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Biology of pod borer (*Maruca vitrata)* infesting Dolichos bean under laboratory conditions

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Abstract
The laboratory investigation on biology of pod borer, *Maruca vitrata* (Geyer) was carried out during the year 2016-17 at the Department of Agricultural Entomology, College of Agriculture, Dapoli, Dist. Ratnagiri. The laboratory studies on the biology of pod borer, *M. vitrata* recorded that the pre-oviposition, oviposition and post-oviposition period lasted for 3.4, 3.3 and 1.4 days, respectively. A female laid on an average 64.4 eggs singly or in batches on flower buds and tender pods. Incubation period lasted for 3.3 days with 79 percent egg hatching. The first instar larva was greenish white with head breadth 0.14 mm and body length 1.41 mm, but prior to pupation larvae changed its colour from deep white to green and pupated at the corner of petri plate. The larval development completed within 12.2 days through five instars, duration of each instar observed to be 2.3, 2.2, 2.2, 2.3 and 3.2 days, respectively. The full grown larva measured 1.6 mm in head breadth and 15.94 mm in body length. The pre pupal and pupal period lasted for 2.2 and 8.8 days, respectively. Longevity of male and female moths was 4.5 and 8.9 days, respectively. Male moth measured 11.08 mm in length, 2.15 mm in width and 24.46 mm in wing expanse. Female measured 11.90 mm in length, 2.22 mm in width and 25.32 mm in wing expanse. The sex ratio for male and female was 1: 1.17. The life cycle male and female was completed within 32.2 and 36.7 days, respectively.

Keywords: biology, *Maruca vitrata*, dolichus bean and laboratory condition

Introduction
The grain legumes occupy a unique position in the world agriculture by virtue of their high protein content and capacity of fixing atmospheric nitrogen. For many of the developing countries, pulses constitute the only concentrated source of dietary protein. As regards the developed countries, grain legumes are an important source of protein being animal feeds of good biological value. Indians, in general, prefer vegetarian food and main source of getting protein is pulses. The major portion of the country is under rainfed condition and the pulses have been adjusted well in different mixed cropping, inter cropping and crop rotations. In India, pulses are being grown mostly in Madhya Pradesh, Rajasthan, Maharashtra, Karnataka, Uttar Pradesh and Aandhra Pradesh. In India, the total area under pulses was 23.10 million hectares with an annual production of 17.19 million tonnes (Anonymous 2015a) [1] while in Maharashtra the total area under pulses was 3.14 million hectares with annual production of 1.74 million tonnes (Anonymous 2015b) [2]. In Konkan the total area under pulses is 88000 hectares with an annual production of 37 metric tonnes (Anonymous, 2015c) [3].
Dolichos bean is an ancient legume crop widely grown throughout the world for its vegetable or pulse for human consumption or as animal forage or feed. *Lablab purpureus* L. (Sweet) Usually known as Dolichos bean, Hyacinth bean or Field bean is one of the most ancient crops among cultivated plants. It is a bushy, semi erect, perennial herb, showing no tendency to climb. It is mainly cultivated either as a pure crop or mixed with finger millet, groundnut, castor, corn, bajra or sorghum in Asia and Africa. It is a multipurpose crop grown for pulse, vegetable and forage. The crop is grown for its green pods, while dry seeds are used in various vegetable food preparations. It is also grown in home gardens as annual crop or on fences as perennial crop. It is one of the major source of protein in the diets in southern states of India. The consumer preference varies with pod size, shape, colour and aroma (pod fragrance). It is also grown as an ornamental plant, mostly in USA for its beautiful dark green, purple veined foliage with large spikes clustered with deep violet and white pea like blossoms.

The lablab bean, *Lablab purpureus* Linnaeus is an important pulse-cum-vegetable crop in India cultivated for its tender and mature pods, seeds and an also for fodder. The Wal is rich in nutritive value. The pods and seeds contain high protein content (20-28 percent). The green pods contain about 3.8 percent protein with moisture 86.1 percent, carbohydrates 6.7 percent and fat 0.7 percent. It also contains 1.8 percent fibre and 0.9 percent ash. The approximate composition of the dry pulse is 24.9 percent protein with 9.6 percent moisture, 60.1 percent carbohydrate, 0.8 percent fat, 1.4 percent fibres and 3.2 percent ash content.

Govindan (1974) [8] recorded as many as 55 species of insects and one species of mite feeding on the crop from seedling stage till the harvest in Karnataka. Among the various pests, pod borer complex comprising of *Helicoverpa armigera* (Hubner), *Adisura atkinsoni* (Moore), *Maruca vitrata* (Geyer), *Etiella zinckenella* (Treitschke), *Cydia ptychora* (Meyrick), *Exelastis atomosa* (Walshinghan), *Sphenarches caffer* (Zeller) and *Lampides boeticus* (Linnaeus) are of considerable importance causing 80 percent pod damage.

The larvae of pod borer, *M. vitrata* are known to cause considerable damage to lablab bean attacking various parts *viz*., buds, flowers, pods and seeds. Its nature of damage is exhibited by weaving unopened buds and flowers. The larva further damages the reproductive parts of flower leading to poor pod setting and pod formation. In the later period of crop growth, it behaves as a pod borer and completes its larval and pupal development inside the pod. This leads to poor pod formation, reduction in grain yield as well as adverse effect on market value of green pods.

The lablab bean, locally called as 'wal' is one of the important pulse crops of Konkan region grown in the *rabi* season. It is severely infested by pod borer, *M. vitrata*. Since few years, considerable research work on biology of this pest has been done in abroad and India, but not from Konkan region of Maharashtra.

Materials and Methods

The laboratory investigations on biology of pod borer, *Maruca vitrata* (Fabricus) was carried out during the year 2016-17 at the Department of Agricultural Entomology, College of Agriculture, Dapoli, Dist. Ratnagiri. Under laboratory conditions from January, 2017 to March, 2017. A brief account of techniques employed and material used in the present study is described below. (Plate II and III)

Materials used

1. Camel hair brush	9. Cotton swab
2. Rubber bands	10. Plastic trays
3. Glass jars (23×11cm)	11. Honey solution
4. Muslin cloth	12. Scissor
5.Small plastic bottles (10×08cm)	15.Acrylic cage
6. Small plastic vials (7×25cm)	16. Plastic pots (40×30 cm)
7.Dolichos bean leaves	17.deno-lite digital microscope

Maintenance of culture

The initial culture of pest was obtained by collecting larvae from Botany Farm, College of Agriculture, Dapoli, during the month of January. The larvae were reared in the glass jars (41 cm height and 30 cm diameter). Fresh buds of lablab bean were provided daily as food for larvae till pupation. Freshly formed pupae were kept individually in small sized plastic jar, the top of which was covered with muslin cloth and secured firmly with rubber band. The cotton swab soaked in 5 percent honey solution was kept suspended in the jar from the top as food for newly emerged adults. The freshly emerged moths were collected and ten pairs of freshly emerged male and female adult were confined individually into the glass jar. The inner side of glass jar was wrapped with black coloured paper to observe egg laying. The cotton swab soaked in 5 percent honey solution was kept suspended in a glass jar as food for moths. The swab soaked in honey solution was changed daily. The twig of lablab bean along with tender buds and pods were kept in 250 ml conical flask with water. The mouth of conical flask was closed with cotton to avoid falling of moths into the water. It was done to provide host in natural condition for egg laying. Dates of pre-oviposition, oviposition and post oviposition period were recorded.

Pre-oviposition period

The period required from the emergence of female moth from pupa to the commencement of egg laying was recorded for ten females. On this basis, average pre-oviposition period was worked out.

Oviposition period

To work out the oviposition period, dates of first and last egg laid by female moth was recorded. The period between those two dates was considered as oviposition period. Such oviposition period was recorded for ten females and mean oviposition period was worked out.

Post-oviposition period

The period from ceasation of oviposition by female moth till death was recorded for ten females. On this basis average post-oviposition period was worked out.

Site of oviposition

Microscopic observations on the site of oviposition under captivity were made while working out the oviposition period. All the plant parts, paper surface, glass jar surface and muslin cloth were observed critically for the eggs.

Fecundity

To study the fecundity, total numbers of eggs laid by each female during its life span were counted. Such ten females were observed and mean fecundity was worked out.

Egg morphometrics

The morphometrics of eggs were recorded by using "computerized micrometer". The average length and breadth was recorded on the basis of ten eggs.

Incubation period

To study the incubation period, the number of days from egg laid till the hatching of egg was recorded as incubation period. A set of hundred eggs was kept under observation.

Larval period, instars and morphometrics

For this study, fifty petri plates containing single larva in each were kept in the laboratory and provided with fresh buds of lablab bean twice in a day. Further observations on larval instars and larval periods were recorded. For recording larval instars, the larva in each plate was observed daily for moulting. The number of moultings was determined on the basis of casted head capsule. The period between each moulting was recorded as period for corresponding instar. The duration of larval instars was recorded and described. The

linear measurements on head width and body length were recorded using "computerized micrometer scale" for ten larvae. Thus, the data obtained were averaged out and presented.

Pre-pupal period

The period required from full development of larva as indicated by ceasation of feeding till complete formation of pupa was recorded for ten larvae and average prepupal period was worked out and data are presented.

Pupal period

To record pupal period, ten freshly formed pupae were kept under observation in plastic jars till emergence of adult and on this basis the average pupal period was worked out. The mean length and breadth of pupa were also recorded by using "millimeter scale" on the basis of measurements taken for ten pupae.

Adult longevity

Newly emerged adults were separated for their sexes and released in a separate plastic jar and cotton swab soaked in five per cent honey solution was kept suspended in the jar as food for moth. To record the longevity of adult moths without food, ten newly emerged male and female moths were released in another jar without five percent honey solution. The top of all the jars were covered with muslin cloth and secured firmly with rubber band. The longevity of ten males and ten females was recorded by observing the duration between emergence and the death of the adult. The data thus obtained were used to calculate average longevity of male and female moths with food as well as without food.

Adult morphometrics

The measurements on body width, body length and wing expanse were recorded by using "millimeter scale" for ten adults of both the sexes separately. The body width was recorded across the thorax while wing expanse was recorded by spreading the wings completely and measured horizontally. The data thus obtained were averaged out and presented.

Sex ratio

To calculate sex ratio hundred pupae obtained from the egg mass of a female were kept under observation separately. The adults emerged from them were separated according to their sexes and sex ratio was worked out on the basis of number of male and female adults emerged from the total number of pupae.

Life cycle

The total period for the completion of life cycle was worked out based on the duration of egg, larval, pre-pupal, pupal and adult stage.

Table 1: Pre-oviposition, oviposition, post-oviposition period and fecundity of *M. vitrata*

Sr. No	Pre-oviposition period (days)	Oviposition Period (days)	Post- oviposition Period (days)	Fecundity
1	4	3	1	67
2	3	4	2	38
3	3	3	1	78
4	3	4	2	56
5	4	2	1	80
6	3	3	1	45
7	4	3	2	62
8	4	4	1	60
9	3	4	2	84
10	3	3	1	74
Range	3-4	2-4	1-2	38-84
Mean	3.4	3.3	1.4	64.4
S.D.±	0.516398	0.67	0.52	15.20

Table 2: Morphometrics of eggs of *M. vitrata*

Sr. No.	Length (mm)	Breadth (mm)
1	0.61	0.40
2	0.60	0.39
3	0.62	0.41
4	0.59	0.40
5	0.61	0.42
6	0.63	0.42
7	0.64	0.39
8	0.60	0.41
9	0.64	0.40
10	0.64	0.39
Range	0.59-0.64	0.39-0.42
Mean	0.62	0.40
S.D.±	0.018738	0.011595

Table 3: Incubation period and hatching percentage of *M. vitrata*

Sr. No.	No. of eggs observed	No. of eggs hatched (days)				Total eggs hatched	Hatching percentage	Average incubation period
		1	2	3	4			
1	10	-	-	2	5	7	70	3.5
2	10	-	-	3	7	10	100	3.5
3	10	-	-	4	4	8	80	3.5
4	10	-	2	4	-	6	60	2.5
5	10	-	-	7	1	8	80	3.5
6	10	-	2	5	-	7	70	2.5
7	10	-	-	6	2	8	80	3.5
8	10	-	-	4	3	7	70	3.5
9	10	-	-	6	4	10	100	3.5
10	10	-	-	5	5	8	80	3.5
Range						6-10	60-100	2.5-3.5
Mean						7.9	79	3.3
S.D.±						1.286684	12.86684	0.421637

Table 4: Larval development period of *M. vitrata*

Sr. No.	Duration of larval instars (days)					Total larval Period (days)
	I	II	III	IV	V	
1	2	2	2	3	3	12
2	2	2	2	2	3	11
3	2	2	2	2	4	12
4	3	2	3	2	3	13
5	2	3	2	3	3	13
6	2	2	2	2	3	11
7	3	2	2	2	3	12
8	2	2	2	2	4	12
9	2	3	2	3	3	13
10	3	2	3	2	3	13
Range	2-3	2-3	2-3	2-3	3-4	11-13
Mean	2.3	2.2	2.2	2.3	3.2	12.2
S.D.±	0.48	0.42	0.42	0.48	0.42	0.79

Table 5: Morphometrics of first instar larvae of *M. Vitrata*

Sr. No.	First instar larva	
	Head breadth (mm)	Body length (mm)
1	0.14	1.32
2	0.12	1.34
3	0.15	1.42
4	0.18	1.50
5	0.13	1.30
6	0.14	1.54
7	0.18	1.38
8	0.12	1.45
9	0.15	1.51
10	0.13	1.36
Range	0.12-0.18	1.30-1.54
Mean	0.14	1.41
S.D.±	0.021705	0.085088

Table 6: Morphometrics of second instar larvae of *M. vitrata*

Sr. No.	Second instar larva	
	Head breadth (mm)	Body length (mm)
1	0.24	1.90
2	0.21	2.10
3	0.25	2.55
4	0.20	1.86
5	0.26	2.51
6	0.21	2.18
7	0.26	2.42
8	0.24	2.34
9	0.25	2.15
10	0.22	2.04
Range	0.20-0.26	1.86-2.60
Mean	0.234	2.205
S.D.±	0.022211	0.242773

Table 7: Morphometrics of third instar larvae of *M. Vitrata*

Sr. No.	Third instar larva	
	Head breadth (mm)	Body length (mm)
1	0.78	5.28
2	0.72	5.25
3	0.81	5.31
4	0.86	5.51
5	0.84	5.38
6	0.76	5.56
7	0.83	5.42
8	0.80	5.39
9	0.73	5.48
10	0.82	5.53
Range	0.72-0.86	5.25-5.56
Mean	0.795	5.411
S.D.±	0.046726	0.108367

Table 8: Morphometrics of fourth instar larvae of *M. Vitrata*

Sr. No.	Fourth instar larva	
	Head breadth (mm)	Body length (mm)
1	1.41	12.24
2	1.32	13.67
3	1.46	12.18
4	1.37	13.90
5	1.40	12.00
6	1.43	12.55
7	1.30	13.12
8	1.45	14.00
9	1.35	12.73
10	1.40	13.88
Range	1.30-1.46	12.00-14.00
Mean	1.389	13.027
S.D.±	0.053427	0.786399

Table 9: Morphometrics of fifth instar larvae of *M. Vitrata*

Sr. No.	Fifth instar larva	
	Head breadth (mm)	Body length (mm)
1	1.66	16.00
2	1.50	16.03
3	1.72	15.20
4	1.59	16.41
5	1.61	15.94
6	1.74	15.49
7	1.48	16.32
8	1.70	16.60
9	1.43	15.30
10	1.69	16.12
Range	1.50-1.74	15.20-16.60
Mean	1.612	15.941
S.D.±	0.109423	0.471957

Table 10: Prepupal and pupal period of *M. vitrata*

Sr. No.	Prepupal period (days)	Pupal period (days)
1	2	8
2	2	9
3	3	9
4	2	8
5	2	10
Range	2-3	8-10
Mean	2.2	8.8
S.D.±	0.447214	0.83666

Table 11: Morphometrics of pupae of *M. vitrata*

Sr. No.	Length (mm)	Breadth (mm)
1	12.20	2.84
2	12.17	3.00
3	12.11	2.89
4	12.03	2.91
5	12.08	2.84
6	12.14	2.88
7	12.19	3.00
8	12.10	2.80
9	12.15	2.96
10	12.20	2.90
Range	12.00-12.20	2.80-3.00
Mean	12.137	2.902
S.D.±	0.056578	0.067791

Table 12: Longevity of adults of *M. vitrata*

Sr. No.	Without food (days)		With food (days)	
	Male	Female	Male	Female
1	1	2	4	9
2	2	1	5	9
3	1	2	4	8
4	2	3	5	10
5	1	2	4	9
6	1	2	4	9
7	2	1	5	9
8	2	3	4	8
9	1	2	5	9
10	2	3	5	9
Range	1-2	1-3	4-5	8-10
Mean	1.5	2.1	4.5	8.9
S.D.±	0.527046	0.737865	0.527046	0.567646

Table 13: Morphometrics of adults of *M. vitrata*

Sr. No.	Female			Male		
	Body length (mm)	Body breadth (mm)	Wing expanse (mm)	Body length (mm)	Body breadth (mm)	Wing expanse (mm)
1	12.18	2.15	25.7	11.24	2.19	24.4
2	11.60	2.00	25.2	11.40	2.23	24.3
3	12.20	2.31	24.9	10.97	2.00	24.5
4	11.88	2.40	25.5	10.80	2.05	24.7
5	11.66	2.25	25.3	11.00	2.30	24.4
Range	11.60-12.20	2.00-2.40	24.9-25.7	10.80-11.40	2.00-2.30	24.3-24.7
Mean	11.904	2.222	25.32	11.082	2.154	24.46
S.D.±	0.28	0.15	0.30	0.24	0.13	0.15

Table 14: Sex ratio in *M. vitrata*

Sr. No.	No of adults Examined	Female moth	Male moth
1	10	6	4
2	10	6	5
3	10	5	4
4	10	6	5
5	10	4	6
6	10	7	3
7	10	5	5
8	10	6	4
9	10	5	5
10	10	4	5

Table 15: Life cycle of *M. vitrata*

Sr. No.	Particulars	Duration (days)		
		Minimum	Maximum	Mean
1	Egg period	3	3.5	3.25
2	Larval period			
	Ist instar	2	3	2.5
	IInd instar	2	3	2.5
	IIIrd instar	2	3	2.5
	IVth instar	2	3	2.5
	Vth instar	2	4	3
	Total larval period	10	16	13
3	Pre-pupal period	2	3	2.5
4	Pupal period	8	10	9
5	Life cycle (egg to emergence of adult)	23	32.5	27.7
6	Pre-oviposition period	3	4	3.4
	Oviposition period	2	4	3.3
	Post -oviposition period	1	2	1.4
7	Adult longevity			
	Male (with food)	4	5	4.5
	Female (with food)	8	10	9
	Male (without food)	1	2	1.5
	Female (without food)	1	3	2
8	Total life cycle			
	Male with food	27	37.5	32.2
	Female with food	31	42.5	36.7

Results and Discussions

The results obtained during the study are presented and discussed under the following headings.

Biology of pod borer, *M. vitrata*

The observations of morphometrics are taken with dino lite digital microscope (Plate III). The results obtained are presented and discussed hereunder.

Pre-oviposition, oviposition and post-oviposition period

The pre-oviposition, oviposition and post-oviposition period were recorded and the results are presented in (Table 3). It was revealed that the pre-oviposition period varied from 3 to 4 days with an average of 3.4 days. The oviposition period ranged between 2 to 4 days with an average 3.3 days. The post-oviposition period was recorded only for 1 to 2 days with a mean of 1.4 days.

These observations are in conformity with the findings of the Chinnabhai and Venkataith (2002) [6] who reported that preoviposition, oviposition and post-oviposition period of 1.71, 3.53 and 1.71 days, respectively when studied the biology of *M. vitrata* on green gram. While studying biology of *M.vitrata* on black gram, they reported pre-oviposition, oviposition and post-oviposition period of 1.56, 3.53, and 1.03 days, respectively.

Karmarkar (2006) [9] revealed that the pre-oviposition period was 3 to 4 days with an average of 3.30 days. The oviposition period ranged between 2 to 4 days with an average of 3 days. The post-oviposition period was recorded only of 1 to 2 days with an average of 1.30 days.

Fecundity

The data recorded on fecundity of bean pod borer, *M. vitrata* revealed that the total number of eggs laid by female in her life span varied from 38 to 84 with an average of 64.2. (Table 3). The observations are in accordance with Karmarkar (2006) [9] who reported that the female of *M. vitrata* laid 37 to 81 eggs and Shinde (2014) who reported that the female of *M. vitrata* laid to 38-82 eggs.

Site of oviposition

The female usually laid eggs on flower buds and tender pods singly or in groups of 2 to 3. Eggs were also observed on the black coloured paper, which was wrapped on the inner side of glass jar as well as on muslin cloth that was used to close the mouth of glass jar.

The result are in conformity with the findings of the Sharma (1998) who reported that eggs are deposited on floral buds and flowers, leaves, terminal shoots and pods were usually deposited in batches of 2 to 16.

Eggs

The freshly laid eggs were oval and yellowish white or creamy white in colour and glued to the surface of bud. The colour of the eggs changed gradually to white just before hatching. The eggs measured 0.59 to 0.64 mm in length with an average of 0.62 mm and 0.39 to 0.42 mm in breath with an average of 0.40 mm (Table 4).

The present findings regarding eggs of *M. vitrata* are in confirmity with Panickar and Jhala (2007) who reported the colour of eggs was creamy white and average length of eggs ranged from 0.62 to 0.64 mm and 0.47 to 0.48 mm width. Karmarkar (2006) [9] reported that an egg measured on an average 0.58 mm in length and 0.38 mm in breadth. Rachappa (2015) [11] reported that the average length and breadth of the egg of *M. vitrata* was 0.68mm and 0.45mm respectively.

Incubation period and hatching percentage

The data on incubation period and hatching percentage are presented in (Table 5). It was evident from the data that the incubation period ranged from 2.5 to 3.5 days with a mean of 3.3 days. Hatching percentage ranged from 60 percent to 100 percent with an average of 79 percent.

Similar observations were recorded by Vaidya (2008) who reported that the incubation period varied from 3.0 to 3.5 days with mean of 3.40 days and with 80 percent egg hatching.

Rachappa *et al*. (2015) [11] Laboratory studies revealed that, the incubation period varied from 2.85±0.40 days. Chinnabhai *et al.* (2002) [6] reported the incubation period of 3.14 days on green gram.

Larval development

During present studies, it was observed that there were five larval instars (Plate IV). The observations on larval instars and larval period are given in (Table 6). The development period of larvae ranged from 11 to 13 days with an average of 12.2 days. During this period larvae moulted four times. The instar wise description of larva is presented here under.

The present observations are in close confirmity with reports of Chandrayudu *et al*. (2005) revealed that the total larval period on mung bean was 11.65. Chinnabhai *et al*. (2002) [6] reported that the larval development was completed within 11.12 days on green gram. Taro *et al.* (2004) reported the larval period of 12.9 days at 24-27º C under 95 percent relative humidity.

a. First instar

The first instar lasted for 2 to 3 days with mean of 2.3 days (Table 6). Newly hatched larva was tiny, active and greenish white. Head was chitinised; light brown and smaller in size than the rest of the body. The morphometrics of first instar larvae of *M. vitrata* are given in (Table 7). The breath of head capsule ranged from 0.12 mm to 0.18 mm (mean 0.14 mm). The larva measured 1.30 mm to 1.54 mm (mean 1.41 mm) in length.

b. Second instar

The second instar lasted for 2 to 3 days with mean of 2.2 days (Table 6). The second instar larva was very active, white in colour with dark brown spot on the body. The head was dark brown. The breadth of head capsule varied 0.20 mm to 0.26 mm (mean 0.23 mm). The larva measured 1.86 mm to 2.60 mm (mean 2.20 mm) in length (Table 8).

c. Third instar

The third instar lasted for 2 to 3 days with an average of 2.2 days (Table 6). Larva was green in colour. The head capsule measured 0.72 mm to 0.86 mm (mean 0.79 mm) in breadth. The larva measured 5.25 mm to 5.56 mm (mean 5.41 mm) in length (Table 9).

d. Fourth instar

The fourth instar lasted for 2 to 3 days with an average of 2.3 days (Table 6). The sparse hair was present around the brown spot on the body of fourth instar larva. The fourth instar larva was very active. The head was dark brown, whereas the body colour was deep white. The head capsule measured 1.30 mm to 1.46 mm (mean 1.38 mm) in breath. The larva measured

12.00 mm to 14.00 mm (mean 13.02 mm) in length (Table 10).

e. Fifth instar

The fifth instar lasted for 3 to 4 days with an average of 3.2 days (Table 6). The colour of larva was white with dark brown spot all over the body and sparse hair was also noticed. The head capsule was measured 1.50 mm to 1.74 mm (mean 1.61 mm) in breadth. The larva measured 15.20 mm to 16.60 mm in length (mean 15.94 mm) (Table 11).

The present findings are in accordance with Sureja *et al.* (2010) [15] who reported that average developmental periods of first, second, third, fourth and fifth instars were 2.32 ± 0.67, 2.85 ± 1.25, 2.78 ± 0.90, 2.54 ± 1.04 and 2.88 ± 0.80 days, respectively. The morphometrics of larval instar are similar to Panickar and Jhala (2007). Karmarkar (2006) [9] also reported that average developmental periods of first, second, third, fourth and fifth instars were 2.30, 2.20, 2.10, 2.10 and 3.30 days, respectively.

Pupation

The observations on the development period of prepupa and pupa are presented in (Table 12) and (Plate V)

Prepupal period

The full grown larva before pupation passed through a prepupal stage, it stopped feeding and gradually shrunk in length and became sluggish. The colour changed from deep white to green. The pupation takes place in loose silken netting at the corner of petriplate. The prepupal period lasted for 2 to 3 days with an average of 2.2 days.

Pupal period

The larva before pupation become complete green and considerably decreased in length. The freshly formed pupa was yellowish to pale yellowish colour. The pupa was obtect type, broader anteriority and tapering posteriorly. The duration of pupal period ranged from 8 to 10 with an average of 8.8 days (Table 12). The pupa measured from 12.00 to 12.20 mm in length with an average of 12.13 mm and the breadth ranged from 2.80 to 3.00 with an average of 2.90 mm (Table 13).

Prepupal period

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Nature of damage

The larva soon after hatching started boring the bud and tender pod. The larva reached to the reproductive parts of flower i.e. anther and ovary and feed on them. The entry hole was plugged with the faecal material. The larva damaged the buds by webbing together the adjoining buds and fed voraciously on them by living inside. Thus the webbing of buds and flowers and entry hole on the buds were the important symptoms of the attack of *M. vitrata*.

Similarly, the larva bored the tender pods by entering inside the pod and was observed to feed voraciously on developing grains. Such entry holes were observed on the pods. Feeding on the buds adversely affects the pod formation and pod damage resulted into the reduction in grain yield. (Plate VII). Similar nature of damage was observed by Karmarkar (2006) [9] and Sharma (1998).

Adult longevity

The adult longevity was studied in laboratory for both the sexes with and without food and the observations are presented in (Table 14). It was noticed that male moth was short lived. They lived without food for 1 to 2 days with an average of 1.5 days, while females lived without food for 1 to 3 days with an average of 2.1 days. However, when fed with 5 percent honey solution, the adult longevity increased considerably and ranged from 4 to 5 days with an average of 4.5 days in males, while the longevity of female moths ranged from 8 to 10 days with an average of 8.9 days.

ChiChung and WuKang (2001) [5] recorded the life span of female 9 ± 2.6 days with food. Shinde (2014) obtained the mean adult longevity of 1.4 and 1.7 days for males and females, respectively, when kept without food. When they were provided with 5 percent honey solution, it was 4.6 and 9 days for males and females, respectively.

Adults

The adult moth of *M. vitrata* was slender, medium size and brown in colour. The forewings were brown with a white spot across the wing. The hind wings were white in colour with brown border. The hind wings were smaller and broader than forewing. The female abdomen was slightly broader than male and with an opening at the tip, while the tip of the abdomen of male was black, curved and longer than the abdomen of female. (Plate VI) Almost similar description of adult moth has been given by Shinde (2014).

The length, breadth and wing expanse of female moth ranged from 11.60 to 12.20 mm (average 11.90 mm), 2.00 to 2.40 mm (average 2.22 mm), and 24.9 to 25.7 mm,(average 25.32 mm) respectively. (Table 15)

The male moth length, breadth, and wing expanse ranged from 10.80 to 11.40 mm (average 11.08 mm), 2.00 to 2.30 mm (average 2.154 mm), and 24.3 to 24.7 mm (average 24.46 mm) respectively. (Table 15)

The observations are in accordance with Panickar and Jhala (2007) who recorded the length of male and female moth from head to tip of abdomen ranged from 10.72 to 11.81 mm and 10.85 to 11.99 mm, respectively. The wing expanse ranged from 23.56 to 24.44mm and 23.35 to 24.85 mm in male and female, respectively.

Sex ratio

In the laboratory study, sex ratio was worked out by examining 100 adults and presented in (Table 16). Out of 100 adults examined, 46 were observed to be males and 54 were females. The male to female ratio was 1: 1.17

Sex ratio Male: Female
46:54
1:1.17

The present observations are closely matched with Shinde (2014), who recorded the sex ratio of 1: 1.08

Life cycle

The observations pertaining to minimum, maximum and mean life cycle are presented in (Table 17). The total period required to complete life cycle from eggs to emergence of adult varied from 23 to 32.5 days with an average of 27.7 days, whereas the generation from eggs to death of male and female i.e. total life cycle was found to be completed within 27 to 37.5 days with an average of 31.3 days and 31 to 42.5 with an average of 35.7 days, respectively. (Plate VIII)

The present findings are in conformity with the findings of earlier research workers. Sureja *et al.* (2010) [15] recorded total life span from egg to death of adult for male and female was 35.10 ± 2.42 and 39.60 ± 3.68 days, respectively. Karmarkar (2006) [9] observed total life span from egg to death of adults for male and female was 28 to 35.5 and 32 to 40.5 days, respectively.

Conclusions

The lablab bean is one of the important pulse crops of Konkan region. It is severely infested by pod borer, *Maruca vitrata* (Geyer) causing heavy loss in yield. No comprehensive information was available on the pest, particularly under the conditions of Konkan region. Therefore, the present investigation was carried out, to study biology of pod borer, *M. vitrata* (Geyer) under Konkan conditions.

A Lab experiment was carried out to The studies on the biology of lablab bean pod borer, *M. vitrata* revealed that the mean pre-oviposition, oviposition and post-oviposition period lasted for 3.4, 3.3 and 1.4 days, respectively. The female laid on an average 64.4 eggs singly or in groups on flower buds and tender pods. The eggs were white or creamy white in colour and glued to the bud or pod surfaces. The incubation period lasted for 3.30 days with 79 per cent egg hatching. The newly hatched larva was very active and creamy white. The larvae moulted four times and passed through five larval instars. The first instar larva was greenish white with head breadth of 0.14 mm and body length of 1.41 mm. The larva prior to pupation changed its colour from greenish to yellowish and pupated on the corner of the petri plate. The larval development completed within 12.2 days through five instars. The duration of each instar was found to be 2.3, 2.2, 2.2, 2.3 and 3.2 days, respectively. The full grown larva measured 1.6 mm in head breadth and 15.94 mm in body length.

The pupation took place in loose silken netting at the corner of the petri plate. The mean pre-pupal and pupal periods lasted for 2.2 and 8.8 days, respectively. The adult moth was slender, medium sized; forewings were brown with a white semi-transparent spot across the wing. The hind wings were white in colour with brown border. In male, abdomen was tapering towards the terminal end, whereas in female, the abdomen was long with bulged tip. The male moth lived without food for 1 to 2 days with an average of 1.5 days, while female lived without food for 1 to 3 days with an average of 2.1 days. When they were fed with 5 per cent honey solution, the adult longevity increased considerably and ranged from 4 to 5 days with an average of 4.5 days in male, and 8 to 10 days with an average of 8.9 days in female. The male moth measured 11.08 mm in length, 2.15 mm in width with wing expanse of 24.46 mm. The female was measured 11.90 mm in length, 2.22 mm in width with wing expanse of 25.32 mm. The sex ratio for male and female was 1: 1.17. The generation from egg to death of male to female *i. e.* total life cycle was found to be completed within 28 to 36.5 days, with an average of 32.25 days and 32 to 42.5 days with an average of 37.25 days, respectively.

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