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Biology of early shoot borer, *Chilo infuscatellus* Snellen on sugarcane, *Saccharum officinarum* L

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Abstract
Biological studies of early shoot borer, *Chilo infuscatellus* Snellen (Crambidae; Lepidoptera) were conducted during March, 2017 to July, 2017 in laboratories of CCS Haryana Agricultural University, Regional Research Station, Karnal on sugarcane genotype CoH 119. Results on biology of *C. infuscatellus* revealed that freshly laid eggs were creamish white which are initially transparent and later turn to yellowish in colour with pin head size spot and chorion was colourless and transparent. Incubation period varied from 3 to 5 days. The larvae of *C. infuscatellus* moulted four times and passed through five instars. Total larval duration of *C. infuscatellus* ranged from 18 to 26 days with an average of 22.31±1.16 days. The pupal duration of *C. infuscatellus* female ranged from 4 to 6 days and duration of male pupae varied from 4 to 5 days. The genital aperture was situated on the ventral side of eighth abdominal segment in the form of slit in female pupae whereas, in male pupae, the genital aperture was situated on the raised oval sclerite with linear depression in the middle of ninth abdominal segment. Female pupae were slightly bigger in size as compared to that of male pupae. Longevity of female moths varied from 3 to 5 days with an average of 4.07 days whereas longevity of male moths ranged from 3 to 4 days with an average of 3.24 days. The total life span of *Chilo infuscatellus* ranged from 29 to 44 days for female and 29 to 42 days for male.

Keywords: Biology, *Chilo infuscatellus* and sugarcane

Introduction
Sugarcane (*Saccharum officinarum* L.) is one of the most efficient crops in the world that is cultivated in approximately 80 nations in semi-tropical, tropical and sub-tropical regions of the world, primarily for its ability to store high concentration of sucrose in the stem and in converting energy from sunlight to chemical energy that is usable as a fuel source. Sugarcane is a raw material for the production of white sugar, khandsari and jaggery (gur). Besides sugar production, sugarcane produces numerous valuable by-products like, alcohol used by pharmaceutical industry, ethanol used as fuel, production of electricity power and press mud used as a rich source of organic matter for crop production.

Sugarcane is an important commercial cash crop grown in numerous countries like Brazil, India, China, Thailand, Pakistan, Mexico, Australia, Philippines, Argentina and Colombia. In India, sugarcane cultivation and sugar industry plays a vital role towards socio-economic development by mobilizing rural resources and generating higher income and employment opportunities. About 45 million sugarcane farmers and their dependents including agricultural labourer are involved in Indian sugar industry (Dhanraj and Dharne, 2013) [6]. Sugar industry is second largest agro-based industry which comprises of more than 500 sugar mills, next to textiles (Takale, 2013) [14]. In India, sugarcane occupies an area of 4.51 million ha with annual production of 305.25 million tonnes and productivity of 67.57 tonnes per ha, whereas in Haryana, it occupies an area of 0.11 million ha with the production of 8.53 million tones and productivity of 74.21 tonnes per ha (Anon., 2016) [1].

Sugarcane is vulnerable to attack by several insect-pests at all the stages of crop growth, both in sub-tropical and tropical regions of the country and this problem is more serious in the sub-tropical region than in tropical regions of the country. Sugarcane by virtue of its growth provides homogenous agro-ecosystem and thereby serving as abundant source of shelter and food to a host of organisms over considerable period of year (Chaudhary, 2008) [3]. Sugarcane is damaged by a number of insect-pests during its crop growth. In India, 211 species have been recorded, out of which 18 species have attained major pest status (David and Nandgopal, 1986) [4]. Amongst various insect-pests, termites, borers, pyrilla, whiteflies and bugs etc. attack

the crop and causes heavy losses in yield and quality. Among these pests, borers are the key factors in causing crop losses in plants and number of millable canes which results in huge loss of sugar (Sharma *et al.*, 2011) [13]. Borers are the major pests attacking sugarcane throughout growth period, starting from germination to harvesting of the crop in the field. Amongst tissue borers, early shoot borer, *Chilo infuscatellus*; top borer, *Scirpophaga nivella;* root borer, *Emmalocera depressella* and stalk borer, *Chilo auricilius* are major pests in sub-tropical region.

Early shoot borer, *C. infuscatellus* attacks in early phase of plant growth by entering laterally through holes in the shoot and damage complete cane by boring producing 'dead hearts'. Its caterpillars destroy about 20 per cent of the young shoots during April to June (Dhaliwal and Atwal, 2004) [5]. *C. infuscatellus* destroys approximately 60 per cent of the mother shoots, 35 to 43 per cent of tillers and 15.8 to 41.8 per cent reduction in yield which ultimately reduces cane yield (Jhansi, 2009) [8]. In India, this species is widely distributed particularly in sugarcane growing parts of country (Karnataka, Bihar, Haryana, Punjab, Uttar Pradesh, Gujarat and Tamil Nadu).

C. infuscatellus has become very serious pest in recent years in sub-tropics and causes economic damage to the production of sugarcane. Thus, it is very necessary to find out management strategies for this pest for higher production of sugarcane. Biology of the pest is essential to know the feeding habit and duration of different developmental stages and behaviour which in turn help in its management. The information on biology of a pest is a condition precedent to work out its control measures. There is a specific time period at which *C. infuscatellus* population reaches at its peak under field conditions. Keeping in view, to predict peak period of its incidence and to develop an effective pest management strategy, it was felt necessary to study biology of *C. infuscatellus.*

Materials and Methods

Biological studies: Studies on the biological parameters of early shoot borer, *Chilo infuscatellus* was carried out during March, 2017 to July, 2017 in laboratories of CCS Haryana Agricultural University Regional Research Station, Karnal on sugarcane cultivar, CoH 119. The culture of *C. infuscatellus* was raised by collecting their larvae from the sugarcane infested fields and was reared on small cut pieces (7-10 cm) of sugarcane shoots. A slanting cut was given to cut pieces with the help of knife leaving the posterior part of cut piece intact with the shoot and a cavity was made for release of larva. One larva in each cut piece was released. Cut pieces containing larvae were tied with rubber band to provide natural conditions for feeding of larvae and placed in battery glass jars. Glass jars were covered with muslin cloth and tied with rubber band to avoid escape of larvae from jars. Fresh food was changed on alternate days. Full grown larvae stopped feeding and contracted in size were taken out from cane cut pieces and put in separate glass battery jars over moist cotton swab covered with blotting paper for pre-pupation and pupation. Adults from this culture were released in the glass battery jars containing moist sand (5-7 cm). Sugarcane leaves were inserted in the sand for the resting of moths and egg laying. Cotton swab soaked in 10 per cent honey solution was provided as food to adults and changed daily. Glass jars were covered with muslin cloth and tied with the help of rubber band to avoid escaping of the moths. Sugarcane leaves were changed daily for egg laying. In this way culture of insect was maintained in laboratory for further biological studies.

Duration of immature stages (egg, larva, pre-pupa and pupa) was recorded on 100 individuals (20 individuals in five replications) while observations on adults were made on 20 individuals each. Data on adult longevity (male and female moth) and fecundity/female was also recorded for unfed moths. Observations on per cent hatchability, larval survival, pre-pupal survival and adult emergence were made for 250 individuals (50 individuals per replication in 5 replications). For recording these observations culture of *C. infuscatellus* was also maintained in laboratory.

Ten specimens of each life stage of *C. infuscatellus* i.e. egg, larva, pre-pupa, pupa and adults (male and female moths) were preserved, measured and studied in details. The eggs, different larval instars, pre-pupae and pupae were preserved in 70 per cent alcohol with a few drops of glycerol. While adult moths were killed in cyanide killing bottle. The eggs, first two larval instars, pre-pupa, pupae and adult moths were measured under a stereoscopic binocular microscope with the help of ocular and stage micro-meter scale. However, stages of later instars were measured with the help of vernier calliper and scale having accuracy to measure up to 0.5 mm. The length of each immature stage was measured along the mid-dorsal line (length-wise) and maximum width was taken across mid of the specimen under observation. The body length of adult moths (male and females) was measured along mid-dorsal line between apex of head and tip of abdomen and width was measured across the wing expanse.

Statistical analysis: The data collected during present studies was statistically analyzed. Data on various biological parameters of *C. infuscatellus* were subjected to statistical analysis by calculating the mean value. The standard deviation was also calculated for all biological parameters.

Results and Discussion

Egg stage

Chilo infuscatellus freshly laid eggs were creamish white which are initially transparent and later turn to yellowish in colour with pin head size spot and chorion was colourless and transparent (Plate 1). The black head of larvae was clearly visible before hatching from dorso-ventrally flattened eggs. Adults laid the eggs in several masses on the lower surface of the leaves. Larvae came out from the eggs by cutting holes through chorion. The empty egg cells were white and remain attached to the leaf. *C. infuscatellus* incubation period was ranged from 3 to 5 days with an average of 3.37 ± 0.28 days (Table 1). The results are in confirmatory with findings of Gupta 1940 [7] who reported that the incubation period of *C. infuscatellus* varied from 4 to 6 days. Findings of Usman *et al.* 1957 [15] also give support to findings of present investigations, who reported that incubation period ranged from 4 to 5 days. Kalariya and Radadia 2014 [9] reported that incubation period ranged from 4 to 6 days with an average of 4.76 days give partial support to present investigations. Hatchability of *C. infuscatellus* eggs was recorded 74.4 per cent (Table 2). The present results partially confirm to the findings of Bhavani 2013 [2] who reported that hatchability of *C. infuscatellus* eggs varied from 69.5 to 94.5 per cent with an average of 87.33 per cent. The variations in findings in hatchability of *C. infuscatellus* of present studies and that of earlier researchers may be due to variation in laboratory

temperature, relative humidity and genotype used as host plant.

Length of *C. infuscatellus* egg varied from 0.90 to 1.02 mm with an average of 0.97 ± 0.04 mm and breadth varied from 0.64 to 0.70 mm with an average of 0.67 ± 0.03 mm (Table 4). Findings of Gupta 1940 [7] who reported that egg of *C. infuscatellus* measured 0.7 to 0.9 mm in length and 0.65 in width and Kumar *et al.* 2004 [11] who reported that it measured 0.86 to 0.95 mm in length and 0.62 to 0.68 mm in width give partial support to present findings. Findings of Bhavani 2013 [2] who reported that an individual egg of *C. infuscatellus* measured on an average 0.90 ± 0.02 mm in length and 0.63 ± 0.02 mm in width support present findings.

Larval stage

Larvae of *C. infuscatellus* were moulted four times and passed through five instars to become pre-pupa. The total duration of *C. infuscatellus* larvae ranged from 18 to 26 days with an average of 22.31±1.16 days (Table 1). The findings of Gupta 1940 [7] who reported that the total duration of *C. infuscatellus* larvae ranged from 16 to 30 days in field studies and 21 days under laboratory conditions give partial support to present findings. However, the present finding differ with the findings of Kumar *et al.* (2004) [11] who reported that the total larval period ranged from 16.68 to 17.10 days and Bhavani 2013 [2] who reported that total larval period ranged from 16.0 to 16.3 days. The present findings on larval instars are in agreement with those of Kumar *et al.* (2004) [11] who reported five distinct larval instars under laboratory conditions in Andhra Pradesh. However, Gupta 1940 [7] reported that *C. infuscatellus* larvae moulted 4 to 5 times and passed through 5 to 6 instars does not give support to present findings.

The first instar larvae of *C. infuscatellus* took 2 to 3 days to become second instar with an average of 2.67 ± 0.20 days. The second instar larvae took 3 to 4 days to become third instar with an average of 3.29 ± 0.20 days. The duration of third instar larvae averaged 3.94 ± 0.26 days and ranged from 3 to 5 days. The fourth instar larvae took 4 to 6 days to become fifth instar with an average of 5.49 ± 0.26 days. The duration of fifth instar larvae varied from 6 to 8 days with an average of 6.92 ± 0.24 days (Table 1). The present findings on larval instars and their duration are in accordance with the findings of Bhavani 2013 [2] who reported that larvae of *C. infuscatellus* passed through four moults with five instars and a mean duration of I to V larval instars was 2.19, 3.21, 3.31, 3.60 and 4.72 days, respectively support results of present findings. Kalariya and Radadia 2014 [9] reported that larvae of *C. infuscatellus* passed through five instars with a duration of 2.60, 3.73, 4.08, 4.88 and 6.08 days also give partial support to present findings. The variations in number and duration of larval instars of present investigations and that of earlier workers may due to different genotypes used as host plant, or due to meteorological variations at time of experimentation.

Newly hatched larvae of *C. infuscatellus* were very active and moved fast in search of food. Neonate larvae fed on leaf sheath in groups. They were minute and greyish in colour with black head. Mid dorsal stripe was not prominent and very light black dots were present on abdominal tubercles (Plate 1). The freshly hatched larvae (1st instar) measured 1.82 ± 0.05 mm (range 1.74-1.89 mm) in length and 0.23 ± 0.02 mm (range 0.20-0.26 mm) in width (Table 4). The second instar larva was dirty white in colour with black head and impressions of the stripes found on the body (Plate 1). Mid dorsal stripe became dark and prominent in case of second instar larva. The 2nd instar larvae measured 5.14 ± 0.04 mm with an average of 5.10-5.29 mm in length. Width of second instar larvae ranged from 0.45-0.51 mm with an average of 0.48 ± 0.02 mm (Table 4).

The third instar larva of *C. infuscatellus* was dirty white in colour with dark black head (Plate 1). The body was more distinct in third instar larvae as compared to that of the second instar larvae. The length of 3rd instar larvae ranged from 11.94-12.14 mm with an average of 12.07 ± 0.05 mm. Width of third instar larvae ranged from 1.89-1.98 mm with an average of 1.92 ± 0.03 mm. The fourth instar larva was dirty white in colour with dark brown head (Plate 4). The abdominal segments were larger as compared to that of the third instar larvae. Prominent five violet stripes were present on the larval body surface, one on dorsal surface, one pair each on the sub-dorsal and lateral surfaces of the body. Prominent black spots were also observed on the tubercles. The 4th instar larvae measured 16.99 ± 0.04 mm (range 16.94-17.04 mm) in length and 2.94 ± 0.04 mm (range2.86-2.98mm) in width (Table 4). The fifth instar larva of *C. infuscatellus* was also dirty white in colour with dark brown head (Plate 1). Prominent five violet stripes were present on the larval body surface and extending from second thoracic to eighth abdominal segment. The abdominal segments were larger as compared to that of the fourth instar larvae. The crochets on the prolegs of *C. infuscatellus* were arranged in the form of incomplete circle. The 5th instar larvae measured 23.41 ± 0.23 mm (range 23.18-23.83 mm) in length and 3.74±0.14 mm (range 3.69-3.98 mm) in width (Table 4).The present findings with regard to length and width of full grown larvae of *C. infuscatellus* are in accordance with Gupta 1940 [7] and Usman *et al.* 1957 [15] who reported length of I, II, III, IV & V instar larvae measured 1.68, 5.08, 11.93, 16.85 and 22.73 mm and 0.21, 0.45, 1.83, 3.22 and 3.72 in breadth, respectively. However, findings of Bhavani 2013 [2] who reported length of 1.84 to 1.86 mm for 1st instar larvae and 23.8-23.9 mm for last instar larvae of *C. infuscatellus* on sugarcane do not support the present investigations. He also reported that first instar larva was active, greyish white in colour with black head and immediately after hatching moved fast in search of the food support the present results. He further reported that the second instar larva was dirty white in colour with prominent dark stripe on mid dorsal portion and impressions of the stripes were found on the body surface support results of present findings. Findings of Kalariya and Radadia 2014 [9] who reported that the second instar larva was dirty white in colour with black head and prominent dark lines on dorsal portion give support to present investigations. Findings of Bhavani 2013 [2] who reported that the third instar larva was dirty white in colour with dark black head and black spots on tubercles were absent support the present results. Findings of Kalariya and Radadia 2014 [9] who reported that the fourth instar larva was dirty white in colour with dark brown head. They also reported that the five violet stripes were observed on the body of larvae support the present results. They further reported that the fifth instar larva was dirty white in colour with dark brown head with five violet stripes up to second thoracic to eighth abdominal segment and crochets on the prolegs were arranged in the form of incomplete circle which open towards outside give support to present investigations.

Pre-pupal stage

During pre-pupal stage, larvae of *C. infuscatellus* were stopped feeding, became inactive and contracted in size. The

pre-pupal period of *C. infuscatellus* varied from 1 to 2 days with an average of 1.26 ± 0.08 days. Survival of pre-pupae was reported 94.4 per cent (Table 2). No information is available in the literature on survival of pre-pupae and pre-pupal duration of *C. infuscatellus*. Morphometric studies indicate that length of pre-pupae ranged from 15.76 to 18.04 mm with an average of 16.53 ± 0.27 mm. The width of pre-pupae ranged from 3.12 to 3.58 mm with an average of 3.44 ± 0.17mm (Table 4). Literature is silent with regard to description and morphometrics of pre-pupal stage of *C. infuscatellus.*

Pupal stage

The pupal duration of *C. infuscatellus* male varied from 4 to 5 days with an average of 4.14 ± 0.14 and duration of female pupae ranged from 4 to 6 days with an average of 4.63 ± 0.20 days. The present results on pupal duration give partial support with findings of the Gupta 1940 [7] who reported that the average pupal period of *C. infuscatellus* was 7 days. However, no information is available in the literature on duration of male and female pupae of *C. infuscatellus*. Newly formed pupa of *C. infuscatellus* was elongated, slender and yellowish to dark brown in colour. Integument was transparent. The pupa was obtect type. Colour of pupa changes to dark brown before adult emergence. The genital aperture of *C. infuscatellus* was situated on the ventral side of eighth abdominal segment in the form of slit in female pupae whereas, in male pupae, the genital aperture was situated on the raised oval sclerite with linear depression in the middle of ninth abdominal segment.

The larvae of *C. infuscatellus* pupate within the shoot itself generally at its base under field conditions. Before pupating, a larva cuts a slanting hole leading outside the shoot and plugs it with its frass to facilitate emergence of the adult moth. Female pupae were slightly bigger in size as compared to that of male pupae. The findings of Bhavani 2013 [2] who reported that the newly formed pupae were greyish in colour support to present findings and the integument transparent, turned light brown in colour on the second day and subsequently turned to dark brown. Morphometric studies indicate that length of the male pupa ranged from 12.76 to 12.92 mm with an average of 12.84 ± 0.10 mm, whereas length of female pupa ranged from 17.05 to 17.13 mm with an average of 17.08 ± 0.03 mm. The width of male pupa ranged from 2.10 to 2.23 mm with an average of 2.17 ± 0.05 mm and that of female pupa ranged from 3.18 to 3.28 mm in width with an average of 3.23 ± 0.04 mm (Table 4). Findings of Kalariya and Radadia 2014 [9] who reported that female pupae of *C. infuscatellus* ranged from 14.42 to 17.25 mm in length with an average of 16.21 ± 0.04 mm while male pupae of *C. infuscatellus* ranged from 12.48 to 12.62 mm in length with an average of 12.55 ± 0.04 mm give partial support to present findings.

Adult stage

The adult emergence of *C. infuscatellus* was 79.6 per cent (Table 2). The adults of *C. infuscatellus* emerged mainly at night and also in early hours of morning. Not much information is available in the literature on adult emergence of *C. infuscatellus*. However, findings of Pradhan and Bhatia 1956 [12] who reported adult emergence from 83.3 to 92.3 per cent derive partial support to present investigations.

Sex ratio of *C. infuscatellus* was 1:1.53 (M: F). The data revealed that females outnumbered male moths. The results of experiments of Usman *et al.* 1957 [15] who reported that sex ratio of male to female was 1:2.0 and Kumar *et al.* 2004 [11] who reported sex ratio 1:1.92. Kalariya and Radadia 2014 [9] reported that the sex ratio of male to female was found 1:2.1 do not support the findings of present investigations.

The copulation period of *C. infuscatellus* varied from 112 to 186 minutes with an average of 145 ± 18 minutes. It was further observed that adults paired on first night after emergence and mating occurred only at night or in dark places. One male copulated with only one female. The present results are in accordance with findings of Gupta 1940 [7] who reported that the mating took place in the early hours of the night and copulation generally occurred at night for two and half hours.

The pre-oviposition period of *C. infuscatellus* ranged from 0.3-0.6 days with an average of 0.42 ± 0.11days.The oviposition period of early shoot borer varied from 2-4 days with an average of 2.62 ± 0.68 days. The post-oviposition of *C. infuscatellus* ranged from 0.5-1.5 days with an average of 0.93 ± 0.39 days. Most of the eggs were laid during dusk or night. Gupta 1940 [7] reported that the oviposition period varying 2-3 days also giving partial support to the present findings. Kalariya and Radadia 2014 [9] reported that pre-oviposition, oviposition period and post-oviposition period ranged from 0-1, 2-4 and 1-2 days, respectively give partial support to the present findings. A single female moth of *C. infuscatellus* could lay 280 to 345 eggs with an average of 317.7 ± 9.84 eggs during her life time when adults were fed on 10 per cent honey solution. Fecundity of unfed females ranged from 24 to 42 eggs with an average of 34.6 ± 3.44 eggs. The average fecundity as reported by Gupta 1940 [7] varied from 216-239 eggs per female. However, no information in literature is available on fecundity of unfed females.

The longevity of *C. infuscatellus* male ranged from 3 to 4 days with an average of 3.24 ± 0.19 days whereas longevity of females varied from 3 to 5 days with an average of 4.07 ± 0.22 days when 10 per cent honey solution was provided as food (Table 3). Longevity of unfed male adults ranged from 1 to 3 days with an average of 1.82 ± 0.24 days whereas longevity of unfed female moths ranged from 2 to 3 days with an average of 2.46 ± 0.32 days when adults were not provided honey solution as food. Hence, the males were short lived than females. The present results are in agreement with findings of Gupta 1940 [7] and Usman *et al.* 1957 [15] who have reported adult longevity up to 3 to 6 days. Findings of Kumar *et al.* 2004 [11] who reported that the longevity of male and female moth varied from 3.60 to 3.82 and 3.32 to 4.46 days, respectively also support the present investigations. Bhavani 2013 [2] reported the longevity of male moths ranged from 3.6 to 4.0 days with an average of 3.73 ± 0.13 days and longevity of female moths ranged from 4.3 to 5.0 days with an average of 4.57 ± 0.33 days give partial support to present investigations.

Moths of *C. infuscatellus* were light straw to brownish straw in colour (Plate 1). Female moths were without any darker markings on the outer edge of the fore wings and the hind wings were greyish white in colour. In male moth, fore wings were light straw to brownish grey coloured with dark markings on the outer edge while hind wings were greyish white. The findings of Bhavani 2013 [2] who reported that female moth was light straw to brownish in colour without any dark markings on the outer edge of the forewings and the hind wings were greyish white in colour support the present findings. He also reported that the male moths were light

straw to brownish grey coloured forewings with dark markings on the outer edge and greyish white hind wings and female moths were observed to be slightly bigger in size than male moths give support to present investigations. The moths were nocturnal in habit and emerged in the morning generally before sunrise. Under field conditions, adult moths were found resting on the stem of the plants on the underside of the leaves during day time. Female moths were slightly bigger as compared to that of male moths. Antennae were lamellate, flat in male and filiform in female moth. Studies made by Kalariya and Radadia 2014 [9] that the moth emerged in morning before sunrise and was nocturnal in habit and resting on the stem of the plants on the underside of the leaves or hiding beneath leaf sheath or trash in field during day time give support to present findings.

The morphometric studies of *C. infuscatellus* revealed that the length of male moth varied from 9.89 to 9.97 mm with an average 9.93 ± 0.03 mm, but it was slightly bigger in female moth. Length of female moth varied from 13.41 to 13.59 mm with an average of 13.52 ± 0.08 mm. Width across the wing expanse in female moth varied from 24.65 to 25.15 mm with an average of 24.72 ± 0.16 mm and in male moth it varied from 21.84 to 22.08 mm with an average of 21.89 ± 0.06 mm. Findings of Gupta 1940 [7] who reported that adults of *C. infuscatellus* had wing span in female measured 23 to 35 mm and in case of male19 to 26 mm give partial support to the present findings. The present findings derives support from Bhavani 2013 [2] who reported female moth measuring 25.4 to 25.43 mm in wing expanse & 13.4 to 13.5 mm in length and male moth measuring 21.99 to 22.1 mm wing expanse & 9.9 to 9.92 mm in length.

Total life cycle

The total life span of females of *C. infuscatellus* ranged from 29 to 44 days with an average of 35.61 ± 0.94 days while those of males varied from 29 to 42 days with an average of 34.32 ± 0.85 days (Table 3). Findings of Gupta 1940 [7] who reported that the entire life span of *C. infuscatellus* was completed in 32 to 33 days give partial support to the present findings. However, Kalra and Kumar 1966 [10] reported during the first four generations from March to October, total life cycle was completed in 30 to 53 days also give partial support to the present investigations. Kalariya and Radadia 2014 [9] reported that total life cycle was completed in 28.50 to 36.50 days with an average of 32.60 ± 4.07 days also give support to findings of present investigations. The variation in findings of present studies and that of earlier workers may be due to the different genotypes used as host plant or due to meteorological variation at the time of investigations.

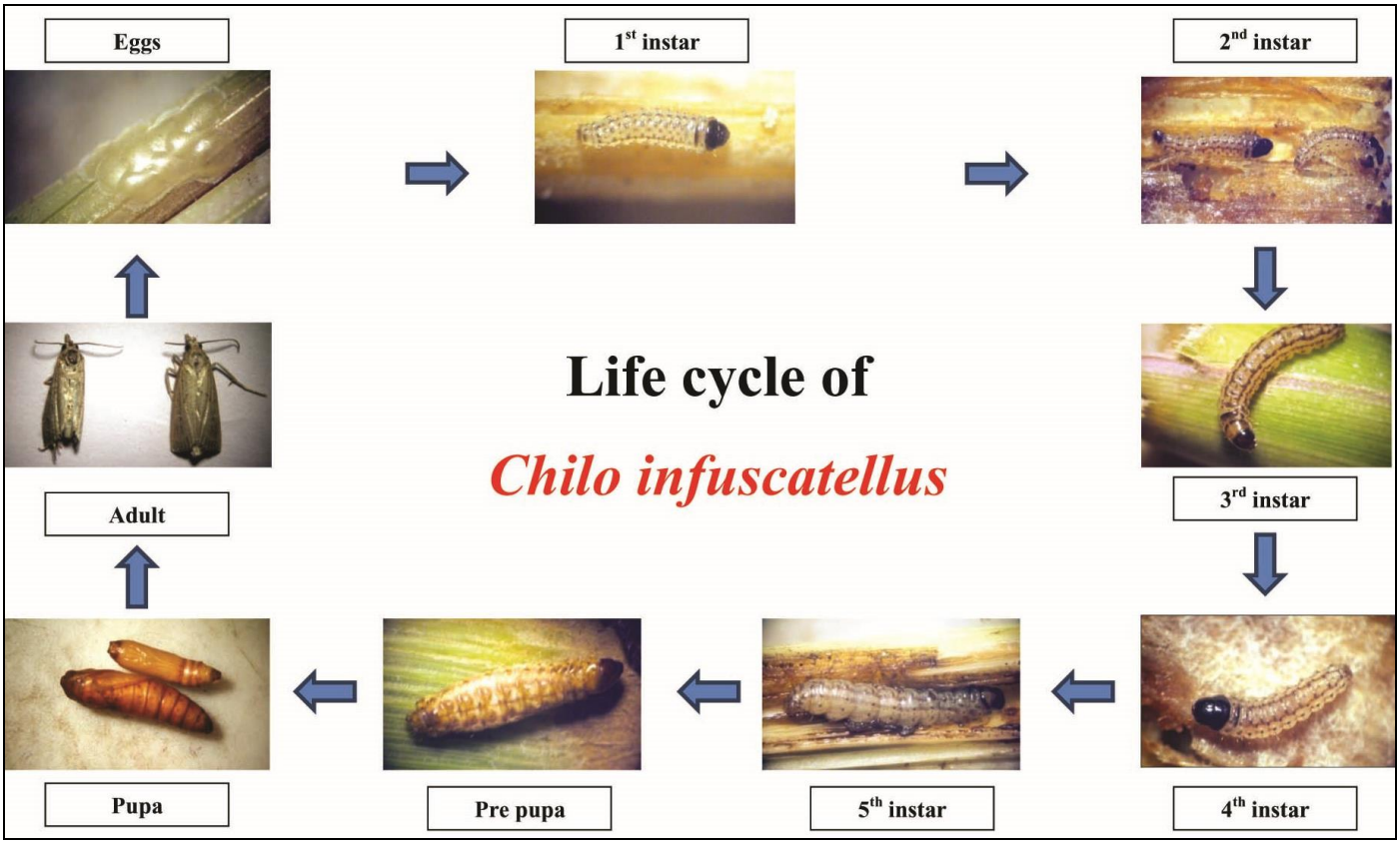

Plate 1: Different life stages of *Chilo infuscatellus* on sugarcane genotype CoH119

Table 1: Duration of different immature stages of *C. infuscatellus* on sugarcane (CoH 119)

Insect stage	Number observed	Mean ± SD	Range
Larval period (days)			
1st instar	100	2.67±0.20	2-3
2nd instar	100	3.29±0.20	3-4
3rd instar	100	3.94±0.26	3-5
4th instar	100	5.49±0.26	4-6
5th instar	100	6.92±0.24	6-8
Total larval period (days)	100	22.31±1.16	18-26

Pre-pupal period (days)	100	1.26±0.08	1-2
Pupal Period (days)			
Male	100	4.14±0.14	4-5
Female	100	4.63±0.20	4-6
Incubation period (days)	100	3.37±0.28	3-5

SD: Standard Deviation

Insect Stage	Temperature (range)	Relative Humidity (range)
Larval period	34.1-37.4 ºC	34-62%
Pre- pupal & pupal period	34.8-37.9 ºC	33-58%
Incubation period	33.4-38.6 ºC	40-52%

Table 2: Egg hatchability, larval survival, adult emergence and sex ratio of *C. infuscatellus* on sugarcane (CoH 119)

Insect stage	Number observed	Per cent survival± SD
Egg hatchability	250 eggs	74.4±5.70
Larval survival	250 larvae	49.6±5.78
Pre-pupal survival	250 pupae	94.4±3.17
Adult Emergence	250 pupae	79.6±2.32
Sex Ratio (M:F)	250 adults	1:1.53

SD: Standard Deviation

Table 3: Duration of different adult stages and fecundity of *C. infuscatellus* on sugarcane (CoH 119)

Insect stage	Mean ± SD	Range
Adult		
Pre-oviposition period (days)	0.42±0.11	0.3-0.6
Oviposition period (days)	2.62±0.68	2-4
Post-oviposition period (days)	0.93±0.39	0.5-1.5
Copulation period (minutes)	145±18	112-186
Adult longevity		
Male (with food)	3.24±0.19	3-4
Female (with food)	4.07±0.22	3-5
Male (without food)	1.82±0.24	1-3
Female (without food)	2.46±0.32	2-3
Total life cycle		
Male	34.32±0.85	29-42
Female	35.61±0.94	29-44
Fecundity / female(with food)	317.7±9.84	280-345
Fecundity / female(without food)	34.6±3.44	24-42

SD: Standard Deviation

Insect stage	Temperature(range)	Relative Humidity (range)
Adult	34.6-38.2 ºC	34-59%

Table 4: Morphometrics of various life stages of *C. infuscatellus* on sugarcane (CoH 119)

Insect stage	Length		Width	
	Mean ± SD (mm)	Range	Mean ± SD (mm)	Range
Egg	0.97±0.04	0.90-1.02	0.67±0.03	0.64-0.70
Larvae				
1st instar	1.82±0.05	1.74-1.89	0.23±0.02	0.20-0.26
2nd instar	5.14±0.04	5.10-5.29	0.48±0.02	0.45-0.51
3rd instar	12.07±0.05	11.94-12.14	1.92±0.03	1.89-1.98
4th instar	16.99±0.04	16.94-17.04	2.94±0.04	2.86-2.98
5th instar	23.41±0.23	23.18-23.83	3.74±0.14	3.69-3.98
Pre-pupa	16.53±0.27	15.76-18.04	3.44±0.17	3.12-3.58
Pupa				
Male	12.84±0.10	12.76-12.92	2.17±0.05	2.10-2.23
Female	17.08±0.03	17.05-17.13	3.23±0.04	3.18-3.28
Adult				
Male	9.93±0.03	9.89-9.97	21.89±0.06	21.84-22.08
Female	13.52±0.08	13.41-13.59	24.72±0.16	24.65-25.15

SD: Standard Deviation

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