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Biology of diamondback moth, *Plutella xylostella* (Linnaeus), Lepidoptera: Plutelliadae of cabbage under laboratory condition

KY Bhure, HV Pandya and BV Naikwadi

Abstract

The female of *P. xylostella* preferred the lower surface of leaves for egg laying and it deposited eggs singly or in the batches of 2 to 16. The average incubation period was 2.2 ± 0.65 days. The average duration of 1st, 2nd, 3rd and 4th instar larvae was 1.84 ± 0.69 , 2.68 ± 0.69 , 2.88 ± 0.78 and 2.92 ± 0.81 days, respectively and total larval duration was on an average 10.32 ± 1.22 days. The average pupal period was 7.44 ± 1.47 days. The sex ratio of male: female was 1:1.25 under laboratory condition on cabbage. The average duration of pre-oviposition, oviposition and post-oviposition period was 1.93 ± 0.80 , 10.40 ± 1.40 and 5.87 ± 1.19 days, respectively. The total life cycle of *P. xylostella* occupied on an average 28.87 ± 3.40 days in male, while 30.93 ± 3.84 days in female. Thus, the total life cycle of female was longer than male.

Keywords: Biology, *Plutella xylostella*, cabbage

1. Introduction

Cabbage (*Brassica oleracea* var. capitata Linnaeus) is most important cole crop origin from Cyprus and Mediterranean region. It belongs to the genus Brassica of the family Brassicaceae. The cruciferous vegetables (cole crops) represents as one of the highly polymorphic classes which include crops like cabbage, cauliflower, turnip, knol-khol, broccoli and mustard. Cabbage is locally known as Kobij, Kobi, Bandh Kobi and Karam Kala. In 1984, the Food and Agriculture Organization (FAO) of the United Nations listed cabbage as a top twenty vegetable and an important food source sustaining world population, (Anonymous, 2005) [3]. In addition to several minerals such as P, K, Ca and Fe, cabbage also contains high percentage of vitamin A, B and C. It is consumed either cooked or raw as salad. Now a days, more and more people are inclined towards vegetarianism all over the world, there by vegetable market is expanding. Thus, there is a good scope for hiking vegetable production to meet domestic demand to top foreign exchange in the world market.

In India, the total cultivated area of cabbage is about 369 (000" HA) with the total production about 7949 (000" MT) and the productivity is 21.5 MT/HA. In Gujarat, cabbage crop is cultivated in almost all the districts, with majority observed in Mehsana, Kheda, Baroda, Gandhinagar, Anand, Surat and Valsad. In Gujarat, this crop is cultivated in about 28.2 (000" HA) area with 553.6 (000" MT) production and 19.6 MT per hectare productivity (Anon., 2010) [4].

Cabbage is an input intensive crop, which is prone to many insect pests especially to diamondback moth (Bonnemaison *et al.*, 1965) [5]. This is one of the most serious and widely distributed pests of the cruciferous crops in many countries including India. Among them, the chief constraint in the production of cabbage is damage caused by pest complex right from germination till harvesting stage (Sachan and Srivastava, 1972) [11]. It is attacked by the various important insect pests *viz.*, diamond back moth, *Plutella xylostella* (Linnaeus), cabbage butterfly, *Pteris brassicae* (Linnaeus), cabbage aphid, *Brevicoryne brassicae* (Linnaeus), leaf webber, *Crociodolomia binotalis* (Zeller), cabbage cutworm, *Spodoptera litura* (Fabricius), painted bug, *Bagrada cruciferarwn* (Kirkaldy), head eating caterpillar, *Helicoverpa armigera* (Hubner) and mustard sawfly, *Athalica proxima* (Klug).

Among them, diamond back moth, *P. xylostella*, head eating caterpillar, *H. armigera*, cabbage cutworm, *S. litura* and cabbage aphid, *B. brassicae* are the major insect pests found in Gujarat. The young larva of *P. xylostella* feeds by scrapping the epidermal tissue and producing typical

white patches, while in advanced stage, larvae bites the hole in leaves and produce a poor quality heads. The extent of damage due to diamond back moth was reported 31.9 per cent on cabbage (Abraham and Padmanaban, 1968) [1]. Under south Gujarat conditions where intensive cultivation of cruciferous crops is most common practice, diamond back moth (DBM) infestation to cabbage head was reported to the peak activity found in month of January (Mala, 2006) [8]. The diamond back moth, *P. xylostella* alone is capable of reducing cabbage yield up to 100 per cent (Sachan and Srivastava, 1972) [11]. Keeping all these points in view, detailed investigations were undertaken with the following objectives to study the biology of diamond back moth, *P. xylostella*.

2. Materials and Methods

2.1 Biology of *P. xylostella* (L.)

The biology of Diamond back moth was studied in the laboratory of Department of Entomology, N. M. College of Agriculture, NAU, Navsari, during 2012-13. Minimum and maximum temperatures and relative humidity were recorded during the course of study.

A. Rearing technique

The larvae were reared in the laboratory on respective host in transparent plastic tubes were covered with perforated lids to facilitate aeration. Sufficient amount of fresh leaves of cabbage were provided as a food to the larvae of diamond back moth till pupation. All the pupae obtained were kept in separate tubes for adult emergence. As soon as the adult moths emerged from the pupae they were collected daily until the last adult emerged out. The male and female moths could also be distinguished on the basis of their abdominal tips. For egg laying, a pair of newly emerged male and female moths was carefully transferred in a oviposition glass jar (23 cm diameter x 10 cm height). Cut ends of fresh cabbage leaves were dipped in conical flask filled with fresh water to maintain turgidity of the leaves. The leaves of cabbage were observed daily for the egg laying by females. The leaves containing eggs were removed and fresh leaves were provided daily. Freshly laid eggs were used for further study.

B. Study on various stages of *P. xylostella*

1. Egg: To study the incubation period and hatching percentage, the eggs laid on leaves of cabbage were picked up with the help of fine camel hair brush and counted numbers of eggs were placed on the leaf in glass petridishes (10 cm diameter). Incubation period was calculated from the date of egg laying to the date of hatching. Hatching per cent was calculated from the number of eggs hatched out of the total number of eggs kept for hatching. Measurement of eggs was recorded under microscope with the help of stage and ocular micrometers.

2. Site of egg laying: Usually the adult female of *P. xylostella* preferred lower surface of the leaves for egg laying mainly along with the midrib and radiating veins in cabbage.

3. Larva: With a view to determine the duration of different larval instars and total larval period newly hatched 25 larvae were placed individually on cabbage leaves with the help of fine camel hair brush and placed in plastic culture tubes measuring 2.5 cm in diameter and 7.5 cm in length. The pieces of cabbage leaves in each tube were changed daily in the morning and developing larvae from the old pieces were

transferred to the fresh pieces.

In order to determine the number of larval instars, the size of head capsule of individual larva was observed daily. Exuvium as well as casted off head capsule exuvium was also observed. Measurements of immature stages were recorded under microscope with the help of stage and ocular micrometers.

4. Pre-pupa: To record the pre-pupal period, the larva was observed from the time when it became fully matured, stopped feeding and became sluggish before it turned to pupa.

5. Pupa: The pre-pupa developed from each larva was kept in plastic tubes (2.5 cm x 7.5 cm) along with infested leaves and allowed to pupate. Observations on pupal duration, size, colour and place of pupation were also recorded.

6. Adult: The male and female adults emerged out from the pupae were transferred in glass jar (23 cm x 10 cm) on the same day. One pair was kept separate in each jar. They were provided with five per cent honey solution as a food. In each jar fresh leaves of cabbage were provided for resting and oviposition for the adults. The leaves were changed daily while counting the eggs. Observations on pre-oviposition, oviposition and post-oviposition periods were recorded. To determine the fecundity, a pair of male and female was kept in glass jar (23 cm x 10 cm size) and the open end was covered with muslin cloth tied with rubber band. Fifteen pairs were studied for egg laying capacity. Honey solution 5 per cent was provided as a food for adults. Cut ends of fresh cabbage leaves were dipped in conical flask filled with fresh water and kept in each glass jar for egg laying. Eggs laid by a single female were collected daily in the morning and counted till the death of the female. The observations on adult period as well as colour and size of the adult were also recorded. The length and breadth with their wing expansion were measured directly with the help of standard scale. The total life span of insect was counted from the date of egg laid till the death of the adult. Longevity of male and female was calculated separately from the date of emergence till the death of adult. From recorded data average longevity was calculated.

7. Sex ratio: In order to determine the sex ratio (male: female) under laboratory conditions, counted number of pupae were kept in separate plastic tubes. After emergence the male and female moths were separated and counted to work out the sex ratio.

3. Results

The study on biology of *P. xylostella* on cabbage was carried out during January and February 2013. The average temperature and relative humidity in laboratory were 23.27 ± 1.04 °C and 52.84 ± 13.78 per cent, respectively.

Egg: The freshly laid eggs were almost similar in size under studies. Our results state that the length of the eggs ranged from 0.44 mm to 0.55 mm with an average of 0.50 ± 0.03 mm, while the breadth ranged from 0.23 to 0.33 mm with an average of 0.29 ± 0.03 mm (Table 1). The incubation period (Table 1) revealed that the incubation period of eggs varied from 1 to 3 days with an average of 2.2 ± 0.65 days. Our recorded data showed that hatching percentage of eggs of diamond back moth, *P. xylostella* on cabbage was varied from 83.23 to 92.55 with an average of 89.36 ± 2.65 per cent on cabbage (Table 2).

Larvae: Observation of Larval duration of each instar of *P. xylostella* state that the duration of first Instar larva ranged from 1 to 3 days with an average of 1.84 ± 0.69 days. The duration of second instar larva varied from 2 to 4 days with an average of 2.68 ± 0.69 days. The duration of third instar larva ranged from 2 to 4 days with an average of 2.88 ± 0.78 days on cabbage. The duration of fourth instar larvae ranged from 2 to 4 days with an average of 2.92 ± 0.81 days on cabbage. The total larval period of *P. xylostella* ranged from 8 to 12 days on cabbage with an average of 10.32 ± 1.22 days (Table 3). The data on measurement of first instar larva showed that the length and breadth ranged from 1.32 to 1.46 and 0.14 to 0.23 mm with an average of 1.39 ± 0.04 mm, 0.19 ± 0.03 mm,

respectively (Table 4). The length of the second instar larva ranged between 2.20 to 2.80 mm with an average of 2.54 ± 0.12 mm, while the breadth varied from 0.24 to 0.32 mm with an average of 0.28 ± 0.03 mm. The data on measurement of third instar larva revealed that the length and breadth ranged from 3.75 to 4.75 and 0.32 to 0.43 mm with an average of 4.27 ± 0.33 and 0.38 ± 0.03 mm, respectively. The data on measurement of fourth instar larva revealed that the length and breadth ranged from 4.37 to 5.70 and 0.46 to 0.56 mm with an average of 5.03 ± 0.45 and 0.51 ± 0.03 mm, respectively on cabbage. The total larval period of *P. xylostella* ranged from 8 to 12 days on cabbage with an average of 10.32 ± 1.22 days (Table 4).

Table 1: Measurement of eggs and incubation period of *P. Xylostella*

Number of eggs observed	Measurement						Incubation Period (Days)		
	Length			Breadth			Min.	Max.	Avg.± S.D
	Min.	Max.	Avg.± S.D	Min.	Max.	Avg.± S.D			
25	0.44	0.55	0.50 ± 0.03	0.23	0.33	0.29 ± 0.03	1	3	2.2 ± 0.65

Table 2: Hatching percentage of eggs of *P. xylostella*

Number of eggs observed	Hatching of eggs				Hatching percentage		
	No. of eggs observed		No. of eggs hatched		Min.	Max.	Avg.± S.D
	Min.	Max.	Min.	Max.			
12	240	322	220	293	83.23	92.55	89.36 ± 2.65

Table 3: Duration of different larval instars of *P. xylostella*

Larval Instars	No. of larvae observed	Duration (Days)		
		Max.	Min.	Avg. ± S.D
First	25	1	3	1.84 ± 0.69
Second	25	2	4	2.68 ± 0.69
Third	25	2	4	2.88 ± 0.78
Fourth	25	2	4	2.92 ± 0.81
Total Larval Period	25	8	12	10.32 ± 1.22

Table 4: Length and breadth of different larval instars of *P. xylostella*

Stage of larvae	Number of larvae	Length (Avg. ±S.D)	Breadth (Avg. ±S.D)	Length (mm)		Breadth (mm)	
				Min.	Max.	Min.	Max.
I Instar	25	1.4 ± 0.04	0.2 ± 0.03	1.32	1.46	0.14	0.23
II Instar	25	2.5 ± 0.12	0.3 ± 0.03	2.2	2.8	0.24	0.32
III Instar	25	4.3 ± 0.33	0.4 ± 0.03	3.75	4.75	0.32	0.43
IV Instar	25	5.0 ± 0.45	0.5 ± 0.03	4.37	5.7	0.46	0.56

Pre-pupal and pupal period: Results showed that the duration of pre pupal period of *P. xylostella* ranged from 1 to 3 days with an average of 2.12 ± 0.73 days. The data on pupal

period revealed that it ranged from 5 to 9 days with an average of 7.44 ± 1.47 days (Table 5).

Table 5: Duration of Pre-pupal and Pupal period of *P. Xylostella*

Number of eggs observed	Duration (Days)					
	Pre-pupal (Days)			Pupal period (Days)		
	Min.	Max.	Avg.± S.D	Min.	Max.	Avg.± S.D
25	1	3	2.12 ± 0.73	5	9	7.44 ± 1.47

Life cycle of adult: The total life cycle from egg to death of male ranged from 23 to 34 days with an average of 28.87 ± 3.40 days, while in case of female, total life cycle ranged from 25

to 37 days with an average of 30.93 ± 3.84 days. Thus, the total life cycle of female was longer than that of male (Table 6).

Table 6: Total life cycle of *P. Xylostella*

Number of adults observed	Duration (Days)					
	Male			Female		
	Min.	Max.	Avg.± S.D	Min.	Max.	Avg.± S.D
15	23	34	28.87 ± 3.40	25	37	30.93 ± 3.84

Sex Ratio: The sex ratio was studied and the data are presented in Tables 7. It indicated preponderance of female

over male. The sexratioof male to female was 1:1.25 (Table 7).

Table 7: Sex ratio of *P. xylostella*

Sr. No.	Number of adults observed	Sex		Sex ratio (Male: Female)
		Number of male	Number of female	
Overall	1130	502	628	1:1.25

Adult Body length and Breadth: The body length of male moth ranged from 4.80 to 5.00 mm with an average of 4.86 ± 0.04 mm, whereas, the breadth varied from 12.85 to 12.95 mm with an average of 12.88 ± 0.03 mm. Similarly in case of female the body length ranged from 5.22 to 5.32 mm with an

average of 5.26 ± 0.03 mm, while breadth across the expanded wings recorded oncabbage was varied from 14.85 to 14.94 mm with an average of 14.89 ± 0.03 mm. Thus, it clearly indicated that the femalewas longer than male in size (Table 8).

Table 8: Measurement of adults of *P. xylostella*

No. of adults 25	Measurement of adults(mm)			
	Male		Female	
	Length (mm)	Breath (mm)	Length (mm)	Breath (mm)
Minimum	4.8	12.85	5.22	14.85
Maximum	5	12.95	5.32	14.94
Av. \pm S.D.	4.86 ± 0.04	12.88 ± 0.03	5.26 ± 0.03	14.89 ± 0.03

Total development period: The pre-oviposition period varied from 1 to 3 days with an average of 1.93 ± 0.80 days. The oviposition period varied from 8 to 12 days with an average of 10.40 ± 1.40 days on cabbage under laboratory condition. The post-oviposition period lasted for 4 to 8 days with an average of 5.87 ± 1.19 day. Observations on longevity of adults *P. xylostella* (Tables 9) showed that the longevity of male was 14 to 17 days with an average of 15.47 ± 1.06 days, whereas in case of female, it was 16 to 19 days with an average of 17.33 ± 0.98 days on cabbage. The results on fecundity revealed that the egg laying capacity of the female ranged from 240 to 322 eggs with an average of 280 ± 24.76 eggs on cabbage. The total life cycle from egg to death of male ranged from 23 to 34 days with an average of 28.87 ± 3.40 days, while in case of female, total life cycle ranged from 25 to 37 days with an average of 30.93 ± 3.84 days (Tables 9).

Table 9: Detail life cycle of *P. xylostella*

Particulars	Period (days)		Avg. \pm S.D.		
	Minimum	Maximum			
Egg period	1	3	2.2	\pm	0.65
Hatching period	83.23	92.55	89.36	\pm	2.65
Larval period					
First instar	1	3	1.84	\pm	0.69
Second instar	2	4	2.68	\pm	0.69
Third instar	2	4	2.88	\pm	0.78
Fourth instar	2	4	2.92	\pm	0.81
Total larval period	8	12	10.32	\pm	1.22
Prepupal period	1	3	2.12	\pm	0.73
Pupal period	5	9	7.44	\pm	1.47
Adult period					
Pre-oviposition	1	3	1.93	\pm	0.80
Oviposition	8	12	10.40	\pm	1.40
Post oviposition	4	8	5.87	\pm	1.19
Longevity					
Female	16	19	17.33	\pm	0.98
Male	14	17	15.47	\pm	1.06
Total life cycle					
Female	25	37	30.93	\pm	3.84
Male	23	34	28.87	\pm	3.40
Egg laying capacity(Number)	240	322	280.00	\pm	24.76

4. Discussion

A similar observation on egg was recorded by Mala (2006)^[8] which stated that eggs were average of 0.53 ± 0.03 mm in length and 0.29 ± 0.02 mm in breadth on cabbage and Meena and Singh (2012) also reported an average length of eggs to be 0.53 ± 0.03 mm and breadth with an average of 0.29 ± 0.03 on cabbage. The present findings on total hatching per cent of eggs tallies with Vaghasia (1989)^[12] who recorded 94.27, 92.12 and 86.71 per cent egg hatching on cabbage, cauliflower and mustard, respectively. Similarly, Meena and Singh (2012)^[9] found viability of eggs of diamond back moth ranging from 82 to 92 per cent under laboratory condition. Present findings on duration of larval period of *P. xylostella* are more or less in similar with the findings of Alizadeh *et al.* (2011)^[2] and Meena and Singh (2012)^[9] who reported it to be 2.06 days and 2 to 3 days on cabbage, respectively. In past, according to Mala (2006)^[8], the average duration of third instar larva to be 2.92 days on cabbage. While, it was 2 to 3 with an average 2.70 ± 0.48 days on cabbage as per Meena and Singh (2012)^[9]. Thus, the duration of fourth instar larva are more or less similar with the earlier reports of Mala (2006)^[8] who observed 2.88 days on cabbage. Similarly, Meena and Singh (2012)^[9] also reported the fourth instar duration of 2 to 4 days with an average 2.80 ± 0.79 on cabbage. Our recorded data was similar to the data recorded by Meena and Singh (2012)^[9] which stated that average length and breadth varying from 1.39 ± 0.05 mm and 0.20 ± 0.03 mm and also same larval duration 1 to 3 days on cabbage.

The present findings are thus more or less similar with those of Meena and Singh (2012)^[9] who reported the duration of pre pupal period ranged from 1 to 3 days with an average of 2.20 ± 0.79 days. According to Mala (2006)^[8], the pupal period was 5 to 10 days on cabbage. Whereas, Meena and Singh (2012)^[9] recorded the pupal period which ranged from 5 to 9 days with an average 7.60 ± 1.35 days on cabbage crops, which is more or less in agreement with the present findings.

The present findings are thus more or less similar with the findings of Meena and Singh (2012)^[9] who recorded total life cycle of male moth ranged from 29 to 47 days with an average of 38.60 ± 3.79 days while in case of female moth it

ranged from 30 to 49 days with an average of 40.10 ± 4.35 days on cabbage. The sex ratio of male to female was 1:1.25. The present findings are in confirmation with Chung *et al.* (1990)^[6] and Mala (2006)^[8].

The present findings are more or less in confirmation with Meena and Singh (2012)^[9] who reported that the length and breadth of 2.41 to 2.74 and 0.23 to 0.32 mm, respectively. Similarly, Vaghasia (1989)^[12] recorded 2.13, 2.08 and 1.99 mm length and 0.26, 0.25 and 0.25 mm width on cabbage, cauliflower and mustard, respectively.

In past, Mala (2006)^[8] reported that the average length and breadth of third instar was 4.28 mm and 0.38 mm on cabbage. While in reports of Meena and Singh (2012)^[9], it was 3.80 to 4.78 mm in larval length and 0.33 to 0.43 mm in breadth on cabbage.

The present findings on length and breadth of fourth instar larva are in accordance with the earlier work of Mala (2006)^[8] who reported the average length to be 5.04 and breadth 0.52 mm on cabbage. Vaghasia also reported more or less similar results.

Earlier workers reported that the total larval period was 8.44 days on cabbage (Raghuwanshi *et al.* 2010)^[10]. According to Meena and Singh (2012)^[9] the total larval period of *P. xylostella* was 7 to 13 days with average of 10.00 ± 1.56 days on cabbage.

Our results tallies with finding of Gangurde and Wankhede (2009)^[7] who reported pre-oviposition period of 2 to 4 days on cabbage. In past, Vaghasia (1989)^[12] reported the oviposition period to be 11.12, 9.28 and 9.04 days on cabbage, cauliflower and mustard and also Gangurde and Wankhede (2009)^[7] reported the oviposition period was 6 to 7 days, which are more or less similar to the present findings. Vaghasia (1989)^[12] reported post-oviposition period to be 6.32 days on cabbage and cauliflower and 6.48 days on mustard and Gangurde and Wankhede (2009)^[7] reported the post-oviposition period of 5 to 7 days on cabbage.

Thus, the females were found to live slightly longer than males. The present findings are thus more or less similar with the findings of Meena and Singh (2012)^[9] who recorded total life cycle of male moth ranged from 29 to 47 days with an average of 38.60 ± 3.79 days while in case of female moth it ranged from 30 to 49 days with an average of 40.10 ± 4.35 days on cabbage. Present findings are in conformity with Vaghasia (1989)^[12] who reported that the longevity of male was 17.34, 15.64 and 15.40 days and that of female was 19.24, 17.36 and 17.34 days on cabbage, cauliflower and mustard, respectively. Meena and Singh (2012)^[9] recorded the adult longevity of male to be 15 to 18 days with an average of 16.40 ± 1.26 days, while of female it was 16 to 20 days with an average 17.90 ± 1.20 days cabbage in laboratory. Thus, this variation in longevity might be due to the differences in temperature, humidity and other factors prevailing in the experimental studies.

Alizadeh *et al.* (2011)^[2] reported the fecundity to be 323.45 eggs per female on cabbage while Meena and Singh (2012)^[9] recorded it to be 242 to 305 eggs with an average of 255.3 ± 19.09 eggs on cabbage at $24.4 \pm 2.8^\circ$ C temperature. Thus, the present findings are more or less similar with the above reports.

5. Conclusion

During the investigation, biology of *Plutella xylostella* studied to reduce economical damage causes by DBM which causing severe infestation in South Gujarat condition on cabbage crop.

By using these information farmers, researchers and students aware about of diamond back moth. Based on the above information effective and sustainable management of diamondback moth is an achievable longer term.

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