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Larval Biology of Black Cutworm *Agrotis ipsilon* on Maize in Kashmir

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A B S T R A C T

The present investigation was carried during year 2019-2020 at Division of Entomology, Faculty of Agriculture, Wadura, Sopore. A total of six larval instars of *Agrotis ipsilon*, were noticed in three generations of one calendar year, during the present study. The average length and breadth from first to sixth cutworm caterpillars ranged between 1.88 - 34.21mm and 0.35-3.5mm respectively. Whereas, the mean developmental duration of the various larval instars ranged from 6.93-11.88 days, 4.60-9.38 days and 5.85-10.45 days for first, second and third generation respectively. The mean larval head width gradually increases in the successive instars, The mean larval head width ranges from 0.30 – 3.00mm, 0.30-3.36mm and 0.30- 3.28mm for first to sixth instar in first, second and third generation. Study of larval mortality revealed that the maximum cumulative death percentage was in forth larval instar as 35.67 per cent, while as the minimum larval mortality was computed for first larval instar as 11.00 per cent.

Introduction

In Kashmir valley, *Agrotis ipsilon* is a destructive pest on maize, potato, vegetable crops, flowers and fruit seedlings, reducing the plant stand and biological yields (Reshi, 1967). The extent of damage due to black cutworm in maize is 30-40 percent and 90 percent under moderately and heavily infested conditions respectively. The damage inflicted to maize seedlings is mainly from April to third week of June when saplings are two to six leaf stages and May sown crop is most severely damaged (Lone and Zaki, 1999). This period coincides with sowing and transplanting of most of the crops. The larvae of *Agrotis ipsilon* are popularly known as greasy cutworm or black cutworm in Asia and North America. Black cutworm is a cosmopolitan pest known to attack at least 49 species of cultivated plants besides feeding on many weed species (Odiyo, 1975). The nocturnal larvae of this pest cut the haulms and stalks of young plants at the collar region and defoliate the plants in their early growth stage (Rajendra and Verma, 1989). They rarely consume the entire plant, but more commonly move to the next plant and damage

in the row or to another row. Larvae spoil more than they consume and a severely infested field looks like as if it has been grazed (Johnson and Lewis, 1982 and Showers, 1997). The damage often goes unnoticed until after a significant number of plants have been damaged. Maximum yield losses are reported in com when 4th to 6th instar larvae feed on plants at coleoptile to four leaf stage (Showers *et al.*, 1983). Later stages of cutworm cut entirely through the plants or tunnel into the plants below or above the soil surface, whereas small stage cutworms climb plants and chew small holes in the leaves. Gholson and Showers (1979) indicated that a negative photo taxis is the primary factor governing nocturnal behavior of black cutworm larvae. Early instar larvae are photopositive, whereas later instars are photonegative. To overcome the yield losses and for evolving suitable management strategies, knowledge of life cycle of the pest and its behavior is essential so as to know the most vulnerable stage of the pest. The biology of the pest, number of generations passed and the time taken vary in different agro climatic regions of the world. It is widely accepted that larval survival is greatly determined by the oviposition behavior of adult females, as immature stages have limited mobility (Renwick, 1989) Multiple sets of life table data can be analyzed to identify key mortality factors or critical life stages or periods, which can increase understanding of the dynamics of an insect population and at the same time, reveal the most appropriate period for management (Harcourt, 1969; Southwood, 1978a). Therefore, a regional approach for studying its biology is useful in evoking effective management system for the pest.

Materials and Methods

The biological studies of Cutworm spp. were done in the Experimental laboratory, Division of Entomology SKUAST-K, Shalimar; the initial culture of the pest was maintained by field collection. Neonate larvae of different species collected from different location on solanaceous vegetable/maize crops was held in plastic containers (5.5 x7cm) having leaves of respective crops. To keep the leaves fresh for longer duration, wet cotton will be placed around the leaf petioles. The early instars larvae was reared in same rearing chamber, while later instars will be segregated and reared separately/ individually to avoid cannibalism. The food was changed daily till the larvae pupate.

Observations to be recorded at larval stage

The observations were recorded on ten newly emerged larvae (0-20 hour's age) from egg and rearing them up to pupal stage. The observations to be recorded were:

Growth and duration of curvature
Mortality
Head width
Size (morphometrix)
Change in colour

The length and breadth of the instars larvae was to be measured with the help of digital vernier caliper and graduated scale. The daily observations were recorded in respect of molting, change in colour, size and head width under a microscope for first and second instars and by naked eye for the rest of instars. The listed observations were repeated for all the generations of cutworm spp. To get accurate measurements of larval instars and head width, these stages were preserved in KAAD solution [Kerosene oil (1 part): absolute alcohol (10 parts): glacial acetic acid (2 parts) and dioxane (1 part)].

Results and Discussion

Ten newly hatched (0-12 hours) individuals of larvae from each generation were studied.

Observation with regard to change in colour, length (with help of vernier caliper), head width and moulting showed that larvae passed six instars before changing into pupa. They curve compactly (C- shaped) on being disturbed. The head was dark brown in colour possessing a hard sclerotised capsule. Pair of jointed legs and spiracles on pleural side of each thoracic segment were present. The ventral side of larva was light in colour as compared to that of dorsal side. Abdomen was ten segmented with small setae irregularly sparsed all over the body, and concentrating in the last abdominal segment. Abdominal pro-legs were also present on third, fourth, fifth, sixth and tenth segment respectively. The duration of various larval instars, head width were found to vary from generation to generation and is precisely tabulated and presented in below.

The first (I) instar larvae were grayish in colour with a shining black head. The newly hatched larvae moved like a semilooper and fed on leaf petioles present in the jar. The average length and breadth of I-instar larvae was ranged between 1.8-2.3 mm with mean of 1.88 ± 0.11 and 0.35- 0.52 mm with the mean of 0.42 ± 0.10 respectively. The width of head capsule ranged from 0.30-0.34 mm (0.32±0.03); 0.27-0.34 mm (0.3 ± 0.05) and 0.30- 0.36 mm (0.31± 0.03) for first, second and third generation respectively, and the instar lasted for 6-8 days (6.93 ± 0.22); 4-6 days (4.60 ± 0.32) and 5-7days (5.85 ± 0.29) days, during first, second and third generation respectively.

The second (II) instar larvae on moulting possesses translucent head capsule which later changes to brown and finally black in colour. The length and breadth of second instar varied between 3.1- 4.6 mm (3.51± 0.27) and 0.60-0.83 mm (0.81± 0.04), respectively (Table 1). However, the head width of second instar for first, second and third generation ranged from 0.45-0.52 mm (0.50 ± 0.04); 0.44-0.49 mm (0.48 ± 0.03) and 0.42- 0.47 mm (0.46 ± 0.02) respectively (Table 2). Similarly the duration for development shows differences among the three generations of second instar larva which was 5-7 days (5.88 ± 0.28); 3-4 days (3.23 ± 0.18) and 5-5 days (4.18 ± 0.36) respectively (Table 2).

Studies on third (III) larval instar revealed that its length was recorded to vary from 5.5-7.2 mm (5.99 + 0.21) and breadth ranged from and 0.91- 1.3 mm (1.20 + 0.11) (Table 1). Width of the head capsule for first, second and third generation was found to be ranged from 0.80-0.85 mm (0.83+ 0.02); 0.77- 0.82 mm (0.81+ 0.02) and 0.67- 0.76 mm (0.75 + 0.03) respectively (Table 2). However the developmental period first generations ranged from 5-7 days (6.10 ± 0.27), for second generation 2-4 days (3.34 ± 0.33) and for third generation varies from 3- 5 days (4.00 ± 0.29) (Table 3).

Observation on fourth (IV) larval instar revealed that this was the main damaging (cutting) instar and fed voraciously on the seedlings. The instar was darker than previous instar with typical mid-dorsal and supra-spiracular lines. The length and width/ breadth of fourth instar varies from 7.9 – 8.7 mm (8.41 ± 0.10) and 1.5 – 2.2 mm respectively. Regarding head capsule measurements the larvae also shows significant variation among the three generations ranged from 1.30 – 1.40 mm (1.37 ± 0.03); 1.26 - 1.35 mm (1.34 ± 0.02) and 1.10- 1.42 mm (1.32 ± 0.09) for first, second and third generation respectively (Table 2).

Fifth (V) instar larvae were grayish in colour with usual mid-dorsal and supra- spiracular lines. These were also feeding voraciously and cause more damage to seedlings. Cannibalism was also observed in fifth instar

as when two larvae were kept with each other they started fighting resulted in eating up of weaker one by another. Matrices studies revealed that this instar possess length ranged between 14-20 mm (15.35 ± 0.51) and the breadth of 2.3- 3.5 mm (3.02 ± 0.32). The head capsule width ranged from 2.20- 2.50 mm (2.45 ± 0.09) for the first generation, 2.00 – 2.46 mm (2.34 ± 0.12) for second generation and 1.90- 2.42 mm (2.33 ± 0.10) for third generation (Table 2). Similarly the duration for all the three generation ranges from 6-8 days (7.05 ± 0.25); 4-6 days (5.15 ± 0.33) and 5- 7 days (6.33 ± 0.22) (Table 3).

Table.1 Morphometrics of different stages of *A. ipsilon* during 2019

	Length/diameter(mm)		Breadth/width(mm)	
Stages	**Range**	**Mean ± S.E**	**Range**	**Mean ± S.E**
Egg	0.45-0.52	0.48 ± 0.04	-	-
Larva				
I – instar	1.8-2.3	1.88 ± 0.11	0.35-0.52	0.42± 0.10
II – instar	3.1-4.6	3.51 ± 0.27	0.60-0.83	0.81± 0.04
III – instar	5.5-7.2	5.99 ± 0.21	0.91-1.3	1.20 ±0.11
IV – instar	7.9-8.7	8.41 ± 0.10	1.5-2.2	2.01 ±0.16
V – instar	14.0-20.0	15.35 ± 0.51	2.3-3.5	3.02± 0.32
VI – instar	30.00-36.66	34.21 ± 0.34	3.5-4.8	4.51 ±0.22

Table.2 Head capsule width (mm) of different larval instars of *A. ipsilon* during 2019

First Generation			
Larva	**Range**	**Mean ± S.E**	**Ratio**
I – instar	0.30-0.34	0.32± 0.03	1.56
II – instar	0.45-0.52	0.50± 0.04	1.66
III – instar	0.80-0.85	0.83± 0.02	1.65
IV – instar	1.30-1.40	1.37± 0.03	1.78
V – instar	2.20-2.50	2.45± 0.09	1.37
VI – instar	3.00-3.40	3.37± 0.14	-
Second Generation			
Larva	**Range**	**Mean ± S.E**	**Ratio**
I – instar	0.27-0.34	0.31± 0.05	1.54
II – instar	0.44-0.49	0.48± 0.03	1.68
III – instar	0.77-0.82	0.81± 0.02	1.65
IV – instar	1.26-1.35	1.34± 0.02	1.74
V – instar	2.00-2.46	2.34± 0.12	1.43
VI – instar	3.00-3.38	3.36± 0.12	-
Third Generation			
Larva	**Range**	**Mean ± S.E**	**Ratio**
I – instar	0.30-0.36	0.31 ± 0.03	1.48
II – instar	0.42-0.47	0.46 ± 0.02	1.63
III – instar	0.67-0.76	0.75 ± 0.03	1.76
IV – instar	1.10-1.42	1.32 ± 0.09	1.76
V – instar	1.90-2.42	2.33 ± 0.10	1.40
VI – instar	3.00-3.35	3.28 ± 0.06	-

Table.3 Duration of developmental stages in days of *A. ipsilon* during 2019

	First Generation		Second Generation		Third Generation	
Stages	**Range**	**Mean ± S.E**	**Range**	**Mean ± S.E**	**Range**	**Mean ± S.E**
Egg	6.00-8.00	7.00 ±0.25	5.00-6.00	5.40±0.22	4.00-6.00	5.20±0.28
Larva						
I – instar	6.00-8.00	6.93±0.22	4.00-6.00	4.60±0.32	5.00-7.00	5.85 ±0.29
II – instar	5.00-7.00	5.88 ±0.28	3.00-4.00	3.23±0.18	3.00-5.00	4.18 ±0.36
III – instar	5.00-7.00	6.10 ±0.27	2.00-4.00	3.34±0.33	3.00-5.00	4.00 ±0.29
IV – instar	5.00-6.00	5.43 ±0.17	3.00-5.00	4.03±0.33	4.00-6.00	4.88 ±0.38
V – instar	6.00-8.00	7.05 ±0.25	4.00-6.00	5.15±0.33	5.00-7.00	6.33 ±0.22
VI – instar	10.00-13.00	11.88 ±0.26	8.00-11.00	9.38±0.36	8.00-11.00	10.45 ±0.30
Total	**41.50-44.75**	**43.25 ±0.17**	**27.25-33.00**	**29.71±0.32**	**32.00-37.00**	**35.68 ±0.31**

Table.4 Mortality of larval stage of *A. ipsilon* during different generations at room temperature

Generations	I-instar	II-instar	III-instar	IV-instar	V-instar	VI-instar
I	8.00	12.00	20.00	27.00	9.00	6.00
II	10.00	15.00	23.00	43.00	13.00	8.00
III	15.00	20.00	27.00	37.00	16.00	10.00
Mean	**11.00**	**15.67**	**23.33**	**35.67**	**12.67**	**8.00**

The sixth larval instar was the last instar observed during the whole life cycle. Its appearance was darker than other instars possessing high cannibalistic capacity. Morphologically, the mid dorsal longitudinal line and transverse bands in between segments appeared more prominent and it stops feeding 1 to 2 days before pupation. Body characteristics vary from 30- 36 mm (34.21+ 0.34) in length and 3.5- 4.8 mm (4.51 + 0.22) in breadth. The width of head capsule ranged from 3.00- 3.40 mm (3.37 ±0.14); 3.00- 3.38 mm (3.36 ± 0.12) and 3.00-3.35 mm (3.28 ± 0.06) for first, second and third generation respectively, and the instar lasted for 10- 13 days (11.88 ± 0.26); 8- 11 days (9.38 ± 0.36) and 8- 11 days (10.45 ± 0.30) days, during first, second and third generation respectively.

The larva shed its cuticle six times before the formation and therefore, there were six larval instars in each generation. The observation on ratio of head capsule width with the successive instars were 1.56, 1.66, 1.65, 1.78, and 1.37 for first generation; 1.54, 1.68, 1.65, 1.74 and 1.43 during second generation and 1.48, 1.63, 1.76, 1.76 and 1.40 for the third generation, this confirms to Dyar's law in determination of number of instar (Table 2).

Larval mortality

The per cent larval mortality during different larval instars in all the three generations ranged between 6- 37 per cent. The mortality percentage increased from first larval instar and attained a peak at fourth instar thereafter it decreases in fifth and sixth instar. During first generation the per cent mortality among first to sixth instars was found to be 8, 12, 20, 27, 9 and 6 per cent respectively. Similarly for second generation larval mortality of 10, 15, 23, 43, 13 and 8 per cent was recorded. While as for third generation the following trend was found from first to sixth instars 15,

20, 27, 37, 16, and 10 per cent respectively (Table 4).

The present findings are corroborated with the observations made by Nasr and Naguib (1964) and Alnaji and Ghafoor (1988) who too confirmed existence of six larval instars in each generation. Whereas, Archer and Musick (1977) and Troester (1982) opined that the cutworm larvae passes through seven instars. However, Luckmann *et al.*, (1976) and Thippeswamy *et al.*, (1981) found that larva had six instars with a portion of the population having the seventh instar. The author also recorded mean larval length as 2.1-19.50 mm from first to sixth larval instars are contradictory to the present observations. The variation might be probably due to the variation in agro-climatic regions and favorable abiotic factors required for growth and development. Though, Atwal (1986) reported that newly hatched caterpillar was 1.5 mm long and is in close conformity with present findings. Similarly, Vizi and Baghat (1998), revealed the mean larval length and breadth of 0.91- 47.00mm and 0.16-5.62 mm during different larval instars and are not in accordance with present investigations. However, the authors recorded the maximum mean per cent larval mortality in fourth instar as 28.00 per cent and minimum in newly hatched caterpillar which is in concurrence to current findings. According to Verma and Verma (2002) the mean length of larva from first to sixth instar was 3.03-44.3mm. Similarly, Pathnia (2010) also recorded an average larval breath in the successive instars as 0.44-4.7mm and six imago stages during the course of study supports the present study. In union territory of Jammu and Kashmir, Bhat (1991) who opined the presence of six larval stages, also noticed the mean larval length between the range of 1.75 -34.02mm from first to sixth larval instar, with the mean larval duration as 7.13-13.53 days in first generation, 4.8-10.56 days in second generation and 5.86-11.2 days in third generation form first to sixth instar, respectively. Whereas, head capsule in the successive instar was in range as 0.3-3.2mm are in concurrence with the study

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