Bionomics of the Diamondback Moth in the Northwestern Himalaya

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Abstract

The paper presents the bionomics of the diamondback moth, *Plutella xylostella* (L), in the northwestern Himalaya. Diamondback moth is one of about two dozen insect pests which are harmful, or potentially harmful, to cruciferous vegetables in the region. Laboratory observations on its life history have shown that lifecycle of the female and the male moth on average respectively last 35.65 and 27.95 days in the first and 29.50 and 25.30 days in the second generation, when temperature and relative humidity fluctuated from 16.1° to 34.1°C and from 29.0 to 63.5%. In the field, the pest was observed seriously damaging the cabbage seed crop during September and October in dry cold areas but was seen in small numbers on off-season cabbage and cauliflower crops grown during wet months (June through August) and on the cauliflower seed crop from December to May. *Apanteles plutellae* and *Diadegma fenestralis* were found parasitizing larval and pupal stages of the moth.

Introduction

Amongst the lepidopterous pests of cruciferous crops, especially cauliflower, *Brassica oleracea* var *botrytis* (L) and cabbage, *B. oleracea capitata* (L), the diamondback moth (DBM), *Plutella xylostella* (L) (Lepidoptera: Yponomeutidae) is the most serious and widely distributed pest throughout the world (Bonnemaison 1965). Its resistance to many of the commonly used insecticides makes it one of the most difficult pests to manage (Ankersmit 1953, Mo 1959, Sudderuddin and Kok 1978, Cheng 1981, Liu et al 1982).

In the northwestern Himalaya, cauliflower (especially Snowball group cultivars) and cabbage are grown mainly for seed production during winter through spring to summer. In addition, these crops are also grown as off-season vegetables during summer under rainfed conditions. Cultivation of these crops has come to stay and is now the most remunerative enterprise for cultivators of the northwestern Himalayan states in India.

Although DBM has not been reported to cause extensive damage to cruciferous crops in the temperate Himalayan region, yet it has a potential to establish itself as a serious pest. Some work on the bionomics of the DBM has been done in other localities in india, for example in Kodaikanal (Abraham and Padmanabhan 1968), Jabalpur (Rawat et al 1968), and in Jobner (Sachan and Srivastava 1972, Yadav et al 1974). However, no attempt has been made to study the pest in the northwestern Himalaya. Detailed studies have been made in other countries (Ullyett 1947, Harcourt et al 1955, Oatman and Platner 1965, Weires and Chiang 1973, Ru and Workman 1979, Borcan 1979, Ko and Fang 1979). This article deals with the bionomics of the DBM under northwestern Himalayan conditions.

Materials and Methods

Life history study

Investigations on DBM biology were carried out in the laboratory of the Department of Entomology and Apiculture, Himachal Pradesh Krishi Vishva Vidyalaya, Solan, India. Temperature during the period varied from 16.1 to 34.1°C, and relative humidity from 29.0 to 63.5%, respectively. Initial culture the moths were raised for the study from caterpillars collected during February 1984, from cabbage and cauliflower crops grown at the University farm. They were released onto cabbage seedlings grown in the laboratory in plastic pots (12.5 x 10.2 cm), which were covered with glass chimneys (20 x 30 cm). Freshly emerged moths were sexed and kept in pairs on potted cabbage plants enclosed within glass chimneys. The adults were provided with 10% sugar solution. Total numbers of eggs laid were counted daily.

Eggs were then transferred to petri dishes (diam 4 cm), containing wet blotting paper at the bottom, so that the incubation period could be recorded. Newly hatched larvae were transferred to petri dishes containing fresh cabbage leaves. First and second instar larvae were observed for moulting. Mature larvae were kept in separate petri dishes for pupation. All measurements were made under a microscope fitted with an ocular micrometer. Data on two generations were recorded. Caterpillars and pupae of the moth were collected from the field and maintained in petri dishes for the emergence of parasites. Identification of parasites was carried out at the Indian Agricultural Research Institute, New Delhi.

Seasonal incidence

Observations over more than 10 years on the seasonal incidence of DBM were made on cauliflower crops, cultivar Snowball, transplanted in early October for seed production. A 0.1 ha plot was established and cauliflower was transplanted with a distance of 60 cm between plants and between rows. All recommended cultural practices were followed for raising a pesticide free crop. Population counts and incidence records were made on between 50 to 100 randomly selected plants at 7 to 10 day intervals starting from October through early May when the crop was finally harvested. The meteorological data were recorded daily during the period of study.

Observations and Discussion

Life history

Data on the life history and biometrical studies are presented in Tables 1 to 3.

Oviposition and fecundity Oviposition took place in the evening and during the night. The eggs were generally laid singly or in groups of two to four on the underside of leaves, often along the mid-rib or principal veins and sometimes on the walls of rearing jars. The oviposition period averaged 5.2 days in the first generation and 4.9 days in the second. Females each laid 220 to 315 (average 284) eggs in the first generation and 177 to 318 (average 243) in the second. The maximum oviposition per day by a female ranged from 78 to 89 (average 80.8) eggs in the first generation and 74 to 89 (average 81.5) eggs in the second. Egg viability averaged 95.7 and 80.0% in the first and second generation, respectively. In the third generation, no female oviposited when laboratory temperatures exceeded 34°C.

Egg The eggs were minute, yellowish white to yellowish green, cylindrical to oblong with average dimensions of 0.48 x 0.25 mm. Mean incubation periods were 3.10 and 2.27 days in the first and second generation respectively.

Table 1. Pre-oviposition, oviposition, post-oviposition periods, and fecundity of DBM[a]

Particulars	First generation		Second generation	
	Mean	Range	Mean	Range
Pre-oviposition period (days)	3.1	3-4	2.5	2-3
Oviposition period (days)	5.2	5-7	4.9	4-6
Post-oviposition period (days)	7.4	5-9	5.9	4-7
No. of eggs per female (per day)	47.88	44-63	49.61	44-63
Maximum number of eggs laid by a female in a day	80.77	70-89	81.50	74-89
Total number of eggs/female	284	220-315	242.80	177-318

[a] Data based on 10 pairs.

Table 2. Measurements of different stages of DBM[a]

Stage	Length (mm)		Breadth/wing expanse (mm)	
	Range	Mean ± S.E.	Range	Mean ± S.E.
Egg	0.46-0.49	0.48 ± 0.001	0.245-0.259	0.25 ± 0.003
Larva				
I	1.22-1.34	1.30 ± 0.036	0.16-0.20	0.18 ± 0.004
II	2.78-3.53	3.10 ± 0.286	0.23-0.25	0.24 ± 0.040
III	4.05-5.92	4.67 ± 0.883	1.09-1.18	1.03 ± 0.040
IV	6.72-9.92	8.62 ± 0.241	1.32-1.50	1.13 ± 0.680
Pupa				
Internal	4.50-6.00	5.15 ± 0.150	1.00-1.25	1.17 ± 0.337
Cocoon	7.50-8.50	7.90 ± 0.144	2.50-3.00	2.52 ± 0.144
Adult				
Male	4.75-5.0	4.97 ± 0.033	12.25-13.00	12.97 ± 0.160
Female	4.75-5.25	4.98 ± 0.034	12.75-13.25	13.06 ± 0.170

[a] Data based on measurements of 10 individuals.

Larva The freshly hatched larva was whitish yellow to pale green with a pale brown head, and on average measured 1.30 x 0.18 mm. Young larvae initially wandered over the leaf surface and then fed like miners. The larvae underwent three moultings resulting in four instars. Full grown larvae averaged 8.62 mm in length and were light green, moderately stout, and smooth with short scattered hairs. At the slightest disturbance, the larvae wriggled actively and dropped down the leaf, suspending themselves by silken threads. Total larval period averaged 11.3 days (range 9 to 13 days) in the first and 10.3 days (range 9 to 12 days) in the second generation.

Pupa The mature caterpillar formed a beautiful gauzy, loosely spun cocoon. Thereafter, it shortened its body longitudinally but remained active. The newly formed pupa was yellowish green, but in a day or two it became brownish and gradually attained a dark brown color by the time of adult emergence. Its mean length was 5.15 mm. The average pupal period in the first and second generations lasted 5.85 and 4.63 days respectively. The pupal mortality was 3.25% in the first generation and 7.8% in the second generation.

Adult The moths were slender and greyish brown and measured 12.97 (male) and 13.0 mm (female) in wing expanse. The male to female sex ratio worked out to be 1.60 : 1 and 1.60: 1.35 in the first and second generations, respectively. Average longevity of the male and the female was 7.7 and 15.40 days in the first generation and 7.1 and 12.3 days in the second. The respective pre-oviposition, oviposition and post-oviposition periods averaged 3.1, 5.2 and 7.4 days in the first and 2.5, 4.9 and 5.7 days in the second generation.

Lifecycle

The lifecycle from egg to adult stage of the female and the male on average took 35.65 and 27.95 days in the first and 29.50 and 25.30 days in the second generation respectively.

Table 3. Lifecycle of DBM under laboratory conditions at Solon, Himalchal Pradesh, India

Item	Generation[a]	
	First	Second
Oviposition period (days)	3.1 (3 - 4)	2.3 (2 - 3)
Egg viability (%)	95.7 (91-97)	80.0 (76-85)
Larval period (days)		
1st instar	3.2 (3 - 4)	2.0 (2 - 3)
2nd instar	2.9 (2 - 3)	2.4 (2 - 3)
3rd instar	2.8 (2 - 3)	2.6 (2 - 3)
4th instar	2.4 (2 - 3)	3.3 (3 - 4)
Total	11.3 (9 -13)	10.3 (9 -12)
Larval mortality (%)	16.7	11.5
Pupal period (days)	5.9 (4 - 6)	4.6 (3 - 5)
Pupal mortality (%)	3.3	7.8
Adult longevity (days)		
Male	7.7 (6 - 9)	7.1 (6 - 8)
Female	15.4 (13-17)	12.3 (10-15)
Lifecycle (days)		
Male	28.0 (22-32)	24.3 (20-28)
Female	35.7 (29-40)	29.5 (24-35)
Sex ratio (male:female)	1.6:1.0	1.35:1.0

[a] Numbers in the parenthesis indicate range.

The life processes of this insect are highly influenced by environmental conditions. Harcourt (1957) in Canada, Ho (1965) in Malaysia, Abraham and Padmanabhan (1968) in southern India, Lee (1968) in Hong Kong and Yadav et al (1974) in northern India have reported that the lifecycle of the DBM took 14 to 21, 10.8 to 27, 24 to 35, 22 to 37 and 25.28 to 27.15 days, respectively. Even in the same region, as in one case reported by Ko and Fang (1979) in Taiwan a single generation took only 9 to 10 days under the most favorable temperature conditions, while during winter one generation could take as long as 110 days. Present findings are more less in agreement with those of Abraham and Padmanabhan (1968), Lee (1968) and Yadav et al (1974). During March to May, 1984, only two overlapping generations of the insect were observed in the present study.

Host plants

DBM was found seriously damaging cabbage seed crops during dry cold September to October in northwesten Himalaya. However, the pest was observed feeding only in small numbers on cabbage and cauliflower grown as off-season vegetables during the wet summer months (June through September) and on cauliflower seed crops from December to May. No other popular cruciferous crops such as turnip, radish, knolkhol, kale, and mustards were found infested by the pest in the region.

Seasonal incidence

DBM larvae were present on the cauliflower seed crop throughout the winter from December, 1973 onward despite extreme temperatures. The population increased gradually and a comparison of temperature records with population growth suggested that daily minimum temperature ranging from 5 to 12°C and daily maximum between 21 and 36°C favored insect multiplication. The peak population was reached by mid-April. Subsequently there was sudden reduction in numbers. The reason could well be that the larvae had pupated, and when the moths emerged they were no longer attracted to this crop as it was almost mature by then. Similar trends in population were observed during 1975-76 and 1978-79 on the seed cauliflower crop.

On the plains of India, where cabbage and cauliflower crops are grown during almost the same period as seed cauliflower in the temperate northwestern Himalaya, the insect seems to exhibit a strikingly different pattern of population build-up on these crops. For example, on the plains Verma et al (1972) observed a serious infestation in cauliflower fields around Hissar (Haryana) during August, whereas Sachan and Srivastava (1972) reported DBM to be active at Jobner (Rajasthan) from September to March. Although the peak activity period was found to be different during the present studies, the multiplication behavior of the moth was found to be similar to that reported by Sachan and Srivastava (1972) so far as the larval population in relation to temperature and humidity was concerned. Lall (1939) observed the threshold of development in DBM was 10°C. This may account for the presence of larvae in cauliflower fields during December-January, when there was considerable fall in the minimum temperature which fluctuated between 0 to 1.0°C while the maximum temperature ranged from 21 to 24°C.

The incidence of attack in northwestern Himalaya varied widely. Between 3% and 73% plants were infested with larval population of between 3 and 415 per 100 plants. Morgan (1929), Prasad (1963) and Sachan and Srivastava (1972) also made similar observations and reported that infestation of plants varied from 5% to 100% during their experimental crop growth seasons.

Natural enemies

During the course of this study, bracond, *Apanteles plutellae* Kurdj (Hymenoptera: Braconidae) parasitized on an average 31% of DBM larvae. Simmonds and Rao (1969) recovered this parasite from DBM from Kashmir and many workers have reported its occurrence from other parts of India (Patel and Patel 1968, Joshi and Sharma 1976, Nagarkatti and Jayanth 1982). The parasite is of widespread occurrence in the world (Yarrow 1970, Chin 1974, Rusinov 1977, Yaseen 1977, Ooi 1979). An ichneumonid, *Diadegma fenestralis* Holmgren (Hymenoptera: Ichneumonidae) was found parasitizing on average 29.37% pupae. Dutt (1925), Abraham and Padmanabhan (1968), and Rusinov (1977) have reported it as an important larval parasite from elsewhere.

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