BIOECOLOGY AND MANAGEMENT OF BER FRUIT BORER, *Meridarchis scyrodes* MEYRICK (Lepidoptera : Carposinidae)

PRAVEEN PATIL

DEPARTMENT OF AGRICULTURAL ENTOMOLOGY
UNIVERSITY OF AGRICULTURAL SCIENCES, DHARWAD-580005
MARCH, 1994

BIOECOLOGY AND MANAGEMENT OF BER FRUIT BORER, *Meridarchis scyrodes* MEYRICK (Lepidoptera : Carposinidae)

Thesis submitted to the
University of Agricultural Sciences, Dharwad
in partial fulfilment of the requirements
for the award of the Degree of

MASTER OF SCIENCE (AGRICULTURE)
in
AGRICULTURAL ENTOMOLOGY

By
PRAVEEN PATIL

DEPARTMENT OF AGRICULTURAL ENTOMOLOGY
UNIVERSITY OF AGRICULTURAL SCIENCES, DHARWAD-580005
MARCH, 1994

DEPARTMENT OF AGRICULTURAL ENTOMOLOGY

UNIVERSITY OF AGRICULTURAL SCIENCES, DHARWAD-5

CERTIFICATE

This is to certify that the thesis entitled **"BIOECOLOGY AND MANAGEMENT OF BER FRUIT BORER *Meridarchis scyrodes* Meyrick (Lepidoptera : Carposinidae)"** Submitted by **Mr. PRAVEEN PATIL** for the degree of **MASTER OF SCIENCE IN AGRICULTURAL ENTOMOLOGY** of the University of Agricultural Sciences, Dharwad, is a record of research work done by him during the period of his study in this University under my guidance and supervision, and the thesis has not previously formed the basis of the award of any degree, diploma, associateship, fellowship or other similar titles.

DHARWAD
March. 1994.

(Dr. B.V. PATIL)
Major Advisor
(I/C) Professor of Entomology,
College of Agriculture, Raichur.

Approved by :

Chairman : 13/4/94
(B.V. PATIL)

Members : 1. 13.4.94
(S. LINGAPPA)

2.
(S.A. PATIL)

3. 13/4/94
(U.G. NALAWADI)

4.
(MANJUNATH M.)

Dedicated
to the
Beautiful world
of
Insects

ACKNOWLEDGEMENT

And so comes the time to express one's subtle ego into words to remember the faces and spirits behind this endeavour with a sense of gratitude.

I wish to express my sincere thanks to Dr. B.V.Patil, Professor of Agricultural Entomology, College of Agriculture Raichur, and Chairman of my advisory committee for his mature guidance and constant encouragement during the course of investigation and sustained interest and help in the preparation of the thesis.

I am grateful to the members of my advisory committee, Dr. S.Lingappa, Director for Institute of Pulse and Oilseed Research, A.R.S., Gulbarga , Dr. S.A. Patil, Director of Instructions (Agri), Dr. U.G. Nalawadi, Director of Instructions (P.G.s) and Dr. Manjunath M., Assistant Professor of Agricultural Entomology, U.A.S. Dharwad, for their valuable suggestions and help in preparing this manuscript.

My sincere thanks are due to teaching and nonteaching staff,Department of Agricultural Entomology and Department of Horticulture at College of Agriculture, Raichur and Dharwad.

I cannot forget helpful and honest personality, Dr.S.G.Patil, Soil Scientist and head ,A.R.S., Gangavati and staff at A.R.S.,Gangavati for their help in carrying out my research work. I do thank staff of Department of Agril. Entomology and Department of Horticulture, for their timely help in conducting my research work at R.R.S., Bijapur.

I wish to record my thanks to International Institute of Entomology, London, U.K., for their timely help in identification of insect specimens. I am grateful to Indian Council of Agricultural Research, New Delhi for awarding junior fellowship to persue my post graduate study.

With all my love and affection, I record my indebtedness to my parents, sisters Poornima, Pratibha and Mamata and all my relatives for their moral support throughout my post graduate study.

I avail this opportunity to thank all my friends Seenu, Shesha, Shashi, Mablu, Nagya, Kadipya, Manja, Mamda, Raj, Venktya, Kiran, Sentil, Kalya, Bhatta, Moods, Sharan, Sangu, Sangya, Sidharth, Emptya, Dada, Chandru[3], Rudra[2], Baththi, Udi, Sachchu, Gopya, Shri Naganagoud, Shri Basavaraj B and family, Mamta, Manju, Manjula, Jyoti and Sharmila. I am also grateful to my senior and junior friends for their cooperation and help. I specially thank C.S. Patil for his help in collecting literature and also I am grateful to the staff of Department of Agril. Entomology and Library, MPAU, Rahuri, Maharashtra.

My sincere thanks are due to Dr. Ravikumar, for his help in statistical analysis. Shri. Guddadamath and my junior Dudhani are to be praised for the neat drawing of figures.

I extend my thanks to M/s Microsoft Computers, Dharwad for neat and timely printing of my Thesis.

Dharwad
March, 1994

(PRAVEEN PATIL)

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

INTRODUCTION

I. INTRODUCTION

Ber (Zizyphus mauritiana Lamarck) is one of the important fruit crops known from ancient times of India. It is found growing wild, semi-wild and cultivated forms in almost all parts of India. Plantations of ber on varied scales exist today in Afghanistan, Iran, Syria, Burma, Australia, France, U.S.A., U.S.S.R. and India (Pareek, 1983).

In India, ber is being cultivated on an estimated area of 12,000 hectares. It is most widely cultivated in plains of Punjab, Haryana, Rajasthan and Uttar Pradesh. Fairly good cultivation of this arid zone fruit is also found in Madhya Pradesh, Bihar, Maharastra, Gujarath, Assam, Karnataka and other places (Bose and Mitra, 1990). Besides being valued for fruits it also serves as an important host plant for lac insect and is extensively grown in the states of West Bengal and Bihar for lac cultivation. Cultivation of high yielding varieties of ber on systematic planted orchards with intensive care and management is a recent development because of its high returns, which has been fast drifting into dry and irrigated lands of North Karnataka from adjoining states, especially from Maharastra.

Though as many as 180 species of insects have been recorded on ber in the world, about 130 species have been reported from India alone. Of these, only 20 species are major/minor pests and only a few species cause substantial economic damage to ber (Lakra and Bhatti, 1985).

Ber fruit fly, Carpomyia vesuviana Costa (Diptera, Tephritidae) and ber fruit borer, Meridarchis scyrodes Meyrick cause damage to edible parts in ber plants and they are considered to be major pests of ber. The pest status of these two insect pests vary in place, season and time (Basha, 1952 and Jejurkar, 1986). Ber fruit borer larvae feeding on the pulp of the ber fruits was recorded for the first time by Fletcher (1916) in the year 1913 at Coimbatore. The species was identified as Meridarchis scyrodes by Meyrick in 1916.

Adult females were observed to lay eggs singly in depression near the stalk of fruit. The newly hatched larvae enter the fruits by puncturing a hole in the rind and feed on the pulp. As a result, the infested fruits are rendered unfit for consumption. Usually a single larva is found in an infected fruit, however, at times three to four larvae are not uncommon. Most of the infested fruits drop down, ferment and emit disagreeable odour. Loss to the extent of 70 per cent

has been observed in cases of heavy infestations (Sonawane, 1965).

Very limited information is available in the past on seasonal incidence, host range, natural enemies, varietal susceptibility, biology and management of ber fruit borer, M.scyrodes. Presently the area under ber cultivation has been rapidly increasing in North Karnataka. Since, fruit borer has been reported to be a major pest which is more serious than fruit fly (Jejurkar, 1986), systematic investigations were undertaken on ber fruit borer, M.scyrodes with the following objectives.

1. To record the insect pests attacking on ber (Z. mauritiana Lamk.) in North Karnataka.
2. To study the biology of ber fruit borer, M.scyrodes under laboratory conditions.
3. To study the seasonal incidence.
4. To study the varietal susceptibility.
5. To evaluate the efficacy of botanical and synthetic insecticides in the management of ber fruit borer.

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

Literature on various aspects of insects attacking ber (Ziziphus mauritiana Lamk.) fruit crop is very much limited. Moreover, the work done on ber fruit borer, Meridarchis scyrodes Meyrick is very scanty. The available literature on ber fruit borer, M. scyrods has been reviewed and presented.

2.1 Insect pests of ber

Review of the published literature revealed that lac insect (Tachardia lacca kerr) feeding on bark of ber tree was recorded as early as 1781 (Kerr, 1781). Lefroy (1909) in his book entitled "Indian Insect Life" reported thirteen pests infesting ber crop in India. Important amongst them were the flea beetle (Platypria andrewesi We.), grey weevil (Xanthochelus superciliosus Gylh.), hairy caterpiller (Thiacidas postica Walk.), leaf miner (Tischeria ptarmica Meyr.), bark borer (Arbela tetraonis Mots.) and various species of butterflies (Dilinia capitata Walker, Taragama siva Lef. and Tarucus theophrastus Fab.). Subsequently in 1920, Fletcher published a list of sixteen additional species feeding on ber. These, however, were considered to be of minor importance. Larvae of lemon butterfly (Papilio demoleus

Linn.) was also recorded to feed on foliage of ber in Belgian Congo (Mayne, 1914). Larvae feeding on the pulp of ber fruits were recorded for the first time by Fletcher (1916) in the year 1913 at Coimbatore and it was identified as Meridarchis scyrodes subsequently, by Meyrick (1916). Maulik (1916) described a new chrysomelid (Chlamys gravelyi sp.n.) infesting ber trees in Bengal. Tiger beetle borer (Neocollyris bonelli orytygia F.), a pest of coffee was noticed boring the twigs of ber at Pusa (Anon, 1917). Beeson (1919) recorded the weevil (Dereodus pollinosus Redt.) and the larva (Coelosterna spinator F.) as the foliage feeders. Several species of coccids recorded on ber in India were Ceroplastes cajani Mask, (Newstead, 1917), Pulvinaria maxima Green (Ayyar, 1925), Anoida longispinia (Takahashi, 1939), Aspidiotus orientalis Newst. (Glover, 1939), Aonida zizyphi F. and Droschi stebbingi F. (Rehman and Ansari, 1941), while Inglisia zizyphi F. and Pseudococcus hibisci Hemip. were reported from South Africa (Brain, 1920) and Egypt (Hall, 1921), respectively. Two new species of mite, Phytoptipalpus transitaus Ewing (Ewing, 1922) and Paratetranychus indicus Hirst (Rehman and Sappra, 1940), were observed to infest ber. Marshall (1941) recorded a new species of weevil (Myllocorns spinicollis Mshll.) feeding on ber in Punjab. Pruthi and Batra (1960) recorded ten new

species, while Mathur and Singh (1960) published a list of 80 insect and non-insect pests attacking ber in India.

Sonawane (1965) recorded thirty insect and non-insect species on ber and detailed studies on bionomics of only four important species *viz.*, tingid (Monosteira sp.), hairy caterpiller (Thiacidas postica Walker), jassid (Empoasca libyca de Berg) and fruit borer (M.scyrodes Meyr.) was carried out. Nayar et al. (1979) has listed fourteen insects attacking ber.

Butani (1979) reported as many as 80 insect species found feeding on ber trees in India. Those of major importance are ber fruit fly, mealy bug, beetles and weevils. Besides, there are various bugs, scale insects and thrips that suck the cell sap from leaves and a large number of lepidopterous pests including bark eating caterpillers, leaf eating caterpillers, leaf rollers, leaf webbers, shoot and fruit borers that occasionally damage ber trees.

Lakra and Bhatti (1985) reported as many as 180 species of insects damaging various parts of ber plant in different parts of the world. Of these, 130 species have been reported from India alone. A large majority of these are mere records of occurrence, and quite a large number of these are

either sporadic or of minor importance. Of these about 20 insect species are major/minor pests and only a few species cause substantial damage to ber.

The incidence of tingid bug, Monosteria zizyphora (Heteroptera : Tingidae) was recorded for the first time as a pest of ber in the orchard of JNKVV Regional Research Station, Khandwa (M.P) (Verma et al., 1993).

2.2 BIOLOGY OF M.SCYRODES

Issac (1927) reported for the first time that the ber fruit borer, M.scyrodes was successfully bred under laboratory conditions at Pusa.

Sonawane (1965) carried out detailed biology of ber fruit borer successfully under laboratory conditions. According to him, females were observed to lay eggs singly in a depression near the stalk of fruit. A newly hatched larvae enters the fruit by puncturing a hole in the rind and feeds on the pulp. As a result, the infested fruits are rendered unfit for consumption. Usually a single larvae is found in an infested fruit, however, at times three to four larvae were noticed. Most of the infested fruits drop down, ferment and emit disagreeable odour. Losses to the extent of 70% have been observed in cases of heavy infestation. However, in the

laboratory egg laying was noticed on the rind of the fruit, blotting paper and other surfaces. Freshly laid egg was silvery white but turns to dirty yellow just prior to hatching. Pre-oviposition period varied from one to two days with an average of 1.5 days. The number of eggs laid per female ranged between 11 and 34 within a period of 1 to 3 days. Incubation period ranged between 4 to 7 days with an average of 5.5 days. Newly emerged larvae wandered on fruit for about 20 to 30 minutes. The entire larval period of 13 to 17 days was completed inside the fruit during which larva passed through five instars. Full grown larva was observed to leave the fruit and pupate in soil. Prepupal and pupal periods were 1 to 2 and 5 to 8 days, respectively. The average life span of adult male and female was 2.8 and 3.4 days, respectively. The insect completes one generation within 30 days.

NATURAL ENEMIES

Ayyar (1923) recorded Microbracon sp as a larval parasite on ber fruit borer. Later Butani (1973) recorded Opius fletcheri Silvestri and Microbracon sp as larval parasites.

ALTERNATE HOSTS

Besides ber, fruit borer has been recorded on Jamun and Olive fruits (Basha, 1952).

2.3. Seasonal incidence of M. Scyrodes

Ayyar (1923) reported that fruit borer was active from July to August, but according to Sonawane (1965) observations on the seasonal incidence of the pest in Poona revealed that the pest attack starts from the last week of September. There was no appreciable incidence till the end of second week of October. Thereafter infestation increased suddenly reaching peak in the second week of November when the average temperature and relative humidity were 23.5°C and 73 per cent, respectively. A gradual decline in pest incidence was noticed thereafter.

2.4. Varietal susceptibility to M. scyrodes

Khare (1923) observed Nagpuri variety of ber to be highly susceptible to the attack of the pest.

Observations of Sonawane (1965) revealed that the intensity of infestation ranged between 4 to 72 per cent. Four varieties were observed to be resistant, 41 moderately resistant, 37 susceptible and 11 highly susceptible to the pest attack. Varieties like "Surati No.1" " Kashi", "Mehroon" and "Mehroon Khirani" recording less than five per cent damage and appeared to be the promising.

A susceptible variety " Kadaka" was choosen by Jejurkar (1986) to conduct insecticide efficacy trials, wherein he recorded 57.86 percent loss due to fruit borer in the untreated control. Similarly "Umran" variety, Shevale and Padule (1992) recorded an average incidence of 36.68 per cent from their three year insecticide efficacy trial wherein peak incidence of 71.76 per cent was recorded in the year 1987.

2.5. Chemical control of M. scyrodes

The studies conducted by Basha (1952) on the control of fruit borer, M. scyrodes and fruit fly, C. vesuviana at Coimbatore indicated the following results.

1. The two borers besides causing premature shedding are responsible for much infestation of fruits over 70 per cent by fruit fly and 10 per cent by fruit borer.

2. Experiments conducted at Panyam during 1950 with sprays of DDT 0.1% and BHC 0.05% gave definite promise of reducing the infestation.

3. The results broadly indicated a gain of about 70 lbs of fruits per tree. Apart from the higher yields, a larger percentage of the fruits was borer free in the treated lots -a point enhancing its market value.

4. The yield was inversely proportional to the infestation.

Sonawane (1965) conducted pesticidal screening trials against M. scyrodes for three seasons in Maharastra state. Two applications were made, first immediately after incidence and second three weeks thereafter. He reported the treatment with 0.02 per cent isobenzene was the most effective in reducing the infestation and was significantly superior to the rest of the treatments like 0.02 per cent diazinon, 0.1 per cent carbaryl, 0.2 per cent DDT and 0.05 per cent malathion, but was on par with 0.02 per cent endrin. The treatments with 0.02 per cent diazinon and 0.1 per cent carbaryl were found to be the next promising insecticides against fruit borer.

According to Jejurkar (1986), three sprays of any one of the eleven pesticides screened at an interval of twenty-one days starting from pea sized stage to fruits of first flush *viz.*, dimethoate 0.03%, methyl demeton 0.03%, quinalphos 0.05%, phosalone 0.05%, phenthoate 0.05%, cypermethrin 0.0075%, fenvalerate 0.01%, fenitrothion 0.05% can be relied upon for reducing the infestations of fruit borer and fruit fly. However, malathion 0.05%, phosphamidon 0.03% and dimethoate 0.02% are relatively more economical.

The research work was carried out at Rahuri by Shevale and Padule (1992) for three years on chemical control of fruit borer. Considering efficacy, economics and the resonable concentration of insecticides, it was concluded that the insecticides *viz.*, deltamethrin at 0.002 per cent, fenvalerate at 0.01 per cent and quinalphos at 0.05 per cent are very effective and suggested for recommendation against ber fruit borer.

MATERIAL AND METHODS

III. MATERIAL AND METHODS

The present investigations on ber fruit borer, Meridarchis scyrodes Meyrick (Lepidoptera: Carposinidae) were carried out at three Research Stations of the University of Agricultural Sciences, Dharwad, Karnataka State during 1992-93 and 1993-94.

The survey of the insect pests of ber was carried out in all the three research stations *viz.*, Agricultural Research station, Gangavati, Regional Research station, Raichur and Bijapur during 1992-93. The biological studies of ber fruit borer were carried out under laboratory conditions at the Department of Agricultural Entomology, College of Agriculture, Raichur, Karnataka during 1993-94. Studies on seasonal incidence and varietal susceptibility to fruit borer were carried out at all the three Research Stations during 1992-93 and only at Regional Reseasrch Station, Raichur during 1993-94. The trials on insecticide efficacy and identification of critical stages for insecticide application were carried out at Agricultural Research Station, Gangavati, during 1992-93.

Location

Regional Research Station, Raichur lies at an altitude of 389.5 m above the mean sea level and between lattitude of 16° 12' North and 76° 24' East longitude. Whereas, Regional Research Staion, Bijapur lies at an altitude of 590.5 m above the mean sea level and between lattitude of 16° 83' North and longitude of 75° 76' East. The Agricultural Research Station, Gangavati is located between lattitude of 15° 15' 40" North and longitude of 76° 31' 40" East at an altitude of 419 m above the mean sea level.

The meteorological data of the above three research stations in the respective years is presented in Appendices I to IV.

3.1. Insect pests of ber

Insect pests found attacking on ber plants, (Zizyphus mauritiana Lamarck) during its flowering and fruiting phases were collected at fortnight interval from all the study sites during 1992-93 season. The insects collected were later confirmed for their feeding on ber under laboratory conditions. These insect pests were preserved dry/wet preserved in 70 per cent alcohol, mounted and sent to International Institute of Entomology, London, United Kingdom for identification.

2.2 Biology of *M. scyrodes*

Infested ber fruits were collected from the field and were spread in a single layer on dry sand and kept in a mass culture wire mesh cage of 1 m^3 (Plate 1).

Freshly emerged adults were collected and separated in plastic boxes. A pair of male and female moths were released in a plastic box containing fresh, stalked, semiripe fruits for oviposition. The diluted honey solution was supplemented as food which was changed daily along with fruits (Plate 2). Observations were recorded daily on the preoviposition and oviposition periods, fecundity, and longevity of adults. The percentage of hatching was also worked out. Longevity of adults was also recorded both in the presence and absence of honey solution. The neonate larvae were placed on the pulp of cut fresh fruit kept in a glass vial covered by muslin cloth (Plate 3). The fresh food was supplemented as and when necessary. The larvae were observed daily for moulting. Soil was provided for last instar larvae for pupation. The pupae were collected from the soil and pupal periods were recorded. All these observations in the above study were conducted during November and December months of 1993 and the laboratory meteorological data is presented in Appendix V and VI.

PLATE : 1 Mass culture cage of M. scyrodes

PLATE : 1

PLATE : 2 Plastic box covered with muslin cloth used for rearing of M. scyrodes

PLATE : 3 Glass vials used for rearing early instars of M. scyrodes larvae

PLATE : 2

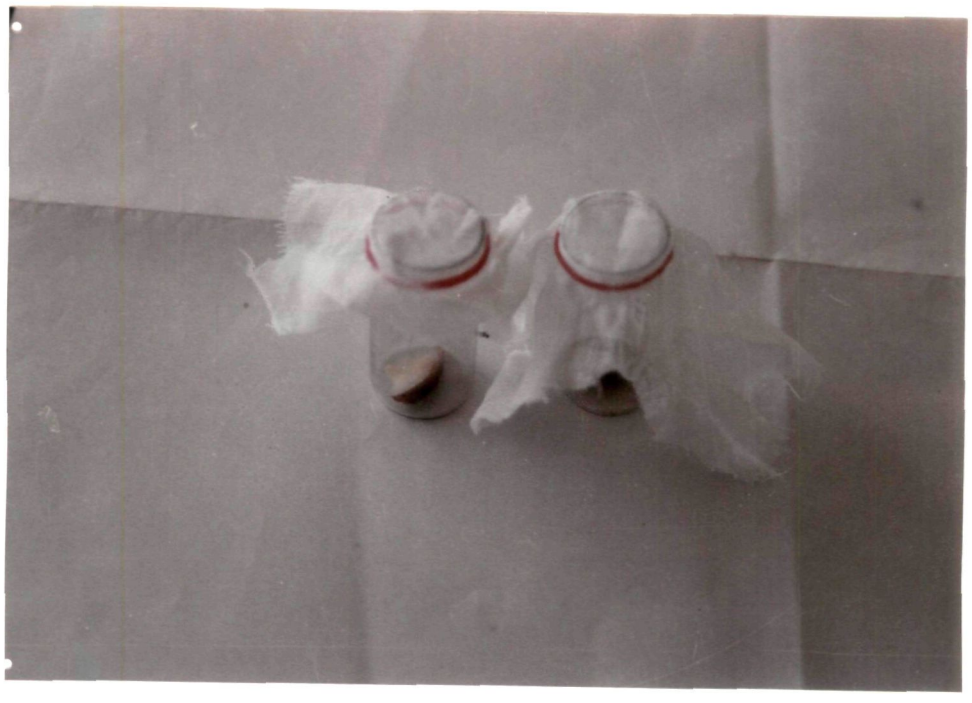

PLATE : 3

3.3. Seasonal incidence of M. scyrodes

Seasonal incidence studies at weekly intervals on ber fruit borer was carried out on Gola, Umran and Sanura-2 which are early, medium and late fruiting varieties at Agricultural Research Station, Gangavati, during 1992-93. Similarly, seasonal incidence studies at fortnightly interval on Umran variety were carried out at RRS, Bijapur during 1992-93 and at Regional Research Station, Raichur during 1992-93 and 1993-94.

One Kilogram of fruits were collected at random during each harvest. Fruits were cut open to record borer infestation based on damage, presence of excreta and pinkish larvae. The data recorded was later expressed on per cent basis.

3.4. Varietal susceptibility to M. scyrodes

Different varieties of ber planted in different research stations of North Karnataka were selected for the purpose. An attempt was made to record the susceptibility of different varieties for fruit borer attack. Three unsprayed plants in each variety were tagged and observed for their susceptibility.

One kilogram of fruits was collected from each of these plants. The fruits were collected during peak harvesting stage of fruits. Fruits were collected from different varieties from all the three research stations during 1992-93 and from RRS, Raichur during 1993-94. Fruits were cut open to recorded borer infestation as described above. The data was expressed on per cent basis.

3.5. Management of fruit borer, M. Scyrodes

Experiments were carried out on the control of M. scyrodes at Agricultural Research Station, Gangavati, during 1992-93. Two experiments were laid out in randomised block designs seperately to evaluate the bioefficacy of different synthetic and botanical insecticides against M. scyrodes and to determine the critical stages of ber plant for effective insecticide application.

In the first experiment, there were seven treatments (Table 1) comprising of different synthetic and botanical insecticides which were replicated thrice to evaluate their bioefficacy against fruit borer. The variety choosen for this experiment was five year old Umran as it was reported to be susceptible to fruit borer attack (Shevale and Padule, 1992). One plant per replication was treated six times at a

Table 1. Synthetic and botanical insecticides screened against ber fruit borer, *M. scyrodes* at Gangavati during 1992–93

Sl. No.	Treatments	Trade name	Dosage (ml/lit)	Conc. (%)	Source
1.	Monocrotophos	(Nuvacron 36SL)	1.0	0.04	Hindustan Ciba–Geigy Ltd.
2.	Endosulfan	(Thiodan 35EC)	2.0	0.07	Hoechest India Ltd.
3.	Dichlorovas	(Nuvan 76EC)	1.5	0.11	Hindustan Ciba–Geigy Ltd.
4.	Dimethoate + Jaggary solution	(Rogar 30EC)	1.0+1.0 gms	0.03:0.10	Rallis India Ltd.
5.	Neem	Neemguard	3.0	0.03	West Coast Herbochem Pvt. Ltd.
6.	Neem	Margocide ck 20EC	5.0	1.00	CSIR,NPL, Pune
7.	Untreated control		–	–	–

fortnightly interval starting from 50 per cent blooming. About two liters of spray solution was used per treatment per replication. Fruits were harvested from treated plants at weekly intervals and harvesting was started 20 days after last spray. One kilogram of fruits was collected randomly from each treatment per replication at three successive harvests.

Fruits were cut open to record the fruit borer incidence based on damage, presence of excreta and pinkish larvae. The data was computed to per cent basis and subjected to angular transformation before statistical analysis.

In the second experiment on identification of critical stage(s) of ber plant for insecticidal application against ber fruit borer, number of sprays varied from nil to six sprays. Treatments were imposed on Umran variety at fortnightly interval such that one spray each at flowering and maturation stage and two sprays each at pea and marble stage were given. One plant per treatment per replication was maintained in each case. The experiment consisted of nine treatment combinations and were replicated thrice. Endosulfan 35 EC at 2.0 ml/liter dosage was used at each spray. Two liters of spray solution was used per treatment per replication. Four different critical stages were identified

in ber plant *viz.*, flowering (Plate 4). Pea (Plate 5), Marble (Plate 6) and maturation stage (Plate 7) accordingly nine different combinations were imposed. The treatment details are as follows.

Treatment	Critical stage(s)	No. of spray(s) applied
1.	Flowering stage	1
2.	Pea stage	2
3.	Marble stage	3
4.	Maturation stage	1
5.	Pea and marble stages	4
6.	Marble and maturation stages	3
7.	Pea, marble and maturation stages	5
9	Flowering, pea, marble and maturation stages	6
9.	Untreated control	-

Fruits were harvested at weekly intervals after 20 days of last spray. One kilogram of fruits was collected randomly from each treatment per replication at three successive harvests. Each fruit was cut open to record fruit borer infestation based on damage, presence of excreta and pinkish larvae. The data was computed to per cent basis and subjected to angular transformation before statistical analysis.

PLATE : 4 Flowering stage of ber (Z. mauritiana)

PLATE : 5 Pea stage of ber fruits

PLATE : 4

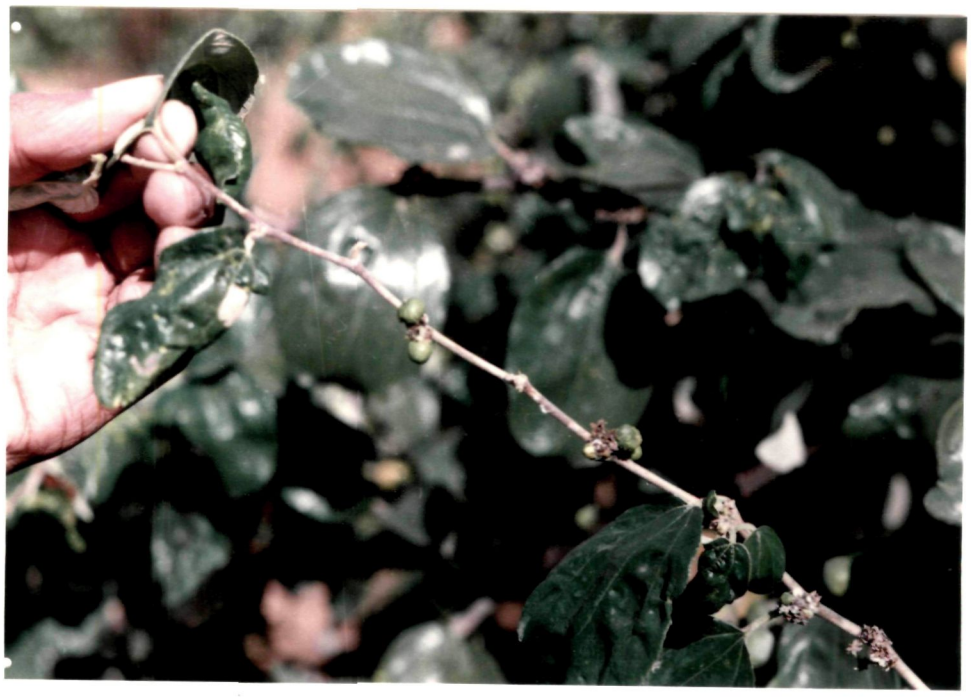

PLATE : 5

PLATE : 6 Marble stage of ber fruits

PLATE : 7 Maturation stage of ber fruits

PLATE : 6

PLATE : 7

EXPERIMENTAL RESULTS

IV. EXPERIMENTAL RESULTS

The results of the present studies on the survey of the insect pests attacking ber in North Karnataka; biology, seasonal incidence, varietal susceptibility, bioefficacy of synthetic and botanical insecticides and determination of critical stages of ber plant for insecticide application for effective management of ber fruit borer, M. scyrodes are presented here under.

4.1 Insect pests of ber

Three research stations in North Karnataka viz., Agricultural Research station, Gangavati, Regional Research Station, Bijapur and Raichur were surveyed during 1992-93 at fortnightly interval to record the insect pests attacking ber during its flowering and fruiting periods.

The list of insect pests recorded on ber are presented in Table 2.

Ash weevil Myllocerous undecimpustulatus Faust was found feeding on the leaves of ber during pea and marble stages only at Raichur. It was not found in other stages of ber. It's feeding damage was not significant and very few weevils were noticed per plant.

Table 2. List of insect pests infesting on ber (Z. **mauritiana**) in North Karnataka during 1992–93

Sl. No.	Scientific name/ Common name	Family	Order	Locality		
				Raichur	Bijapur	Gangavati
1.	Myllocerous undecimpustulatus Faust. Ash weevil	Curculionidae	Coleoptera	+	–	–
2.	Bactrocera correta (Bezzi) Fruit fly	Tephritidae	Diptera	–	–	+
3.	Meridarchis scyrodes Meyrick Fruit borer	Carposonidae	Lepidoptera	+	+	+
4.	Carpomyia vesuviana Costa Ber fruit fly	Tephritidae	Diptera	+	+	+
5.	Leaf eating beetle*	Lycidae	Coleoptera	+	–	+
6.	Leaf eating beetle*	Scrabeidae (Cetoniinae)	Coleoptera	+	–	–
7.	Tree hoppers*	Delphacidae	Hemiptera	+	+	+
8.	Leaf miner*	Gelechidae	Lepidoptera	–	–	+
9.	Mealy bug*	Pseudococcidae	Hemiptera	+	+	–
10.	Fruit weevil*	Curculionidae	Coleoptera	–	+	–

+ Present
– Absent
* Identity of the specimen yet to be confirmed

Fruit samples collected during harvesting period from all the study sites contained ber fruit fly, Carpomyia vesuviana Costa and fruit borer, M. scyrodes. The incidence of ber fruit fly was very less compared to fruit borer. Apart from ber fruit fly, sample collected from Gangavati contained polyphagous fruit fly, Bactrocera correta (Bezzi).

Coleopterans belonging to family Lycidae were found in very large number during flowering period but their damage is not significant. These are reddish beetles with a black stripe in its back and look like red cotton bugs. These were noticed at Raichur and Gangavati. Small brownish beetles, of the family Scarabeidae were found feeding on the leaves of ber at Raichur during maturation stage of the fruit on ber plant.

Tree hoppers were noticed during flowering stage at all the three localities. They were found on the branches in greater numbers and suck the plant sap. Leaf miners were found to attack on leaves of few plants at Gangavati during the flowering stage. Mealy bugs were noticed at the stalk of the semimatured fruits at Raichur and Bijapur.

Weevils were noticed inside the ber fruits which were in pea stage. There was no external symptom of damage

and the weevils were found inside the fruit completely replacing the seed inside and caused fruit drop at Bijapur.

4.2. Biology of ber fruit borer, M. Scyrodes

The life history studies on M. scyrodes were carried out in the laboratory and laboratory meteorological data is presented in Appendices V and VI. Details of the present study are given in the Tables 3,4, and 5.

4.2.1. Egg

Egg is oval and creamy white. It is slightly tapering at the micropylar end which is covered by circular rows of `T` shaped projections. The creamy white colour of egg turns to yellowish, just prior to hatching. Under laboratory conditions eggs were laid individually, in few groups or in circular rows in depression near the stalk of fruit (Plate 8). The incubation period lasted for 5 to 6 days with an average of 5.27 $\pm$ 0.44 days (Table 3). Eclusion period was about 20 minutes. The percentage of hatching was maximum (82.20 per cent) on the fifth day and it was 14.8 per cent on the sixth day (Table 4).

4.2.2. Larva

Details of the larval duration are presented in Table 4.

Table 3. Incubation period and hatching percentage of eggs of ber fruit borer, M. scyrodes under laboratory conditions

Days after oviposition	Per cent hatch	Incubation period (days)	
		Range	Average ± S.D.
1st	–		
2nd	–		
3rd	–		
4th	–	5–6	5.27 ± 0.44
5th	82.20		
6th	14.80		

PLATE : 8 Eggs of M. scyrodes laid near the stalk of ber fruit

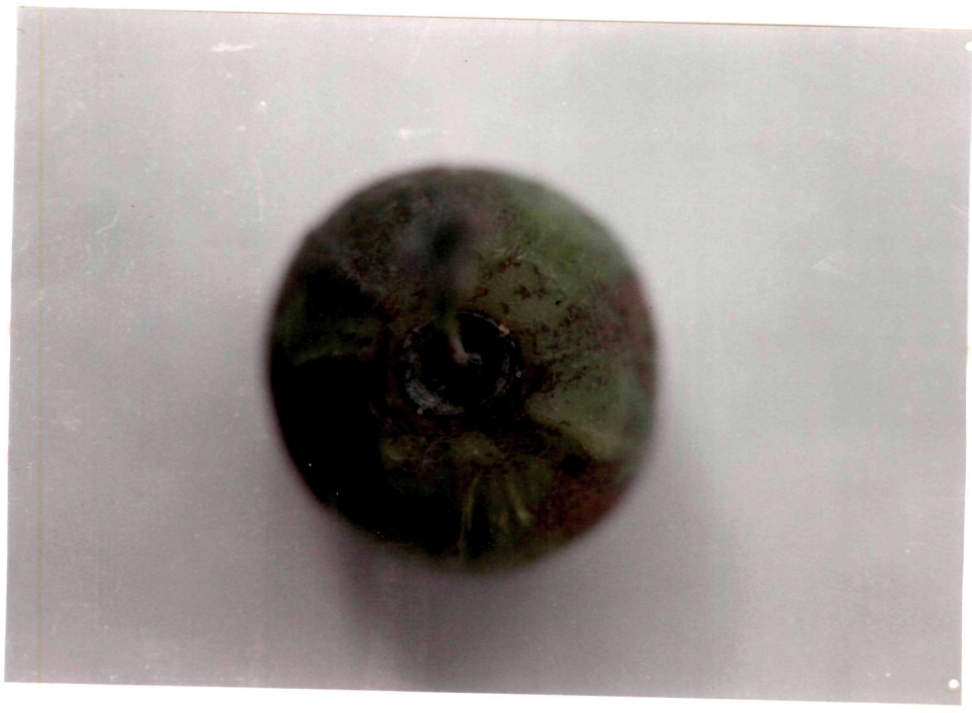

PLATE : 8

First instar

A newly hatched larva is creamy white with dark brown head. The head was smaller compared to body. The larva feeds on the pulp of fruit, measures about 2 mm in length and has a duration of 2.00 days.

Second instar

The larva is structurally similar to that of first instar. It is dirty white in colour with dark brown head, by boring the pulp during feeding, it reaches the seed surface of the fruit. It measures about 3 mm in length and lasts for 2.4 $\pm$ 0.52 days.

Third instar

It starts feeding voraciously leaving behind brownish exereta compared to second instar. The rear end of the larvae is slightly pinkish in colour and rest of the body is dull white in colour (Plate 9). The larvae measures 4 to 5 mm in length with an average length of 4.3 $\pm$ 0.48 mm. The larval duration lasts for 3.00 days.

Fourth instar

The larva is dark pinkish in colour (Plate 9) with brown head. It feeds voraciously around the seed of the fruit. It measures 6 to 7 mm with an average of 6.36 $\pm$ 0.45

mm. It has a maximum duration of four days and a minimum of three days with an average of 3.71 ± 0.8 days.

Fifth instar

Full grown larva is dark pinkish in colour (Plate 9) and measures 10 to 12 mm in length with average length of 11.26 ± 0.77 mm. The feeding habit is similar to the third instar. Excreta is found at the damaged site. It has an average duration of 5.2 ± 0.78 days (ranges from 4 to 6 days). The total larval period averaged 16.30 ± 3.50 days.

4.2.3. Nature of damage

A newly hatched larvae enters the fruit by puncturing a hole on the rind and feeds on the pulp. Gradually larvae reaches the seed surface and starts feeding around the seed. By the time larvae is ready to pupate the whole internal space around the seed is filled with excreta (Plate 10). The seed is not damaged by the larvae. The presence of excreta inside the fruit is the characteristic symptom of borer damage and excreta is not found in the case of fruit fly damage (Plate 11). Bored holes are the external symptoms of fruit borer damage (Plate 12). Usually a single larva is found inside the fruit but up to four larvae were also recorded. At times, both fruit borer and fruit fly were found to attack the same fruit.

PLATE : 9 Third, fourth and fifth instar larvae of *M. scyrodes*.

PLATE : 10 Ber fruit borer, *M. scyrodes* damaged and healthy fruit

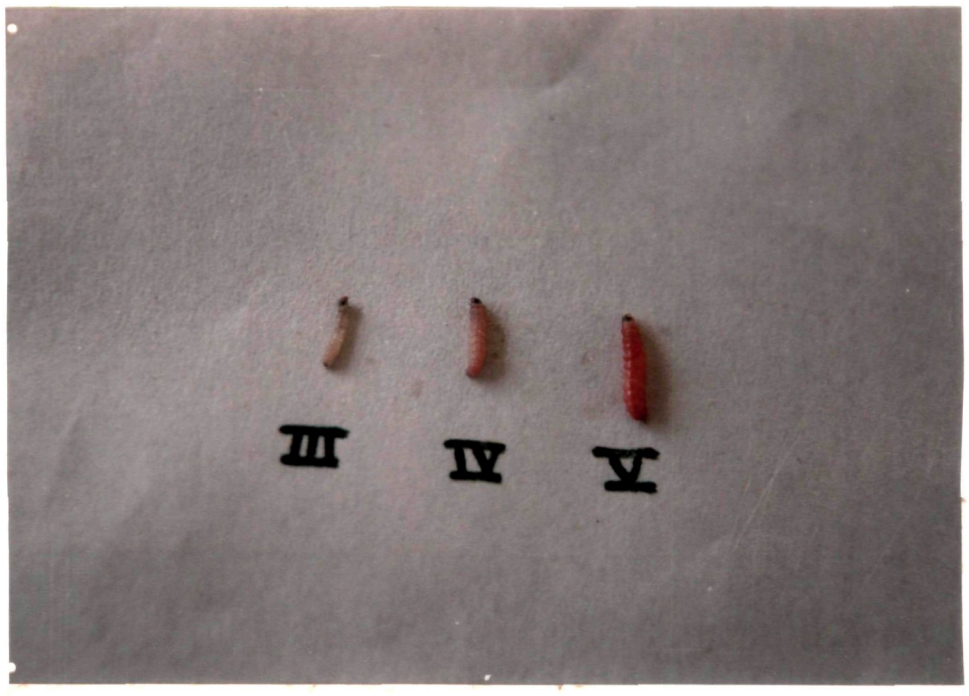

PLATE : 9

PLATE : 10

PLATE : 11 Ber fruit borer, M. scyrodes (A) and fruit fly, C. vesuviana (B) infested fruits

PLATE : 12 Ber fruits showing holes made by M. scyrodes

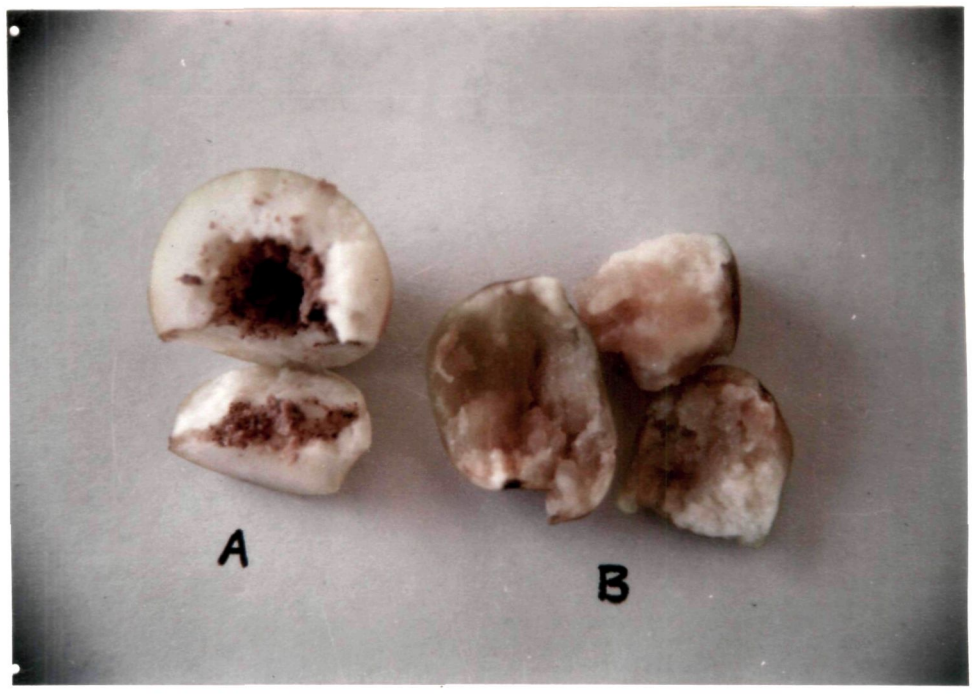

PLATE : 11

PLATE : 12

4.2.4. Pupa

As the full grown larva never pupates inside the fruit, it comes out of fruit for pupation. Under natural conditions it pupates in soil within a white silken cocoon. The prepupa (Plate 13) builds the silken cocoon and its duration lasts for an average of 1.2 $\pm$ 0.4 days.

Under laboratory conditions pupation was found to take place in soil by attaching itself to the fruit (Plate 14) and when soil was removed it was found to pupate in paper folds, muslin cloth, corners of plastic box and other such concealed places. The female pupa is slightly bigger than that of male (Plate 15). Pupa is cylindrical, gradually tapering posteriorly. The pupal period ranges from seven to eight days with an average of 7.5 $\pm$ 0.8 days. The pupa measures about 9.5 mm in length.

4.2.5. Adults

Adults were brownish black in colour. The wings and body were heavily covered with scales. The hind wings were translucent and its outer margin was covered with hairs. Male and female were differentiated based on on abdominal size.Abdomen was bigger in female than that of male (Plate 16). An attempt was made to draw the external reproductive organs of male and female moths using camera lucida.

PLATE : 13 Pre-pupa of ber fruit borer, *M. scyrodes*

PLATE : 14 Pupation on the fruit when kept on soil under laboratory conditions

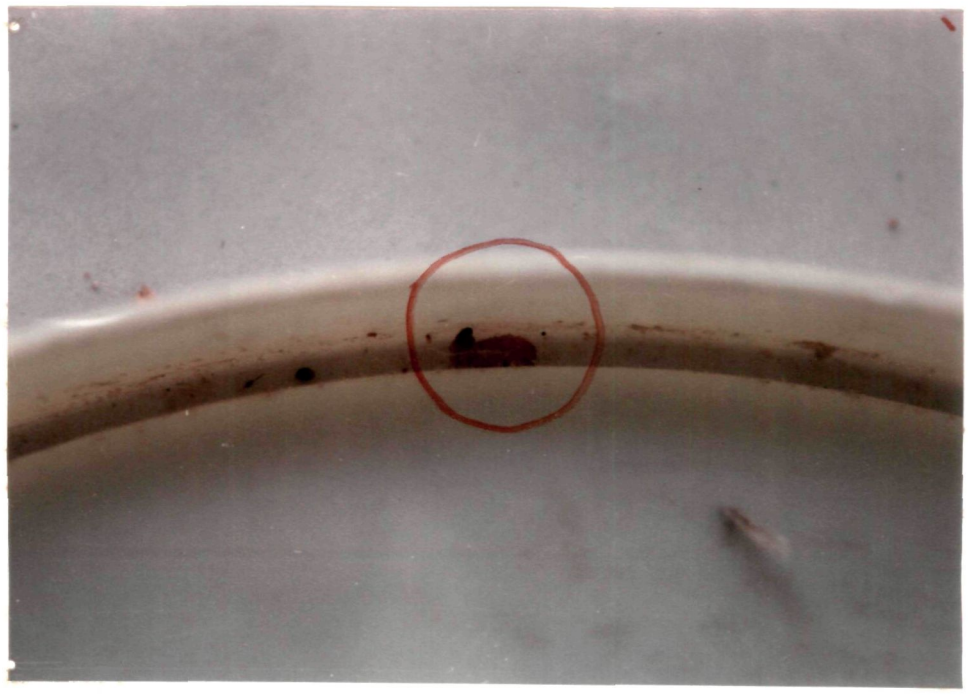

PLATE : 13

PLATE : 14

PLATE : 15 Male and female pupa of M. scyrodes

PLATE : 16 Male and female adults of M. scyrodes

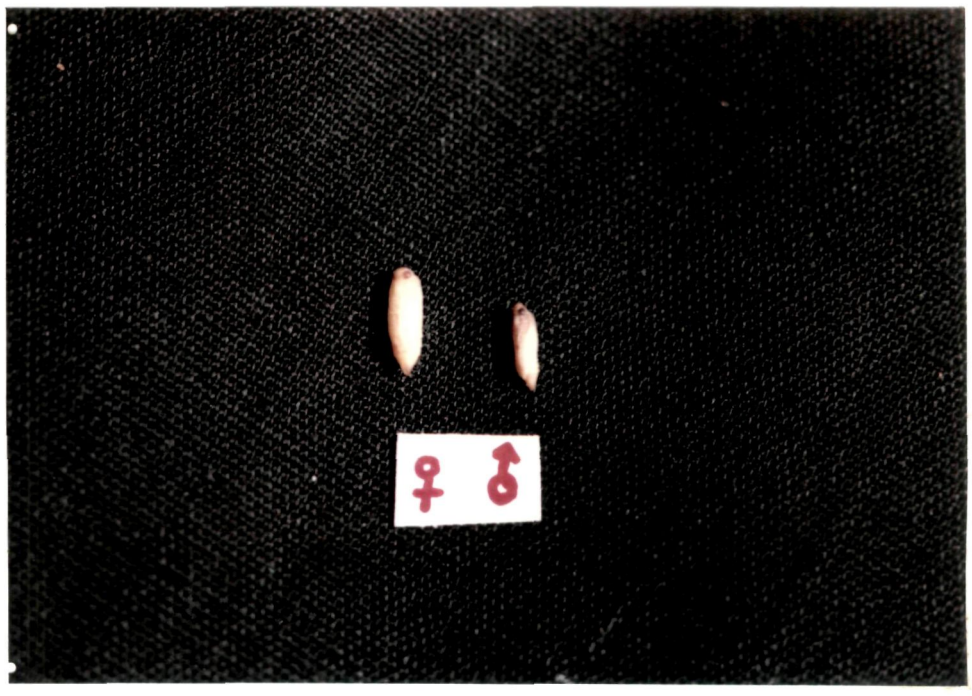

PLATE : 15

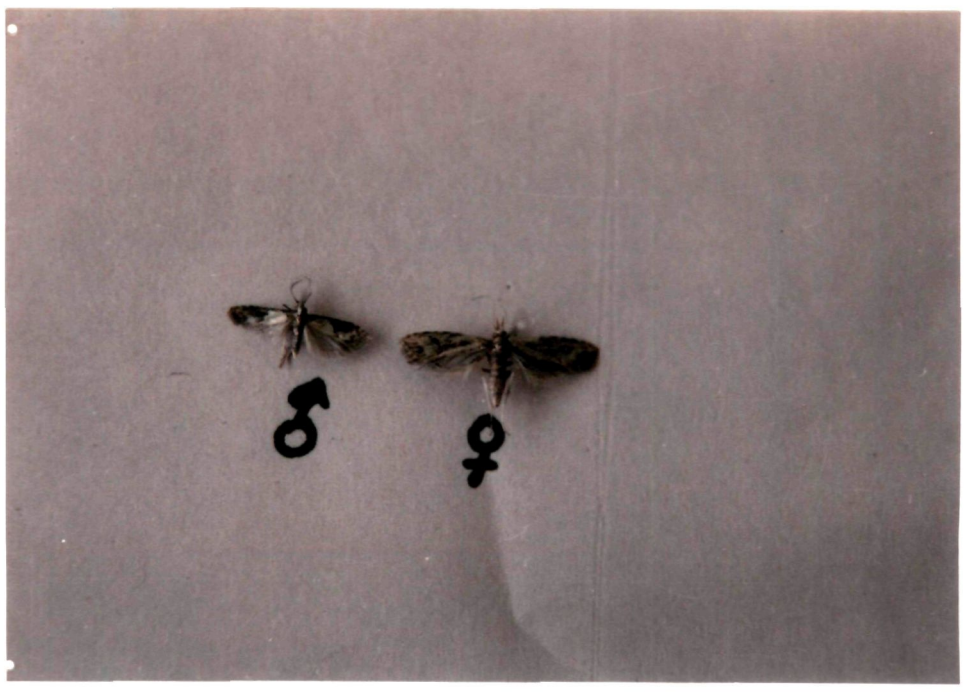

PLATE : 16

The female abdominal tip (Fig. 1) shows ovipositor covered with hairs. The ovipositor is oval shaped and its length (92 μ) is almost twice the width (56 μ).

The male abdominal tip (Fig 2) shows claspers retracted out. The sickle shaped claspers were generally held within. The claspers were covered with dense and long hairs. The function of other structures shown along with claspers were not known. The claspers measure 420 μ in length.

The average duration of pre-oviposition, oviposition and post-oviposition period was observed to be 1.00, 1.08 $\pm$ 0.12 and 0.85 $\pm$ 0.18 days, respectively. The male and female moths in the presence of honey solution survived for an average of 2.65 $\pm$ 0.50 and 3.7 $\pm$ 0.27 days, respectively. In the absence of honey solution, males lived for 1.85 $\pm$ 0.80 days and females for 2.75 $\pm$ 0.65 days. The fecundity ranged from 23 to 35 eggs per female with an average of 28.0 $\pm$ 3.25 eggs (Table 5).

4.2.6. Total life cycle

The total life cycle of fruit borer ranged with the minimum of 27 days to maximum of 34 days (average being 30.0 $\pm$ 2.5 days) (Table 4).

Table 4. Duration of different stages of ber fruit borer, M. scyrodes under laboratory conditions

Sl. No.	stage	Range in days		Average* ± S.D.
		Minimum	Maximum	
1.	Egg period	5	6	5.30 ± 0.40
2.	Larval period			
	a) I instar	2	2	2.00 ± 0.00
	b) II instar	2	3	2.40 ± 0.52
	c) III instar	3	3	3.00 ± 0.00
	d) IV instar	3	4	3.70 ± 0.80
	e) V instar	4	6	5.20 ± 0.78
	f) Total larval Period	14	18	16.30 ± 3.50
3.	Prepupal period	1	2	1.20 ± 0.40
4.	Pupal period	7	8	7.50 ± 0.80
5.	Total life cycle	27	34	30.00 ± 2.50

* Average of ten replications

Table 5. Reproductive characteristics of ber fruit borer. *M. scyrodes* under laboratory conditions

Sl. No.	Stage of insect	Range in days		Average* ± S.D.
		Minimum	Maximum	
1.	Preoviposition period	1.0	1.0	1.00 ± 0.00
2.	Oviposition period	1.0	2.0	1.80 ± 0.12
3.	Post oviposition period	0.5	1.0	0.85 ± 0.18
4.	Adult longivity			
	a) with honey solution			
	– Male	2.0	3.0	2.65 ± 0.50
	– Female	3.0	4.0	3.70 ± 0.27
	b) Without honey solution			
	– Male	1.5	2.0	1.85 ± 0.80
	– Female	2.0	3.0	2.75 ± 0.65
5.	Fecundity	23.0	35.0	28.00 ± 3.25

* Average of ten replications

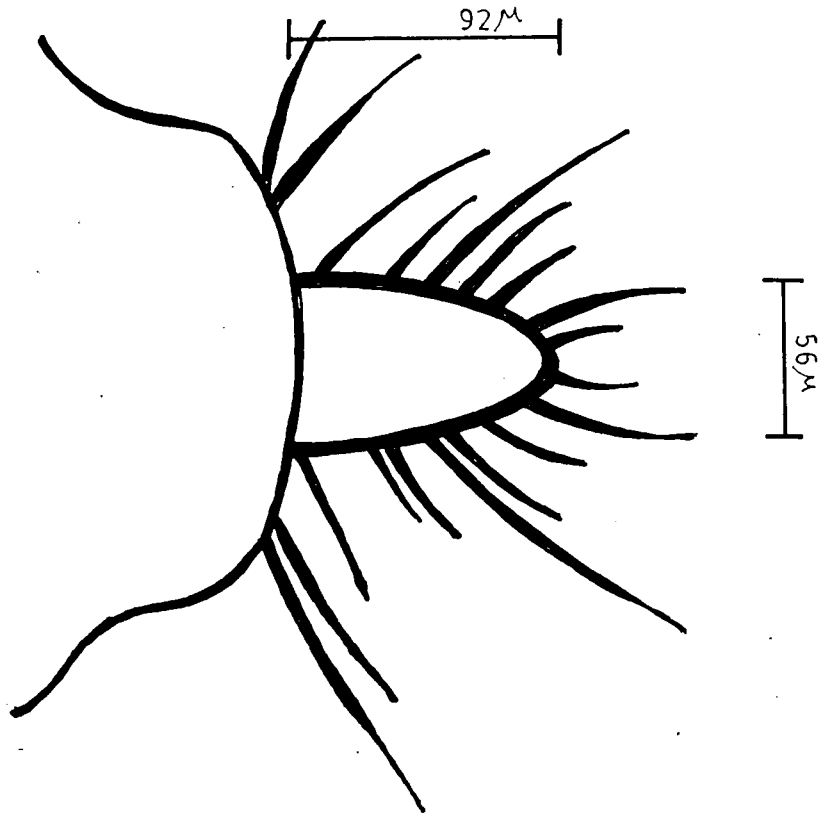

Fig. 1 : Female abdominal tip of ber fruit borer, M. scyrodes.

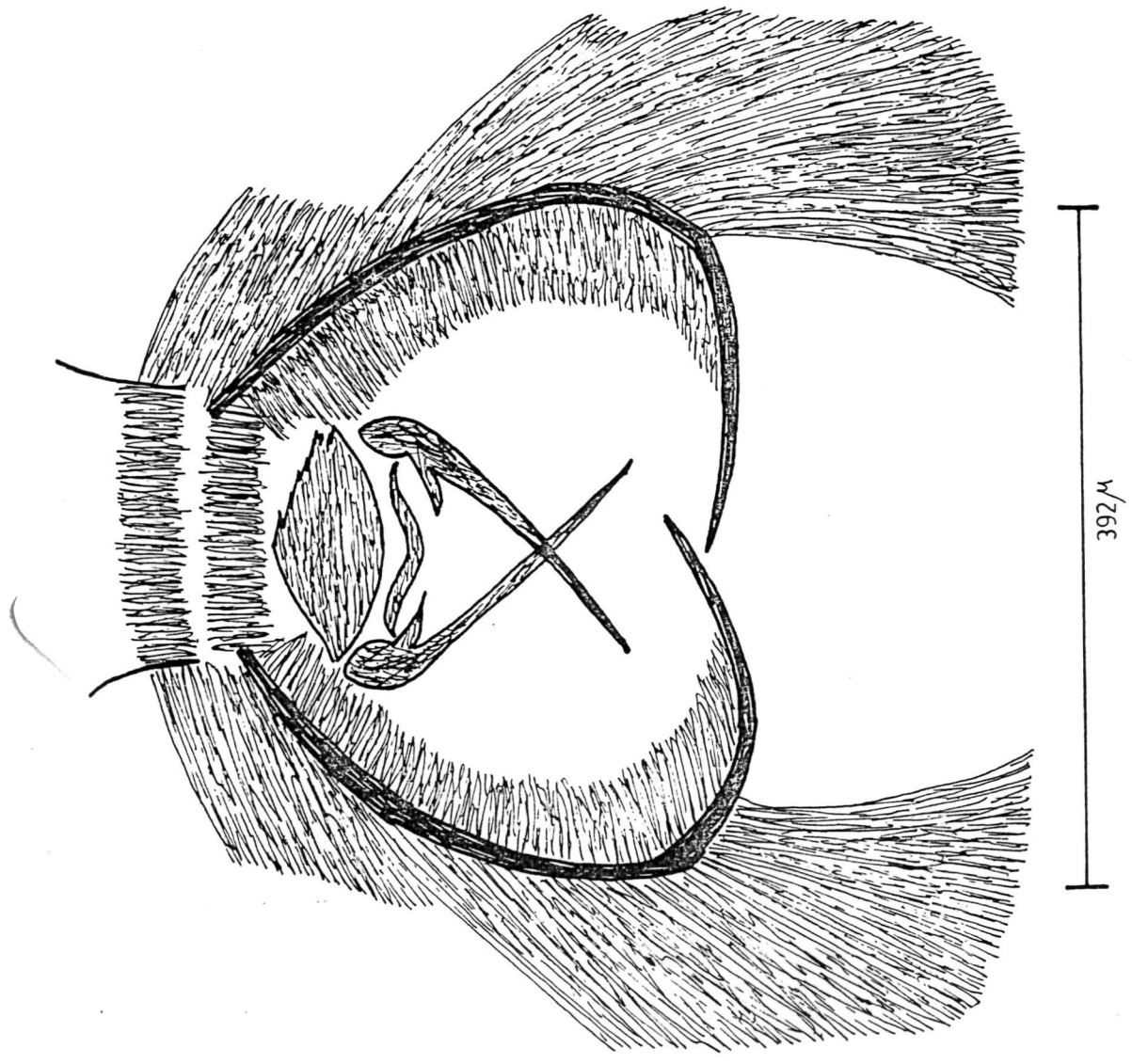

Fig. 2. Male abdominal tip of ber fruit borer, M. scyrodes.

4.2.7. Natural enemies

Chelonus sp. (Hymenoptera: Braconidae) an egg-larvalparasitoid was recorded from the field culture collected to carryout biological studies at the Regional Research Station, Raichur.

A predatory mite (Phytoside) was also found to feed the eggs of fruit borer in laboratory and the same needs to be confirmed.

4.3. Seasonal incidence of M. scyrodes

The incidence of the fruit borer started in the third week of November on variety Gola (5.3 per cent) and lasted till the third week of January on variety Sanura-2 (2.0 per cent) with a peak incidence of 35.7 per cent on variety Umran in the fourth week of December during 1992-93 at Gangavati. The borer incidence level was maximum during December which gradually decreased towards the end of the season (Table 6). The incidence of fruit borer was nil after the third week of January when no fruits were found on plants.

The the data on seasonal incidence recorded at fortnightly interval (Table 7) shows that incidence started during second fortnight of November in both years of study at Raichur and during 1992-93 at Bijapur. The maximum fruit

Table 6. Seasonal incidence of fruit borer, M. scyrodes at Gangavati during 1992–93

Period Month/week	Variety	Per cent borer incidence
November I	–	–
II	–	–
III	Gola	5.3
IV	Gola	12.1
December I	Umran	21.8
II	Umran	27.5
III	Umran	35.7
IV	Sanura–2	17.4
January I	Sanura–2	10.3
II	Sanura–2	6.2
III	Sanura–2	2.0
IV	–	–

Table 7. Seasonal incidence of fruit borer, M. scyrodes on Umran variety at Bijapur and Raichur

Period Month/ /fortnight	Per cent fruit borer incidence at			Mean Per cent incidence
	Raichur		Bijapur	
	1992-93	1993-94	1992-93	
November I	-	-	-	-
II	8.2	13.6	6.6	9.5
December I	25.6	22.2	27.8	25.2
II	32.8	27.5	30.5	30.3
January I	6.3	7.2	5.3	6.3
II	-	-	-	-

borer damage of 25.6 and 32.8 per cent and 22.2 and 27.5 per cent incidence was recorded in the first and second fortnight of December, respectively at Raichur. Similarly peak infestation of 27.8 and 30.5 per cent was noticed in the first and second fortnight of December, respectively at Bijapur. Later fruit borer incidence terminated with the harvest of fruits.

4.4. Varietal susceptibility to M. scyrodes

Different ber varieties planted at three research stations were choosen for evaluation of their susceptibility to fruit borer infestation. Observations on the incidence were recorded at peak harvesting stage and were presented in Table 8.

At Raichur during 1992-93 varieties of Umran, Kadaka and Chuhara recorded highest incidence of 18.4, 14.2 and 12.5 per cent, respectively. Elachi, Jogia and Dandan recorded lowest incidence of 6.0, 6.4 and 8.0 per cent, respectively.

During 1993-94 at Raichur, Umran, Kadaka and Sanura-2 recorded highest incidence of 26.6, 17.5 and 15.2 per cent, respectively. The lowest incidence of 5.2, 6.2 and 6.6 per cent was recorded in Jogia, Dandan and Elachi varieties, respectively.

Observations taken on varieties *viz.*, Umran, Kadaka, Chuhara, Sanura-2 and Gola indicate 29.7, 29.5, 22.0, 17.9 and 10.2, per cent infestation, respectively, at Bijapur during 1992-93.

At Gangavati during 1992-93, Umran, Sanura-6, Mehroon and Sonura-2 recorded maximum fruit borer incidence of 35.7, 20.0, 17.0, and 17.0 per cent, respectively. Gola, Dandan, Kadaka and Jogiamundia recorded lower incidence of 6.0, 10.0, 10.0, and 12.6 per cent fruit borer damage respectively.

The average infestation of each variety over locations indicated that Umran (22.6 per cent) and Kadaka (17.0 per cent) had highest incidence levels of M. scyrodes while lowest incidence was observed in varieties Jogia (5.8 per cent) and Dandan (8.1 per cent) (Table 8).

4.5. Management of ber fruit borer, M. scyrodes

Data on the bioefficacy of synthetic and botanical insecticides and identification of critical stage(s) of ber plant for insecticide application against fruit borer are presented in Table 9 and Table 10.

Table 8. Incidence of fruit borer, M. scyrodes on different varieties in different Research Stations of North Karnataka

Sl. No.	Variety	*Per cent fruit borer incidence at				Mean per cent incidence
		Raichur		Bijapur	Gangavati	
		1992–93	1993–94	1992–93	1992–93	
1.	Umran	18.4	26.6	29.7	35.7	22.80
2.	Gola	10.5	12.2	10.2	6.0	9.60
3.	Dandan	8.0	6.2	–	10.0	8.10
4.	Sanura–2	10.5	15.2	17.9	20.0	15.80
5.	Sanura–6	–	–	–	17.0	17.00
6.	Kadaka	14.1	17.5	29.5	12.6	18.40
7.	Seb	8.2	10.2	–	–	9.40
8.	Elachi	6.0	6.6	–	13.0	8.50
9.	Jogia	6.4	5.2	–	–	5.80
10.	Chuhara	12.5	8.8	22.0	13.0	10.11
11.	Manuki	8.5	7.8	–	13.0	9.70
12.	Mehroon	–	–	–	17.0	17.00
13.	Jogia mundia	–	–	–	10.0	10.00

* Fruit borer incidence at peak harvesting stage
– Indicates absence of variety in that locality

4.5.1. Bioefficacy of insecticides against M. scyrodes

Observations on the bioefficacy of insecticides against fruit borer at first harvest indicated that lowest (3.91 per cent) infestation was recorded in monocrotophos 36 SL at 0.04 per cent concentration and highest (21.78 per cent) was found in case of untreated control. The untreated control was found to differ significantly with the rest of the treatments. The lowest incidence recorded in monocrotophos 36 SL was on par with the recommended insecticide dimethoate 30 EC + jaggary solution (at 0.03 + 1.0 per cent concentration). The following treatments viz., dimethoate 30 EC + Jaggary solution, endosulfan 35 EC (0.07 per cent concentration) and dichlorovas 76 EC (0.11 per cent concentration); endosulfan 35 EC, dichlorovas 76 EC and margocide ck 20 EC (0.10 per cent concentration); Neemguard (0.03 per cent concentration) and margocide ck 20 EC were on par with each other (Table 9).. During second harvest highest fruit borer incidence was recorded in untreated control (27.54 per cent) which was significantly higher when compared to rest of the treatments. Lowest fruit borer infestation was recorded in dimethoate + jaggary solution treatment (7.0 per cent) and it was on par with monocrotophos 36 SL treatment. The level of infestations in monocrotophos 36 SL and dichlorovas 76 EC; margocide CK 20

Table 9. Bioefficacy of synthetic and botanical insecticides against ber fruit borer, M. scyrodes

Sl. No.	Treatments	Conc. (%)	Per cent fruit borer incidence at			Mean Per cent incidence
			I harvest	II harvest	III harvest	
1.	Monocrotophos (Nuvacron 36 SL)	0.04	3.91 (11.41)	8.31 (16.76)	11.73 (20.04)	7.99 (16.42)
2.	Endosulfan (Thiodan 35 EC)	0.07	7.27 (15.65)	12.07 (20.34)	12.59 (20.79)	10.35 (18.77)
3.	Dichlorovas (Nuvan 76 EC)	0.11	7.65 (16.06)	10.42 (18.84)	12.32 (20.55)	13.92 (21.91)
4.	Dimethoate + Jaggary (Rogar 30 EC) solution	0.03 + 1.0	5.32 (13.34)	7.00 (15.35)	9.38 (17.84)	7.24 (15.62)
5.	Neemguard	0.03	12.27 (20.44)	15.85 (23.47)	24.11 (29.41)	17.32 (24.60)
6.	Margocide ck 20 EC	1.00	10.18 (18.61)	13.16 (21.28)	19.50 (26.21)	14.68 (22.53)
7.	Untreated control	–	21.78 (27.82)	27.54 (31.66)	35.74 (36.72)	28.36 (32.18)
	S.Em ±	–	1.01	0.92	0.82	1.39
	CD at 5%	–	3.11	2.83	2.54	4.30

Figures in parenthesis indicate angular transformed values

EC, endosulfan 35 EC and dichlorovas 76 EC; Neemguard and margocide CK 20 EC were found to be on par with each other (Table 9).

Lowest fruit borer incidence during third harvest was recorded once again in dimethoate 30 EC + jaggary solution treatment (9.38 per cent) and was on par with monocrotophos 36 SL treatment (11.73 per cent). The highest incidence was again associated with untreated control (35.74 per cent) and it differed significantly with the rest of the treatments. This was followed by botanical insecticides viz., Neemguard (24.11 per cent) and margocide CK 20 EC (19.50 per cent), which varied significantly with each other and with the rest of the treatments. The second lowest incidence was associated with monocrotophos 36 SL which was on par with dichlorovas 76 EC and endosulfan 35 EC treatments. The overall average per cent infestation of fruit borer in three harvests (Table 9) indicated the lowest infestation in dimethoate 30 EC + jaggary solution treatment (7.24 per cent) which was on par with monocrotophos 36 SL and endosulfan 35 EC treatments. The untreated control recorded significantly higher per cent fruit borer infestation (28.36 per cent) when compared to rest of the treatments. The next best pesticides which recorded lowest incidence were dichlorovas 76 EC and margocide CK 20 EC

which were on par with endosulfan 35 EC and Neemguard treatments.

4.5.2. Critical stage(s) of ber plant for insecticide application

Endosulfan 35 EC at 0.07 per cent concentration was applied at different stages of ber plant to identify critical stage(s) against fruit borer, M. scyrodes. At first harvest, lowest incidence of borer was recorded in treatment T_8 (4.10 per cent) wherein six sprays were applied at all the stages of ber plant viz., flowering, pea, marble and maturation stage and was on par with Treatment T_7 (5.07 per cent) wherein, five sprays were applied at pea, marble and maturation stages and treatment T_6 (5.17 per cent) wherein three sprays were applied at marble and maturation stages. The above three treatments were significantly superior over rest of the treatments (Table 10). Untreated control recorded highest borer incidence of 20.93 per cent which was on par with treatment T_1 (19.72 per cent) wherein one spray was applied at flowering stage and treatment T_2 (17.58 per cent) wherein two sprays were applied at pea stage, which recorded significantly higher borer infestation over rest of the treatments. The next highest incidence was associated with treatment T_4 (one spray at maturation stage) and treatment T_5 (four sprays at pea and

marble stages); treatment T_5 and treatment T_3 (two sprays at marble stage), which were on par with each other and differed significantly from rest of the treatments.

Similar results were observed during second harvest but the highest infestation of 28.19 per cent was noticed in treatment T_1(one spray at flowering stage) and the lowest infestation of 5.7 per cent was recorded in treatment T_7 (five sprays) (Table 10).

During the third harvest, highest incidence was found in treatment T_1(34.59 per cent) which received only one spray at flowering stage and was on par with untreated control and both the treatments differed significantly from rest of the treatments (Table 10). The second highest infestation was noticed in treatment T_2 (which received two sprays at pea stage) and varied significantly with rest of the treatments (Table 10). The lowest fruit borer incidence was noticed in treatment T_8 (7.93 per cent) which was on par with treatment T_7 and treatment T_6 and all these three treatments varied significantly with rest of the treatments. The next best treatment which recorded minimum fruit borer infestation was in treatments T_3. One spray at maturation stage (T_4) and four at pea and marble stage (T_5) and were significantly superior at the remaining treatments.

Table 10. Application of insecticide at different stages of ber fruits for the management of fruit borer, *M. scyrodes*

Sl. No.	Treatments	*No. of sprays	Per cent fruit borer incidence at each harvest			Mean Per cent incidence
			I	II	III	
1.	Flowering stage	1	19.72 (26.37)	28.19 (32.07)	34.59 (36.03)	27.50 (31.63)
2.	Pea stage	2	17.58 (24.79)	23.77 (29.18)	24.30 (29.53)	21.88 (27.89)
3.	Marble stage	2	8.80 (17.26)	12.20 (20.46)	15.23 (22.98)	12.10 (20.35)
4.	Maturation stage	1	11.36 (19.88)	14.75 (22.59)	10.73 (22.57)	13.67 (21.71)
5.	Pea and marble stage	4	10.32 (18.75)	15.99 (23.57)	17.16 (24.45)	14.48 (22.37)
6.	Marble and maturation stage	3	5.17 (13.14)	7.11 (15.47)	9.65 (18.10)	7.43 (15.83)
7.	Pea, marble and maturation stage	5	5.07 (13.01)	5.70 (13.81)	8.79 (17.25)	6.59 (14.88)
8.	Flowering, pea, marble and maturation stage	6	4.10 (11.74)	6.26 (14.50)	7.93 (16.36)	6.18 (14.40)
9.	Untreated control	–	20.93 (27.22)	27.71 (31.77)	34.31 (35.86)	27.66 (31.73)
	S.Em ±		0.86	1.01	0.89	0.68
	CD at 5% level		2.59	3.02	2.67	2.03

Figures in parenthesis indicate angular transformed values

* Endosulfan 35 EC at 0.07 per cent concentration

The trend in the overall average per cent infestation of fruit borer in three harvests (Table 10) were quite similar to that of the third harvest. The lowest incidence was associated with treatments T_8, T_7, and T_6 which were on par with each other and were significantly superior to rest of the treatments. The next lowest incidence was noticed in treatments, T_3, T_4 and T_5, which were on par with each and varied significantly from rest of the treatments. The highest incidence was associated from treatments T_9 and T_1 which were on par with each other and differed significantly with rest of the treatments. The second highest incidence of borer was noticed on treatment T_2 which varied significantly with subsequent treatments.

Application of six sprays of insecticide (one spray at flowering stage, two sprays at pea stage, two sprays at marble stage and one spray at maturation stage) recorded lowest incidence which was on par with application of five and three sprays at pea, marble and maturation stages and at marble and maturation stages, respectively.

Discussion

V. DISCUSSION

Ber is one of the important horticulture crops of North Karnataka with extensive cultivation in arid zones in the recent time. The popularity of ber cultivation is because of high returns with minimum cost of cultivation on marginal soils. Until recently fruit fly was the major pest of ber fruits, but now it has been replaced substituted by fruit borer, Meridarchis scyrodes Meyr. (Jejurkar, 1986). Available literature on ber fruit borer in the past is very meager. Thus systematic investigation on survey of insect pests of ber, biology, seasonal incidence, varietal susceptibility, bioefficacy of synthetic insecticides and botanicals and identification of critical stages in ber for insecticide application against fruit borer, M. scyrodes were undertaken in North Karnataka at Raichur, Bijapur and Gangavati Research Stations. The results of the present study are discussed here under.

5.1. Insect pests of ber (Z. mauritiana)

Insects feeding on ber plant were collected from all the three research stations viz., Gangavati, Raichur and Bijapur at fortnightly interval starting from flowering till the end of fruiting season during 1992-93.

Totally 10 insect species belonging to four different orders were collected during survey. Of the 10 species collected, four belonged to Coleoptera and two each belonged to Lepidoptera, Diptera and Hemiptera. Besides, an egg larval parasitoid, Chelonus spp. and a predatory mite were also recorded from Raichur.

Ber fruit borer, Meridarchis scyrodes Meyrick, was found to attack ber fruits in all the three localities and its infestation was severe when compared to fruit fly, which was similar to the results line reported by Jejurkar (1986). Similarly, ber fruit fly Carpomyia vesuviana Costa was found in all three localities. Batra (1953) reported that ber fruit fly was a monophagous pest and was distributed all over India wherever ber is grown and other fruit flies were also found to attack on ber fruits but were of minor importance. In addition to monophagous fruit fly a polyphogous fruit fly, Bactrocera correta (Bezzi) was recorded during the present study from Gangavati during 1992-93.

Ash weevil, Myllocerous undecimpustulatus Faust was noticed at Raichur as a leaf feeder and the same has been reported as a sporadic pest causing hardly any significant loss (Butani, 1979).

Remaining insect species collected on ber *viz.*, leaf eating beetles (Lycidae and Scarabeidae), tree hopper, leaf miner, mealy bug and fruit weevil needs to be identified. However, Nayar et al. (1976) has compiled the list of insect pests reported on ber which may include the above insect species which are yet to be confirmed.

5.2. Biology of fruit borer, M. scyrodes

In the laboratory, egg laying was noticed in the depression near the stalk of the fruit. Freshly laid eggs were silvery white in colour but turn to dirty yellow colour just prior to hatching. Pre-oviposition period ranged for an average of 1.00 days. The number of eggs laid per female ranged from 23 to 35 with an average of 28.00 ± 3.25 eggs. Incubation period ranged between 5 to 6 days with an average of 5.30 ± 0.40 days. The entire larval period lasted for 14 to 18 days with an average of 16.30 ± 3.50 days during which larvae passed through five instars. The average duration of each instar viz., 2.00, 2.00 ± 0.52, 3.00, 3.70 ± 0.80 and 5.20 ± 0.78 days from first to fifth instar respectively. The first and second instar larvae were of dirty white in colour with dark brown head. During the third instar, the larvae slightly turns into pink colour at its rear end. The fourth and fifth instars turn dark pinkish with dark brown head.

A newly hatched larvae bores into fruit and feeds on pulp. Gradually the larvae reaches the seed surface and feeds on pulp around seed, till it completes its larval period. The damaged fruit is filled with excreta along with larvae. More than one larva was also found in a single fruit. Full grown larva came out of the fruit and pupates in soil. Prepupal and pupal period ranged from 1 to 2 and 7 to 8 days, respectively. The male and female adults in the presence of food survived for an average of 2.65 $\pm$ 0.5 and 3.70 $\pm$ 0.27 days, respectively.

Adults were brownish black in colour. The wings and body were heavily covered with scales. Abdominal size of female moth was slightly bigger than that of male. The life cycle of the insect pest was completed in about 30 days. Information on the biology of fruit borer is very much limited. Issac (1927) for the first time reported that the pest can be reared under laboratory conditions, but the details are not available. Later Sonawane (1965) has given the detailed account of the biology of the pest under laboratory conditions. His observations on life cycle of fruit borer were more or less in agreement with the present findings except for following aspects. In the laboratory, he observed egg laying apart from on the fruits, on blotting paper and

other surfaces which was not observed during the present investigation. There was a slight variation in pre-oviposition (1 to 2 days), fecundity (11 to 34) and incubation period (4 to 7 days). This may be due to variation in laboratory conditions. The total larval period, nature of damage, prepupal period, pupal period, adult longivity and total life cycle were almost on par with the present observations.

Chelonus Spp. (Hymenoptera: Braconidae), an egg-larval parasitoid and a predatory mite (indentity needs to be confirmed) were the two natural enemies recorded on the eggs of ber fruit borer in the present study. The available literature in the past indicates absence of reports on natural enemies on the eggs of fruit borer, but Ayyar (1923) and Butani (1973) have reported few larval parasites of fruit borer.

5.3. Seasonal incidence of M. scyrodes

Seasonal incidence of fruit borer was recorded at weekly interval at the Agricultural Research Station. Gangavati and fortnightly interval at the Regional Research Station, Raichur and Bijapur.

The fruit borer incidence at Gangavati started in third week of November. Thereafter infestation increased suddenly to reach peak in the third week of December (35.70 per cent). Later the level of infestation continued to decrease gradually till the end of fruiting season. The pest prevailed during fruiting season only i.e, from the third week of November to the third week of January (Fig 3).

Similar trend of fruit borer incidence was observed at Bijapur during 1992-93 and at Raichur during 1992-93 and 1993-94 (Fig. 4). These findings indicate that infestation of fruit borer starts from the second fortnight of November and reach peak (average of 30.30 per cent) in the second fortnight of December at both the research stations. Similarly fruit borer disappeared completely at the end of the first fortnight of January.

Ayyar (1923) observed fruit borer activity from July to August which which contradicts the above observations. This may be due to the difference in fruiting period itself. Similarly observations in seasonal incidence of fruit borer made by Sonawane (1965) reveal that the pest prevailed only during fruiting period which are in confirmity with the present observations. However, he reported beginning of fruit

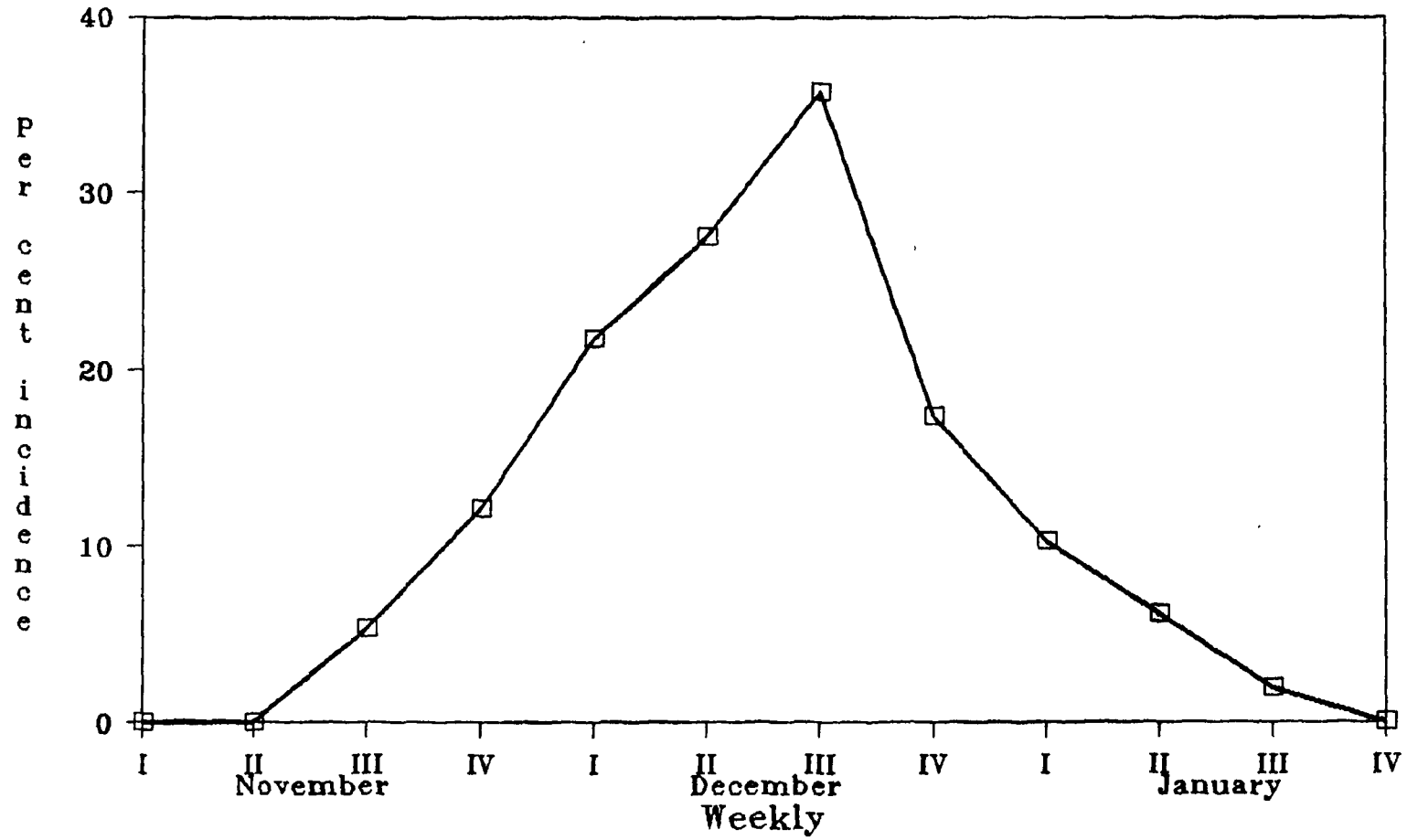

Fig. 3. Seasonal incidence of fruit borer, M. scyrodes at Gangavati during 1992-93

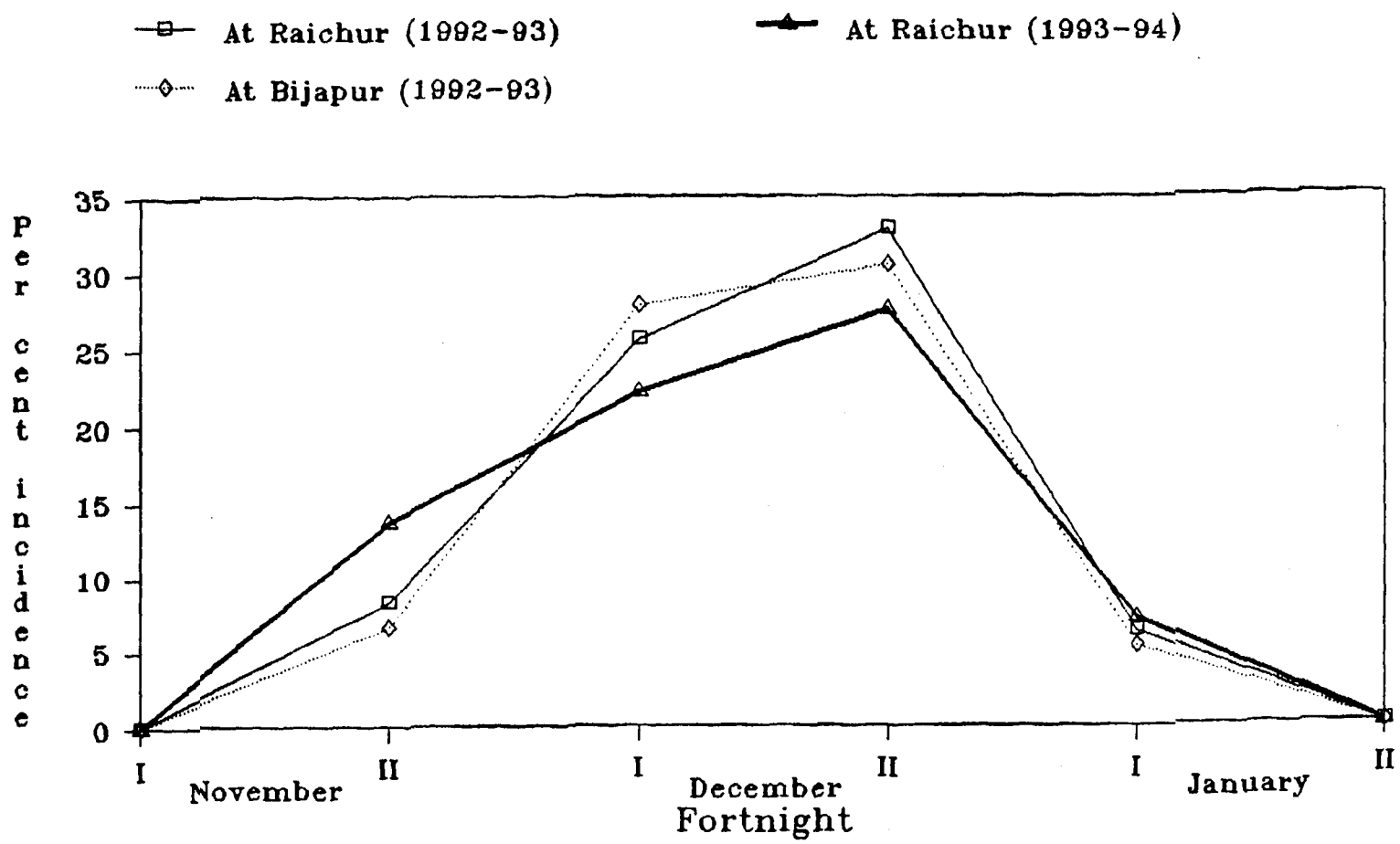

Fig. 4. Seasonal incidence of fruit borer, M. scyrodes on Umran variety at Bijapur and Raichur

borer incidence in the last week of September, which is quite earlier when compared with present observations. This variation may be due to early pruning of varieties which results in early setting of fruits. He observed peak infestation in the second week of November contrary to the present findings. Further he observed the borer to prevail till the end of the season i.e, up to third week of January which agrees with the present findings.

5.4. Varietal susceptibility to M. scyrodes

The varietal susceptibility study was undertaken at three research stations during 1992-93 and only at Regional Research Station, Raichur during 1993-94.

The varieties depending upon the level of infestation were grouped into four classes according to Sonawane (1965) which are as follows.

i) Resistant - upto 5% infestation.

ii) Moderately resistant - 5.1 to 15% infestation

iii) Susceptible - 15.1 to 40% infestation

iv) Highly susceptible - more than 40% infestation.

The results presented in Fig. 5 shows that none of the varieties screened were resistant to fruit borer.

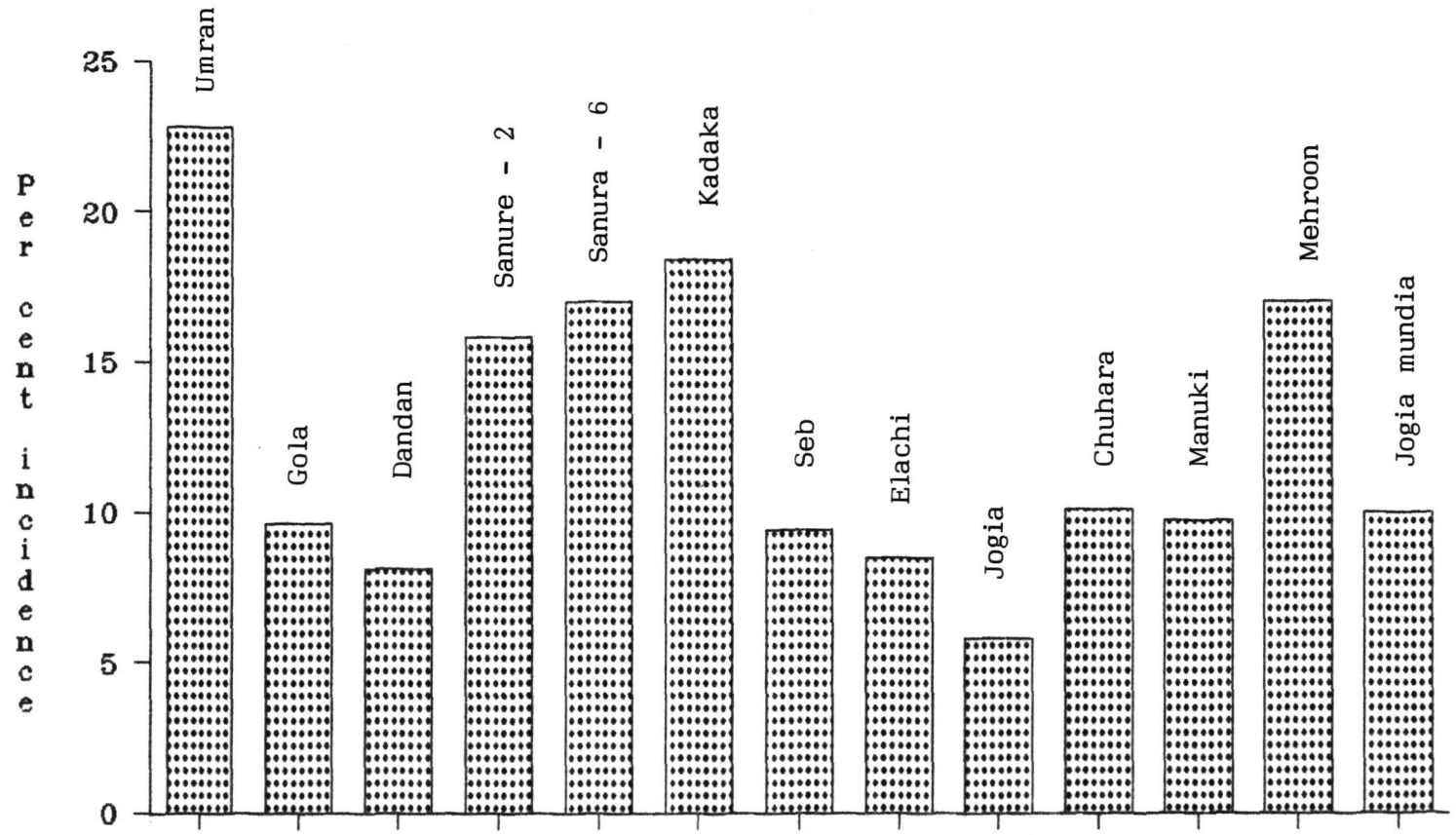

Fig. 5. Incidence of ber fruit borer on different varieties in North Karnataka

Eight of the thirteen varieties screened *viz.*, Chuhara, Jogia Mundia, Mounki, Gola, Seb, Elachi, Dandan and Jogia were found to be moderately resistant by recording less than 15% fruit borer infestation. Umran, Kadaka, Sanura-6, Mehroon and Sanura-2 were found to be susceptible with more than 15 percent fruit borer incidence.

Khare (1923) observed Nagpuri variety to be highly susceptible but its cultivation of this is not in vogue at the study localities. Sonawane (1965) recorded four resistant, 41 moderately resistant, 37 susceptible and 11 highly susceptible varieties. The variety `mehroon` which he classified into resistant variety was found to be a susceptible variety in the present study. The level of resistance/susceptibility in remaining varieties is in agreement with his observations.

Similarly Jejurkar (1986) found Kadaka variety to be highly susceptible to fruit borer which however is included under susceptible category. The popular variety Umran was reported to be a susceptible variety by Shevale and Padule (1992) which recorded an average incidence of 36.68 per cent which agrees with the present findings.

5.5 Management of ber fruit borer, M. scyrodes

5.5.1. Bioefficacy of insecticides

The experiment was conducted at the Agricultural Research Station, Gangavati, during 1992-93 wherein different synthetic and botanical insecticides along with a standard check were included as treatments and spray was applied at fortnightly interval for six times starting from 50 per cent flowering.

The results indicate that bioefficacy of synthetic insecticides in the management of fruit borer was relatively superior to botanical insecticides. The standard check dimethoate 30 EC + jaggary solution (at 0.03 + 1.0 per cent concentration) recorded lowest incidence of fruit borer (7.24 per cent) which was on par with monocrotophas 36 SL (at 0.04 per cent concentration) and endosulfan 35EC (at 0.07 per cent concentration). The untreated control recorded highest borer infestation of 28.36 per cent.

Jejurkar (1986) recommended malathion (at 0.05 per cent concentration), Phosphomidon (at 0.03 per cent concentration) and dimethoate (at 0.03 per cent concentration) as economical and effective insecticides against fruit borer which is in agreement with present findings. He recommended

only three sprays but during the present study six sprays of dimethoate 30 EC were applied along with jaggary solution. Based on the efficiency, economics and concentration of insecticides, Shevale and Padule (1992) recommended deltamethrin at 0.002 per cent, fenvalerate at 0.01 percent and quinolphos at 0.05 per cent. However, these insecticides were not included in the present study for comparisons.

5.5.2. Critical stage(s) of ber plant for insecticide application

The experiment was carried out at Gangavati during 1992-93. Four critical stages were identified in ber plant and endosulfan 35EC at 0.07 per cent concentration was sprayed on Umran variety at fortnightly interval such that one spray each at flowering and maturation stages and two sprays each in pea and marble stages were given. Accordingly nine different combinations of critical stages were imposed as different treatments.

Observations of investigation reveal that lowest incidence of fruit borer viz., 6.18 per cent, 6.59 per cent and 7.43 per cent were associated with application of insecticide at flowering, pea, marble and maturation stages (six sprays); at pea, marble and maturation stages (five

sprays) ; and at marble and maturation stages (three sprays). respectively.

The untreated control and application of one spray at flowering stage recorded highest fruit borer infestation followed by one application at pea stage.

The overall results indicate that application of insecticide alone at flowering stage (one spray), pea stage(two sprays) marble stage (two sprays), maturation stage (one spray) and at pea and marble stages (four sprays) was of no practical significance, since they recorded higher fruit borer infestations. Among the different combinations of critical stages which recorded lowest fruit borer incidence, combination of marble and maturation stages received lowest of only three sprays. Spraying alone at maturation stage was found inferior to spraying at marble and maturation stages. Thus it could be concluded that critical stages of ber plant for insecticide application to manage fruit borer were marble and maturation stages which received two and one spray respectively (totally three sprays).

The present findings are more or less in agreement with the report of Jejurkar (1986), who recommended three sprays at an interval of twenty one days starting from pea

stage to fruits of first flush. Similarly Shevale and Padule (1992) recommended two sprays of insecticide application at an interval of 15 days starting from (first flush) pea nut size. This slight variation may be because of use of different insecticides other than that used during present investigation.

Since egg laying of fruit borer was observed during maturation stage of the fruits, application of insecticide before and during maturation stage helps in reducing borer infestation significantly.

Future line of work

The following research work on fruit borer are suggested

1) Studies on the carry over of the fruit borer during off season.
2) Studies on the alternate hosts of fruit borer
3) Studies on different synthetic and botanical insecticides applied during marble and maturation stages of ber fruit and their residue analysis
4) Role of predatory mite and other natural enemies on fruit borer.

VI. SUMMARY

Studies on survey of insect pests attacking ber plant in North Karnataka; biology, seasonal incidence, varietal susceptibility, bioefficacy of synthetic and botanical insecticides and identification of critical stages of ber plant for insecticidal application against ber fruit borer, M. scyrodes were undertaken during 1992-93 and 1993-94. The results of the investigations are summarised below.

Survey carried out to collect insect pests of ber at Gangavati, Raichur and Bijapur during 1992-93 indicated presence of fruit borer, Meridarchis scyrodes Meyrick and fruit fly Carponemyia vesuviana Costa in all the above three research stations. A polyphagous fruit fly, Bactrocera correta (Bezzi) and ash weevil Myllocerous undecimpustulatus Faust were collected from Gangavati and Raichur, respectively. Identity of some of the insect pests collected are yet to be confirmed and they are as follows; leaf eating beetles (Lycidae and Searabeidae), tree hopper, leaf miner, mealy bug and fruit weevil.

Laboratory studies on the life history of fruit borer, M. scyrodes indicated that the egg, larva, prepupa and

pupal periods averaged 5.27 ± 0.44, 16.30 ± 3.50, 1.20 ± 0.40 and 7.50 ± 0.80 day, respectively. Fecundity ranged from 23 to 35 eggs. The larva completed five instars. Early instars were dirty white coloured and late instars were pinkish colour. Till the completion of larval period, it was found feeding inside the fruit. Full grown larvae was observed to pupate in soil. Adults were of brownish black with full of scales on its body. The longevity of male and female adults in the presence of food was 2.65 ± 0.50 and 3.7 ± 0.77 days, respectively. One generation was completed in about 30 days.

An egg larval parasitoid, Chelonus spp. and a predatory mite were recorded as natural enemies on eggs of fruit borer.

Fruit borer incidence at Gangavati was first noticed in the third week of November. Later, the borer infestation gradually increased to reach peak during third week of December and thereafter declined till the end of fruiting season. The pest activity was noticed upto the third week of January. Similar trend of borer incidence was observed at Bijapur and Raichur locations.

Among the varieties of ber screened for fruit borer susceptibility, Umran and Kadaka and Sanura-6 recorded highest

infestation and Jogia, Dandan and Elachi recorded lowest infestation. None of the varieties screened were found to be resistant to fruit borer attack.

The bioefficacy of different insecticides screened against ber fruit borer indicated that the standard check dimethoate 30 EC + jaggary solution (at 0.03 + 1.0 per cent concentration) was found to be the best insecticide followed by monocrotophos 36 SL (at 0.04 per cent concentration) and endosulfan 35 EC (at 0.07 per cent concentration).

Studies to identify the critical stage(s) of ber plant for effective insecticide application to control fruit borer indicated that application of two sprays at marble stage and on spray at maturation stage of the ber fruit recorded minimum infestation and was more economical than other critical stage combinations.

REFERENCES

VII. REFERENCES

ANONYMOUS, 1917, Tiger beetle borer of coffee. Planters Chronocle, Bangalore, 12: 14-16.

AYYAR, T.V.R., 1923, Short notes on some South Indian insects. Report of Proceedings of 5th Entomological Meeting, Pusa: 263-269.

AYYAR, T.V.R., 1925, The Nim mealy scale. Pulvinaria maxima Green. Memories of Department Agriculture India Entomology, 8: 125-155.

BASHA, J.M.G., 1952, Experiments on control of fruit borer of jujubae (Zizyphus spp.) Carpomyia vesuviana Costa and Meridarchis scyrodes Meyr. in South India. Indian Journal of Entomology, 14: 229-238.

BATRA, H.N., 1953, Biology and control of Dacus diversus Coquillett and Carpomyia vesuviana Cocsta and important notes on other fruit flies in India. Indian Journal of Agricultural Sciences, 23: 87-112.

BEESON, C.F.C., 1919, Food plant of Indian forest insects. Indian forester, 14: 312-323.

BOSE, T.K. AND MITRA, S.K., 1990, Fruits: Tropical and subtropical. NAYA PROKASH, 206, Bidhan Saroni, Calcutta - 700006, India. p.838.

BRAIN, C.K., 1920, The coccidae of South Africa. Bulletin of Entomological Research, 11: 1-42.

BUTANI, D.K., 1973, Insect pests of fruit crops and their control-1. Ber. Pestcides, 7: 33-35.

BUTANI, D.K., 1979, Insects and fruits, Periodicals expert Book agency, Delhi and International Book distributors, Dehradoon. pp. 415.

EWING, H.E., 1922, Three new species peculiar injurious spider mites. Proceedings of Entomological Society of Washington, 22: 104-108.

FLETCHER, T.B., 1916, One hundred notes of Indian insects. Agricultural Research Institute Pusa Bulletin, 59:28.

FLETCHER, T.B., 1920, Pests of fruit crops. Proceedings of Third Entomologists Meet, p.253.

GLOVER, P.M., 1939, Entomological section. Report of the Indian Lac Research Institute, Namkum, pp.22-31.

HALL, W.J., 1921, Hibiscus mealy bug (Pseudococcus hibisci Hamip.). Bulletin of Society of Entomology d'Egypte, 14: 17-29.

ISSAC, P.V., 1927, Rept. of Imperical Entomologist. Science Report on Agricultural Institute Pusa, pp. 71-78.

JEJURKAR, N.K., 1986, Studies on ber fruit borer (Meridarchis scyrodes Meyr.) and ber fruit fly (Carpomyia vesuviana Costa) in respect of losses caused, susceptibility to pestcides. M.Sc. (Agri.) Thesis submitted to Mahatma Phule Agricultural University, Rahuri.

KERR, 1781, Philosophical transactions. Abstract of Bulletin of Entomological Research Institute, Pusa, 143: 1-6.

KHARE, J.L., 1923, Ber fruit (Z. jujuba Lamk.) and its fly pest. Bulletin of Agricultural Research Institute Pusa, 143: 16.

LAKRA, R.K. AND BHATTI, D.S., 1985, Insect pests of `ber' with special reference to fruit fly Carpomyia vasuviana Costa. Paper presented at 3rd National Workshop on Arid Zone Fruit Research, Rahuri.

LEFROY, 1909, Indian Insect Life. W. Thacker and Co. 2, Creed Lane, London.

MARSHALL, G.A.K., 1941, Anew injurious curcnlionidae. Bulletin of Entomological Research, 31: 403-406.

MATHUR, R.N. AND SINGH, B., 1960, a list of insect pests of forest plants in India and adjacent countries. Indian Forest Bulletin, 171: 94-111.

MAULIK, S., 1916, A new chlamys from Calcutta. Records of Indian Mueseum, 12: 101-103.

MAYNE, R.P., 1914, Papilio demoleus L. (Citrus butterfly). Bulletin of Agriculture Belgereo Congress., 4: 598-600.

MEYRICK, E., 1916, M. scyrodes Meyr. Exotic Microlepidoptera, 2:1.

NAYAR, K.K., ANANTHAKRISHNAN, T.N. AND DAVID, B.V., 1979, General and Applied Entomology. Pb. Tata McGraw Hill Publication, New Delhi. pp.589.

NEWSTEAD, R., 1917, Observations on scale insects, coccidae. Bulletin of Entomological Research, 7(2): 125-134.

PAREEK, O.P., 1983, "THE BER". Indian Council of Agricultural Research, New Delhi.

PRUTHI AND BATRA, 1960, Some important fruit pests of North West India, Pest of jujuba, I.C.A.R., Bulletin, Pb. New Delhi 80: 61.

REHMAN, K.A. AND SAPPRA, A.N., 1940, Mites of the family tetranychidae from Lyallphr with description of four new species. Proceedings of Indian Academi of Science, 11: 177-196.

REHMAN, K.A AND ANSARI, A.R., 1941, Scale insects of Punjab and N.w.F.P. usually mistaken for San jose scale (with description of two species). Indain Journal of Agricultural Science, 11: 816-830.

SHEVALE, B.S. AND PADULE, D.N., 1992, Comparative efficiacy of various insecticides against ber fruit borer (Meridarchis scyrodes Meyr.) Maharashtra Journal of Horticulture, 6: 17-19.

SONAWANE, B.R., 1965, Study of pests of tropical ber with special reference to fruit borer Meridarchis scyrodes Meyr. M.Sc. (Agri.) Thesis submitted to Poona University, Poona.

TAKAHASHI, R., 1939, Two new diaspine coccidae from India and Phillipines (Hemiptera). Tenthredo, 2: 339-343.

VERMA, R.S., SHAW, S.S., BADAYA, A.K. AND PARSAI, S.K., 1993, Tingid leaf bug : A new pest of ber. Current Research, 106: 106.

APPENDICES

Appendix I. Meteorological data of Regional Research Station, Raichur during 1992

Month	Temperature °C		Relative humidity	Total rainfall (mm)
	Maximum	Minimum		
January	30.10	16.16	81.00	–
February	34.34	18.57	62.62	–
March	39.13	21.21	44.30	–
April	40.13	23.94	54.53	–
May	40.00	24.47	67.70	205.6
June	35.49	22.94	60.80	62.2
July	34.14	29.93	67.74	110.8
August	31.96	21.81	69.03	123.2
September	33.00	22.22	63.50	105.2
October	32.68	18.98	67.55	42.0
November	30.80	17.47	64.20	155.0
December	29.10	16.18	61.37	–

Appendix II. Meteorological data of Regional Research Station, Raichur during 1993

Month	Temperature °C		R.H.		Total Rainfall (mm)
	Maximum	Minimum	Morning	Afternoon	
January	31.99	14.80	53.20	14.10	–
February	33.48	16.75	42.57	11.37	–
March	37.12	21.70	36.45	12.70	6.4
April	40.27	24.88	50.07	29.64	15.2
May	41.06	26.27	59.38	27.11	35.6
June	37.50	24.90	71.33	36.13	28.2
July	34.57	23.61	76.41	44.22	133.5
August	30.55	26.67	84.00	52.35	262.2
September	30.99	21.83	83.64	53.16	172.0
October	31.98	22.10	86.00	61.00	280.6
November	30.20	17.10	80.00	41.80	1.4
December	28.90	15.50	86.00	41.12	23.2

Appendix III. Meteorological data for the year 1992–93 at Agricultural Research Station, Gangavati.

Month	Temperature (°C)		Relative humidity		Total rainfall (mm)
	Maximum	Minimum	Morning	Afternoon	
January	–	29.00	80.40	38.00	–
February	–	33.30	69.80	31.20	–
March	–	37.10	67.80	22.30	–
April	–	38.75	64.67	24.30	20.40
May	–	40.20	72.00	29.70	66.60
June	–	35.10	75.19	44.76	67.70
July	23.80	33.10	77.90	51.50	21.20
August	22.94	31.52	84.45	60.25	87.80
September	21.89	32.41	80.06	56.33	73.40
October	22.32	31.92	83.70	54.09	34.30
November	19.86	29.30	84.10	0.90	275.70
December	14.55	43.77	84.25	43.77	–
January	15.00	30.36	82.00	38.74	–

Appendix IV. Meteorological data for the year 1992–93 at Regional Research Station, Bijapur

Month	Temperature (°C)		Average relative humidity(%)	Total rainfall (mm)
	Maximum	Minimum		
April	39.9	29.4	50	–
May	39.6	28.4	72	19.5
June	35.4	28.3	87	62.2
July	31.8	28.3	85	100.1
August	30.5	28.9	91	87.6
September	32.5	24.9	84	48.8
October	29.9	28.1	82	–
November	29.4	26.6	76	119.6
December	29.4	18.7	63	–
January	30.2	16.2	56	–
February	32.9	18.1	47	–
March	36.0	21.3	45	–
Total				437.8

Appendix V. Daily temperature and relative humidity under laboratory conditions at Raichur during November, 1994

Month/ Day	Temperature (°C)		Relative humidity(%)	
	Maximum	Minimum	Morning	Afternoon
November				
1	26	20	75	65
2	26	21	80	63
3	26	20	70	60
4	26	20	85	62
5	26	21	87	57
6	25	21	83	63
7	25	20	85	65
8	25	22	85	75
9	25	19	87	60
10	23	20	76	72
11	21	19	86	70
12	21	18	85	75
13	24	19	85	63
14	24	20	85	65
15	25	20	94	70
16	26	20	87	67
17	27	22	85	65
18	28	22	78	52
19	27	22	85	60
20	27	21	84	60
21	27	21	74	48
22	26	21	85	65
23	26	20	70	60
24	26	20	87	65
25	26	19	65	55
26	25	19	68	55
27	25	19	65	60
28	24	18	62	61
29	24	19	65	61
30	24	17	65	60

Appendix VI. Daily temperature and relative humidity unde laboratory conditions at Raichur during December 1994

Month/ Day	Temperature (°C)		Relative humidity	
	Maximum	Minimum	Morning	Afternoon
December				
1	24	18	70	60
2	24	18	75	65
3	22	19	76	70
4	22	17	72	70
5	20	15	75	65
6	21	17	76	70
7	21	18	75	65
8	22	18	70	65
9	23	19	72	65
10	24	20	72	62
11	23	19	93	70
12	24	19	92	65
13	23	19	75	60
14	23	18	55	48
15	23	17	60	47
16	23	17	72	62
17	22	17	75	62
18	22	17	73	56
19	20	17	80	70
20	21	17	85	62
21	24	16	82	75
22	24	18	62	62
23	23	17	83	75
24	22	17	85	75
25	22	17	75	80
26	21	17	75	80
27	20	17	83	70
28	21	16	72	73
29	23	18	90	80
30	24	18	85	70
31	24	19	85	80