Studies on the life cycle of Hadda beetle (*Henosepilachna vigintioctopunctata*) and its management on bitter gourd (*Momordica charantia* Linn.)

THESIS

Submitted to

Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur

In partial fulfilment of the requirements for the Degree of

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In

AGRICULTURE

(ENTOMOLOGY)

By

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2020

CERTIFICATE – I

This is to certify that the thesis entitled ***"Studies on the life cycle of Hadda beetle (Henosepilachna vigintioctopunctata) and its management on bitter gourd (Momordica charantia Linn.)"*** *submitted in partial fulfilment of the requirements for the degree of* ***MASTER OF SCIENCE IN AGRICULTURE*** *in the* ***Department of Entomology*** *of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of the bonafide research work carried out by* ***Mr. Bajrang Lal,*** *I.D. No.* ***180219003*** *under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instruction.*

No part of the thesis has been submitted for any other degree or diploma (Certificate awarded etc.) or has been published part has been fully acknowledged. all the assistance and help received during the course of the investigation has been duly acknowledged by him.

Place: Rewa
Date:

Dr. M. R. Dhingra
(Chairman of the Advisory Committee)

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

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Member	**Dr. R. K. Tiwari**	

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This is to certify that the thesis entitled ***"Studies on the life cycle of Hadda beetle (Henosepilachna vigintioctopunctata) and its management on bitter gourd (Momordica charantia Linn.)"*** *submitted by* ***Mr. Bajrang Lal*** *to the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur in partial fulfilment of the requirements for the degree of* ***MASTER OF SCIENCE IN AGRICULTURE*** *in the* ***Department of Entomology*** *has been, after evaluation, approved by the External Examiner and by Student's Advisory Committee after an oral examination on the same.*

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Declaration and Undertaking by the Candidate

I, **Bajrang Lal** S/o **Shri Satya Narayan** certify the work embodied in the thesis entitled **"Studies on the life cycle of Hadda beetle (*Henosepilachna vigintioctopunctata*) and its management on bitter gourd (*Momordica charantia Linn*.)"** is my own first time bonafide work carried out by me under the guidance of **Dr. Dr. M. R. Dhingra** Associate Professor, Department of Entomology, College of Agriculture, Rewa (M.P).

The matter embodied in the thesis has not been submitted for the award of any other degree/diploma. Due credit has been made to all the assistance and help.

I, undertake the complete responsibility that any act of misinterpretation, mistakes, and errors of fact are entirely of my own.

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Place: **Rewa (M.P.)** **(Bajrang Lal)**

Date:

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LIST OF ABBREVIATION AND ERRATA

Symbol	Abbreviation	Stand for
@		At the rate of
±		Plus or minus
%		Percentage
>		More than
<		Less than
°c		Degree centigrade
	CD	Critical difference
	Hrs	Hours
	Max	Maximum
	Min	Minimum
	NS	Non significant
	S	Significant
	SEm±	Standard error of mean
	SMW	Standard meteorological week
	Temp	Temperature
	Kg	Kilogram
	M	Meter
	L	Liter
	DAS	Days after spray
	Mm	Millimeter
	Cm	Centimeter

CHAPTER – I

INTRODUCTION

INTRODUCTION

Bitter gourd (*Momordica charantia* Linn.) is an important vegetable crop belong to the genus *Momorodica*, family Cucurbitaceae. Its fruits are one of the bitterest fruits which contain a bitter compound called momordicine. It is extensively cultivated crop in the country and occupy the second position at global level. It is consumed as a vegetable to control many health problems of human being as an anti-diabetic, stimulant, stomachic, laxative, blood purifier as well as antidotal, antipyretic, appetizing and antibilious (Sandhya *et al.* 2000). All parts of the bitter gourd are useful but seeds are rich source of protein and oil (Ali *et al*. 2008). The calorific values for leaf, fruit and seed were 213.26, 241.66 and 176.61 Kcal/100 g respectively. The elemental analysis of *M. charantia* leaf revealed the presence of potassium (413 ppm), sodium (2200 ppm), calcium (20510 ppm) as well as zinc (120 ppm). Other elements found present in the leaf include magnesium, iron, manganese and copper. Vitamin A (β-carotene) (0.03 ppm), vitamin E (ȧ-tocopherol) (800 ppm), folic acid (20600 ppm), cyanocobalamin (5355 ppm) and ascorbic acid (66000 ppm) were present. Trace amount of some other vitamins such as niacin (B3), pyridoxine (B6) cholecalciferol (Vitamin D) and phylloquinone (Vitamin K) were also found present in the methanolic and pet-ether leaf extract of *M. charantia.* Phytochemicals like alkaloids, tannins, flavonoids, saponins and glycosides were also found present. (Bakare R. I. *et al.* 2010).

Bitter gourd occupies an area of 99, 8.454 and 0.537 thousand hectares in India, Madhya Pradesh and Rewa district respectively and the productivity varies 121.60 q/ha, 108.20 q/ha and 112.70 q/ha respectively (Anonymous 2019).

Bitter gourd is attacked by many insect pests but red pumpkin beetle, fruit fly or melon fly and aphid are important insect pest in addition to Epilachna beetle whose two species *E. vigintioctopunctata* and *E. dodecastigma* these are major pest of this crop and predominantly found in the region and causing quantitative

yield loss to the crop at national and regional level. Both grubs and adults are damaging stage and feed on the foliage by scraping the green part of leaves present of transparent leaves (skeletoinization) are the symptoms of damage. Under the severe infestation the young plant dies.

The beetles belonging to the *Epilachninae* constitute one sixth of the known species of the coccinellidae. The genus *Epilachna* has nearly 500 phytophagous species and is widely distributed in South East Asia, Australia, Sri Lanka, East Indies, Malaya, America, Siberia, China and India.

In India, the beetle is present in higher hills and in plains of Jammu and Kashmir, Punjab, Himachal Pradesh, Uttar Pradesh, Madhya Pradesh, Karnataka and Bengal.

Epilachna vigintioctopunctata is closely related herbivorous ladybird beetles that have diversified greatly in external morphology and host plant use in and around Indian sub-continent. It is a polyphagous plant feeder and has turned out as destructive pest of many cultivated and wild crops belonging to Solanaceae, Cucurbitaceae, Fabaceae, Convulvulaceae and Malvaceae family such as brinjal, tomato, potato, tobacco, melon, cucumber, gourds and pumpkin in Jammu And Kashmir and in other parts of India. It has also been reported of causing damage to some medicinal plants like *Datura stromonium* L., *D. Metel* L., *D. innoxia* Mill., *Solarium aviculare* Forst., *S. nigrum* L., *Withania sominfera* Dunal., *Physalis minima* L. and wild species of *Amaranthus caudatus* L. (Ganga and Chetty, 1982; Wilson, 1989).

Epilachna vigintioctopunctata is a pest of Bitter gourd, *Momordica charantia* and it showed many life cycles in a year. A single female of *Epilachna vigintioctopunctata* laid 211 to 328 eggs during life span. Eggs were hatched into grubs within 5 to 11 days. The pupal period lasted for 3 to 5 days with an average of 4.4 ± 0.89 days. The average longevity of male and female was 51.4 and 64.8 days

respectively. The pre-oviposition, oviposition and post-oviposition period were 21.4, 26.6 and 21.6 respectively. (Tayde AR and Simon S. 2013).

In a Bitter gourd pest are usually controlled through cultural, mechanical, biological and chemical methods. Indiscriminate and frequent use of insecticide in the Bitter gourd has resulted many side effects and limitations specially development of pest resistance, environmental contamination, residual effects of the consumer, destruction of beneficial insects etc. Although at present, the emphasis of pest control is on the minimum use of chemical insecticides maximum use of other regulatory mechanism, despite that chemical control is still a very common practice to the farmers in developing countries like India because of its quick and obvious action. On the other hand, ever-increasing development of modern insecticides has contributed to a great extent in controlling many important insect pests. The use of insecticides could be more effective when selection of chemicals, doses, methods and time of application are properly followed.

The knowledge of the population dynamics of natural enemies is as important as the knowledge of population dynamics of pest species. Sufficient number of natural enemies regulates and keeps the population of pests under control. Therefore, understanding of seasonal emergence, correct time of peak parasitization, and time of activity of natural enemies helps to utilize the natural enemies as a mean of eco-friendly control measures of pest. Natural enemies of *Henosepilachna* spp. have been recorded from various parts of the country and also outside India. Immature stages (i.e. egg, grub, pupa) of *Henosepilachna* spp. are subjected to attack by number of parasitoids *viz*., *Pediobius foveolatus* (Crawford) (Hymenoptera: Eulophidae), *Pleurotropis epilachnae* Rhower (Hymenoptera: Eulophidae), *T. ovulorum* Ferriera (Hymenoptera: Eulophidae), *Chrysocharis appannai* (Hymenoptera: Eulophidae) etc. Among the various natural enemies which attack *H. vigintioctopunctata*, two

parasitoids i.e. *Tetrastichus* sp. and *P. foveolatus* are of great importance and have been extensively reviewed many times in literature. Therefore, keeping in views the importance of natural enemies to regulate the population density of *Henosepilachna* spp., the studies on occurrence of natural enemies of *Henosepilachna* spp. have been carried out. Looking to the information on pests scenario and the productivity of crop, the present investigation is planned to conduct experiments with the following objective: -

1. To study of the lifecycle of Epilachna beetle on various host plant.
2. Evaluation of efficacy of new insecticide against Epilachna beetle under the climatic condition of Rewa district.
3. Occurrence of the natural enemies at various stage of the beetle during its life cycle.

CHAPTER – II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Biology of *Epilachna* beetle:

Ghosh and Senapati 2001. Studied its biology and seasonal fluctuation on brinjal under Terai region of West Bengal. It was reported that the life cycle was shortest in June (26.74), July and longest in September, October (33.52 days) but the highest fecundity was 272.32 eggs. Also, the life cycle was significantly and negatively correlated with temperature and relative humidity but fecundity was positively correlated.

Kaur and Mavi 2005. Carried out the morphometric studies of various stages of *E*. *vigintioctopunctat* reared on brinjal variety 'Punjab Barsati' and observed that the freshly laid eggs were yellow, elongated oval with mean values of length and width as 1.09 ± 0,04 mm and 0.32 ± 0.03 mm, respectively. The grubs were yellow, elongated and oval with branched spines on thoracic and abdominal segments with mean length values of I^{st}, II^{nd}, III^{rd} and IV^{th} instars of grubs as 1.90 ± 0.04, 2.97 ±0.13, 4.45 ± 0.27 and 6.80 ± 0.25 mm, respectively and the mean values of width as 0.71 ± 0.06, 1.01 ± 0.07, 1.79 ± 0.11 and 3.28 ± 0.08 mm, respectively. The ratios of the length and the width of the first and the last instar grubs were 1: 3.58 and 1: 4.61, respectively. The pupae were hemispherical in shape with mean length and width as 7.05 ± 0.44 and 4.00 ± 0.41 mm, respectively. The male and female adults were brown having 7-14 spots on each elytron and the mean values of length and width of male and female adults were 5.85 ± 0.32, 6.85 ± 0.23 mm and 4.55 ± 0.42, 5.05 ± 0.15 mm, respectively.

Kaur and Mavi 2005. Reported that, the newly laid eggs of *Henosepilachna vigintioctopuntata* incubated on an average of 5.20 days with the range of 3-8 days and pupae were glued on leaves, stems and base of the plant with mean pupal period of 4.10 days under laboratory conditions on brinjal.

Venkatesha MG 2006. Conducted on the completed life cycle in 20.15±1.50 days on *W. somnifera.* The longevity of the male and female adults of the pest was 22.07±3.71 and 31.07±4.38 days, respectively. The gravid females of *H. vigintioctopunctata* laid an average of 287.64±33.38 eggs during their oviposition period of *10AO±2.80* days.

Hossain *et al.* 2008. Studied the biology and food consumption of *Epilachna* beetle in Bangladesh, using bitter gourd leaves as food. Mating period generally lasted for 2.4 hours. A female laid on an average of 260 ±20.15 eggs. The mean incubation period was 4.30 ±0.13 days with 93.18 per cent hatchability. The grubs completed 4 instars with in 11.30 ± 0.48 days. The duration of I^{st}, II^{nd}, III^{rd} and IV^{th} instars was 2.25 ± 0.13, 3.25 ± 0.08, 2.55 ±0.15 and 3.25 ± 0.12 days, respectively. The pre-pupal and pupal stages were lasted 1.0 ± 0.00 and 4.7 ± 0.20 days, respectively. The pre-oviposition period was 4.25 ± 0.13 days whereas the oviposition period was 9.40 ± 0.33 days. Adult longevity was 29.8 ± 0.98 days. The insect completed its life cycle in 21.3 ± 0.81 days. The larva and adult consumed 3650 mm and 18832 mm of leaves, respectively in terms of area.

Varma and Anandhi 2008. Studied the morphometries *of E. vigintioctopunctata* on brinjal and reported that the eggs were yellowish and cigar shaped. The average length and width of 1^{st}, 2^{nd}, 3^{rd} and 4^{th} instar of grubs was 1.14 ± 0.10 mm and 0.40 ± 0.04 mm, 2.33 ± 0.17 mm and 0.96 ± 0.12 mm, 4.70 ± 0.40 mm and 1.89 ± 0.90 mm, 6.60 ± 0.40 mm and 2.73 ± 0.22 mm, respectively. The head capsule length and breadth of 1^{st}, 2^{nd}, 3^{rd} and 4^{th} instars was 0.33 ± 0.22 mm and 0.37 ± 0.013 mm, 0.49 ± 0.022 mm and 0.55 ± 0.033 mm, 0.75 ± 0.031 mm and 0.79 ± 0.034 mm, 0.96 ± 0.043 mm and 1.07 ± 0.043 mm, respectively. The average anteimal length was 0.10 ± 0.041mm, 0.11 ± 0.06mm, 0.21 ± 0.07nim and 0.30 ± 0.03 mm, respectively. The average pre-pupal length and width was 4.50mm and 3.27mm, respectively. The average pupal length and width was 5.02mm and 2.70mm, respectively. The average length and width of male and

female adults were 7.00 ± 1.18 and 4.78 ± 0.28 mm and 7.45 ± 1.35 and 4.95 ± 0.72 mm, respectively. The average anteimal length in male and female was 1.04 ± 0.08mm and 1.06 ± 0.09mm. The thorax length and width were 1.03 ± 1.17 and 1.98 ± 2.29, respectively. The average elytron length was 5.09 ± 0.64.

Kumar *et al.* 2009. Biology and morphometrics of *Henosepilachna vigintioctopunctata* on Ashwagandha (*Withania somnifera* L.) was studied in the department of entomology G.B.P.U.A.T, Pantnagar under laboratory condition revealed the egg stages 5 to7 days with range 3 to 8 days, grub stage, 1st instar 2 to 4 days, 2nd instar 3.3 days, 3rd instar 3.4 days and 4th instar up to pupation 9.6 days; total grub duration 19.4 days. Pupal period 5.7 days, longevity of adult male 70.2 days and female 79.1 days.

Satpathy and Mandal 2010. Studied the life table of *Henosepilachna vigintioctopunctata* on brinjal and reported that female laid as many as 200 eggs in 4-6 batches of 20-60, usually ventral surface of leaf. Incubation period lasted about 3-4 days. The average larval period was 13-15 days, which varied seasonally. Pupation took place on the under surface of leaf and as average pupal period lasted for 4-8 days. The adult emerged after 30-50 days after egg laying. Preoviposition and oviposition periods were of 6-7 days and 8-10 days, respectively. The longevity of the male was 20 days, whereas the female could survive for a month.

Tayde *et al.* 2013. Studied the life cycle of *Epilachna beetle* on bitter gourd in Uttar Pradesh and reported that a single female of *Epilachna vigintioctopunctata* laid 211 to 328 eggs during the life span. Eggs were yellowish elongated and cigar shaped often in a group of 5 to 45. Eggs were hatched into grubs within 5 to 11 days. Newly hatched 1st instar larva was yellowish in colour and had six rows of long branched spines. The full-grown 4th instar grub spent 1 to 3 days in pre-pupal stage. The pupal period lasted for 3 to 5 days with an average of 4.4 ± 0.89 days. The newly emerged adult was shiny yellow in colour later changed to copper brown colour mottled with black

spots. Body was spherical with convex ventral surface and flat dorsal surface and gives appearance of 'D' when viewed from side. The average longevity of male and female was 51.4 and 64.8 days respectively. The pre-oviposition, oviposition and post-oviposition period were 21.4, 26.6 and 21.6 day respectively

Jamwal VVS *et al*. 2013. The Studies conducted the biological parameters of the test insect included in the study revealed that grub and pupal development, survival, longevity and fecundity of *Epilachna vigintioctopunctata* (F.) (Coleoptera: Coccinellidae) adults on given host plants under laboratory conditions (29±1ºC, 60-70% RH) differ significantly. In a choice test *E. vigintioctopunctata* females oviposited most on *Solanum nigrum* (286.80 ± 19.86 eggs), least on *Luffa acutangula* (164.90 ± 26.24 eggs)**.** The incubation period was shortest on *S. nigrum* (3.25 ± 0.97 days) and longest on *Datura Stromonium* (5.40 ± 0.75 days) whereas per cent egg hatchability was highest on *Solanum tuberosum* (91.75 ± 3.73 %) and lowest on *L. acutangula* (82.00 ± 5.94%). *E. vigintioctopunctata* grubs developed differently on eight host plants, shortest on *S. nigrum* (13.25 ± 1.12 days) and longest on *D. stromonium* (21.55 ± 1.70 days) and survived best on *S. nigrum* and *P. minima* (92.00±1.22 and 91.25±0.88%) and worst on *L. acutangula* (45.25±2.45%). More females than males were found among emerged adults and females lived longer than males. Pupal development was shortest on *S. nigrum* (3.85 ± 0.67 days) and longest in *M. charantia* (6.10 ± 0.72 days), wherein, adult emergence rate was highest on *S. nigrum* (94.25±0.98%) and lowest on *L. acutangula* (53.25±2.18%). Further on the basis of growth index, fecundity, survival and adult emergence, *S. nigrum* and *P. minima* were recorded to be the most suitable host plants followed by *S. melongena*, *S. tuberosum*, *S. esculentum*, *M. charantia.*

Bindu SP and Pramanik A. 2015. Studied on the life cycle of *Epilachna beetle* on brinjal and reported the incubation period of *Epilachna beetle* was 3.2 ± 0.84 days the. Total larval period 20.8 ± 3.35 days. The mean pupal period of 3.8 ± 0.84 days, measured

12.34±1.67 mm in length and 4.40±0.47 mm in breadth. The mean adult male beetle longevity was 33.6 ± 2.70 days and recorded 5.93 ± 0.54 mm in length and 4.35 ± 0.34 mm in breadth. The mean lifespan of female beetle of E. *vigintioctopunctata* was observed 38.4 ± 1.52 days, measured 6.87± 0.59 mm in length, 5.23 ±0.63 mm in breadth. The duration of total life cycle varied 62.4 ± 7.13 days. The mean fecundity was recorded as 55.8 ± 7.73 eggs / female, the eggs size of *Epilachna beetle* was recorded as 1.05±0.24 mm in length and 0.41±0.08 mm in breadth.

Tara JS. and Sharma S. 2017. Conducted on the biology *Hensoepilachna vigintioctopunctata* indicated that a gravid female laid 200- 370 eggs on an average in 6-7 batches during her life span. The duration of different stages of life cycle viz. eggs, larvae and pupa lasted for an average of 8±2.23 days, 25.5±10.41 days and 4±0.79 days, respectively. The adult male and female survived for an average period of 23±1.58 days and 30±1.49 days, respectively. The whole body of the adults is covered with fine short hairs. Adults are copper brown coloured mottled with black spots**.**

Qamar *et al.* 2019. Studied morphometries parameters of *E. vigintioctpunctata* on brinjal and reported that the length and width of eggs varied from 1.27-1.42mm (avg. 1.34mm) and 0.42-0.52nim (avg. 0.47mm), respectively. The average length and width of 1st, 2nd, 3rd and 4th instar of grubs was 2.05 ± 0.27mm and 0.68 ± 0.14mm, 2.88 ± 0.32mm and 1.12 ± 0.60 mm, 4.04 ± 0.39mm and 1.52 ± 0.34mm; 5.80 ± 0.70 mm and 2.52 ± 0.51mm, respectively. The average pre pupal length was 4.40 ± 0.52 mm and breadth were 3.17 ± 0.34 mm. The average pupal length was 4.96 ±0.19 mm and breadth were 2.95 ± 0.19 mm. The average length and width of male adults were 7.00 ± 1.08 and 4.73 ±0.19 mm and the average length and width of 7.45 ± 1.35 and 4.95 ± 0.72 mm, respectively, was recorded in case of females.

Management of *E. vigintioctopunctata*

Umapathy and Baskaran 1991. Studied the efficacy of fluvalinate (30, 50 and 70 g a.i./ ha), fenvalerate (110 g a.i./ ha), cypermethrin (55 g a.i./ ha), monocrotophos (400 g a.i./ ha), quinalphos (313 g a.i./ ha) and carbaryl (1000 g a.i./ ha) for the control of *H. vigintioctopunctata* on aubergines. It was found that cypermethrin and carbaryl were effective against larvae of *E. vigintioctopunctata* whereas cypermethrin was effective against adults also.

Sahu *et al.* 2005. Experimented relative toxicity of five insecticides, in comparison with carbaryl, to 3rd instar grubs of *Epilachna sparsa* under laboratory conditions. Based on the LC50 values fipronil, diflubenzuron, triazophos, thiodicarb and cartap hydrochloride were 1.42, 0.69, 0.58, 0.31 and 0.08 times toxic by leaf dip method and 1.54, 14.73, 1.51, 0.64 and 0.34 times toxic by direct spray method compared with carbaryl. Except for diflubenzuron, the test compounds exhibited 1.87 to 7.94 times higher toxicity in leaf dip method than that in direct spray method.

Patra *et al.* 2009. Conducted a field experiment during khan lf 2006 taking 5 insecticides i.e. emamactin benzoate 5 SG, lufenuron 10 EC, spinosad 2.5 SC, insdoxacarb 14.5 SC and methoxyfenozide 24 SC sprayed at 60,75 and 90 days after transplanting and found among above insecticides, the lowest mean shoot as well as fruit infestation (747 and 9.88%) was spinosad 2.5 SC (50g ai ha^{-1}) followed by indoxacarb 14.5 SC 50g ai ha^{-1} (8.89 and 13.13%), emamactin benzoate 5 SG 15g ai ha^{-1} (10.95 and 16.66%) respectively.

Singh *et al.* 2009. Evaluated seven insecticides for control of grubs and adults of *Henosepilachna vigintioctopunctata* at Kumarganj, Faizabad, Uttar Pradesh and found methomyl (Dunet 40 SP) @ 250g ai ha-1 was the most effective followed by spinosad (Tracer 45 SP) @ 100g ai ha^{-1}, carbosulfan (Marshall 25 EC) @ 250g ai g $ha^{-1}$and malathion (Devimalt 50 EC) @ 1000g ai ha-1 against both the stages of pest. The cost benefit analysis revealed that the best cost benefit

ratio of 1:16.58, in case of methomyl followed by carbosulfan (1: 9.59) and malathion (1: 6.86) while spinosad, indoxacarb had cost benefit ratio less than 1.3.

Rahman *et al*. 2009. Revealed that cartap hydrochloride 50 SP was the most effective insecticide for controlling both grubs and adults of *epilachna* beetle in both laboratory and field conditions in brinjal.

Chandranath, H. T. and Katti, P. 2010. Evaluated the efficacy of endosulfan 35EC (2 ml/ litre), neem seed kernel extract (NSKE 5 per cent), etc. against *Epilachna* beetle (*E. vigintioctopunctata*) on ashwagandha (*Withania somnifera* cv. Jawahar) and reported that all the treatments were effective in the reduction of pest population. Endosulfan recorded the lowest number of beetles per plant (6.90). Based on the yield, endosulfan was the most effective among the insecticides (4.06 quintal/ ha), followed by 5 per cent NSKE (3.90 quintal/ ha).

Verma *et al.* 2010. Conducted on both laboratory and field conditions on management of *Epilachna* beetle on bitter gourd with insecticides like endosulfan, carbaryl, malathion, cypermethrin, novaluron, neern-based product nimbicidine, and *Beauvertia bassiana* (Balsamo) Vuillernin revealed that in laboratory evaluation, the toxicity against the larva in descending order was cypermethrin > aovaluroa > carbaryl > malathion > endosulfan > azadirachtin, and the values were 0.00015, 0.0043, 0.0044, 0.0127, 0.0242 and 0.0316 per cent, respectively. Under field conditions cypermethrin proved highly effective giving maximum (93.59%) reduction of the population over control one day after treatment However, the maximum overall mean reduction in population after 15 days (86.23%) was observed in carbaryl followed by endosulfan (84.29%) and cypermethrin (80.68%). The other treatments resulted in significantly lower reduction in *Epilachna* population.

Mondal *et al.* 2010. Conducted in a two years field study in West Bengal on management of *Epilachna* beetle revealed that the

population of *Epilachna* beetle was lowest in soil application of phorat 10G at 1.5 kg ai ha^{-1} at planting followed by foliar spray with chloropyriphos 20EC at 2.5 ml/ lit. of water followed by cartap hydrochloride 50 SP @ 2 ml/lit in potato than other insecticides.

Sharma and Kaushik, 2010. Conducted a field trail was at the research farm of C.S.S. Haryana Agricultural University, Hissar during 2006-07 revealed that seven insecticides comprising spinosad, emamectin benzoate, cypermethrin, quinalphos, endosulfan, lambda cyhalothrin and chloropyrifos were tested against hadda beetle and natural enemies inhabiting eggplant. Spinosad 45 SC was found to be ineffective against hadda beetle since the population of this insect was at par with those in the untreated control.

Ghosh and Chakrabarty 2012. Study conducted on botanicals and microbial pesticides under field conditions of the sub Himalayan region of north east India during rabi season with cartap hydrochloride 50 SP as check insecticide revealed that cartap hydrochloride (check) was the most effective treatment for the controlling *Epilachna* beetle, followed by botanical insecticide.

Sheikh K and Raj Desh 2013. Studies were undertaken to evaluate seven insecticides/biopesticides *viz.*, chlorpyriphos 0.05, carbaryl 0.20, malathion 0.05, endosulfan 0.07, abamectin 0.0015, lambda cyhalothrin 0.004 and azadirachtin 0.0045% against hadda beetle, *Henosepilachna vigintioctopunctata* on bitter gourd at Entomological Experimental Farm, CSKHPAU and farmer's field, Bara (Hamirpur). Lambda-cyhalothrin and carbaryl were found to be the most potent and remained effective throughout the observational period i.e. up to 15 days of application with mean reduction of 89.26 and 85.09 and 87.10 and 83.45% in pest population over untreated check.

Jamwal *et al.* 2013. Studies conducted for management of hadda beetle revealed that carbaryl 50WP (0.10%) proved to be the most effective treatment for two consecutive years on brinjal and bitter

gourd in terms of highest cost – benefit ratio (1:34.00 and i:29.00) and yield (345 and 110 q/ ha) However, fipronil 5SC (1:26.00 and 1:22.27) and lamda cyhalothrin 5SC (24.24 and 1:19.39) were equally effective. *Beauveria bassiana* 1.25WP. *Steinernema carpocapsae* @ 2 billion Us/ ha and NSKE 5% also significantly suppressed the pest population but had low cost benefit ratio of (1:20.82 and 1:23.00), (1:9.80 and 1:9.20) and (1:11.31 and 1:10.08), respectively. Wood ash can be a good alternative for resource poor farmer or organic growers as the same could protect the crop with cost benefit ratio of (1:7.0 and 1:9.2). However, all the treatments were effective in reducing the pest population and increase in the marketable yield of the crops.

Dwivedi *et al.* 2014. Efficacy of different novel insecticides like spinosads, imidacloprid, indoxacarb and dimethoate against insect pests of brinjal revealed that the most effective insecticide in reducing the infestation of brinjal shoot and fruit borer (*L. orbonalis*) was imidacloprid followed by indoxacarb which were equally effective and proved significantly superior over control. With respect to fruit yield the maximum fruit yield was obtained from imidacloprid treated plot followed by indoxacarb followed by spinosad treated plot.

Kodandaram *et al.* 2014. Laboratory and field experiments on the efficacy of novel insecticide molecules against *Henosepilachna vigintioctopunctata* were conducted at IIVR, Varanasi for two seasons during 2010-11 revealed that flubendiamide 39.4 SC @ 50ml ai ha-1 and indoxacarb 14.5 SC @ 50g ai ha^{-1} registered 63.3 and 63.3 per cent mortality of treated grubs and were statistically at par with each other. Lowest grub mortality was recorded in spinosad 2.5 SC @ 17.5 ai ha-1. With respect to field study emamectin benzoate 5 SG @ 10g ai ha -1 and thiodicarb 75 WP @ 70 g ai ha^{-1} proved to be the most effective treatment with highest overall mean reduction of 75.3 and 73.9 per cent in pest population.

Anwar *et al.* 2015. The study was carried out at Agricultural Research Institute, Tarnab, Peshwar during 2011 against insect pests of brinjal. The insecticides tested were spinosad, emamectin benzoate,

chlorpyrifos, profenofos and cypermethrin and were compared with a control. Results showed that emamectin benzoate was the most effective against brinjal fruit borer and resulted in lower infestation (40.1%) followed by Cypermethrin (40.43%).

Gowrish *et al.* 2015. Field experiment was carried out in brinjal during summer and kharif, 2013 to evaluate the efficacy of spinosad 45 SC @ 0.4 ml/l, azadirachtin 1% @ 2 ml/l and malathion 50 EC @ 2ml/l against *Epilachna vigintioctopunctata* revealed that during summer malathion 50 EC @ 2ml/l recorded least infestation at 15 days interval spraying four times.

Bala *et al.* 2016. Field trials were laid out to test the effectiveness of insecticides i.e. cypermethrin 25 EC against Jassid (*Amrasca biguttula*) and *Epilachna* beetle (*Epilachna vigintioctopunctata* Fab), infesting brinjal under Gangatic basin of West Bengal. The experiment was conducted under randomized block design with three replications. Various dosages *viz;* 0.16, 0.20, 0.30 and 0.40 kg a.i/ha of cypermethrin 25 EC were compared with conventional insecticides *viz;* chloropyrifos 20 EC (1 kg a.i /ha) and fenvelerate 20 EC (0.5 kg a.i /ha.) to spray against *E. vigintioctopunctata* and *A. biguttula* in the year 2015. This experiment revealed that all these treatments were significantly superior over untreated control. The most effective treatment was cypermethrin 25 EC @ 0.4 kg a.i/ha followed by cypermethrin 25 EC @ 0.3 kg a.i/ha.

Negi K. and Srivastava, R.P. 2018. The contact toxicity of three combination insecticides was determined against 10 days old grubs (mean wt. 0.02 g/grub) of *H. vigintioctopunctata* by atomization method under laboratory conditions (Temp. 28°C, R.H. 78%). At 48 HAE, deltamethrin + triazophos and profenofos + cypermethrin were equitoxic (LC50 = 0.0003%) showing 1.5 times lesser toxicity than chlorpyriphos + cypermethrin (LC50 = 0.0002%); and at 72 HAE, all the three were equitoxic (LC50 = 0.0002%). In another experiment, the contact and stomach toxicity of six combination insecticides was determined against adults (mean wt. 0.021 g/adult) of *H.*

vigintioctopunctata by leaf dip bioassay method under laboratory conditions (Temp. 28°C, R.H. 78%). At 24 HAF, beta-cyfluthrin + imidacloprid (LC50 = 0.0001%) showed 130 and 9 times higher toxicity than ethion + cypermethrin (LC50 = 0.0139) and chlorpyriphos + cypermethrin (LC50 = 0.0009%), respectively; at 48 HAF, the order of toxicity was beta-cyfluthrin + imidacloprid (LC50 = 0.00004%) > chlorpyriphos + cypermethrin (LC50 = 0.0005%) > deltamethrin + triazophos (LC50 = 0.0009%) > ethion + cypermethrin (LC50 = 0.0024%) > profenofos + cypermethrin (LC50 = 0.0026%) > cypermethrin + indoxacarb (LC50 = 0.0065%); and at 72 HAF, profenofos + cypermethrin and cypermethrin + indoxacarb proved equitoxic (LC50 = 0.0013%) being 65, 2.60 and 1.62 times less toxic than beta-cyfluthrin + imidacloprid (LC50 = 0.00002%), deltamethrin + triazophos (LC50 = 0.0005) and ethion + cypermethrin (LC50 = 0.0008%), respectively.

Natural enemy complex

Jamwal VVS *et al.* 2014. The studies revealed that the maximum parasitization by *Tetrastichus sp*. of egg masses was observed during August 2009 (20.56%) and 2010 (24.72%) followed by July 2009 (17.44%) and 2010 (21.23%). The mean per cent parasitism of *Tetrastichus* sp. was observed as 22.64% (Table 1). The least parasitization of 3.04 and 5.22% was recorded during November 2009 and 2010, respectively. The maximum parasitization by *P. foveolatus* of beetle pupae was observed during August 2009 (7.82%) and 2010 (5.42%) followed by July 2009 (4.72%) and 2010 (3.92%). The mean parasitism of was observed as 6.62%. The least parasitization of 1.02 and 0.62% and was recorded during November 2009 and 2010, respectively.

Reddy S.S. and Mandal S.K. 2016. The Studies conducted during April-May of 2014 at Department of Agricultural Entomology, BCKV, Mohanpur, West Bengal. The present investigation revealed that two species of parasitoids namely, *Tetrastichus* sp. attacks the egg stage and *Pediobius foveolatus* attacks the larval and pupal stage of

the Hadda beetle, *Epilachna vigintioctopunctata. Tetrastichus* sp. parasitized 21.82 % of eggs whereas, the parasitoid, *Pediobius foveolatus* parasitized 48.09 % of fourth instar grubs and 33.87 % of pupae. *P. foveolatus* completed its life cycle in 11.63 days. On the basis of overall performance, *Tetrastichus* sp., *Pediobius foveolatus* were recognised as key mortality factors i.e. parasitoids of the pest.

Jamwal VVS *et al.* 2017. The studies conducted 28-spotted hadda beetle *Henosepilachna vigintioctopunctata* Fab. (Coleoptera: Coccinellidae) is a poly-phagous pest, commonly infesting solanacious crops including brinjal, *Solanum melongena* L. Upon its severe infestation on brinjal, it causes considerable damage to the foliage and also to the calyx of fruits. The studies were made to record the seasonal abundance of hadda beetle and identification of its natural enemies present in the region for two consecutive years. The pooled data for two years showed that the maximum number of *H. vigintioctopunctata* egg clusters on brinjal were recorded in the 27th (0.40 egg cluster/ plant), followed by grub population in 35th (3.78 grubs/ plant), pupae in 33rd and 39th (0.83 pupae/ plant) and adult beetles in 36th (5.48 adults/ plant) standard meteorological weeks, respectively. It was observed that the key meteorological factors had 35.9%, 87.3%, 66.8% and 81.9% effect on the abundance of egg clusters, grubs, pupae and adults respectively in summer planted brinjal crop. Two natural enemies of hadda beetle viz. *Tetrastichus* sp. (egg parasitoid) and *Pediobius foveolatus* (pupal parasitoid) were recorded. The maximum parasitisation by *Tetrastichus* sp. and *P. foveolatus* on the egg clusters and pupae was recorded 22.64% and 6.62% respectively, during the month of August (34th and 35th standard meteorological week respectively). Further, the morphometric parameters of these two adult parasitoids were recorded and greater morphometric variability was observed in *P. foveolatus* in comparison to *Tetrastichus* sp.

Roy S. and Thakur A. 2018. Study on identify the key mortality factors and effectiveness of natural enemies to suppressing the

population of *Epilachna vigintioctopunctata* (Fabr.) on brinjal grown at the KVK farm at Dantewada district of Chhattisgarh during 2016-17. In this Field cum laboratory studies was found two species of parasitoids namely, *Tetrastichus sp.* and *Pediobius foveolatus,* three species of predators, i.e. lygaeid, reduviid and pentatomid bugs attacked various stages of the pest. *Tetrastichus* sp. parasitized 23.48 % of eggs whereas, the parasitoid, *P. foveolatus* parasitized 47.69 % of 4th instar grubs and 35.38 % of pupae. *P. foveolatus* completed its life cycle in 11.21days. The egg and larval predator *Geocoris* sp., was the most dominant causing upon 16.42% natural predation of eggs. The rate of consumption of different predators was studied. On the basis of overall performance, *Tetrastichus* sp., *P. foveolatus* and *Geocoris* sp. were recognized as key mortality factors of the pest.

Qamar M *et al.* 2019. Carried out The population dynamics of two hymenopteran parasitoids (i.e. *Pediobius foveolatus* (Crawford) and *Tetrastichus* sp. (Hymenoptera: Eulophidae) of *Henosepilachna* spp. were for two successive years (2015 and 2016) on various crops *viz*., brinjal, bitter guard, tomato and winter cherry, in an experimental field of Department of Plant Protection, Aligarh Muslim University, Aligarh, India. Observations were taken on 4 randomly selected plants from each plot by collecting various developmental stages (i.e. eggs, grubs, pupae and adults) of *Henosepilachna* spp. These developmental stages were brought to the laboratory and continuously kept under watch for the emergence of any parasitoids from parasitized hosts. After emergence of parasitoid from parasitized stages of *Henosepilachna* spp., they were collected in glass vials separately and samples were identified by the experts. Results of the study showed that temperature range of 29.10 to 31.81 ºC, relative humidity between 61.86 to 85.07% and rainfall between 0 to 50.80mm, favoured the population of *P. foveolatus* and *Tetrastichus* sp. to maximize the percentage of grub parasitization of *Henosepilachna* spp. on all tested host plants. From the present study, it can be concluded that the sufficient knowledge of biotic and abiotic factors affecting the seasonal

incidence of natural enemies of pest is an important part of Integrated Pest Management (IPM) program, which helps growers/farmers to check the population of pests at below economic threshold level by using natural enemies as a mean of pest control tactics, thereby reducing the use of synthetic pesticides.

CHAPTER – III

MATERIAL AND METHODS

MATERIAL AND METHODS

The present investigation entitled, **Studies on the life cycle of Hadda beetle (*Henosepilachna vigintioctopunctata*) and its management on bitter gourd (Momordica charantia Linn.)** was comprised three experiments conducted under the field and laboratory condition College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Rewa, Madhya Pradesh during *Kharif* season 2019.

Experimental details:

The experiments were laid out in three set:

1. To study of the lifecycle of Epilachna beetle on various host plant.
2. Evaluation of efficacy of new insecticide against Epilachna beetle under the climatic condition of Rewa district.
3. Occurrence of the natural enemies at various stage of the beetle during the life cycle of insect.

Methodology:

Objectivel 1: To study the life cycle of Epilachna beetle on various host plants.

The study was carried out in the laboratory of Department of Entomology of College of Agriculture, Rewa in Kharif 2019. The life cycle of Epilachna beetle was studied on two host plant i.e. bitter gourd (*Momordica charantia* Linn.) and macoy (*Physalis minima*).

Observation details:

The full-grown grubs were collected from the field and laboratory reared adult of Epilachna beetle were paired used for the study of life cycle of insects on bitter gourd (*Momordica charantia* Linn.) and macoy (*Physalis minima*). Epilachna beetle has completed his life cycle on both the host plant. Twenty grubs were reared in separate Petri dish; fresh leaves were fed to them daily up to pupation of grub. Observation were recorded on fecundity period, number and duration of various instars of grub and their size, pre pupation and pupal period, size of pupa, period of adult emergence, size of adult and the fecundity of adult on bitter gourd.

Objective 2 : Evaluation of insecticides against *Epilachna* beetle.

This experiment was carried out under natural field condition. The details of the experiment are given below.

Observation details :

Field efficacy of insecticides were carried out against *Epilachna* beetle on the bitter gourd.

Table 1. Details of experiment layout :

1.	Design	Randomized block design (RBD)
2.	No. of replication	Three
3.	No. of treatment	Nine
4.	Season	Kharif
5.	Crop	Bitter gourd
6.	Variety	Aman shree
7.	Seed rate	3 seed/ pit
8.	Total no. of plots	27
9.	Plot size	2.5 m x 2 m
10.	Spacing	120 cm x 90 cm
11.	Fertilizer application	75:50:25 (N:P:K) kg/ha
12.	Date of sowing	09.08.2019

Treatment details :

Application of insecticide were done as soon as sufficient number of grubs / adults seen on the crop. The observations on the number of insects were recorded one day before & 1, 3, 7 and 10 days after spraying (DAS). The data obtained was statistically analyzed as per the RBD design after angular transformation for percentage value and square root transformation for population values.

Table 2. Particulars of insecticides selected for field evaluation.

Treat.	Name of insecticides	Dose (g or ml ai/ha)	Formulation / ha. (g or ml)
T1	Chlorantraniliprole 18.5% SC	30	162
T2	Flubendiamide 39.35 % SC	50	127
T3	Quinalphos 25 % EC	250	1000
T4	Imidacloprid 17.8 % SL	25	140
T5	Thiamethoxam 25 % WG	25	100
T6	Lambda cyhalothrin 5% EC	15	300
T7	Emamectin benzoate 5% SG	10	200
T8	Thiacloprid 21.7 % SC	70	323
T9	Untreated	-	-

Layout :

R1	R2	R3
T1	T4	T6
T2	T5	T7
T3	T6	T8
T4	T7	T9
T5	T8	T1
T6	T9	T2
T7	T1	T3
T8	T2	T4
T9	T3	T5

Objective 3 : Occurrence of natural enemies at various stages of beetle.

Observation details :

This study was carried out in laboratory condition in the Department of Entomology, College of Agriculture, Rewa (M.P). The egg masses, grubs, pupae, and adults were collected from the field in sufficient number and reared on the fresh leaves of bitter gourd in separate Petri dishes. Daily observations were made on the parasitoid emergence from different stages of insects. The parasitoids were identified at College and University level. The percentage of parasitoidation stages were worked out.

Analysis of Data:

The data generated in the laboratory experiments in Completely Randomized Design (CRD) and field experiment laid out in Randomized Block Design (RBD) on various aspects of study were subjected to statistical analysis after suitable transformation of the generated data following the standard statistical procedure of Gomez and Gomez (1984) and the mean value of different treatments were compared using critical difference (C.D.) at 0.05 probability.

Table 3. Skeleton of Analysis of Variance (ANOVA).

Sources of variance	D.F.	S.S.	M.S.S.	$F_{cal.}$	F_{tab}
Replication	(r-1)	SSR	VR	VR/VE	
Treatments	(t-1)	SST	VT	VT/VE	F at 5% (t-1), (r-1) (t-1)
Error	(r-1) (t-1)	SSE	VE	-	-
Total	(r.t-1)	-	-	-	-

Where,

r = number of replications

t = number of treatments

VR = replication mean sum of square

VT = treatment mean sum of square

VE = error mean sum of square

The significance among different treatment means was judged by critical difference (C.D.) at 5% level of significance for comparison among the treatments, for which the marginal means of each treatment was considered.

The following formula was used for various estimations:

(1) $SEm\pm = \sqrt{\frac{Ems}{r}}$

(2) $C.D. = SEm \pm X\sqrt{2} \times t_{0.05}$

where,

Ems = error mean sum of square

t = 't' value at 5 % level at error d.f.

r = number of replications

SEm±= Standard error of any treatment mean

CD = Critical Difference

CHAPTER – IV

RESULTS

RESULTS

The Findings of the experiment **"Studies on the life cycle of *Epilachna* beetle (*Henosepilachna vigintioctopunctata*) and its management on bitter gourd (*Momordica charantia Linn*.) in Rewa district"** were recorded as per methodology and data is duly analyzed and described in this chapter under respective objectives:

4.1. To study of the lifecycle of *Epilachna* beetle on various host plant :

The life cycle of the *Epilachna* beetle was studied under laboratory conditions the temperature 25-35 ° C and 60-70% RH at Jawaharlal Nehru krishi Vishwa Vidhyalaya, college of Agriculture Rewa. Results presented in Table 4 on different stages of the *Epilachna beetle* revealed the following observations :

4.1.1. Morphometrics of different life stages *Henosepilachna vigintioctopunctata* (Table 4):

S.No	Life stages	*H. vigintioctopunctata*	
		Length (mm) Mean ± S.D.	Width (mm) Mean ± S.D.
1.	**Eggs**	1.02 ± 0.29	0.39 ± 0.11
	Grub instars		
2.	1st instar	2.04 ± 0.53	0.64 ± 0.17
3.	2nd instar	2.82 ± 0.60	1.02 ± 0.21
4.	3rd instar	4.88 ± 0.71	2.08 ± 0.54
5.	4th instar	5.64 ± 0.92	3.09 ± 0.41
6.	Pre-pupal stage	6.49 ± 1.03	4.62 ± 0.54
7.	Pupal stage	5.38 ± 0.89	3.27 ± 0.42
	Adult beetle		
8.	Male	6.77 ± 0.94	4.83 ± 0.63
9.	Female	7.09 ± 0.70	5.16 ± 0.61

S.D. - Standard deviation

4.1.1.1. Egg :

The eggs were laid in clusters on the underside of the leaves. The freshly laid individual eggs were stalked, shiny yellow, elongate-oval tapering at top end, clustered vertically with smooth texture. On maturity the colour changed from yellow to light yellow and ultimately to creamy yellow at hatching. On the basis of twenty randomly selected eggs from different clusters laid by a female beetle, the length and width of the eggs varied from 1.02 ± 0.29 mm and 0.39 ± 0.11 mm, respectively.

4. 1. 1. 2. Grubs :

On hatching, the grubs came out by rupturing the chorion from apical. The grub moulted thrice. After each moult there was an increase size. The cast skin of the last grub instar was found remained glued to the posterior part of the puparium.

4. 1. 1. 2. 1. First Instar :

Newly hatched grubs were yellowish brown in colour, elytriform in structure and usually occurred on lower side of leaf. The body length and width varied from 2.04 ± 0.53 mm and 0.64 ± 0.17 mm, respectively. This stage did not move at all and sticked to the point of hatching and fed on the lower side of tender leaf.

4. 1. 1. 2. 2. Second Instar :

The body was chitinised; the thoracic and abdominal segments were covered with well developed branched spines, which were further divided into 3-7 sub-branches. This stage moved on the under surface of the host plant leaves and scraped the green matter in patches in a characteristic manner leaving behind transparent membrane. The respective body length and width of this stage was recorded 2.82 ± 0.60 mm and 1.02 ± 0.21 mm.

4. 1. 1. 2. 3. Third Instar :

Thorax was rugose where pro and mesothorax were fused together. This stage was swift in movement and fed on green matter from both the surfaces of the leaves and even the twigs flowers and fruit of the

plant. The body length and width of third instar grub varied from 4.88 ± 0.71 mm and 2.08 ± 0.54 mm, respectively.

4. 1. 1. 2. 4. Forth Instar :

There were 9 abdominal segments each provided with paired spinal, dorsal hairs long and pointed, clearly visible in the full grown grub instar. The spines on ventral side were dense and relatively larger than dorsal ones. This stage was noticed to be voracious feeder of the foliage, causing skeletonization of leaves. The body length of the grub instar was recorded from 5.64 ± 0.92 mm and width 3.09 ± 0.41 mm.

4. 1. 1. 3. 1. Pre-pupa :

The full-grown grub stopped feeding and attached itself to the leaf surface. The respective body length and width measurement of pre pupa was 6.49 ± 1.03 mm and 4.62 ± 0.54 mm.

4. 1. 1. 3. 2. Pupa :

The newly formed pupa was shinning yellow but turned creamy brown with spots on the dorsal surface. It was anteriorly broad and tapering posteriorly with a bunch of grey hairs on the posterior end. Obtect type brown pupa was observed glued to the leaf surface. The body length and width of the pupal stage were recorded as 5.38 ± 0.89 mm and 3.27 ± 0.42 mm, respectively.

4. 1. 1. 4. Adult Beetle :

The beetles were oval, convex, with black head, elytron pale brown with black spots. Antennae were clavate and nine segmented with black compound eyes rather closely faceted.

4. 1. 1. 4. 1. Male :

The measurement of the body length of the male was recorded 6.77 ± 0.94 mm and width 4.83 ± 0.63 mm, respectively.

4. 1. 1. 4. 2. Female :

The females were slightly bigger than males. Measurement of the respective body length and width of the female beetle were 7.09 ± 0.70 mm and 3.27 ± 0.42 mm.

4.1.2. Developmental duration of different life stages *H. vigintioctopunctata* on host plant bitter gourd (*Momordica charantia Linn*.) and macoy (*Physalis minima*) (Table 5) :

S. No	Life stages	Bitter gourd	Macoy
		Average Days ± S.D.	Average Days ± S.D.
1.	**Eggs**	3.95 ± 1.32	4.55 ± 1.23
Grub instars			
2.	1st instar	4.30 ± 0.98	4.05 ± 0.94
3.	2nd instar	3.35 ± 0.75	3.55 ± 0.60
4.	3rd instar	4.65 ± 0.88	5.05 ± 1.10
5.	4th instar	3.70 ± 1.03	3.55 ± 0.89
6.	Pre-pupal period	2.70 ± 0.66	2.45 ± 0.60
7.	Pupal period	5.05 ± 0.94	4.45 ± 1.10
8.	Developmental period	27.80 ± 1.58	26.25 ± 1.37
Adult longevity			
9.	Male	15.95 ± 1.28	17.30 ± 1.63
10.	Female	25.25 ± 1.62	30.05 ± 3.95
11.	Fecundity	169.05 ± 12.31	190.80 ± 20.11

S.D. - Standard deviation

4.1. 2.1. Egg period:

The female laid egg masses on the under side of bitter gourd leaves which varied from 145 to 189 eggs / female. With an average of 169.05 ± 12.31 eggs/female. The female egg laid on macoy an average 190.80 ± 20.11 of eggs/female between156 to 225 eggs/female. The eggs were orange yellow colour and deposited in batches of 2-5 particulars to the ventral surface of the leaf. In each batch the number of eggs varied

from 35 to 65. The egg period on bitter gourd and macoy were 3.95 ± 1.32 days and 4.55 ± 1.23 days, respectively.

4. 1. 2. 2. Grub period :

Instar-I

The newly hatched grubs were yellowish in colour. These neonate grubs initially remained attached to the egg cell then distributed on the lower surface of the leaves. The duration of 1st instar grubs were 4.30 ± 0.98 days and 4.05 ± 0.94 days on bitter gourd and macoy respectively.

Instar-II

The second instar grubs were also yellowish in colour with very tiny spines. The duration of 2nd instar grubs were 3.35 ± 0.75 days and 3.55 ± 0.60 days on bitter gourd and macoy respectively.

Instar III

Grubs were bright yellow with quite prominent of branched spine over the body surface and found actively feeding by scrapping the lower epidermal layer of the leaf. The average duration of 3rd instar grubs on bitter gourd and macoy varied 4.65 ± 0.88 days and 5.05 ± 1.10 days respectively.

Instar IV

The 4th instar grubs were bright yellow in colour and rows of branched spines were distinctly visible in naked eyes. The mean duration of 4th instar grub were 3.70 ± 1.03 days and 3.55 ± 0.89 days on bitter gourd and macoy respectively.

4. 1. 2. 3. Pre-pupal and Pupal period :

The full-grown grub stopped feeding for a day or two and transformed to pupa which remained attached below the surface of the leaf or other plant parts. The coated skin of the grub remains attached to the pupa which imparted appearance. The pre-pupal period on an average 2.70 ± 0.66 and 2.45 ± 0.60 days on bitter gourd and macoy respectively. The pupal period was observed 5.05 ± 0.94 and 4.45 ± 1.10 days on bitter gourd and macoy respectively.

4. 1. 2. 4. Developmental Period :

The total developmental period from egg to adult emergence was observed on an average 27.80 ± 1.58 days on bitter gourd and 26.25 ± 1.37 days on macoy.

4. 1. 2. 5. Adult Longevity :

The longevity of the adult beetle was an average recorded for male 15.95 ± 1.28 and 17.30 ± 1.63 days while in case of female 25.25 ± 1.62 and 30.05 ± 3.95 days on bitter gourd and macoy respectively.

4. 1. 2. 6. Fecundity :

The total number of eggs produced regardless of their fertility is considered as one of the important biological aspect of insect pest and their populations build up. The eggs were laid in clusters usually on the under surface of the leaves. The data in respect of the fecundity showed that a female laid 11-15 eggs every day, continuously for 12-14 days in batches of 2-5 on the ventral surface of the leaf. The total number of egg laid by female on bitter gourd varied from 145 to 189 eggs / female. On an average of 169.05 ± 12.31 eggs/female. The female egg laid on macoy an average 190.80 ± 20.11 of eggs/female between156 to 225 eggs/female.

Plate 1

Eggs

1st instar grub

2nd instar grub

3rd instar grub

4th instar grub

Pre pupa

Pupa

Adult

Life stages of *Henosepilachna vigintioctopunctata.*

Plate 2

Newly adult hatched

Mating

Newly hatch adult and mating notice.

4. 2. 1. Evaluation of efficacy of new insecticide against *H. vigintioctopunctata* under the climatic condition of Rewa district (Table 6) (Mean of spray):

S. NO.	Treatments	Dose (g/ml/ha)	% conc. In spray soln.	Mean number of grub / adults per plants					
				Pre - treatment	Post-treatment				Over all mean of spray
					1 DAS	3 DAS	7 DAS	10 DAS	
T_1	**Chlorantraniliprole 18.5% SC**	30	0.006	8.67 (3.02)	4.00 (2.08)	3.33 (1.93)	2.33 (1.64)	2.00 (1.56)	2.92 (1.84)
T_2	**Flubendiamide 39.35 % SC**	50	0.010	8.33 (2.96)	4.33 (2.18)	3.67 (2.02)	2.67 (1.77)	2.33 (1.64)	3.25 (1.93)
T_3	**Quinalphos 25 % EC**	250	0.050	9.00 (3.07)	4.00 (2.06)	2.67 (1.74)	2.33 (1.57)	2.00 (1.47)	2.75 (1.79)
T_4	**Imidacloprid 17.8 % SL**	25	0.005	9.33 (3.13)	2.00 (1.56)	0.67 (1.00)	0.33 (0.88)	0.33 (0.88)	0.83 (1.12)
T_5	**Thiamethoxam 25 % WG**	25	0.005	8.00 (2.90)	6.00 (2.53)	5.67 (2.47)	4.67 (2.26)	3.67 (2.00)	5.00 (2.34)
T_6	**Lambda cyhalothrin 5% EC**	15	0.003	8.33 (2.96)	5.33 (2.40)	4.00 (2.08)	3.33 (1.93)	2.33 (1.64)	3.75 (2.04)
T_7	**Emamectin benzoate 5% SG**	10	0.002	10.67 (3.34)	3.00 (1.81)	1.67 (1.44)	1.33 (1.27)	1.00 (1.17)	1.75 (1.48)
T_8	**Thiacloprid 21.7 % SC**	70	0.014	9.67 (3.18)	2.33 (1.60)	1.00 (1.17)	0.67 (1.05)	0.33 (0.88)	1.08 (1.23)
T_9	**Untreated**	-	-	8.00 (2.90)	8.67 (3.02)	9.00 (3.07)	9.33 (3.13)	10.33 (3.28)	9.33 (3.13)
	SEm±			**0.17**	**0.25**	**0.21**	**0.21**	**0.26**	**0.08**
	CD at 5%			**NS**	**0.74**	**0.61**	**0.64**	**0.75**	**0.24**

= Figures in parentheses are square root (√x+0.5) transformed values.

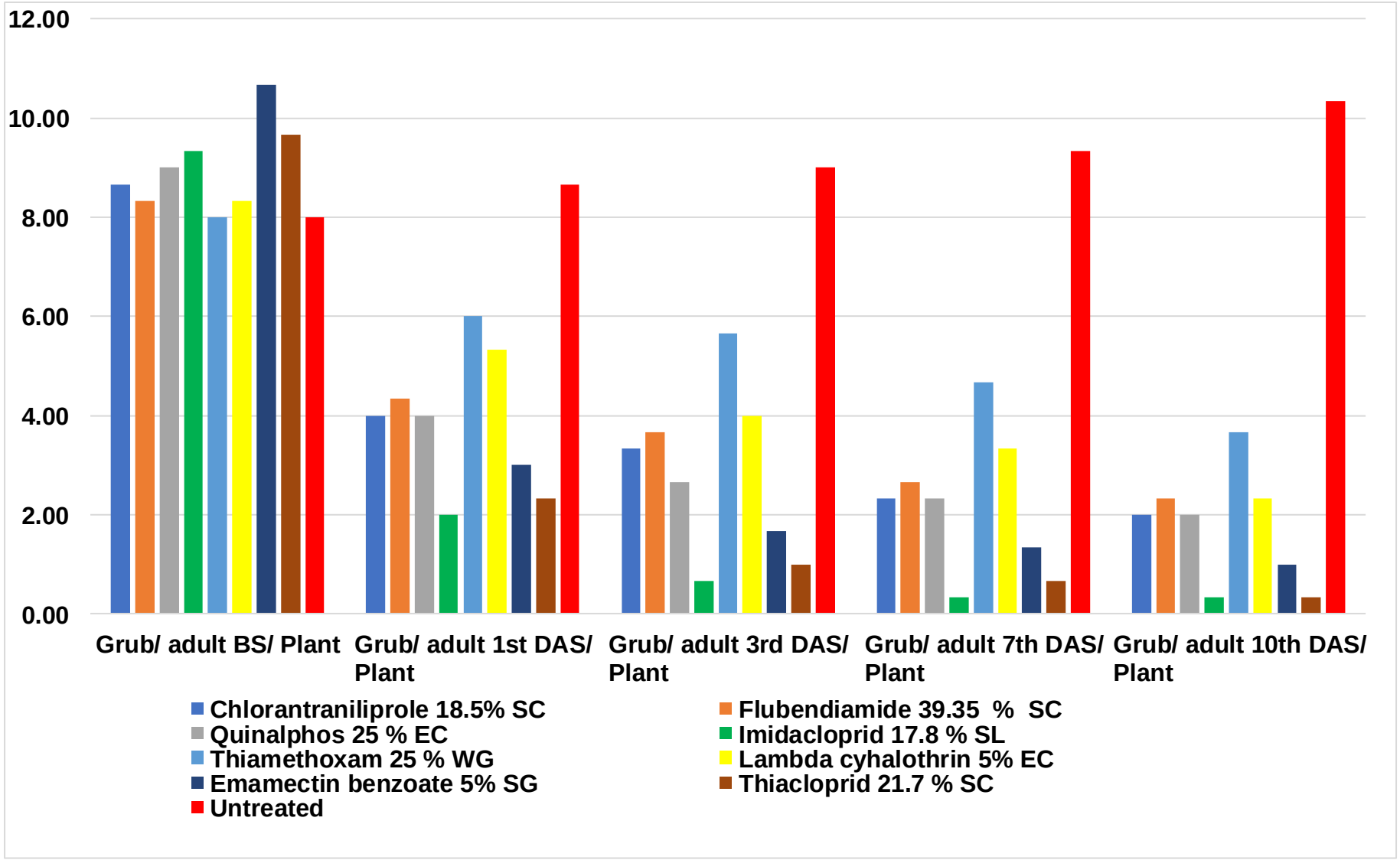

Figure 1. Overall impact of different new insecticide on grub/adult population of *H. vigintioctopunctata* on Bitter gourd.

4. 2. 1. Evaluation of efficacy of new insecticide against *Epilachna beetle* under the climatic condition of Rewa district (Mean of spray) :

4. 2. 1. 1. Pre-treatment :

Average beetle population per plant among different treatments were not significantly different 24 hours before treatment.

4. 2. 1. 2. 1. One day after spray :

One day after spray (Table 6), all the insecticidal treatments significantly reduced the beetle population as compared to control 8.67 (3.02) beetles/ plant. Imidachloprid 17.8% SL @ 25 ml ai/ha was found the most effective among all the treatments as it recorded lowest beetle population 2.00 (1.56) beetles/ plants) followed by Thiacloprid 21.7 % SC @ 70 ml ai/ha 2.33 (1.60) beetles/ plant, Emamectin benzoate 5% SG @ 10g ai/ha 3.00 (1.81) beetles/ plant, Quinalphos 25 % EC @ 250 ml ai/ha 4.00 (2.06) beetles/ plant, Chlorantraniliprole 18.5% SC @ 30 ml ai/ha 4.00 (2.08) beetles/ plant, Flubendiamide 39.35 % SC @ 50 ml ai/ha 4.33 (2.18) beetles/ plant, Lambda cyhalothrin 5% EC @ 15 ml ai/ha 5.33 (2.40) beetles/ plant and Thiamethoxam 25 % WG @ 25 g ai/ha 6.00 (2.53) beetles/ plant.

4. 2. 1. 2. 2. Three days after spray :

Three day after spray (Table 6), all the insecticidal treatments significantly reduced the beetle population as compared to control 9.00 (3.07) beetles/ plant. Imidachloprid 17.8% SL @ 25 ml ai/ha was found the most effective among all the treatments as it recorded lowest beetle population 0.67 (1.00) beetles/ plant followed by Thiacloprid 21.7 % SC @ 70 ml ai/ha 1.00 (1.17) beetles/ plant, Emamectin benzoate 5% SG @ 10 g ai/ha 1.67 (1.44) beetles/ plant, Quinalphos 25 % EC @ 250 ml ai/ha 2.67 (1.74) beetles/ plant, Chlorantraniliprole 18.5% SC @ 30 ml ai/ha 3.33 (1.93) beetles/ plant, Flubendiamide 39.35 % SC @ 50 ml ai/ha 3.67 (2.02) beetles/ plant, Lambda cyhalothrin 5% EC @ 15 ml ai/ha 4.00 (2.08) beetles/ plant and Thiamethoxam 25 % WG @ 25 g ai/ha 5.67 (2.47) beetles/ plant.

4. 2. 1. 2. 3. Seven days after spray :

Seven day after spray (Table 6), all the insecticidal treatments significantly reduced the beetle population as compared to control 9.33 (3.13) beetles/ plant. Imidachloprid 17.8 % SL @ 25 ml ai/ha was found the most effective among all the treatments as it recorded lowest beetle population 0.33 (0.88) beetles/ plant followed by Thiacloprid 21.7 % SC @ 70 ml ai/ha 0.67 (1.05) beetles/ plant, Emamectin benzoate 5% SG @ 10 g ai/ha 1.33 (1.27) beetles/ plant, Quinalphos 25 % EC @ 250 ml ai/ha 2.33 (1.64) beetles/ plant, Chlorantraniliprole 18.5% SC @ 30 ml ai/ha 2.33 (1.64) beetles/ plant, Flubendiamide 39.35 % SC @ 50 ml ai/ha 2.67 (1.77) beetles/ plant, Lambda cyhalothrin 5% EC @ 15 ml ai/ha 3.33 (1.93) beetles/ plant and Thiamethoxam 25 % WG @ 25 g ai/ha 4.67 (2.26) beetles/ plant.

4. 2. 1. 2. 4. Ten days after spray :

At ten day after spray (Table 6) all the insecticidal treatments significantly reduced the beetle population as compared to control 10.33 (3.28) beetles/ plant. Imidachloprid 17.8 % SL @ 25 ml ai/ha was found to be significantly effective among all the treatments as it recorded lowest beetle population 0.33 (0.88) beetles/ plant followed by Thiacloprid 21.7 % SC @ 70 ml ai/ha 0.33 (0.88) beetles/ plant, Emamectin benzoate 5% SG @ 10 g ai/ha 1.00 (1.17) beetles/ plant, Quinalphos 25 % EC @ 250 ml ai/ha 2.00 (1.47) beetles/ plant, Chlorantraniliprole 18.5% SC @ 30 ml ai/ha 2.00 (1.56) beetles/ plant, Flubendiamide 39.35 % SC @ 50 ml ai/ha 2.33 (1.64) beetles/ plant, Lambda cyhalothrin 5% EC @ 15 ml ai/ha 2.33 (1.64) beetles/ plant and Thiamethoxam 25 % WG @ 25 g ai/ha 3.67 (2.00) beetles/ plant.

4. 2. 1. 3. Overall mean of spray :

Overall mean of spray (Table 6), indicate all the insecticidal treatments significantly reduced the beetle population as compared to control 9.33 (3.13) beetles/ plant. Imidachloprid 17.8 % SL @ 25 ml ai/ha were found to be significantly effective among all the treatments as it recorded lowest beetle population 0.83 (1.12) beetles/ plant followed by

Thiacloprid 21.7 % SC @ 70 ml ai/ha 1.08 (1.23) beetles/ plant, Emamectin benzoate 5% SG @ 10 g ai/ha 1.75 (1.48) beetles/ plant, Quinalphos 25 % EC @ 250 ml ai/ha 2.75 (1.79) beetles/ plant, Chlorantraniliprole 18.5% SC @ 30 ml ai/ha 2.92 (1.84) beetles/ plant, Flubendiamide 39.35 % SC @ 50 ml ai/ha 3.25 (1.93) beetles/ plant, Lambda cyhalothrin 5% EC @ 15 ml ai/ha 3.75 (2.04) beetles/ plant and Thiamethoxam 25 % WG @ 25 g ai/ha 5.00 (2.34) beetles/ plant.

4. 3. Natural enemies at various stage of the beetle during the life cycle of insect :

Field studies were undertaken to identify the key mortality factors of *H. vigintioctopunctata* on bitter gourd crop. All the life stages of the pest were inspected to record the parasitoids attacking the pest under field condition. During the period of study, one species of egg parasitoid *Tetrastichus* spp. and one species of larval – pupal parasitoid *P. foveolatus* (Crawford) were recorded to parasitize *H. vigintioctopunctata.* (Table 7).

4. 3. Parasitoids attacking *H. vigintioctopunctata* (Table 7):

Parasitoids			
Order	**Family**	**Scientific name**	**Stage of the host attacked**
Hymenoptera	Eulophidae	*Tetrastichus* spp.	Egg
Hymenoptera	Eulophidae	*Pediobius foveolatus* Crawford	3rd and 4th instar larva and pupa

4. 3. 1. Natural parasitzation of eggs of *H. vigintioctopunctata* by *Tetrastichus* spp :

The natural parasitisation of eggs of *H. vigintioctopunctata* by the egg parasitoid *Tetrastichus* spp. was observed during February–March. The extent of parasitization was recorded on an average per cent 56.25% at the end of February and 43.75 % in the beginning of March. The percent of eggs parasitized per egg was observed between 12.39 to 100 % in different observations (Table 8). However, the average percentage of eggs parasitization ranged from 21.43 in the beginning of march 2020 and the end of February 2020, respectively.

4. 3. 1. Natural parasitzation of eggs of *H. vigintioctopunctata* by *Tetrastichus* spp (Table 8) :

S. No.	Date	% Egg Masses Parasitized	% Parasitization	Range %
1	3rd February	54.17	23.08	12.39-100.00
2	10th February	51.85	21.43	17.47-86.00
3	17th February	53.57	20.00	15.82-85.50
4	24th February	56.25	27.78	23.73-90.57
5	3rd March	43.75	21.43	22.50-100.00
6	10th March	50.00	16.67	20.50-76.68
7	17th March	53.85	21.43	14.06-100.00
8	24th March	52.38	18.18	11.92-94.57
Average		**51.98**	**21.25**	

4. 3. 2. Natural parasitisation of grub and pupa.

Grub and pupa of *H. vigintioctopunctata* were found parasitization *P. foveolatus* 2020 in the field condition during February to march 2020. Highest larva parasitization 54.24 % was recorded in the first week of February 2020 and the lowest 40.74% at the end of march 2020 (Table 9).

4. 3. 2. Natural parasitization of *H. vigintioctopunctata* later instar larva by *P. foveolatus* (Table 9) :

Weekly Intervals	No. of Larva	No. of Larva Parasitized	% Parasitization
1st week	59	32	54.24
2nd week	67	33	49.25
3rd week	71	36	50.70
4th week	56	25	44.64
5th week	72	37	51.39
6th week	76	34	44.74
7th week	66	31	46.97
8th week	54	22	40.74
Average			**47.83**
* 1st - 8th week indicates beginning of 1st week of February to last week of March.			

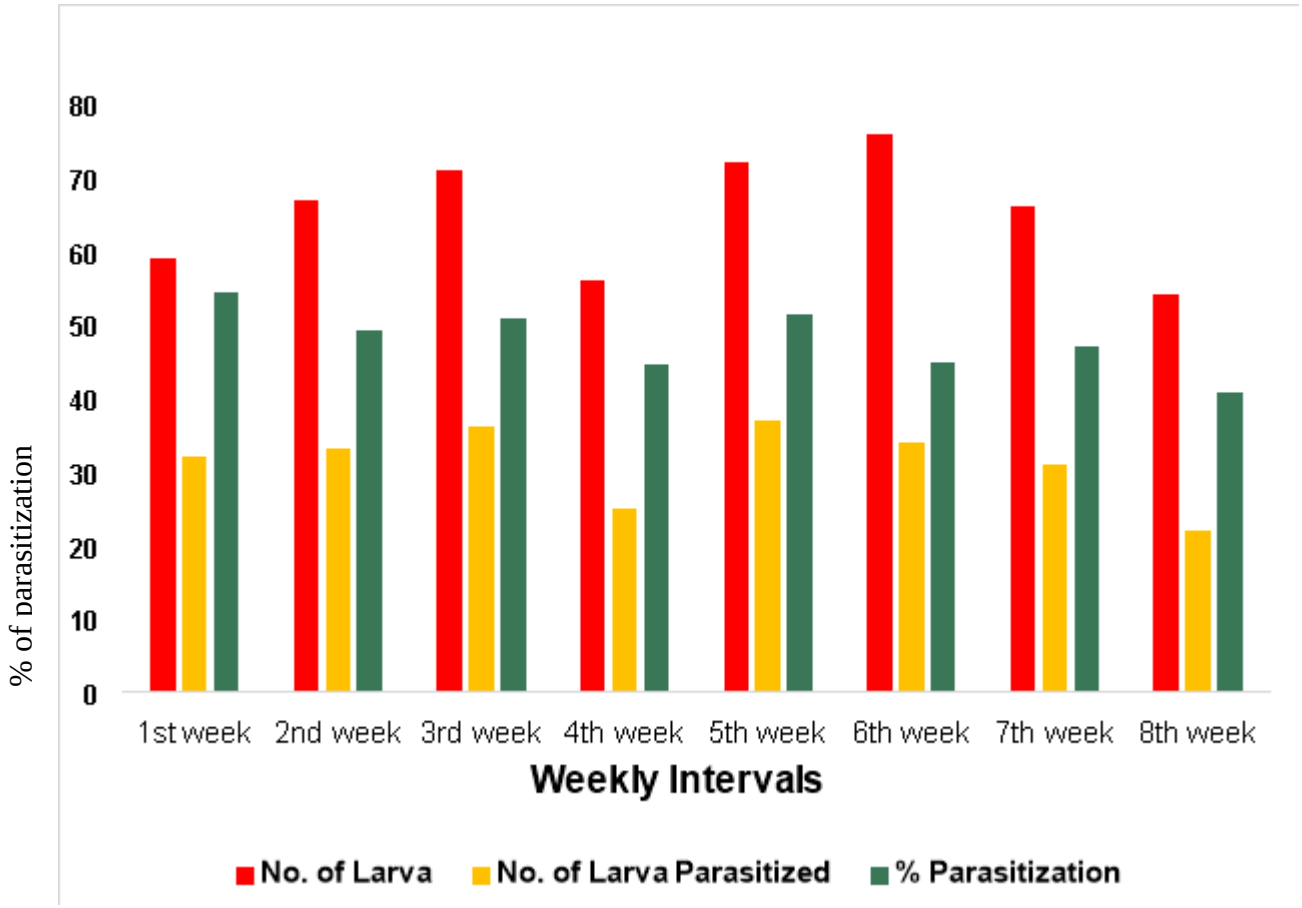

Figure 2. Natural parasitization of *H. vigintioctopunctata* later instar larva by *P. foveolatus.*

4. 3. 3. Natural parasitisation of pupa by *P. foveolatus :*

Natural parasitisation of the pupae of *H. vigintioctopunctata* by the larval – pupal parasitoid, *P. foveolatus* was recorded in the field during February – March 2020. Maximum parasitisation occurred in the 1st week of February 2020 (44.83 %) which declined gradually to 30.30 % in initial week of march 2020 and then increase per cent parasitisation 35.29 % in 2nd week of march and after gradually decrease the per cent parasitisation 31.25% in last week of march 2020. (Table 10).

4. 3. 3. Natural parasitisation pupa of *Epilachna* beetle pupa by *P. foveolatus* (Table 10) :

Weekly Intervals	No. of Pupa	No. of Pupa Parasitized	% Parasitization
1st week	29	13	44.83
2nd week	31	11	35.48
3rd week	24	9	37.50
4th week	35	12	34.29
5th week	33	10	30.30
6th week	34	12	35.29
7th week	28	9	32.14
8th week	32	10	31.25
Average			**35.14**
*** 1st - 8th week indicates beginning of 1st week of February to last week of March.**			

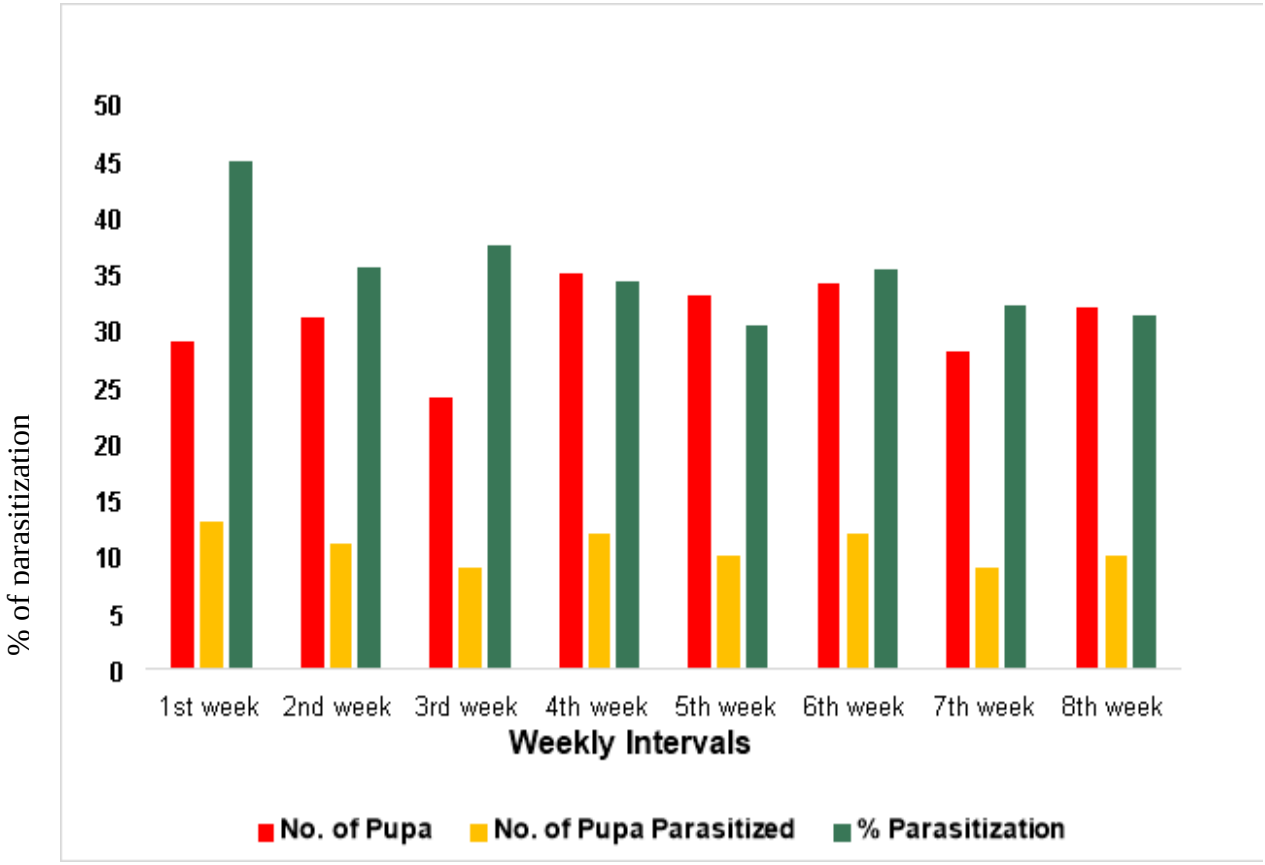

Figure 2 Natural parasitisation pupa of *H. vigintioctopunctata* pupa by *P. foveolatus.*

CHAPTER – V

DISCUSSION

DISCUSSION

The findings on the bitter gourd related to the relevant objectives of the study is discussed here by in the light of the findings of earlier workers.

5.1. The lifecycle of *Epilachna* beetle on various host plant :

5.1.1. Morphometrics of different life stages *Henosepilachna vigintioctopunctata* :

The eggs were laid in clusters on the underside of the leaves. The freshly laid individual egg was stalked, shiny yellow, elongate-oval tapering at top end, pointed distally and clustered vertically with smooth texture, on maturity the colour changed from yellow to light yellow and ultimately to creamy yellow at hatching. On the basis of twenty randomly selected eggs from different clusters laid by a female beetle, the length and width of the eggs varied from 1.02 ± 0.29 mm and 0.39 ± 0.11 mm, respectively. Kaur and Mavi (2005) observed that the freshly laid eggs were yellow, elongated oval with mean values of length and width as 1.09 ± 0.04 mm and 0.32 ± 0.03 mm. Varma and Anandhi (2008) also reported that the average length and width of egg was 1.13 ± 0.10 mm and 0.41 ± 0.07 mm. Qamar *et al.* 2019 studied morphometries parameters of *E. vigintioctpunctata* on brinjal and reported that the length and width of eggs varied from 1.27-1.42mm (avg. 1.34mm) and 0.42-0.52nim (avg. 0.47mm), respectively. Which is in conformity with present finding.

Newly hatched grubs were yellowish brown in colour, elatriform in structure and shape, usually occurred on lower side of leaf. The body length and width 1st instar larvae varied from 2.04 ± 0.53 mm and 0.64 ± 0.17 mm, respectively. This stage did not move at all and sticked to the point of hatching and fed on the lower side of tender foliage. The respective body length and width of 2nd instar larvae was recorded 2.82 ± 0.60 mm and 1.02 ± 0.21 mm. Thorax was rugose where pro and mesothorax were fused together. This stage was swift in

movement and fed on green matter from both the surfaces of the leaves and even the twigs flowers and fruit of the plant. The body length and width of third instar grub varied from 4.88 ± 0.71 mm and 2.08 ± 0.54 mm, respectively. There were 9 abdominal segments each provided with paired spinal, dorsal hairs long and pointed, clearly visible in the full grown grub instar. This stage was noticed to be voracious feeder of the host plant foliage, completely scraped the green matter and skeletonized the leaves.

The body length of 4th instar grub was recorded as 5.64 ± 0.92 mm and width 3.09 ± 0.41 mm. Kaur and Mavi (2005) observed that the grubs were yellow, elongated and oval with branched spines on thoracic and abdominal segments with mean values of length of 1st, 2nd, 3rd and 4th instars of grubs as 1.90 ± 0.04, 2.97 ±0.13,4.45 ± 0.27 and 6.80 ± 0.25 mm and mean values of width as 0.71 ± 0.06, 1.01 ± 0.07, 1.79 ± 0.11 and 3.28 ± 0.08 mm, respectively. The ratios of the length and the width of the first and the last instar grubs were 1: 3.58 and 1: 4.61, respectively. Varma and Anandhi (2008) also reported that the average body length and width of 1st, 2nd, 3rd and 4th grub instars was 1.14 ± 0.10 and 0.40 ± 0.04 mm, 2.33 ± 0.17 and 0.96 ±0.12 mm, 4.70 ± 0.40 and 1.89 ± 0.90 mm, 6.60 ± 0.39 and 2.73 ± 0.20 mm, respectively. Kumar *et al.* (2009) observed that the average body length and width of 1st, 2nd, 3rd and 4th grub instars was 2.05 ± 0.27 and 0.68 ± 0.14 mm, 2.88 ± 0.32 and 1.12 ± 0.60 mm, 4.04 ± 0.39 and 1.52 ± 0.34 mm, 5.80 ± 0.70 mm and 2.52 ± 0.51 mm, respectively. Qamar *et al.* 2019 studied morphometries parameters of *E. vigintioctpunctata* on brinjal and reported that the average length and width of 1st, 2nd, 3rd and 4th instar of grubs was 2.05 ± 0.27mm and 0.68 ± 0.14mm, 2.88 ± 0.32mm and 1.12 ± 0.60 mm, 4.04 ± 0.39mm and 1.52 ± 0.34mm; 5.80 ± 0.70 mm and 2.52 ± 0.51mm, respectively.

The full-grown grub stopped feeding and attached itself to the leaf surface. The respective body length and width measurement of pre pupa was 6.49 ± 1.03 mm and 4.62 ± 0.54 mm. Our results differ from the findings of Varma and Anandhi (2008) who reported that average body length and width of pre-pupa 4.50 ± 0.67 mm and 3.27 ± 0.43

mm, respectively. Similarly, Kumar *et al.* (2009) also recorded the average body length and width of pre-pupa as 4.40 ± 0.52 mm and 3.17 ± 0.34 mm respectively on brinjal crop. This might be due to the difference in the host plant.

The body specifications in terms of length and width of the pupal stage were recorded as 5.38 ± 0.89 mm and 3.27 ± 0.42 mm. respectively. The pupae were hemispherical in shape with mean length and width as 7.05 ± 0.44 and 4.00 ± 0.41 mm (Kaur and Mavi, 2005). Varma and Anandhi (2008) also reported that the average body length and width of pupa was 5.02 ± 0.15 and 2.93 ±0.18 mm. The average body length and width of pupa was 4.96 ±0.19 and 2.95 ±0.19 mm, respectively (Kumar *et al,* 2009). These findings are in conformity with our results.

The beetles were oval, convex, with black head, elytron pale brown with black spots. The measurement of the body length of the male was recorded 6.77 ± 0.94 mm and width 4.83 ± 0.63 mm, respectively. The females were slightly bigger than males. The average measurement of the body length and width of the female beetle was 7.09 ± 0.70 mm and 3.27 ± 0.42 mm, respectively. Similar results were obtained by Kaur and Mavi (2005) who observed that the male and female adults were brown having with mean values of length and width of male and female adults as 5.85 ± 0.32, 6.85 ± 0.23 mm and 4.55 ± 0.42, 5.05 ± 0.15 mm, respectively. Varma and Anandhi (2008) also reported that the average length and width of male was 7.00 ±1.18 and 4.78 ± 0.28 mm, whereas, length and width of female was 7.45 ± 1.35 and 4.95 ± 0.72 mm. Similarly, Kumar *et al.* (2009) recorded the average body length of male as 7.00 ± 1.08 mm and width 4.73 ± 0.19 mm whereas, in female length was recorded as 7.32 ± 1.37 mm and the width 4.95 ± 0.43 mm. Qamar *et al.* 2019 reported that the average length and width of male adults were 7.00 ± 1.08 and 4.73 ±0.19 mm and the average length and width of 7.45 ± 1.35 and 4.95 ± 0.72 mm, respectively, was recorded in case of females.

5.1.2 Developmental duration of different life stages *H. vigintioctopunctata* on host plant bitter gourd (*Momordica charantia Linn*.) and macoy (*Physalis minima*).

5.1.2.1 Egg period

Incubation period of *E. vigintioctopunctata* was studied on Bitter gourd and macoy under laboratory conditions during January 2020 to march 2020. It was observed that the average incubation period was 3.95 ± 1.32 and 4.55 ± 1.23 days respectively. Which varied from 3 to 6 days in which could be due to the impact of temperature and humidity. Our findings are in agreement with those of Hossain *et al.* 2008 who reported that incubation period was 4.30 ±0.13 days on Bitter gourd. brinjal. Qamar *et al.* (2009) also reported an incubation period of 3-7 days with an average of 4.00 ± 1.28 days on brinjal. Bindu and Pramanik 2015 also reported an incubation period of an average of 3.2 ± 0.84 days on brinjal. which also supports our results.

5.1.2.2 Grub duration

On bitter gourd, the stadial average duration 1^{st}, 2^{nd}, 3^{rd} and 4^{th} instars 4.30 ± 0.98, 3.35 ± 0.75, 4.65 ± 0.88 and 3.70 ± 1.03 days respectively. On macoy, the stadial average duration 1^{st}, 2^{nd}, 3^{rd} and 4^{th} instars 4.05 ± 0.94, 3.55 ± 0.60, 5.05 ± 1.10 and 3.55 ± .89 days respectively. Our results are in similar line with the findings of Qamar *et al.* (2009) reported that the total grub period was completed between 10-23 days by *E. vigintioctopunctata* with an average of 14.9 ± 0.43 days. Varma and Anandhi (2008) reported that the average duration of 1^{st}, 2^{nd}, 3^{rd} and 4^{th} grub instars varied from 2.6 ± 0.48, 2.9 ± 1.04, 2.5 ± 0.50 and 6.8 ± 1.94 days. Our findings are in conformity with Hossain *et al.* (2008) who reported that the grubs completed 4 instars within 11.30 ± 0.48 days. The duration of 1st, 2nd, 3rd and 4th grub instars was 2.25 ± 0.13, 3.25 ± 0.08, 2.55 ± 0.15 and 3.25 ± 0.12 days, respectively, on bitter gourd.

5.1.2.3 Pre-pupa and pupa

The full-grown grub stopped feeding for a day or two and transformed to pupa which remained attached below the surface of the leaf or other plant parts. The coated skin of the grub remains attached to the pupa which imparted appearance. The pre-pupal periods were average 2.70 ± 0.66 and 2.45 ± 0.60 days and pupal period were 5.05 ± 0.94 and 4.45 ± 1.10 days on bitter gourd and macoy respectively. Our results are in similar line with the findings of Varma and Anandhi (2008) also recorded that the pupal period ranged from 3-6 days with an average of 4.60 ± 0.9 days. Hossain *et al.* (2008) also reported that pre-pupal and pupal stages lasted for 1.00 ± 0.15 and 4.70 ± 0.20 days on bitter gourd, respectively. Similarly, Qamar *et al*. (2009) showed that the pupal period lasted for 3-6 days with an average of 4.6 ± 1.01 days.

5.1.2.4 Total developmental Period

The total developmental period from egg to adult emergence on an average 27.80 ± 1.58 and 26.25 ± 1.37 days on bitter gourd and macoy respectively. Our findings are in conformity with results obtained by Hossain *et al.* (2008) reported that insect *E. vigintioctopunctata* completed its life cycle in 21.3 ± 0.81 days on bitter gourd. Ghosh and Senapati (2001) also reported that the life cycle duration was shortest (26.74 days) during June-July and longest (33.52 days) in September-October on brinjal.

5.1.2.5 Adult longevity

The longevity of male was found 15.95 ± 1.28 and 17.30 ± 1.63 days while in case of female 25.25 ± 1.62 and 30.05 ± 3.95 days on bitter gourd and macoy. Our findings are in conformity with results obtained by Qamar *et al.* (2009) observed that the male longevity ranged fi-om 41-69 days with an average of 57.2 ±7.12 days, whereas, female longevity was 45-76 days with an average of 60.80 ± 9.73 days. Bindu SP and Pramanik A. 2015 also reported the mean adult male beetle longevity was 33.6 ± 2.70 days. Tara JS. and Sharma S. 2017

conducted the adult male and female survived for an average period of 23±1.58 days and 30±1.49 days, respectively.

5.1.2.6. Fecundity :

The total number of eggs produced regardless of their fertility is considered as one of the important biological aspect of insect pest and their populations build up. The eggs were laid in clusters usually on the under surface of the leaves. The data in respect of fecundity evidenced that a female laid 11-15 eggs every day, continuously for 12-14 days in batches varying from 169.05 ± 12.31 and 190.80 ± 20.11 eggs on bitter gourd and macoy. Our findings are in conformity with results obtained by Jamwal VVS *et al*. 2013 the Studies conducted Bindu and Pramanik 2015 reported the mean fecundity was recorded as 55.8 ± 7.73 eggs / female. Tara and Sharma 2017 conducted on the biology *Hensoepilachna vigintioctopunctata* indicated that a gravid female laid 200- 370 eggs on an average in 6-7 batches during her life span. Tayde *et al.* 2013. Studied the life cycle of *Epilachna beetle* on bitter gourd in reported that a single female of *Hensoepilachna vigintioctopunctata* laid 211 to 328 eggs during the life span. Satpathy and Mandal 2010 Studied the life table of *Henosepilachna vigintioctopunctata* on brinjal and reported that female laid as many as 200 eggs in 4-6 batches of 20-60, usually ventral surface of leaf.

5.2.1. Evaluation of efficacy of new insecticide against *Epilachna* beetle.

The efficacy of eight insecticides namely Chlorantraniliprole 18.5% SC @ 30 ml ai/ha, Flubendiamide 39.35 % SC @ 50 ml ai/ha, Quinalphos 25 % EC @ 250 ml ai/ha, Imidachloprid 17.8 SL @ 25 ml ai/ha, Thiamethoxam 25 % WG @ 25 g ai/ha, Lambda cyhalothrin 5% EC @ 15 ml ai/ha, Emamectin benzoate 5% SG @ 10 g ai/ha, Thiacloprid 21.7 % SC @ 70 ml ai/ha was tested and compared with control. Results revealed that all the insecticides were effective against *H. vigintioctopunctata*.

The efficacy of eight insecticides namely Chlorantraniliprole 18.5% SC @ 30 ml ai/ha, Flubendiamide 39.35 % SC @ 50 ml ai/ha, Quinalphos 25 % EC @ 250 ml ai/ha, Imidachloprid 17.8 SL @ 25 ml ai/ha, Thiamethoxam 25 % WG @ 25 g ai/ha, Lambda cyhalothrin 5% EC @ 15 ml ai/ha, Emamectin benzoate 5% SG @ 10 g ai/ha, Thiacloprid 21.7 % SC @ 70 ml ai/ha were evaluated including untreated control. Results revealed that all the insecticides were effective against *H. vigintioctopunctata*.

Overall mean of treatments, indicated significant effect of treatments by reducing reduced the beetle population as compared to control (9.33 beetles/ plant). Imidachloprid 17.8 % SL @ 25 ml ai/ha were found to be significantly superior among all the treatments as it recorded lowest beetle population (0.83 beetles/ plant) and non significantly followed by Thiacloprid 21.7 % SC @ 70 ml ai/ha (1.08 beetles/ plant),while rest of the treatments were significantly inferior to the above insecticide but definitely superior than untreated. The order of efficacy was found as given below. Emamectin benzoate 5% SG @ 10 g ai/ha (1.75 beetles/ plant), Quinalphos 25 % EC @ 250 ml ai/ha (2.75 beetles/ plant), Chlorantraniliprole 18.5% SC @ 30 ml ai/ha (2.92 beetles/ plant), Flubendiamide 39.35 % SC @ 50 ml ai/ha (3.25 beetles/ plant), Lambda cyhalothrin 5% EC @ 15 ml ai/ha (3.75 beetles/ plant) and Thiamethoxam 25 % WG @ 25 g ai/ha (5.00 beetles/ plant).

Umapathy and Baskaran 1991. Also reported that the quinalphos (313 g a.i./ ha) and carbaryl (1000 g a.i./ ha) for the control of *H. vigintioctopunctata* on aubergines. and found effective again the *Epilachna* beetle which agree with the present finding

On the contrary the finding of the Sheikh K and Raj Desh 2013, Jamwal *et al.* 2013. do not agree with present finding. They reported lambda cyhalothrin as the most effective.

The finding of Kodandaram *et al.* 2014, Anwar *et al.* 2015. revealed the effectiveness of emamectin benzoate 5 SG @ 10g ai ha^{-1} proved to be the most effective treatment with a mean reduction of 75.3

and 73.9 per cent in pest population. Their study supports the present finding regarding Emamectin benzoate 5% SG @ 10 g ai/ha.

5. 3. 1. Natural parasitzation of eggs of *H. vigintioctopunctata* by *Tetrastichus* spp :

Eggs parasitisation started from the 3rd February and maximum was recorded i.e. 27.78% in the 4th week of February 2020 and minimum 16.67% on 10th march 2020 which is average 21.25%. Reddy and Mandal 2016. reported of 21.82 % eggs parasitisation and Jamwal *et al.* 2014 to the extent 20.56% (2009) and 24.72% (2010) by *Tetrastichus* spp.

Grub and pupa were parasitized by *P. foveolatus* to the extent of 40.74% to 54.24% and 30.30% to 44.83% respectively. Reddy and Mandal 2016 also reported parasitization of grub and pupa by *P. foveolatus* 48.09% and 33.87% respectively. However, Jamwal *et al.* 2014 have reported the pupal parasitization as 7.82% in (2009) and 5.42% in (2010).

Roy S. and Thakur A. 2018 also studies the key mortality factors and effectiveness of natural enemies to against the population of *Epilachna vigintioctopunctata* (Fabr.) on brinjal and reported *Tetrastichus sp.* and *Pediobius foveolatus*. *Tetrastichus* sp. caused 23.48 % of eggs and parasitoid, *P. foveolatus* parasitized 47.69 % of 4th instar grubs and 35.38 % of pupae. These finding extent support to the present study.

CHAPTER – VI

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

6.1. SUMMARY

Investigation on **"Studies on the life cycle of Hadda beetle (*Henosepilachna vigintioctopunctata*) and its management on bitter gourd (*Momordica charantia* Linn.)"** was comprised three experiments conducted under the field and laboratory condition at J.N.K.V.V. College of Agriculture, Rewa, Madhya Pradesh during Kharif season 2019.The present investigation was an attempt to study on the life cycle of Epilachna beetle (Henosepilachna vigintioctopunctata) and its management on bitter gourd (*Momordica charantia* Linn.) are summarized in this chapter.

The data obtained from the morphometric studies revealed that the length and width of *H. vigintioctopunctata* eggs varied from 1.02 ± 0.29 mm and 0.39 ± 0.11 mm, respectively. The average body length and width of 1st, 2nd, 3rd and 4th grub instars was 2.04 ± 0.53 mm and 0.64 ± 0.17 mm, 2.82 ± 0.60 mm and 1.02 ± 0.21 mm, 4.88 ± 0.71 mm and 2.08 ± 0.54 mm, 5.64 ± 0.92 mm and width 3.09 ± 0.41 mm respectively. The body length and width of pre-pupa was 6.49 ± 1.03 mm and 4.62 ± 0.54 mm. The body length and width of the pupal stage was as 5.38 ± 0.89 mm and 3.27 ± 0.42 mm, respectively. The measurement of the over all body length and width of the male and female were recorded 6.77 ± 0.94 mm and 4.83 ± 0.63 mm, 7.09 ± 0.70 mm and 3.27 ± 0.42 mm, respectively.

The studies on developmental duration of different life stages of *H. vigintioctopunctata* on bitter gourd (*Momordica charantia Linn*.) and macoy (*Physalis minima*) plant. The finding revealed that the average incubation period on bitter gourd and macoy were 3.95 ± 1.32 days and 4.55 ± 1.23 days, respectively. The 1st, 2nd, 3rd and 4th grub instars period on an average were 4.30 ± 0.98 days and 4.05 ± 0.94 days, were 3.35 ± 0.75 days and 3.55 ± 0.60 days, 4.65 ± 0.88 days and 5.05 ± 1.10 days, 3.70 ± 1.03 days and 3.55 ± 0.89 days, on bitter gourd and macoy respectively. The pre-pupal period varied on an average 2.70 ± 0.66 and 2.45 ± 0.60 days on bitter gourd and macoy

respectively. The pupal period was observed 5.05 ± 0.94 on bitter gourd and 4.45 ± 1.10 days and macoy. The total developmental period from egg to adult emergence was observed on an average 27.80 ± 1.58 days on bitter gourd and 26.25 ± 1.37 days on macoy. The longevity of the adult beetle was recorded on an average 15.95 ± 1.28 and 17.30 ± 1.63 days for male on bitter gourd and macoy respectively. while in case of female it was 25.25 ± 1.62 and 30.05 ± 3.95 days on bitter gourd and macoy respectively. The eggs were laid in clusters usually on the under surface of the leaves. The data in respect of the fecundity evidenced that a female laid 11-15 eggs every day, continuously for 12-14 days in batches of 2-5 mainly on the ventral surface of the leaves. The total number of egg laid by female on bitter gourd varied from 145 to 189 eggs / female. Averaging 169.05 ± 12.31 eggs/female. The egg laid on macoy was found on an average 190.80 ± 20.11 of eggs/female with a range of 156 to 225 eggs/female.

Trials on management of the *H. vigintioctopunctata* revealed that all the treatments were significantly superior over control the maximum reduction in pest population was occurred in Imidachloprid 17.8% SL @ 25 ml ai/ha followed by Thiacloprid 21.7 % SC @ 70 ml ai/ha, Emamectin benzoate 5% SG @ 10g ai/ha, Quinalphos 25 % EC @ 250 ml ai/ha, Chlorantraniliprole 18.5% SC @ 30 ml ai/ha, Flubendiamide 39.35 % SC @ 50 ml ai/ha, Lambda cyhalothrin 5% EC @ 15 ml ai/ha and Thiamethoxam 25 % WG @ 25 g ai/ha. The order of relative efficacy of different insecticides after 1, 3, 7 and 10 days of the application was observed in the decreasing order Imidacloprid 17.8 % SL > Thiacloprid 21.7 % SC > Emamectin benzoate 5% SG > Quinalphos 25 % EC > Chlorantraniliprole 18.5% SC > Flubendiamide 39.35 % SC > Lambda cyhalothrin 5% EC > Thiamethoxam 25 % WG.

As regard to the natural enemies of the pest, two parasitoids viz. *Pediobius foveolatus* (Crawford) and *Tetrastichus* sp. were recorded on the papulation attacking *H. vigintioctopunctata*. On bitter gourd, maximum parasitization by *Tetrastichus sp.* (27.78%) (egg parasitiod), *Pediohius foveolatus* (pupal parasitiod) (44.83%) and *Pediohius*

foveolatus (larva parasitiod) (54.24%) was observed during the study period.

6.2. CONCLUSION:

On the basis of the results obtained following conclusions can be drawn:

- ✓ The pest was invariably found on cultivated as well as on wild host plant macoy which act as a pest reservoir.
- ✓ The developmental duration of the pest was shorter on macoy as compared to bitter gourd.
- ✓ Two parasitoids viz. *Pediobius foveolatus* Crawford and *Tetrastichus* sp. were recorded attacking *H. vigintioctopunctata* Conservation of these natural enemies will help in natural pest population management.
- ✓ Imidachloprid 17.8% SL @ 25 ml ai/ha was found as the most effective insecticide in reducing the pest population, followed by Thiacloprid 21.7 % SC @ 70 ml ai/ha and Emamectin benzoate 5% SG @ 10g ai/ha, which were also equally effective.

Suggestion

1. Life cycle of Epilachna beetle should be carried out on other host plant like brinjal, potato and parora.
2. Population dynamics of the pest be studied on different host plants under the changing climate conditions.
3. Level of parasitization at different stages of insects be carried out throughout the year.
4. Evaluation of new molecules of novel insecticides.

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APPENDICES

APPENDIX

ANOVA 1: **Pre-treatment :**

Sources of variance	D.F.	S.S.	M.S.S.	F.CAL.	F.TAB. 5%
Replication	2.00	0.24	0.12	1.33	
Treatments	8.00	0.50	0.06	0.69	2.59
Error	16.00	1.44	0.09		
Total	26.00				
SEm± = 0.17			CD at 5% = NS		

ANOVA 2: **One days after spray :**

Sources of variance	D.F.	S.S.	M.S.S.	F.CAL.	F.TAB. 5%
Replication	2.00	0.72	0.36	1.88	
Treatments	8.00	5.23	0.65	3.44	2.59
Error	16.00	3.04	0.19		
Total	26.00				
SEm± = 0.25			CD at 5% = 0.74		

ANOVA 3: **Three days after spray :**

Sources of variance	D.F.	S.S.	M.S.S.	F.CAL.	F.TAB. 5%
Replication	2.00	1.00	0.50	3.83	
Treatments	8.00	9.96	1.25	9.53	2.59
Error	16.00	2.09	0.13		
Total	26.00				
SEm± = 0.21			CD at 5% = 0.61		

ANOVA 4: **Seven days after spray :**

Sources of variance	D.F.	S.S.	M.S.S.	F.CAL.	F.TAB. 5%
Replication	2.00	1.09	0.54	3.93	
Treatments	8.00	11.12	1.39	10.07	2.59
Error	16.00	2.21	0.14		
Total	26.00				
SEm± = 0.21			CD at 5% = 0.64		

ANOVA 5: **Ten days after spray :**

Sources of variance	D.F.	S.S.	M.S.S.	F.CAL.	F.TAB. 5%
Replication	2.00	0.40	0.20	1.00	
Treatments	8.00	12.64	1.58	7.97	2.59
Error	16.00	3.17	0.20		
Total	26.00				
SEm± = 0.26			CD at 5% = 0.75		

ANOVA 6: **Overall mean of spray :**

Sources of variance	D.F.	S.S.	M.S.S.	F.CAL.	F.TAB. 5%
Replication	3.00	1.36	0.45	22.08	
Treatments	8.00	11.94	1.49	72.47	2.36
Error	24.00	0.49	0.02		
Total	35.00				
SEm± = 0.08			CD at 5% = 0.24		

CURRICULUM VITAE

CURRICULUM – VITAE

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S. No.	Institution	Degree Awarded	Year	Per.
1.	Triveni Bal SR SEC, School Chohilanwali Hanumangarh Rj.	10th class	2011	74.33
2.	Govt. SR SEC SCH, Pilibangan Rj.	12th class	2013	62.20
3.	A.U, Kota (Rj.)	B.Sc. (Ag)	2018	66.40
4.	JNKVV, Rewa (M.P.)	M.Sc. (Ag)	2020	70.50

For the partial fulfillment of the master's degree programme he choosed a research problem on **"Studies on the life cycle of** Hadda **beetle (*Henosepilachna vigintioctopunctata*) and its management on bitter gourd (*Momordica charantia Linn*.)"** This was successfully conducted by him and being submitted in the form of the thesis.