BIOLOGY OF PINK STEM BORER , *Sesamia inferens* (WALKER) ON WHEAT

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ABSTRACT

Biology of pink stem borer, Sesamia inferens (Walker) (Lepidoptera: Noctuidae) was studied during 2016-17 in the laboratory of Department of Entomology, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar on Lok 1 variety at room temperature. Female of S. inferens laid eggs in 2 to 3 rows between leaf sheath of wheat plant. The eggs were small, oval and creamy white in colour. The average length and breadth of eggs were recorded 0.6 2± 0.01 mm and 0.49 ± 0.01 mm, respectively. The mean incubation period of egg was recorded to be 5.8 ± 0.82 days. Average hatching percentage of eggs was 79.53 ± 3.02 per cent. The average larval period was recorded to be 31.44 ± 5.84 days. The first, second, third, fourth, fifth and sixth instar larva were measured as 1.44 ± 0.12 mm, 5.99 ± 1.29 mm, 9.76 ± 1.72 mm, 16.02 ± 3.35 mm, 23.28 ± 2.89 mm and 24.72 ± 2.66 mm in length and 0.25 ± 0.01 mm, 0.62 ± 0.11 mm, 0.89 ± 0.29 mm, 2.20 ± 0.29 mm, 2.83 ± 0.28 mm and 2.99 ± 0.18 mm in breadth, respectively. Average duration of each larval instar was observed to be 4.04 ± 0.84, 3.44 ± 1.16, 4.96 ± 0.79, 5.56 ± 1.04, 6.00 ± 0.82 and 7.44 ± 1.19 days, respectively. In the course of development, it passed through six larval instars and pupation took place inside the stem. The average length and breadth of male pupa were measured as 12.44 ± 1.59 and 2.99 ± 0.31 mm, respectively, while average measurements of female pupa were 13.61 ± 1.48 mm in length and 3.46 ± 0.30 mm in breadth. The pupal period varied from 7 to 10 days with average 8.04 ± 0.89 days in male, while in female it varied from 8 to 12 days with average 9.72 ± 1.24 days. The average longevity of male was recorded 3.64 ± 0.99 days and 6.36 ± 1.71 days in female. Average length and breadth (with expanded wings) of adult male moth were measured as 20.44 ± 1.60 mm and 25.60 ± 0.52, respectively. The female was larger in size than the male moth. Average longevity of male and female was 3.64 ± 0.99 and 6.36 ± 1.71 days, respectively. The mean fecundity was 241.68 ± 58.62 eggs with average hatching percentage of 79.53 ± 3.02 per cent. The total life cycle completed in 50.44 ± 9.05 days in males, whereas 54.84 ± 10.12 days in females.

KEY WORDS: Biology, Pink stem borer, Sesamia inferens, wheat, Triticum aestivum, Lok 1

INTRODUCTION

Wheat, *Triticum aestivum* L., is an important cereal crop grown in diversified environments. Next to rice, wheat is the most important food- grain of India and is the staple food of millions of Indians, particularly in the northern and north-western parts of the country. It is consider as

the principle food of human being, the properties of gluten in wheat are such that, it produces bread stuffs, generally superior to those from any other cereal grains, it is grounded into flour to make different kinds of foods and bakery item like bread, porridge, crackers, biscuits, Muesli, pancakes, pies, pastries, cakes, cookies, muffins, rolls, doughnuts, gravy and breakfast cereals. Because of its excellent baking quality, wheat has become the most important source of carbohydrates and protein makes it more important human food as compared to other cereal grains in the majority of countries in temperate zone. A small amount of wheat is also used in manufacturing of dextrose, alcohol and certain breakfast food.

The minor insect pests like pink stem borer, *Sesamia inferens* Walker and gram pod borer, *Helicoverpa armigera* (Hubner) are becoming major pests of wheat in India due to change in environment and tillage system. Among the various pests attacking this crop, the wheat pink stem borer is a polyphagous pest occurring in almost all the wheat growing countries in Asia. In India, the pest was recorded for the first time in wheat by Patel (1972). Singh and Kular (2015) included pink stem borer in the list of emerging pests of different crops. Dhaliwal *et al.* (2010) described it as a well established pest of wheat. The pest is active during the month of December to March (Godhani, 1987).

The pinkish brown caterpillar of *S. inferens* with cylindrical body bores into the stem, feed on tissues inside and gradually kill the central shoot of the plant, thus, causing "Dead heart" (Deol, 2002). The infected ear heads may not bear grains which expressed as 'white ears' (Deol, 2002 and Singh, 2012) and the yield is directly affected. Wheat is damaged by the over-wintering to first generations larvae in some regions of China, the average per cent damage ranged from 6.17 to 9.83 per cent (Lina *et al.*, 2012).

Till date, very little work is available on the biology of *S. inferens* in wheat, keeping in view the increasing importance of this pest, the present study is planned to identify weak links in the life cycle of pink stem borer for its effective management on wheat crop. It is therefore, essential to know the life history and habit of this borer for finding out the most vulnerable stage during its life span, which help in devising suitable management strategy.

MATERIALS AND METHODS

Biological parameters of pink stem borer, *S. inferens* were studied during 2016 to 2017 in the laboratory of Department of Entomology, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar on Lok 1 variety at room temperature. The culture was raised by collecting the full grown larvae from wheat fields and was reared on cut stem of wheat. Adults obtained from this culture were reared on wheat plants in ovipositional cages. Adults were fed on five per cent honey solution. After release of the moths in ovipositional cages, wheat plants were removed after 5-6 days and leaf sheaths containing egg masses were cut and kept for incubation in jars till the emergence of neonate larvae. Larvae were reared in cut stem portion of wheat in tubes. In this way culture was maintained in laboratory for further biological studies. The duration of developmental stages *i.e.* larval instars, pupal period were recorded by observing 25 individuals for each stage. For recording the adult longevity of *S. inferens*, adults were observed from the day of emergence started. The duration of adults in each cage was recorded and longevity of each sex was calculated. For recording pre-oviposition, oviposition and post-oviposition period, the newly emerged pairs of *S. inferens* were

collected and confined in new insect rearing cages keeping 10 replications for adults from Lok 1. Each cage was observed daily during oviposition period for recording the fecundity of females. The numbers of eggs laid by female inside the leaf sheath were examined. A pair of freshly emerged male and female moth was introduced on 10-12 days old wheat plants. Plants were removed daily to check egg laying. Leaf sheath containing egg portion were cut and new plants was introduced daily till their death. The per cent hatchability, larval survival and adult emergence were recorded by observing 25 number of egg, larvae and pupa, each. The length and width of different stages were measured with the help of ocular and stage micrometer by observing 25 individuals of each stage *viz.* egg, first to sixth instars, pupa and adult (male and female) under the binocular microscope. Data on various biological parameters of *S. inferens* were subjected to statistical analysis by calculating mean value. Standard Deviation was also calculated for all biological parameters.

RESULTS AND DISCUSSION

Biology of *S. inferens*

Egg

The freshly laid eggs of *S. inferens* were small, oval and creamy white in colour (Plate IA) and changed to pink colour (Plate IB) than dark pink in colour (Plate IC) and ultimately turn in to black before hatching (Plate ID). The eggs were round with flattened poles and looked like depressed sphere. The chorion had sinuous ribs. The developing head capsules within the egg shells were visible under the binocular microscope, when they were about to hatch. At the time of colossal, the larvae bit the chorion, making an aperture and wriggled out from the egg shell (Plate IE). The colour of the eggs became light pinkish after 5 to 6 days. Unfertilized eggs did not show this pattern of colour changes. They remained creamy white in colour, got shrunk and did not hatch at all. Minimum to maximum length was 0.60 mm to 0.64 mm whereas size of breadth was 0.48 mm to 0.51 mm. The average length of egg was 0.62 ± 0.01 mm, average breadth was 0.49 ± 0.01 mm (Table 1). Similar observations were noticed by Godhani (1987) in wheat, Rajendra (1976) in sugarcane and Dale (1994) in rice crop. Generally, it was very difficult to locate eggs of *S. inferens* in the field, but these were seen in laboratory which was used to study the biology of pink stem borer. These were laid in clusters (Plate IA).

In present investigation, the eggs were laid in 2 to 3 rows between leaf sheath and stem of wheat plant in the laboratory conditions which were in accordance with the results found by Aggarwal (2002). Similarly, it was found on the inner side of third leaf sheath in case of basmati rice (Joshi *et al.*, 2009). In case of maize, the maximum numbers of eggs were observed on the first leaf sheath. Sometimes, 2 to 3 rows of eggs were also observed near the surface of soil (Sekhar *et al*., 2009). Variation in diameter of eggs in present studies and that of above mentioned workers may be due to host plant and environmental factors.

Incubation period and hatchability

The duration of egg stage known as incubation period and are summarized in Table 2. Perusal of the data revealed that the minimum incubation period was 5 days and the maximum was 7 days with an average of 5.80 ± 0.82 days. Incubation period of 6 to 8 days was recorded by Singh (2013), Atwal and Chaudhry (1967) and Karim and Riazuddin (1999), while Joshi *et al.* (2009) recorded it 5.34 ± 0.10 days in rice crop. Rajendra (1976) reported that it was 4 to 5 days in November, 7 to 8 days in January and 8 to 9 days in February in sugarcane crop. It was observed that the incubation period got enhanced during later months

when the photoperiod was short. The larva with a prominent black head became visible after 6 to 7 days. Unfertilized eggs turned dark, shriveled up and failed to develop, as far as hatching is concerned, it started fifth days after egg laying and was maximum on the seventh day, after which it started declining. Difference in hatchability might be due to variation in environmental conditions.

Larva

Number and duration of larval instars

Observations on number and duration of larval instars are presented in Table 2. From the data, it was obvious that there were six larval instars before attaining the pupal stage (Plate II). Six larval instars of this pest were also recorded by various workers (Butani, 1961; Anonymous, 1968; Nair, 1975; Judal, 1978; Godhani, 1987 and Sharma *et al.*, 2017). The duration of first, second, third, fourth, fifth and sixth larval instars varied from 3 to 5, 2 to 5, 4 to 6, 4 to 7, 5 to 7 and 5 to 9 days with an average of 4.04 ± 0.84, 3.44 ± 1.16, 4.96 ± 0.79, 5.56 ± 1.04, 6.00 ± 0.82 and 7.44 ± 1.19 days, respectively. Similar observations were also recorded by Godhani (1987) and Judal (1978) on wheat. In the present investigation, the total larval period varied from 23 to 39 days with an average of 31.44 ± 5.84 days which are in agreement with the findings of Nagarjuna *et al*. (2015). The variation in findings of present studies and that of earlier workers may be due to the difference in host plants, genotype or due to meteorological variation at the time of experimentation.

Larval instars

First instar larva

The caterpillar, when emerged from the egg, was a tiny delicate worm with slightly pinkish cylindrical body, gradually tapering, towards the posterior region (Plate II). The head capsule was conspicuous, reddish brown in color and broader as compared to the breath of the body. Similar observation were also reported by Singh (2013), Butani (1961) and Grist and Lever (1969). Three pairs of legs were presented on thoracic segments and pair of prolegs was observed on each of the 3rd, 4th, 5th and 6th abdominal segments. The nine pairs of spiracles (one pair on prothoracic segment and remaining eight on 1st to 8th abdominal segments) were visible.

The minimum body length was 1.25 mm and the maximum body length was 1.60 mm. The minimum breadth was 0.24 mm and maximum breadth was 0.26 mm. The average measurements of body length and breadth of first instar larva were 1.44 ± 0.12 mm and 0.25 ± 0.01 mm, respectively (Table 1) and average period was 4.04 ± 0.84 days (Table 2).

Second instar larva

The Second instar larva resemble the first instar larva in general appearance except the body size (Plate II). The minimum body length was 3.71 mm and the maximum body length was 7.80 mm. The minimum breadth was 0.50 mm and the maximum breadth was 0.88 mm. The average measurements of body length and breadth of second instar larva were 5.99 ± 1.29 mm and 0.62 ± 0.11 mm, respectively (Table 1) as well as larval period was 3.44 ± 1.16 days (Table 2).

Third instar larva

The third instar larva was larger than the larva of second instar. The head capsule of larva soon after moulting remained white in colour for some time and later it turned reddish brown. The antennae were clearly visible and the setae were observed arising from dark brown spots under binocular microscope. The spiracles became prominent during this instar (Plate II). Duration of third instar larva of *S. inferens* was 4.96 ± 0.79 days (Table 2). The minimum body length was 6.56 mm and the maximum body length was 11.62 mm. The

minimum breadth was 0.51 mm and the maximum breadth was 1.50 mm. The average measurements of body length and breadth of third instar larva were 9.76 ± 1.72 mm and 0.89 ± 0.29 mm, respectively (Table 1).

Fourth instar larva

The fourth instar larva was larger and more pinkish than the third instar larva with stout body. The setae were well developed **(**Plate II) and duration was 5.56 ± 1.04 days (Table 2). The minimum body length was 10.4 mm and the maximum body length was 19.10 mm. The minimum breadth was 1.52 mm and the maximum breadth was 2.60 mm. The average measurements of body length and breadth of fourth instar larva were 16.02 ± 3.35 mm and 2.20 ± 0.29 mm, respectively (Table 1).

Fifth instar larva

The fifth instar larva resembled the fourth instar larva except the increased body size. The prothoracic shield became prominent. The setae spiracles were more prominent (Plate II). Duration of fifth instar larva of *S. inferens* was 6.00 ± 0.82 days (Table 2). The minimum to maximum body length was 18.22 to 27.10 mm. The minimum breadth was 1.83 mm and the maximum breadth was 3.12 mm. The average measurements of body length and breadth of fifth instar larva were 23.28 ± 2.89 mm and 2.83 ± 0.28 mm, respectively (Table 1).

Sixth instar larva

The larva was the thickest, cylindrical and tapering posteriorly. The body of the larva was purple-pink dorsally and whitish yellow ventrally, whereas the head capsule was orange-red. The antennae were well defined with six ocelli on the head. The setae were well developed arising from reddish brown spots on the skin. The prologs were of equal size and crochets on them were unordinal and arranged in semicircle fashion. The spiracles were elongate oval with black peritremes. The pair of 8th abdominal spiracles was larger than that of the others. The skin was well chitinized body (Plate II). The average measurements of body length and breadth of sixth instar larva were 24.72 ± 2.66 mm and 2.99 ± 0.18 mm, respectively (Table 1). The duration of VI instar larvae was 7.44 ± 1.19 days (Table 2). More or less similar measurements were also recorded by Butani (1961) on maize, Grist and Lever (1969) on rice and Singh (2013) on wheat.

Pre-pupa

Usually, it took 1 to 2 days for the larvae of pink stern borer to get completely transformed into pupal stage. This time interval was regarded as pre-pupal period in life cycle of lepidopterous Insects. The average pupal period was 1.52 ± 0.51 days (Table 2). The minimum length was 17.12 mm and maximum length was 19.80 mm. The minimum breadth was 3.10 mm and the maximum breadth was 3.98 mm. The average measurements of body length and breadth were 18.28 ± 0.76 mm and 3.65 ± 0.22 mm, respectively (Table 1).

Pupa

Colour, shape and size

With the passage of time, the colour of pupae gets changed from whitish brown to dark brown. Pupa in its early developmental stage was very agile and sensitive to disturbance. The male and female pupae could be differentiated on the basis of pupal size as well as genital aperture. The size of female pupae was comparatively larger than male (Plate III). Genital aperture was present on ventral side of (9th sternite) in case of female, while it was on 8th sternite in case of males.

The length of the male pupa ranged from 10.13 to 15.78 mm with a mean of 12.44 ± 1.59 mm (Table 1). The corresponding figures in case of female pupa were 11.13 to 16.78 mm and 13.61 ± 1.48 mm, respectively. The breadth of the male

pupa ranged from 2.35 to 3.48 mm with a mean of 2.99 ± 0.31 mm (Table 1). The corresponding figures in case of female pupa were 3.00 to 3.92 mm and 3.46 ± 0.30 mm, respectively. The studies of Isaac and Venkatraman (1941) revealed higher length of pupa which varied from 16 to 22 mm and it differed from present investigation. However, the present results were endorsed by the findings of Rajendra (1976), who reported smaller size of pupa in sugarcane crop. Similarly, Patel and Verma (1980) and Joshi *et al.* (2009) found large size of female pupa as compared to male pupae in rice crop. The observed variation in pupal duration might be due to different environmental conditions and the crop on which its biology was studied.

Pupal period

The minimum pupal period was 7 days and the maximum pupal period was 10 days in male pupa. The mean pupal duration of male pupae were 8.04 ± 0.89 days (Table 2). The minimum pupal period was 8 days and the maximum pupal period was 12 days in female pupa. The mean pupal duration of female pupae were 9.72 ± 1.24 days (Table 2). The present findings are in conformity with Grist and Lever (1969), who submitted that the pupal period ranged from 12 to 36 days during winter months in rice crop. No hibernation shorter pupal period (9-11 days) of *S. inferens* was observed by Rajendra (1976) in sugarcane crop. The current finding on pupal duration during February and March are in line with those of Aggarwal (2002), who reported 22.40 ± 0.99 and 26.60 ± 0.48 days as pupal period of male and female, respectively in the month of December. The present investigation of longer papal duration during December to February differed from Atwal and Chaudhry (1967), Rothschild (1971), Aggarwal (2002) and Joshi *et al.* (2009) who reported shorter pupal period during summer months in rice crop. The results of the findings of Areekul and Chamchanya (1973) indicated that the length of pupal periods of *S. inferens* varied inversely with the increase of temperature, Pathak and Khan (1994) also observed that the threshold temperature for pupal development was 15-16˚C and optimum temperature for their development was 33-35˚C. Rahman and Khalequzzaman (2004) reported that no pupal development was observed at temperature of 10˚C or below it.

Pupation site

Pupation takes place inside of the stem. The final instar larvae of *S. inferens* stopped feeding and spun a cocoon around them consisting of white silken thread. Gradually, the larva became inactive and started shrinking. The pupation site was observed regularly in the laboratory throughout the experiment period, few pupae were observed inside wheat stem (Plate III).

Adult

Colour, shape and size

The adult moths were dull coloured, having light brown forewings and off-white hind wings (Plate III). A large number of light brownish scales/hairs were present throughout the exposed surface of the body including wings. The colour of the head was dark brown. The antennae were pectinate in males and filiform in females. This is an important character which helps in the identification of male and female insects, as in most of the lepidopterous moths, the abdomen tapered towards its distal end.

The body length of males ranged from 18.13 to 22.98 mm with a mean of 20.44 ± 1.60 mm. In comparison to males, higher length of females was observed which ranged from 20.10 to 25.32 mm with a mean of 21.85 ± 1.49 mm. The body breadth of males and females ranged from 24.40 to 26.25 mm and 25.80 to 29.75 mm, respectively. The mean body breadth of males was 25.60 ± 0.52 mm, whereas the body breadth of females emerged was 27.80

± 1.30 mm (Table 1). It can be concluded from the above mentioned measurements that the adults emerged were stronger having greater length and breadth than the adults that emerged.

In order Lepidoptera, the size of adults relies primarily on reserves accumulated during the larval stage, since adults have little opportunity to accumulate additional resources. Thus, the final size of lepidopterous insect was often determined by the population density and availability of food and prevailing environmental conditions during larval stage (Jones *et al.*, 1982; Honek, 1993 and Tammaru *et al.*, 1996). The length of male and female of *S. inferens* was 13 mm and 14.6 mm, respectively, in sugarcane crop (Rajendra, 1976). The size of males emerging from the pupae of *S. nonagrioides* Lef was slightly smaller as compared to females (Babilis and Mazomenos, 1992). The morphological studies on *S. cretica* revealed significant difference in the size of males and females even at P = 0.01 (Al-Allan, 2009). The present investigation on adult size differed from Listinger (1977), who reported 14 to 17 mm adult size in rice crop. Similarly, Patel and Verma (1980) and Khan *et al.* (1991) reported larger size of adult moths ranging from 26 to 35 mm. However, present studies on adult size are in total agreement with those reported by Aggarwal (2002) and Sharma *et al.* (2017).

Pre-oviposition, oviposition and post-oviposition periods

The peak of ovipositional activity has been observed one day after mating and then decreased progressively. Similar ovipositional activity was also observed in other Noctuidae borer such as *Heliothis zea* (Boddie). The active egg laying period went on decreasing with the age of female moth. The minimum pre-oviposition period of female was one day and maximum pre-oviposition period of females was two days. The mean of pre-oviposition period of females was 1.36 ± 0.49 days. The minimum to maximum oviposition period was 2 days to 5 days. The mean of oviposition period was 3.56 ± 0.71 days. The mean of post oviposition period was 1.44 ± 0.51 days (Table 2). The pre-oviposition and oviposition periods of *S. cretica* were 4 and 8 days on corn plant (Masoud *et al.*, 2010), which indicated the contradictory results to the present results and it might be due to the variation in the pest species.

Longevity of adults

The longevity of males ranged from 2 to 5 days with a mean of 3.64 ± 0.99 days (Table 2). However, the females lived slightly longer 4 to 9 days with a mean of 6.36 ± 1.71 days. The present findings are in accordance with Rajendra (1976), Lu and Tan (1981) and Aggarwal (2002), who reported 5 to 7, 4.55 to 6.50 and 4 to 5 days adult longevity. A shorter adult life span of 3.65 days was reported in case of *S. cretica* (Younis *et al*., 1984). The longevity of adult females was reported as 6.5 to 8.2 days for *S. nonagrioides* (Al-salti *et al*., 1986) and 5 to 7 days for *S. calamistis* (Allsopp and Sallam, 2001). However, the present results differ from the studies of Joshi *et al*. (2009), who reported a relatively longer period of adult longevity in *Taratori basmati* rice. According to them, average longevity of male and female adults was 10.90 ± 0.48 and 11.40 ± 0.75 days, respectively.

Fecundity and hatchability

The fecundity of females of *S. inferens* varied from 120 to 350 with the average fecundity of 241.68 ± 58.62 (Table 2). Per cent hatchability of eggs was the maximum (84.00) (Table 2). These studies were substantiated by the findings of Allsopp and Sallam (2001) and Aggarwal (2002), who reported 300 and 76 to 271 as fecundity of females of *S. inferens*, respectively, in the month of November. The average fecundity and hatchability of *S.*

inferens were 332.1 and 87.04 ± 3.18 per cent, respectively in *Taratori basmati* rice (Joshi *et al*., 2009). Rajendra (1976) reported 150 to 400 eggs as the fecundity of *S. inferens* in sugarcane crop. Similarly, the eggs laid by *S. cretica* varied from 22 to 309 with an average of 120 eggs per female (Allsopp and Sallam, 2001).

Total life span

The total life span of *S. inferens* from egg laying to adult emergence including males and females was completed in 50.44 ± 9.05 and 54.84 ± 10.12 days, respectively. The minimum total life span in male was 38 days and the maximum total life span in male was 63 days. In case of female of *S. inferens*, the minimum total life span was 41 days and the maximum total life span was 69 days (Table 2). The results of the present study revealed that the life of *S. inferens* got extended during winter season. This has also been reported by Krishnamurti and Usman (1952) in ragi crop (*Eleusine coracana*/*Eleusine indica*) in Mysore. Shorter life cycle of 34 to 44 days was reported by Atwal and Chaudhry (1967) in summers in rice crop. Similarly, the life cycle of *S. inferens* ranged 38 to 68 days in Philippines (Cendana and Calora, 1967), 45 to 90 days in Malaysia (Listinger, 1977) during different months in rice crop, Rajendra (1976) reported that *S. inferens* lived for 65 to 84 days during different months on sugarcane crop. The total life cycle *S. grisescens* has been reported as 60 to 70 days (Allsopp and Sallam, 2001). Studies of Joshi *et al.* (2009) on *Taratori basmati* rice are in total agreement with present findings, which explained that the *S. inferens* completed its post embryonic development in 50.44 days in males and 54.84 days in females.

Sex ratio

The sex ratio was calculated from the number of males and females emerged during in 2016-17 crop seasons. The sex ratio was 1 : 1 which indicated that approximately equal number of males and females emerged (Table 2). The present observations are in agreement with those reported by Aggarwal (2002) and Singh and Kular (2015).

CONCLUSION

The biology of an insect pest is a condition precedent to find out its management strategies. The biology of *S. inferens* on wheat was not studied in western part of the country. Having regards to the fact that no systematic work on this aspect has been carried out. The present study conducted on biology of this pest which will be helpful for developing efficient pest management strategies against *S. inferens.*

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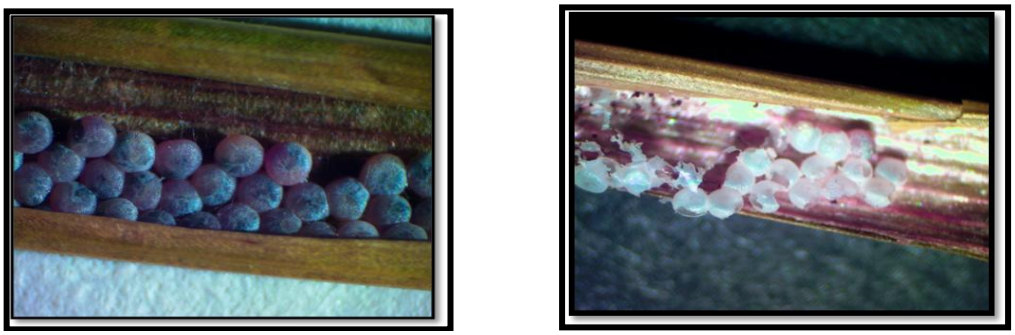
Table 1: Measurements of different stages of *S. inferens* reared in wheat

Sr. No.	Life Stage	Particulars	Measurement (mm)		
			Min.	***Max.***	**Mean ± SD**
1.	**Egg**	Length	0.60	0.64	0.62 ± 0.01
		Breadth	0.48	0.51	0.49 ± 0.01
2.	**Larva :**				
	I instar	Length	1.25	1.60	1.44 ± 0.12
		Breadth	0.24	0.26	0.25 ± 0.01
	II instar	Length	3.71	7.80	5.99 ± 1.29
		Breadth	0.50	0.88	0.62 ± 0.11
	III instar	Length	6.56	11.62	9.76 ± 1.72
		Breadth	0.51	1.50	0.89 ± 0.29
	IV instar	Length	10.4	19.10	16.02 ± 3.35
		Breadth	1.52	2.60	2.20 ± 0.29
	V instar	Length	18.22	27.10	23.28 ± 2.89
		Breadth	1.83	3.12	2.83 ± 0.28
	VI instar	Length	20.10	28.12	24.72 ± 2.66
		Breadth	2.60	3.27	2.99 ± 0.18
3.	**Pre-pupa**	Length	17.12	19.80	18.28 ± 0.76
		Breadth	3.10	3.98	3.65 ± 0.22
4.	**Pupa :**				
	Male	Length	10.13	15.78	12.44 ± 1.59
		Breadth	2.35	3.48	2.99 ± 0.31
	Female	Length	11.13	16.78	13.61 ± 1.48
		Breadth	3.00	3.92	3.46 ± 0.30
5.	**Adult :**				
	Male	Length	18.13	22.98	20.44 ± 1.60
		Breadth	24.40	26.25	25.60 ± 0.52
	Female	Length	20.10	25.32	21.85 ± 1.49
		Breadth	25.80	29.75	27.80 ± 1.30

Table 2: Duration of different life-stages of *S. inferens* reared in wheat

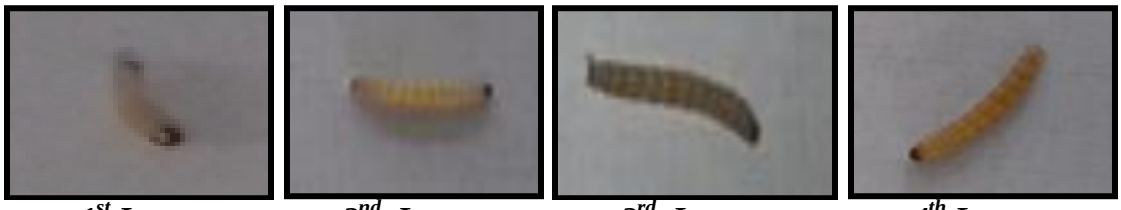
Sr. No.	Life stage	Period (days)		
		Min.	***Max.***	**Mean ± SD**
1.	**Egg**	5	7	5.80 ± 0.82
	Hatching (%)	76.00	84.00	79.53 ± 3.02
2.	**Larva**			
	I instar	3	5	4.04 ± 0.84
	II instar	2	5	3.44 ± 1.16
	III instar	4	6	4.96 ± 0.79
	IV instar	4	7	5.56 ± 1.04
	V instar	5	7	6.00 ± 0.82
	VI instar	5	9	7.44 ± 1.19
	Total :-	23	39	31.44 ± 5.84
3.	**Pre-pupa**	1	2	1.52 ± 0.51
4.	**Pupa**			
	Male	7	10	8.04 ± 0.89
	Female	8	12	9.72 ± 1.24
5.	**Adult**			
	Pre-oviposition	1	2	1.36 ± 0.49
	Oviposition	2	5	3.56 ± 0.71
	Post-oviposition	1	2	1.44 ± 0.51
	Longevity			
	Male	2	5	3.64 ± 0.99
	Female	4	9	6.36 ± 1.71
	Fecundity	120	350	241.68 ± 58.62
6.	**Total life span : Egg to adult death**			
	Male	38	63	50.44 ± 9.05
	Female	41	69	54.84 ± 10.12
7.	**Sex ratio (Male : Female)**			
	Average	-	-	1:1

A.Freshly laid eggs in cluster *B.Eggs changed to pink* *C.Dark pink coloured eggs*



D. Grayesh black coloured eggs *E.Empty egg shell left after the emergence of neonates*

Plate 1. Pattern of colour changes in the eggs of S. inferens reared on wheat



1st Instar *2nd Instar* *3rd Instar* *4th Instar*

5th Instar *6th Instar*

Plate 2. Different larval instar of S. inferens

Pre- pupa

Pupa inside the stem

Male pupa ***Female pupa***

Male adult

Female adult

Plate 3. Pre-pupal, Pupal and Adult stage of S. inferens

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