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Biology and behavior of white stem borer (*Scirpophaga fusciflua)* on rice (*Oryza sativa*) in India

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ABSTRACT

The laboratory and screen house experiment was conducted to study the biology and behavior of *Scirpophaga fusciflua* Hampson (Lepidoptera: Crambidae) during *kharif* 2015. The female moth oviposited both on dorsal and ventral surfaces of the leaf. The eggs were laid in masses and covered with brownish hairs of anal tuft. The eggs were hatched in 5-7 days with an average of 5.25±0.09 days. The maximum eggs hatched on 5th day (93.62%) with 92.31 % egg hatchability. The females laid eggs in the night between 9:00 pm to 11:00 pm during the study. The insect has five larval instars. The pupal period lasted for 7-9 days and the adults emerged out from the pupae at night between 6:00 pm to 8:00 pm during dusk hours. Adults exhibited sexual dimorphism. The number of eggs per female ranged from 64-212 with an average of 138.60±15.67 eggs. The longevity of male and female ranged from 2-3 days in male and 2-4 days in female, respectively. The morphometrics of different development stages are also discussed. This study is the first to describe the biology *S. fusciflua* in India.

Key words: Fecundity, Hatchability, Incubation period, Longevity, Rice, *Scirpophaga fusciflua*

Rice (*Oryza sativa* L.) is a staple food of more than 60 % of the world population. In India it is grown on an area of 43.38 million hectare with total production of 104.30 million tones (Anonymous 2016). Basmati rice group occupies more than 80 % area in north India (APEDA 2017). Rice is growing in warm and humid environment which is conducive to the survival and proliferation of insects. Rice harbour more than hundred species of insects are known to attack the rice crop. Lepidopteron stem bores are the most important pest of rice all over the world. Of all the stem borer species documented in rice so far in the (country six species), viz. yellow stem borer [*Scirpophaga incertulas* (Walker)], white stem borers [*Scirpophaga nivella* (Fabricius), *Scirpophaga inotata* (Walker)*, Scirpophaga fusciflua* Hampson], striped stem borer [*Chilo suppressalis* (Walker)], gold fringed borer [*Chilo auricilius* (Dudgeon)] and pink stem borer, [*Sesamia inferens* (Walker)]. The main overwintering sites for rice stem borers are rice stubbles after crop harvesting (Wu *et al*. 2014). The general symptoms of damage are common the borers cause damage to rice throughout the crop growth period. The damage is manifested as 'dead heart' due to death of growing point in the vegetative phase and 'white ears' at reproductive stage (Katti *et al.* 2011). Recently, Srivastava *et al.* (2012) reported *S. fusciflua* in northern part of India at different localities and appeared early as compared to other species of stem borer except *Sesamia inferens*. The studies on biology of this pest is least documented however, some work is there from Directorate of Rice Research, Hyderabad, India. The knowledge of insect ecology, biology and morphometrics are the basic and important elements for identification of pest as well as to develop integrated pest management (IPM) strategies for sustainable agriculture.

MATERIALS AND METHODS

The biology of white stem borer on rice cultivar CSR 30 (Basmati) was studied at Chaudhary Charan Singh Haryana Agricultural University, Rice Research station, Kaul (29º51' N latitude, 76º41' E longitude), Haryana, India. The culture was initiated by collecting the larvae and adults from university farm and farmers' field adjoining the research farm. Adults were released on 40-50 days old plants. Ten egg masses laid on leaves were kept individually in test tubes (150×18 mm) containing wet sponge at bottom to keep them fresh until hatching. The incubation period, time of hatching and the number of larvae emerging out from each egg mass was recorded. After hatching, each egg mass was dipped in 70 % alcohol for 15 min and the hairs on eggs were separated with the help of soft camel

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hair brush to count per cent hatching and their number in each egg mass. Larval period was studied by rearing the newly hatched larvae in test tube on cut stem of 40-45 days old plants individually. Fresh food of tender stem was provided to larvae at two days interval. The base of the cut stems were wrapped with water socked cotton wool to keep them fresh and turgid. The duration of different instars and their characteristics were recorded**.** The per cent larval survival was recorded on 4, 8, 12, 16, 20, 24 and 28 days after release by releasing 20 larvae (two larvae on each cut stem) in a jar (150×20 cm) containing little water and constitutes a replication. There were five replications. Other parameters such as larval duration, pupal period, pupal weight, per cent pupation, per cent adult emergence and sex ratio were also recorded. Ovipositional periods, fecundity, percent adult emergence, longevity, behavior of both the sexes, egg masses/adult and sex ratio were determined by releasing pair of newly emerged adults in a mylar cage on 40-45 days potted rice plant and top of the cage was covered with muslin cloth. There were 10 such cages and each cage represents a replication. Sugar solution (10%) was provided to the moths. The duration of above parameters was recorded separately for each pair and average duration was computed. Larval length, pupal length, wing expanse and size of egg masses were measured with digital vernier calliper and head capsule width by using calibrated ocular micrometer in a binocular dissecting microscope according to Dyar's rule (Gullan and Cranston 2005). The biology of rice stem borer on rice was analyzed with analysis of variance completely randomized design (CRD).

RESULTS AND DISCUSSION

The results on the biology of *S. fusciflua* has been discussed on the basis of genus *Scirpophaga* because of first time study on species *fusciflua.* This species is very close to *S. virginia* except the difference in subteguminal process, which is bi-lobed in *S. fusciflua* instead of rounded in *S.virginea* (Saini *et al.* 2017). The female moth oviposited both on dorsal and ventral surface of the leaf. The dorsal surface of leaf (71 %) was preferred most followed by ventral surface (20%) and minimum eggs were laid on leafsheath/ stem. The female moth moved its abdomen top to either side slowly to lay the eggs. The eggs were laid in masses and covered with brownish hairs of anal tuft (Fig 1A). The egg masses were varied in shape from oval, flattened and rectangular. The average incubation period was 5.25 days and maximum eggs were hatched on 5th day. Oviposition took place during night from 9:00 pm to 11:00 pm and hatching from egg masses took places in afternoon hours. It took 20 to 35 minutes for complete hatching of eggs. Larvae emerged through several holes present on the sides of egg masses. The same behavior and preference of egg laying has also been reported by several researchers in genus *Scirpophaga* (Malhi and Brar 1998, Brar *et al*. 2001, Hugar *et al.* 2010, Jadhao and Khurad 2012). The time of egg laying was observed from 9:00 pm to 11:00 pm during the study are in agreement with the finding of Panigrahi and Rajamani (2008) who reported the time of egg laying during night between 9:00 pm to 1:00 am in other *Scirpophaga* spp. The neonate larvae were green in colour with black head. There were five larval instars. Larval period ranged from 26-31 days with a mean duration of 28.82 days (Table 1). The third instar larvae were dirty white in colour with inverted 'v' shape notch and two brownish dots on prothorax. The segments were marked by brownish rings. The larval instars after third moults were light yellow in colour and the discolouration of prothorax rings from brownish to dirty yellowish. The posterior region of prothorax is mottled, however anterior region was white in colour. There is curved shape mark on the anterio-lateral side of the prothorax just above prothoracic legs. The larvae of this instar start to make a silken web of white colour. The fifth instar larvae were greenish yellow in colour with orange head and feed inside it (Fig 1B). Pathak and Khan (1994) reported that the lepidopterous stem borers usually undergo four to seven larval instars depending upon temperature and availability of quality food. The *S. fusciflua* has five larval instars (DRR 2012). The larvae feed inside the silken web with prominent crochets and attained pre pupal stage thereafter. The mean larval survival varied from 54-70 % at different period of observation. Pupation took place in stem under white silken web by making an exit hole. Pupal period ranged from 7-9 days. The execrate pupae were pale in colour and gradually turned dark brown (Fig 1C). The female pupae were slightly larger and heavier than male pupae.

The instars could be distinguished from their size, prothoracic mark and colour intensity of head. Delineation of larval instars is important in physiological, morphological, ecological and molecular studies and also for implementing control measures at most damaging stage. The length and breadth of male and female pupae of *S. fusciflua* varied from 9-10 and 11-12 mm (length) and 1.59-1.62 and 1.75-1.82 mm (breadth), respectively with an average of 9.50± 0.22 and 11.10±0.27 mm (length) and 1.60±0.003 and 1.79±0.006 mm (breadth), respectively. Total developmental period was ranged from 34-42 days. The adults were emerged out from the pupae at night between 6:00 pm to 8:00 pm during dusk hours with prepondance of males to female (Table 2). The

Table 1 Duration of various larval instars, larval length and head capsule width of *Scirpophaga fusciflua* on plants of rice cultivar CSR 30

Larval instars	Average duration and range (days)		Larval length and head capsule width (mm) (Mean ± SE)	
	Larval Duration	Range	Larval length	Head capsule width
First	4.62 ± 0.069	4-5	2.30 ± 0.15	0.18 ± 0.003
Second	5.60 ± 0.070	5-6	5.10 ± 0.23	0.35 ± 0.007
Third	4.66 ± 0.068	4-5	9.00 ± 0.25	0.49 ± 0.004
Fourth	6.66 ± 0.068	6-7	13.90 ± 0.23	0.63 ± 0.003
Fifth	7.28 ± 0.064	7-8	17.80 ± 0.29	0.78 ± 0.014

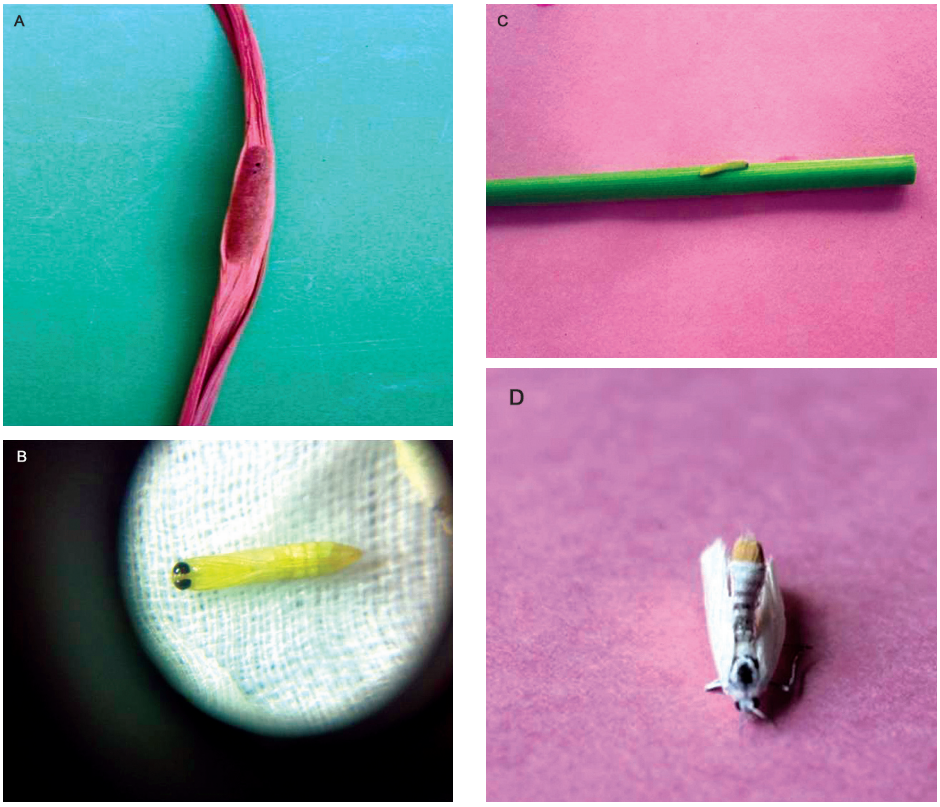

Fig 1 Developmental stages of *Scirpophaga fusciflua*

adults exhibited remarkable sexual dimorphism and the males moths were smaller than females. The forewings were pale ocherous white in colour with prominent wing venation in both the sexes. The abdomen are wide and the tip of abdomen is covered with tuft of ocherous yellow hair in female (Fig 1D). The antennae were filliform in both the sexes. The colour characterstics of adults were very close to *S. innotata* and *S. virginia* (Saini *et al.* 2017). Average length and breadth of the male were 9.40±0.16 and 16.60±0.22 mm, respectively. Whereas those of female were 11.00±0.25 and 19.00±0.25 mm, respectively.

Table 2 Larval survival, adult emergence and sex ratio of *Scirpophaga fusciflua* on plants of rice cultivar CSR 30

Days after release	Mean survival (%)	Pupation (%)	Moth emergence (%)	Sex ratio (Male: Female)
4	70.00 (62.37)			
8	65.00 (55.59)			
12	61.00 (53.16)			
16	58.00 (52.55)			
20	57.00 (47.87)			
24	55.00 (46.70)			
28	54.00 (45.55)	51 ± 1.87	89.73 ± 3.53	1.3:1
CD (P=0.05)	(4.66)			
SE(m)	2.67			

Figures in parentheses are angular transformed value

The adult females survived longer (2.90 days) than the males (2.20 days). Mating took place during the night and eggs were laid in masses. The number of egg masses laid and number of eggs per egg mass varied from female to female. The average number of eggs laid by female were 138.60±15.67 eggs (Table 3). The freshly laid egges were oval in shape and after hairs separation were creamy white in colour. The lepidopterous laid eggs in masses are in accordance with other researchers (Khan *et al*. 1991, Pathak and Khan 1994, Hugar *et al.* 2010, Manikandan *et al.* 2013, Manikandan *et al.* 2016). The pre-oviposition, oviposition and post-oviposition periods were on an average 1.20, 1.40 and 0.30 days, respectively. The egg masses length and breadth of *S. fusciflua* ranged from 8-17 mm with an average of 12.80 mm and 3.0-3.5 mm with an average of 3.20 mm, respectively. The length of egg masses laid were more than the eggs laid by other lepidopteron borers in rice

Table 3 Duration of different development stages and reproductive behavior of *Scirpophaga fusciflua* on plants of rice cultivar CSR 30

Insect stage/ Duration	*S. fusciflua*	
	Mean (days)	Range
Incubation period	5.25±0.09	5-7
Total larval duration	28.82±0.30	26-31
Pupal		
Pre pupal period	1.15±0.08	1-2
Pupal period	7.70±0.08	7-9
Total developmental period	37.67±0.46	34-42
Adult		
Preoviposition	1.20±0.13	1-2
Oviposition	1.40±0.16	1-2
Postoviposition	0.30±0.15	0-1
Male longevity	2.20±0.13	2-3
Female longevity	2.90±0.17	2-4
Reproductive behavior		
Fecundity (No. of eggs laid/female)	138.60±15.67	64-212
No. of egg masses/female	2.20±0.20	1-3
No. of eggs/egg mass	95.75±6.68	62-153
Hatching (%)	87.79±1.37	81.44-93.60

during the study. The yellow stem borer is a major pest of rice in north India and was present throughout the season during the study. The eggs laid by *Scirpophaga incertulas* may create confusion, so the morphometrics on eggs were recorded and compared. The length of *S. incertulas* eggs were ranged from 7-9 mm with an average of 8.10 mm whereas, 12.80 mm in *S. fusciflua* can play a significant role in pest forecasting (Malhi and Brar 1998). The difference in the sizes of egg masses may be due to varying conditions under which the insect was reared. The freshly emerged larvae moved towards the tip of the plant and thereafter entered inside the plant tissue by making small pinholes in leaf sheath.

The present study reported here is the first comprehensive report on biology of *S. fusciflua* which may assume a status of serious pest in paddy growing areas of nsorth India. The study is of great significance because it's the first of its kind which address the study of life cycle which is important for understanding behavioral characteristics, total developmental period, population dynamics, life table analysis, peak occurrence to predetermine the time of infestation and actual population density to decide insecticidal applications. Morphometrics is an important parameter for proper identification of eggs, larval instars and pupae which would help in understanding the various frontier areas of insect science like physiological processes, insect plant interaction and aid in developing prediction model for forecasting.

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