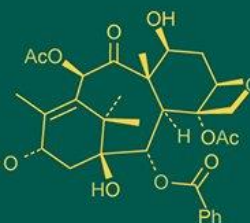
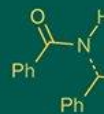


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Studies on biology and morphometrics of diamondback moth *Plutella xylostella* (L.) on cabbage under *in-vitro* conditions

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Abstract

The present investigation entitled studies on biology and morphometrics of diamond back moth, *Plutella xylostella* (L.) on cabbage under *in-vitro* were investigated under laboratory conditions ($28 \pm 2^\circ\text{C}$ and $65 \pm 5\%$ RH) using cabbage leaves as the host. The insect completed its life cycle through egg, four larval instars, pupa and adult stages. The mean incubation was (2.67 ± 0.33), larval and pupal periods were, 7.67 ± 1.33 and 3.67 ± 0.88 day. Female adults exhibited greater longevity (9.60 ± 1.52 days) and a longer life cycle (22.33 ± 1.20 days) than males (7.80 ± 1.30 and 19.00 ± 1.00 days). Morphometric observations revealed a progressive increase in body dimensions through successive larval instars. Female adults were larger than males in body length, body width and wing length, indicating clear sexual dimorphism. These findings provide essential baseline on biological and morphometric information for the laboratory rearing of *P. xylostella*.

Keywords: *Plutella xylostella*, biology, morphometrics and cabbage

1. Introduction

Cabbage, *Brassica oleracea* var. *capitata* (L.) is one of the most important cole vegetable crops cultivated throughout the world. It belongs to the family Brassicaceae and is believed to have originated in the Mediterranean region. The Brassicaceae comprises a diverse group of economically important vegetables, including cabbage, cauliflower, broccoli, knol-khol, mustard and turnip. In India, cabbage is cultivated extensively under both tropical and subtropical conditions owing to its high nutritional value, market demand and economic importance. It is rich in vitamins, minerals, dietary fibre and antioxidants, making it an essential component of a balanced diet and an important source of income for vegetable growers (Khan *et al.*, 2017) [9].

Among the insect pests attacking cabbage, the diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae) is recognized as the most destructive and economically important pest of cruciferous crops worldwide. The pest was first reported from India by Fletcher (1914) and is now distributed across more than 128 countries, wherever cruciferous crops are cultivated. Annual crop losses caused by *P. xylostella*, including management costs, amount to billions of dollars globally. Under severe infestation, yield losses may exceed 90%, particularly when effective management practices are not adopted (Furlong *et al.*, 2013) [12].

The destructive nature of *P. xylostella* is attributed to its short life cycle, high reproductive potential, rapid generation turnover and remarkable ability to adapt to diverse agro-climatic conditions. The larvae feed voraciously on leaf tissues, producing characteristic window-pane damage during the early stages and irregular holes as feeding progresses. Severe infestations may result in complete defoliation, leaving only the leaf veins intact and adversely affecting head formation and marketable yield. Single larvae of DBM feeds away 62 to 78% leaves and plants growth are stunted resulting in the reduction of quantity as well as quality (Gangurde and Wankhede, 2009) [3].

In addition, the pest has developed resistance to several groups of insecticides, making its management increasingly difficult and emphasizing the need for environmentally sustainable control strategies.

Although several studies have described the biology of *P. xylostella*, information on its biological and morphometric characteristics under the laboratory conditions of western Uttar Pradesh remains limited. Variations in temperature, humidity, host plant quality and geographical location can significantly influence the developmental period, survival and body measurements of the insect. Furthermore, standardized baseline information on the biology and morphometrics of *P. xylostella* is essential for designing

effective biological control strategies and integrated pest management (IPM) programmes.

2. Material and Methods

2.1 Experimental site

The experiments were conducted during 2025-26 at Bio-control laboratory, SVP University of Agriculture & Technology, Meerut, India under controlled laboratory conditions at $28 \pm 2^\circ\text{C}$ and $65 \pm 5\%$ relative humidity (RH) with longitude 77.694035°E , latitude 29.086828°N ; altitude 247 m above mean sea level. (Figure 1 is depicted the location map of experimental site showing the geographical position of experiment area in India).

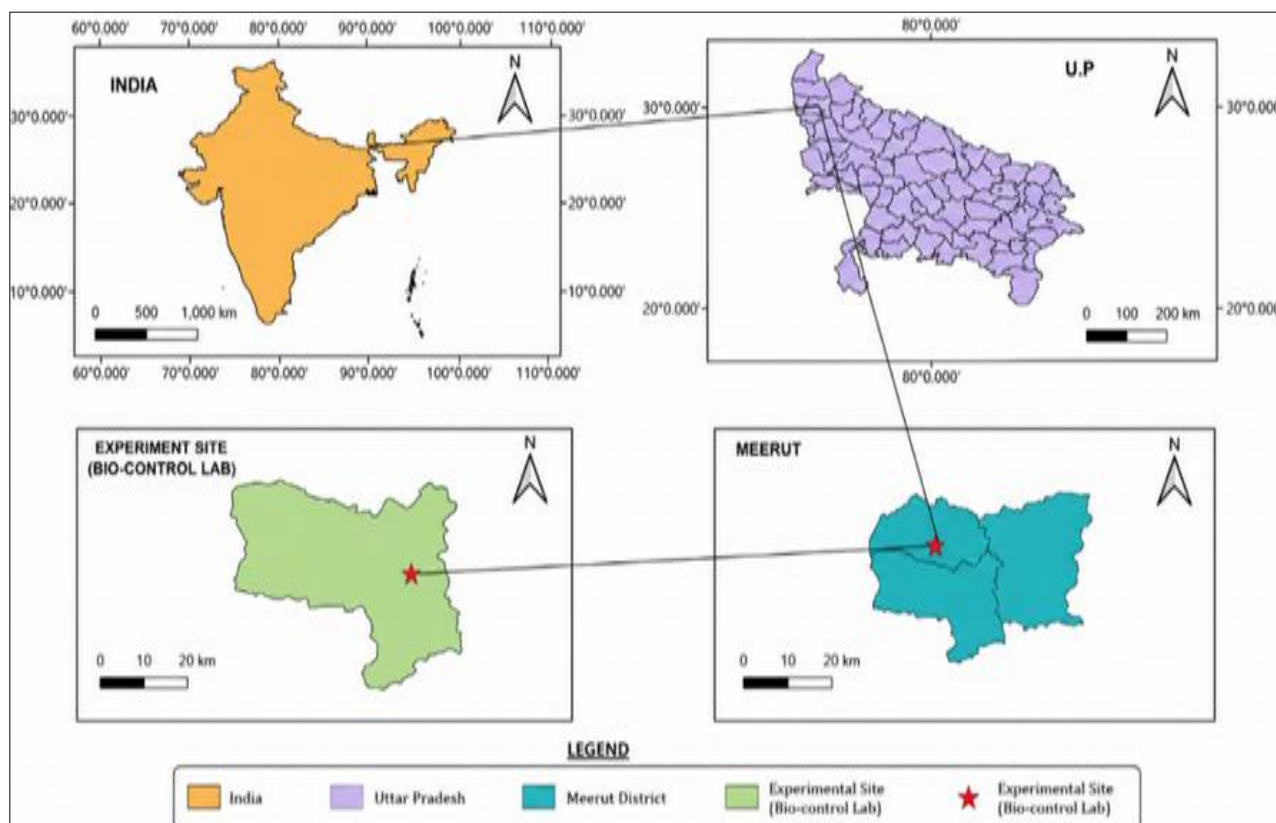


Fig 1: The location map of experimental site showing the geographical position of experiment area in India)

2.2 Collection of larvae

The initial culture of *Plutella xylostella* was collected from larvae collected from unsprayed cabbage fields around the experimental farm of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India.

3. Methodology

Fresh cabbage (*Brassica oleracea* var. *capitata*) leaves were used as the food source throughout the experiment. The larvae were reared in plastic containers and fresh leaves were replaced twice daily to ensure a continuous supply of food. For biological observations, 10 larvae were maintained individually and observed daily from egg hatching until adult emergence. The duration of each developmental stage, namely egg, four larval instars, pupa and adult, was recorded. Larval instars were identified based on moulting, body colour and increase in body size. The period from egg hatching to pupation was considered the total larval period, while the pupal period was recorded from pupation until adult emergence. Newly emerged adults were sexed based on external morphological characteristics and maintained in rearing cages. Ten adults (5 males and 5

females) were used to record adult longevity. Adults were provided with 10% honey solution soaked in cotton swabs as a food source. Adult longevity was recorded from emergence until death. The total life cycle was calculated from egg laying to adult mortality separately for male and female insects.

For morphometric studies, measurements of different developmental stages, including egg, first, second, third and fourth larval instars, pupa and adult male and female, were recorded. Egg length and width, larval body length and width of each instar, pupal length and width, adult body length, body width and wing length were measured using an ocular micrometer calibrated with a stage micrometer under a stereoscopic microscope. Ten individuals of each developmental stage were measured and the observations were expressed as range and mean $\pm$ standard deviation.

4. Result

4.1 Biological parameters of *Plutella xylostella* (L.)

The biological parameters of *Plutella xylostella* were studied under laboratory conditions on cabbage leaves and the observations recorded for different developmental stages

are presented in Table 1. The incubation period of *P. xylostella* varied from 2 to 3 days, with a mean of 2.67 ± 0.33 days. The larva completed its development through four instars. The duration of the first, second, third and fourth instars ranged from 2–3, 1–3, 1–2 and 2–4 days, with mean durations of 2.33 ± 0.33 , 1.67 ± 0.67 , 1.33 ± 0.33 and 3.00 ± 0.58 days, respectively. The total larval period ranged from 5 to 9 days, averaging 7.67 ± 1.33 days. The pupal period lasted 2–5 days, with a mean duration of 3.67 ± 0.88 days.

Adult longevity differed between the sexes. Male adults survived for 6–9 days (mean 7.80 ± 1.30 days), whereas female adults survived for 8–11 days (mean 9.60 ± 1.52 days). Female adults exhibited greater longevity than males. Similarly, the total life cycle was longer in females than in males. The male completed its life cycle within 17–20 days, with a mean duration of 19.00 ± 1.00 days, while the female required 20–24 days, with an average of 22.33 ± 1.20 days. These results indicate that female *P. xylostella* had a comparatively longer developmental period and adult longevity than males under laboratory conditions.

4.2 Morphometrics of *Plutella xylostella* (L.)

The morphometric characteristics of different developmental stages of *P. xylostella* reared on cabbage under laboratory conditions and their results presented in Table 2. The eggs were oval, smooth and creamy white immediately after oviposition, gradually turning pale yellow before hatching. Egg length ranged from 0.40 to 0.44 mm, with a mean of 0.42 ± 0.014 mm, while the width ranged from 0.22 to 0.26 mm, mean 0.246 ± 0.016 mm. The larvae passed through four distinct instars, exhibiting progressive increases in body size with each moult.

Table 1: Biological parameter of different developmental stages of *Plutella xylostella* reared on cabbage under *in-vitro*.

Biological parameter		Range	Mean $\pm$ SE
Egg incubation period		2–3	2.67 ± 0.33
Larval instar	First larval instar	2–3	2.33 ± 0.33
	Second larval instar	1–3	1.67 ± 0.67
	Third larval instar	1–2	1.33 ± 0.33
	Fourth larval instar	2–4	3.00 ± 0.58
Total larval period		5–9	7.67 ± 1.33
Pupal period		2–5	3.67 ± 0.88
Adult	Male	6–9	7.80 ± 1.30
	Female	8–11	9.60 ± 1.52
Total life cycle	Male	17–20	19.00 ± 1.00
	Female	20–24	22.33 ± 1.20
Fecundity (eggs/female)		188–220	202.67 ± 9.33

Values are expressed as Range and Mean $\pm$ SD

The first instar measured 1.4–1.8 mm in length (mean 1.62 ± 0.12 mm) and 0.16–0.19 mm in width (mean 0.18 ± 0.01 mm). The second instar measured 2.6–2.9 mm in length (mean 2.80 ± 0.10 mm) and 1.10–1.30 mm in width (mean 1.22 ± 0.08 mm). The third instar ranged from 4.0–4.6 mm in length (mean 4.36 ± 0.22 mm) and 1.60–1.80 mm in width (mean 1.67 ± 0.07 mm). The fourth instar measured 5.1–5.5 mm in length (mean 5.26 ± 0.13 mm) and 2.10–2.30 mm in width (mean 2.16 ± 0.07 mm). A gradual increase in body dimensions from the first to the fourth instar was observed.

The pupa was obdect and enclosed within a loosely woven silken cocoon. Fresh pupae were light green, gradually turning yellowish-green and finally brown before adult

emergence. Pupal length varied from 5.9 to 6.2 mm, with a mean of 6.08 ± 0.13 mm, while the width ranged from 2.0 to 2.2 mm, averaging 2.14 ± 0.11 mm. Sexual dimorphism was evident in adults, with females being larger than males. Male adults measured 5.8–6.8 mm in body length (mean 6.30 ± 0.32 mm) and 1.30–1.70 mm in body width (mean 1.50 ± 0.12 mm). Female adults measured 6.5–7.6 mm in body length (mean 7.00 ± 0.35 mm) and 1.50–1.90 mm in body width (mean 1.70 ± 0.13 mm). Wing length also differed between the sexes, ranging from 4.7–4.9 mm (mean 4.80 ± 0.10 mm) in males and 5.0–5.4 mm (mean 5.24 ± 0.15 mm) in females. Overall, females were larger and possessed longer wings than males.

5. Discussion

The present investigation on the biology and morphometrics of *Plutella xylostella* under laboratory conditions on cabbage revealed that the insect successfully completed its life cycle within 19.00 ± 1.00 days in males and 22.33 ± 1.20 days in females.

The egg incubation period recorded in the present study ranged from 2 to 3 days, with a mean of 2.67 ± 0.33 days. These findings are in close agreement with those of Gangurde and Wankhede (2010) [3], who reported an incubation period of 3–4 days, Alizadeh *et al.* (2011), who recorded 2.39 ± 0.17 days, Bhure *et al.* (2019) [3, 11, 2], who observed 2.20 ± 0.65 days, Kaur *et al.* (2021) [8], who reported incubation periods ranging from 1.92 to 2.68 days in different populations. Rasool *et al.* (2022) [5] also reported an incubation period of 2–5 days (3.60 ± 1.34 days). However, the incubation period observed by Ahmad *et al.* (2011) [1] (4.40 ± 0.22 days) was comparatively longer than that recorded in the present study.

Table 2: Morphometric measurements of different developmental stages of *Plutella xylostella* reared on cabbage under *in-vitro*.

Stage		Length (mm)		Width (mm)	
		Range	Mean $\pm$ SD	Range	Mean $\pm$ SD
Egg		0.40–0.44	0.42 ± 0.014	0.22–0.26	0.246 ± 0.016
Adult	First larval instar	1.4–1.8	1.62 ± 0.12	0.16–0.19	0.18 ± 0.01
	Second larval instar	2.6–2.9	2.80 ± 0.10	1.10–1.30	1.22 ± 0.08
	Third larval instar	4.0–4.6	4.36 ± 0.22	1.60–1.80	1.67 ± 0.07
	Fourth larval instar	5.1–5.5	5.26 ± 0.13	2.10–2.30	2.16 ± 0.07
Pupal		5.9–6.2	6.08 ± 0.13	2.0–2.2	2.14 ± 0.11
Adult	Male	5.8–6.8	6.30 ± 0.32	1.30–1.70	1.50 ± 0.12
	Female	6.5–7.6	7.00 ± 0.35	1.50–1.90	1.70 ± 0.13
Adult Wings	Male	4.7–4.9	4.80 ± 0.10		
	Female	5.0–5.4	5.24 ± 0.15		

Values are expressed as Range and Mean $\pm$ SD

The larval stage consisted of four instars with a total larval duration of 7.67 ± 1.33 days. This result is in close conformity with Gangurde and Wankhede (2010), who reported a larval period of 7–11 days and Alizadeh *et al.* (2011) [3, 11], whose combined duration of four larval instars was approximately 8.92 days. The present findings are also supported by Kaur *et al.* (2021), who reported total larval periods ranging from 8.18 to 11.21 days and Rasool *et al.* (2022) [8, 5], who observed a total larval period of 11.40 ± 1.81 days. In contrast, Bhure *et al.* (2019) [2] reported a

comparatively longer larval duration (10.32 ± 1.22 days). Such variations may be due to differences in host plant, environmental conditions and insect strains. The pupal period observed in the present investigation (3.67 ± 0.88 days) agrees well with the findings of Gangurde and Wankhede (2010), who reported 3–5 days, Alizadeh *et al.* (2011) (4.23 ± 0.23 days) and Rasool *et al.* (2022) ^[3, 11, 5] (4.40 ± 0.89 days). However, Bhure *et al.* (2019) ^[2] recorded a relatively longer pupal duration (7.44 ± 1.47 days) indicating the influence of environmental conditions on pupal development.

Adult longevity differed between the sexes in the present study, with females (9.60 ± 1.52 days) surviving longer than males (7.80 ± 1.30 days). Similar observations were reported by Ahmad *et al.* (2011) ^[1], who recorded male and female longevity of 7.0 ± 0.25 and 11.8 ± 0.44 days, respectively. Likewise, Gowri and Manimegalai (2016) ^[10] observed that females survived longer (16 days) than males (12 days) under laboratory conditions. Bhure *et al.* (2019) and Rasool *et al.* (2022) ^[2, 5] also reported a longer life cycle and greater longevity in females than males. In contrast, Alizadeh *et al.* (2011) ^[11] observed considerably longer adult longevity under their laboratory conditions, suggesting that environmental factors greatly influence adult survival. The total life cycle observed in the present study (19.00 ± 1.00 days in males and 22.33 ± 1.20 days in females) was comparable with the findings of Gangurde and Wankhede (2010), who reported completion of the life cycle within 14–22 days and Ahmad *et al.* (2011) ^[3, 1], who reported a mean developmental period of 21.50 ± 1.10 days. Bhure *et al.* (2019) and Rasool *et al.* (2022) reported comparatively longer life cycles, whereas Ramzan *et al.* (2019) ^[2, 5] observed a life cycle ranging from 13 to 23 days, which encompasses the values obtained in the present study.

The morphometric observations revealed progressive increases in body length and width from the egg stage to the fourth larval instar. Similar growth patterns have been reported by Ram *et al.* (2017) ^[7], who observed significant geographical variation in egg size, wing expansion and developmental period among different populations of *P. xylostella*. In the present investigation, females were larger than males in body length, body width and wing length. This observation corroborates the findings of Gowri and Manimegalai (2016) ^[10], who also reported a greater wingspan and larger body size in female moths than males. Environmental conditions are known to influence the biology of *P. xylostella*. Haripriya *et al.* (2021) demonstrated that temperature significantly affects developmental duration and reproductive parameters, whereas Shinde *et al.* (2021) ^[4, 6] reported that survival from egg to adult varied considerably under different temperature regimes.

6. Conclusion

The study demonstrated that *Plutella xylostella* successfully completed its life cycle under laboratory conditions on cabbage leaves through four larval instars. Females exhibited greater longevity, larger body size and a longer life cycle than males. Progressive increases in body dimensions were observed during larval development, and distinct sexual dimorphism was evident in adults. These biological and morphometric data provide essential baseline information for the mass rearing of *P. xylostella* and for laboratory evaluation of biological control agents and insecticidal treatments.

7. Declaration

The authors declare that they have no conflicts of interests.

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