suspension and naffatia leaves extract 5 per cent suspension gave higher mortality of *A. mercatoria* larvae. Further, it was obvious from the results that 37.97 per cent mortality of larvae of *A. mercatoria* in the laboratory was achieved by the treatment of kadvi mahendi leaves extract 5 per cent suspension.

BIBLIOGRAPHY

BIBLIOGRAPHY

Ahuja, D. B.; Noor, A. and Mathur, B. N. (1995). Efficacy of some insecticides against castor semi-looper *Achaea janata* Linn. on castor. *Pestology*, **19**(12): 32-36.

Anonymous (1982). Research Report, 1981-82. Dept. Ento., G. A. U., Navsari presented in 24th PPSC of AGRESCO held on May 17-19, 1982 at Junagadh, pp. 7-4 (Unpublished).

Arivudainambi, S. and Nachiappan, R. M. (1993). Evaluation of antifeedant property of extracts of *Ipomoea carnea* Jacquin against the semilooper, *Achaea janata* Linn. *J. Ent. Res.*, **17**(3): 225-226.

*Bhatnagar, Anuj and Agrawal, A. P. (1997). Antifeedant activity of neem formulations against the larvae of castor semi-looper, *Achaea janata* Linn. *Plant Prot. Bull.* (Faridabad), **49**(1/4): 17-18. (Fide: *RAE*, **88**(1): 501)

Bose, T. K. (1985). Fruits of India, Tropical and Sub-tropical. B. mitra Naya Prakash, Calcutta, India. pp. 439-464.

Butani, D. K. (1979). Insect and Fruits. Periodical Expert Book Agency, Delhi-110 032. pp. 87-94.

Byale , A. N. and Bilapate, G. G. (1990). Biometrics and biology of *Achaea janata* on castor and pomegranate. *J. Maharashtra Agric. Univ.*, **15**(1): 10-12.

*Chakravarthy, A. K. (1999). Role of Starthane 75 SP in integrated pest management. *Insect Environment*, **4**(4): 137-139. (Fide: *RAE*, **87**(10): 9750).

Chari, M. S. and Muraleedharan, C. M. (1985). Neem (*Azadirachta indica* Linn.) as feeding deterrent of castor semilooper, *Achaea janata* Linn. *J. Ent. Res.*, **9**(2): 243-245.

Cheema, G. S.; Bhatt, S. S. and Naik, K. C. (1954). Commercial Fruits of India. Mc Millan and Co., Calcutta.

Dalaya, V. P.; Rajput, S. G.; Awate, B. G. and Mohite, P. B. (1985). Chemical control of castor semilooper, *Achaea janata* Linnaeus. *Indian J. Plt. Prot.*, **11**(1/2): 136-137.

Dani, A.; Sharma, N. and Sehgal, S. S. (1980). The method of sexing pupae and adults of castor semi-looper, *Achaea janata* (Linn.). *Indian J. Ent.*, **42**(2): 310-311.

Deshmukh, S. D.; Akhare, M. D. and Borle, M. N. (1979). Insecticidal control of the insect pest of castor. *J. Plt. Prot.*, 7(1): 66-68.

*Dhingra, S. (1998). Susceptibility status of castor semilooper, *Achaea janata* Linn. to pyrethroid and non-pyrethroid insecticides during the last decade. *J. Ent. Res.*, **22**(1): 43-47. (Fide: *RAE*, **86**(11): 10488)

Dodia, D. A.; Patel, I. S. and Pathak, A. R. (1995). Antifeedant properties of some indigenous plant extracts against larvae of castor semilooper, *Achaea janata* L. *Pestology*, **19**(7): 21-22.

*Dyar, H. G. (1890). The number of moults of Lepidopterous larvae. *Psyche*, **5**: 420-422.

*Edwards, E. D. (1978). A review of the genus *Achaea* Hubner in Australia (Lepidoptera: Noctuidae). *J. Australian Entomologcal Society*, **17**(4): 329-340. (Fide: *RAE*, **67**(11): 4299)

*Grewal, G. S.; Garacha, H. S. and Gurdip Singh (1988). Chemical control of castor semilooper, *Achaea janata* Linn. (Lepidoptera: Noctuidae) on castor in Punjab. *J. Res. Punjab Agric. Univ.*, **25**(4): 581-586. (Fide: *RAE*, **78**(2):1721).

Henderson, C. F. and Tilton, E. W. (1955). Tests with acaricides against the brown mite. *J. Econ. Ento.*, **48**: 157-161.

*Ismail, A. and Salim, J. (1982). An outbreak and some notes of the noctuid *Achaea janata* L. *Excoecaria agallocha* L. in Huntan Melintang, Perk. *MAPPS Newsletter*, **6**(2): 2-3. (Fide: *RAE*, **71**(2): 984).

Jayani, D. B.; Bharpoda, T. M. and Patel, J. R. (1996). Bio-efficacy of azadirachtin (Neem) based formulations against castor semilooper (*Achaea janata*). Alleopathy in pest management for sustainable agriculture. Scientific Publishers, Jodhpur, India. pp. 201-206.

John, A. and Muraleedharan, D. (1989). Biology and morphometrics of castor semilooper, *Achaea janata* Linn. (Lepidoptera: Noctuidae). *Uttar Pradesh J. Zool.*, **9**(1): 48-55.

Karmawati, E. and Tobing, S. L. (1988). Laboratory biology of *Achaea janata* L. castor large semi-loopers. *Industrial Crops Res. J.*, **1**(1): 37-42.

Kushwaha, K. S. and Pal, S. K. (1978). Effectiveness of some insecticides against castor semilooper, *Achaea janata* Linn. *Indian J. Ent.*, **39**(2): 193-196.

*Muthukrishnan, J. and Ananthagowri, B. (1994). Botanical pesticides and energetics in the control of castor semi-looper, *Achaea janata*. *Phytophaga* (Madras), **6**(2): 127-131. (Fide: *RAE*, **84**(2): 1950).

*Nafus, D. and Schreiner, I. (1991). Oviposition by herbivorus insects on spider webs as an anti-predation defence. *Ecological Ento.*, **16**(4): 513-517. (Fide: *RAE*, **80**(8): 6351).

Pal, S. K. (1979). Relative effectiveness of some chemical insecticides and bacterial insecticides against castor semilooper, *Achaea janata* L. *Indian J. Plt. Prot.*, **5**(2): 195-198.

*Pandey, N. D.; Sukhani, T. R. and Gupta, R. L. (1969). Bionomics of the *Achaea janata* L. (Lepidoptera: Noctuidae). *Lahdev J. Sci. Technol.*, **5**(2): 127-128. (Fide: *RAE*, **57**(9): 2159).

Parthasarthy, S. and Rao, P. A. (1989). Chemical control of castor semilooper, *Achaea janata* Linn. *J. Oilseed Res.*, **6**(1): 158-161.

Patel, G. T. (1981). Biology and chemical control of chikoo bud borer, *Anarsia* sp. (Lepidoptera: Gelechidae) a pest of chickoo. M. Sc. (Agri.) thesis submitted to Gujarat Agricultural University, Sardar Krushinagar, India. (Unpublished).

Rai, P. S. and Jayaramaiah, M. (1978). The castor semilooper, *Achaea janata* Linnaeus (Lepidoptera: Noctuidae) and its control. *J. Maharashtra Agric. Univ.*, **3**(1): 73-74.

Ramchandran, R. and Mukherjee, S. N. (1989). Effect of food deprivation and concentration of azadirachtin on the performance of *Achaea janata* and *Spodoptera litura* on young and mature leaves of castor. *Entomologia Experimentalis et. Applicata*, **51**(1): 29-35.

Rao, P. J. and Subrahmanyam, B. (1987). Effect of azadirachatin on *Achaea janata* Linn. and *Spodoptera litura* (F.) (Noctuidae: Lepidoptera). *J. Ent. Res.*, **11**(2): 166-169.

Rao, Srinivasa, M.; Venkateshwarlu, B. and Sankaram, A. V. B. (1996). Evaluation of neem and custard apple formulations against castor semilooper, *Achaea janata* Linn. *Pestology*, **20**(8): 16-19.

*Samee, L. (1962). *Achaea janata* L. - A noctuidae defoliating the flush of *Theobroma cacao*. *Pupua New Guinea Agric J.*, **14**(4): 163-165. (Fide: *RAE*, **52**: pp. 332).

Senapati, B. and Dash, A. N. (1989). Insecticidal control of castor semilooper and capsule borer. *Madras Agric. J.*, **76**(1): 40-42.

*Sharma, R. N.; Gupta, A. S.; Patwardhan, S. A.; Hebbalkar, D. S.; Tare, V. and Bhonde, S. B. (1992). Bioactivity of Lamiaceae plants against insects. *Indian J. Exp. bio.*, **30**(3): 244-246. (Fide: *RAE*, **80**(10): 8627).

Singh, D. S.; Sircar, P.; Saxena, P. N. and Dhingra, S. (1985). Comparative toxicity of pyrethroid and non-pyrethroid insecticides to *Achaea janata* Linn. *Indian J. Ent.*, **45**(4): 390-395.

Singh, M. P. (1982). Studies on the damage of castor semi-looper, *Achaea janata* (Linn.) to some fruit plants and its chemical control. *Indian J. Plt. Prot.*, **10**(1/2): 37-39.

*Singh, R. P. and Pant, N. C. (1978). Antifeedant property of sub-family Amarylloidoidae. *Entomologists' News Letter*, **8**(3): 8. (Fide: *RAE*, **67**(11): 4708).

Singh, S.; Krishnamurthi, S. and Katyal, S. I. (1963). Fruit culture in India. ICAR, New Delhi. pp. 192-198.

Tahiliani, B. D. (1985). Castor semi-looper *Achaea janata* Linnaeus outbreak in North Gujarat. *Pestology*, **11**(3): 7-8.

Vevai, E. J. (1971). Know your crop, its pest problem and control. *Pesticides*, **5**(11): 33-41.

Vyas, H. N. (1994). Biology of castor semi-looper Achaeae janata L. on rose, *Rosa indica*. *Crop Res.* (Hisar), **7**(1): 109-111.

---

* Original not seen

CERTIFICATE

This is to certify that I have no objection for supplying to any scientist only one copy or any part of this thesis at a time through reprographic process, if necessary for rendering reference service in a library or documentation centre.

Place : Navsari

Date : December 27, 2000

(**N. V. Patel**)