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COMPARATIVE BIOLOGY OF DIAMONDBACK MOTH *PLUTELLA XYLOSTELLA* L. (LEPIDOPTERA: PLUTELLIDAE) ON MAIN CROP (CABBAGE) AND TRAP CROP (MUSTARD)

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ABSTRACT

The investigation was carried out during October–November 2024-25 in the NFSM Laboratory, Department of Entomology, University of Agricultural sciences Raichur, College of agriculture Raichur. The duration of different developmental stages of *Plutella xylostella* (L.) varied between cabbage and mustard. On cabbage, the mean periods recorded for the egg, larval, pre-pupal and pupal stages were 3.8, 10.8, 1.2 and 7.8 days, respectively. In contrast, these stages slightly shorter on mustard, with durations of 4.0, 9.6, 1.5 and 5.2 days. Adult longevity also differed between hosts: males and females survived for 9.2 and 10.9 days on cabbage, whereas on mustard their longevity was 8.6 and 10 days, respectively. Overall, the developmental stages of the diamondback moth tended to extend marginally on cabbage compared to mustard. The incubation period and total larval duration were greater on cabbage, while the pupal period and total life cycle longer on cabbage. Thus, most biological stages of *P. xylostella* exhibited slightly prolonged development on cabbage in comparison with mustard.

Keywords **:** Diamondback moth, *Plutella xylostella*, Cabbage, Main crop, Mustard, Trap crop.

Introduction

Cruciferous vegetables such as cabbage, *Brassica oleracea var capitata* L. and cauliflower *Brassica oleracea botrytis* L. are popular exotic vegetables grown both on small and large scales all year round in urban and rural areas (Cobblah *et al*., 2012). The cruciferous vegetables (Cole crops) represent one of the highly polymorphic classes, which include crops like cabbage, cauliflower, turnip, knol-khol, broccoli and mustard. Cabbage is the most important cole crop, originating from Cyprus and Mediterranean region. It belongs to the genus Brassica of the family Brassicaceae. Cabbage is locally known as Kabij, Kabi, Bandh Kobi and Karam Kala. In ancient times, cabbage was referred by the Greeks as Capuche for its resemblance to the human brain. 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 the world population. In addition to several minerals such as P, K, Ca and Fe, it also contains a high percentage of vitamins A, B and C. It is consumed either cooked or raw as a salad.

The area under cabbage in the world is about 0.28 million ha with a production of about 6.10 million tonnes (Anon., 2022). Although the crop has got huge domestic requirement, a number of limiting factors have been attributed to low productivity, among them, one of the chief constraints in the production of cruciferous vegetables is damage caused by pest complex from germination till the harvesting stage (Sachan and Srivastava, 1972). Cruciferous vegetables are infested by a group of lepidopteran pests such as; the diamondback moth, *Plutella xylostella* (Linnaeus), cabbage worm, *Pieris rapae* (Linnaeus), cabbage looper, *Trichoplusia ni* (Hubner), corn earworm, *Helicoverpa armigera* (Hubner), cabbage webworm,

Hellula undalis (Fabricius), common cutworm, *Spodoptera litura* (Fabricius) and cabbage head caterpillar *Crocidolomia binotalis* (Zeller). Another important insect that damage the cruciferous vegetables is a striped flea beetle, *Phyllotreta striolata* (Fabricius). These insects greatly reduce both yield and quality of the produce (Morallo and Sayaboc, 1992).

Globally, diamondback moth is the most destructive pest of cabbage. It was first observed in North America during 1854, in Illinois and had spread to Florida and Rocky Mountains by 1883. It was reported from British Columbia by 1905. The *Plutella xylostella* (Linnaeus) was introduced from Europe in the nineteenth century and is now widely distributed throughout North, Central and South America and Asia, it prefers to feed on cruciferous vegetables of more than 40 species, including cabbage, rapeseed-mustard and radish. It is one of the devastating pest of crucifers throughout the world. In India growing of trap crops like cabbage + mustard in 1:4 ratio for management is recommended. A conservative estimate of the total global costs associated with *P. xylostella* management was reported to be USD four billion to five billion. On the other hand, control of cabbage insect pests is difficult due to its fast development rate and high reproductive potential and further, this pest has a wide spectrum and rapid development of resistance. It has developed resistance to a variety of pesticides, especially pyrethroids, carbamates and organophosphorus insecticides etc, which make *P. xylostella* is a highly resistant global pest. Diamondback moth has even been reported to be resistant to hard-to-resist microbial insecticides like *Bacillus thuringiensis* (Bt) spray formulations derived from subspecies *kurstaki* (with Cry1Aa, Cry1Ab, Cry1Ac, Cry2A and Cry2B toxins) and *Bacillus thuringiensis sub-species aizawai* (Cry1Aa, Cry1Ab, Cry1C and Cry1D and Cry2B) have been used as part of an IPM approach for controlling DBM since the late 1980s (Heckel *et al*., 2004), but due to genetic resistance in populations to some Bt strains (Tabashnik *et al*., 1987), attention has again been turned to developing alternative control measures. Keeping all these points in view, detailed investigations were undertaken with the following objectives to study the biology of diamond back moth, *P. xylostella*.

Materials and Methods

Biology of *P. xylostella* L. The biology of Diamond back moth was studied in the laboratory of Department of Entomology, University of Agricultural, sciences Raichur College of Agriculture Raichur, during 2023-25. Minimum and maximum temperatures and relative humidity were recorded during the course of study.

Mass rearing of diamondback moth on Cabbage

The larvae were reared in the laboratory on their natural host plant. Individual larvae were placed in transparent plastic tubes fitted with perforated lids to ensure proper aeration. Fresh cabbage leaves were supplied daily as food until the larvae pupated. The pupae were then transferred to separate tubes to allow for adult emergence. Newly emerged adults were collected daily. Males and females were differentiated in larval stage based on visible testes. For oviposition, one male and one female were released into a glass jar (23 cm diameter × 10 cm height). The leaves were examined daily for egg deposition. Once eggs were observed, the leaf sections containing them were removed and replaced with fresh leaves. Freshly laid eggs were used for subsequent experimental work.

Mass rearing of diamondback moth on Mustard

Mass rearing of *P. xylostella* (diamondback moth) was carried out by following the method suggested by Liu and Sun (1984), with necessary modifications to suit laboratory conditions. The insects were reared on mustard seedlings, which were raised in plastic vial caps filled with vermiculite containing a uniform mixture of red soil, sand and farmyard manure. Small holes were made at the bottom of the caps to facilitate excess water drainage. The seeds were dibbled into the medium and allowed to germinate, with proper moisture maintained to ensure optimal germination. Five days after germination, the seedlings were transferred to insect rearing containers (20×15 cm) and the larvae were allowed to feed on them until they reached the pupal stage. Sex differentiation was done in the larval stage itself. The pupae were then collected and placed in small petri dishes, which were subsequently transferred to oviposition containers measuring 20 × 15 cm. These containers were covered with black cloth to stimulate darkness and encourage oviposition. Emerged adults were provided with a 10 per cent honey solution supplemented with 0.1 per cent yeast, supplied through cotton swabs placed inside the cages to provide essential nutrition and moisture. Adults were allowed to mate and oviposit on fresh mustard seedlings for 24 hours.

After 24 hours, the seedlings were removed and replaced daily with fresh ones to facilitate continuous oviposition for five consecutive days. Seedlings containing eggs were kept inside the new rearing boxes and incubated for two to three days to allow hatching and further larval development. Once the mustard seedlings were largely consumed, fresh seedlings were

introduced into the rearing trays. The larvae migrated to the new seedlings on their own. As they developed, the larvae were transferred to mustard seedlings either by gentle tapping or with the aid of a camel hair brush. Fresh mustard seedlings were provided regularly as required. Rearing was conducted at a temperature of 25 ± 1.5°C.

To determine the incubation period, freshly laid eggs on cabbage leaves were carefully removed using a fine camel hair brush and placed in glass Petri dishes (10 cm diameter). The incubation period was recorded from the day of oviposition to hatching. Hatching per cent was calculated based on the number of eggs that successfully hatched in relation to the total eggs observed. The oviposition behaviour of adult females was observed. Females typically deposited eggs on the lower surface of cabbage leaves, particularly near the midrib and along major veins. To study larval duration and number of instars, twenty-five newly hatched larvae were individually transferred to plastic rearing tubes (2.5 cm diameter × 7.5 cm length) containing fresh cabbage leaf pieces. Leaves were replaced daily and larvae were gently transferred using a camel hair brush. Head capsule measurements were taken daily to determine instar transitions, and exuviae were examined to support stage identification. The pre-pupal period was recorded from the time larvae completed feeding and showed reduced activity until pupation occurred. Each pre-pupa was kept in an individual rearing tube to allow pupation. Observations were recorded on pupal duration, size, colour and the location of pupation on the foliage or rearing surface.

Newly emerged adults were paired (one male and one female) and placed in glass jars (23 cm × 10 cm). Adults were provided with a 5% honey solution as a food source. Fresh cabbage leaves were supplied daily for resting and oviposition. Pre-oviposition, oviposition and post-oviposition periods were recorded. Fifteen pairs were monitored to determine fecundity. Eggs laid by each female were collected and counted daily until the female died. Adult longevity was calculated separately for males and females. Adult body length and wing expansion were measured using a standard scale. Total life span was recorded from egg stage to adult death. To determine sex ratio, pupae were individually placed in separate tubes. After emergence, males and females were counted and the male-to-female ratio was calculated.

Results and Discussion

The biological studies on *P. xylostella* were conducted during October–November 2024-25. The average laboratory temperature and relative humidity were 23.27 ± 1.04 °C and 80-90 (%), respectively.

Egg Stage

The eggs are tiny, cylindrical to slightly oblong and appear whitish to light yellow green. On cabbage, they required about 3.8 days to hatch, while on mustard the incubation averaged 4 days. Earlier studies have shown similar trends: Jayarathanam (1977) found that eggs typically hatched in 3 to 4 days in both field and laboratory settings. Satapathi (1990) reported a 4 days incubation period on mustard, whereas Kandoria *et al.* (1994) documented a much shorter duration of around 1.8 days at room temperature on cauliflower.

Larval Stage

Newly emerged larvae are pale white with a light brown head capsule, eventually turning into green caterpillars that grow to 8 to 9.5 mm in length. The early instars move across the leaf surface before beginning to mine the tissue. In the present observations, the larvae passed through four instars, although Patil and Pokharkar (1971) described five.

- 1st instar: ~3.1 days on cabbage, ~2.8 days on mustard
- 2nd instar: ~2.8 days on cabbage, ~2.5 days on mustard
- 3rd instar: ~2.4 days on cabbage, ~ 2.1 days on mustard
- 4th instar: ~2.5 days on cabbage, ~2.2 days on mustard, and responsible for the heaviest feeding

Total larval development required 10.8 days on cabbage and 9.6 days on mustard, followed by a pre-pupal stage lasting 1.2 and 1.5 days, respectively. Satapathi (1990) reported a considerably longer larval phase of about 16 days on Indian mustard, which included a 1.5 day pre-pupal period. According to Ramegowda *et al.* (2006), larvae on Indian mustard could require 27 to 32.75 days, averaging 29.66 days, still with four instars. Kandoria *et al.* (1994) noted a very wide range of 6.5 to 24.7 days, with 0.7 to 2.4 days for the pre-pupal stage.

Pupal Stage

Fully grown larvae construct a loose silken cocoon for pupation. Newly formed pupae are light green but darken from brownish to dark brown as they mature. The average pupal duration was 7.8 days on cabbage and 5.2 days on mustard. Ramegowda *et al.* (2006) found a shorter duration on Indian mustard, typically 3.5 to 4.75 days (mean 4.27 days). Other reports vary: Chauhan *et al.* (1997) recorded 5.9 days under Himachal Pradesh laboratory conditions,

Satapathi (1990) noted 5 days, while Kandoria *et al*. (1994) documented a much broader range of 3.3 to 11.4 days.

Adult Stage

The adults are slender moths with a grey-brown appearance. On cabbage, males lived for an average of 9.2 days and females for 10.9 days; on mustard, the respective longevities were 8.6 and 10 days. Ramegowda *et al*. (2006) reported a shorter lifespan of about 4.27 days on mustard seedlings, while Satapathi (1990) recorded 10 days at 24°C and 85 per cent RH. Chauhan *et al*. (1997) observed longer adult survival during March to April in Himachal Pradesh, with males living 18.6 days and females 15.6 days.

Table 1: Biology of *Plutella xylostella* L. on cabbage and mustard at 23.27 ± 1.04 ^{0}C temperature

Stage	Diamondback moth *Plutella xylostella* L.			
	Duration in (days)			
	Cabbage		Mustard	
	Mean±	Range	Mean±	Range
Egg				
Incubation period	3.8 ± 0.23	3-4	4.0±0.24	3-4
Larva				
I	3.1 ± 0.21	2.5-3.5	2.8±0.14	2-3
II	2.8±0.25	2.5-3	2.5±0.23	2-3
III	2.4±0.14	2-3	2.1±0.19	2-3
IV	2.5±0.20	2-3	2.2±0.23	2-3
Total larval period	10.8	9-12.5	9.6	8-12
Pre pupal period	1.2 ±0.15	1 -1.5	1.5± 0.18	1-2
Pupal period	7.8±0.21	7-8.5	5.2 ±0.25	5-6
Adult longevity				
Male	9.2±0.26	9-9.5	8.6 ± 0.23	8-9
Female	10.9±0.38	10-12	10 ± 0.28	9-11
Total life cycle				
Male	32.8± 0.59	27-36	28.9± 0.45	25-33
Female	34.5 ± 0.54	30-38.5	30.3± 0.51	26-35

Life cycle

The total life cycle of diamond back moth was 32.8 days for male and 34.5 days for female on cabbage and 28.9 days for male and 30.3 days for female on mustard. The life processes of this insect are highly influenced by environmental conditions. Harcourt (1957) in Canada, Abraham and Padmanabhan (1968) in Southern India, Lee (1968) in Hong Kong and Yadav *et al*. (1974) in northern India have reported that the life cycle of Diamond Back Moth took 14 to 21, 24 to 35, 22 to 37 and 25.28 to 27.15 days, respectively. Kandoria *et al*. (1994) reported that the total life cycle was 12 days in June to 44 days during December and January. The complete life cycle from egg to imago took 20-28 days at 24°C and 15-20 days at 26°C (Grillo and Hernandez, 1994) While Ramegowda *et al*. (2006) observed the total developmental period 27.00 to 32.75 days on Indian mustard. Therefore, results concluded that incubation period of the DBM was slightly longer when it reared on cabbage and total larval period also higher on cabbage. The pupal period higher on cabbage with total life cycle. Thus, the biology of *Plutella xylostella* on cabbage and mustard revealed that except longevity of female adult, all other *stages* lasted for marginally longer duration on cabbage than mustard.

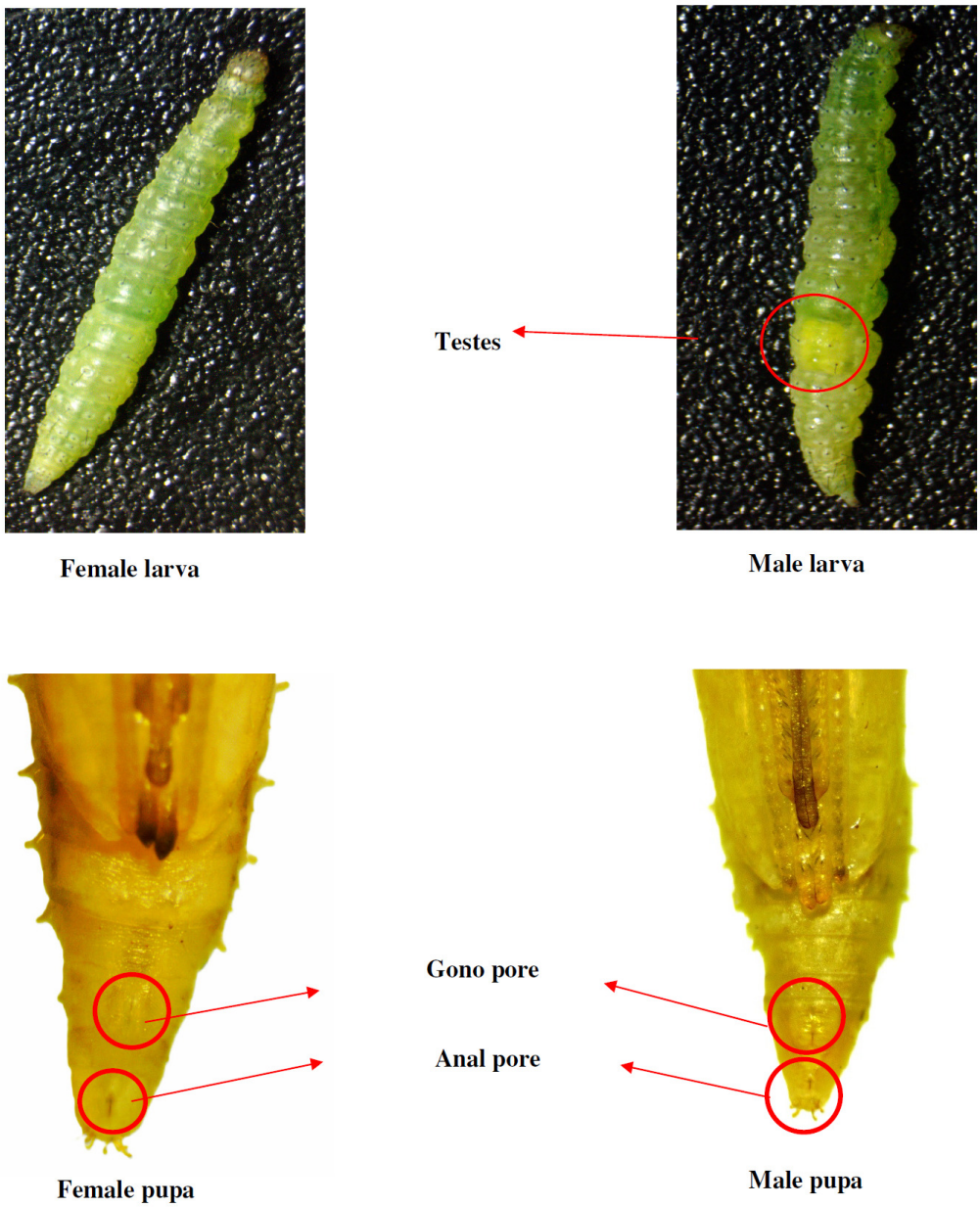

Plate 1 : Sexual dimorphism characters of *P. xylostella* in larval and pupal stage

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