



Biological parameters and comparative morphometrics studies of *Scirpophaga* spp. in rice

A Kumar[#], L Ram, SS Yadav, S Mehra and MK Jat

Summary

The comparative biological studies on yellow stem borer, *Scirpophaga incertulas* (Wlk.) and white Stem Borer, *Scirpophaga fusciflua* Hampson showed that the moths of both species preferred to lay eggs on the dorsal surface of leaves. The eggs were laid in masses during night hours and covered with brownish hairs of the anal tuft. The maximum eggs of *S. incertulas* hatched on 6th day, whereas the *S. fusciflua* eggs hatched on the 5th day with per cent hatchability of 86 and 93 per cent, respectively. There were six larval instars in *S. incertulas* with 25-34 days larval duration and five for *S. fusciflua* with 26-31 days larval duration. The pupal period lasts for 7-9 days in both species, and the adults emerge from the pupae during dusk hours. Adults exhibited sexual dimorphism. The longevity of male and female moths was also similar in both species. The morphometries of larval head capsule width were more in *S. incertulas* as compared to *S. fusciflua*. Male pupal weight of both the species were almost similar but it was varied significantly in female pupa *S. incertulas* (0.024mg) and *S. fusciflua* (0.032mg).

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Introduction

Rice (*Oryza sativa* L.) is a staple food of more than half of the world population. In India it is grown on an area of 43.38 million hectare with total production of 104.30 million tonnes (Anonymous 2016). Basmati group's rice occupies more than 80 per cent of North India's area (APEDA 2017). Rice is growing in warm and humid environment which is conducive to the insect pest's survival and proliferation. Rice plant attacked by more than hundred species of insects among them lepidopteron stem borers, has a major concern worldwide. Of all the stem borers species documented in rice so far in the country six species viz. yellow stem borer, *Scirpophaga incertulas* (Walker), white stem borer, *Scirpophaga nivella* (Fabricius), *Scirpophaga innotata* (Walker), *Scirpophaga fusciflua* Hampson, striped stem borer, *Chilo suppressalis* (Walker), gold fringed borer, *Chilo auricilius* (Dudgeon) and pink stem borer, *Sesamia inferens* (Walker). Wu et al. (2014) reported that the main overwintering sites for rice stem borers are rice stubbles after crop harvesting and may also cause damage to next season crops in the cropping system. The general symptoms of damage are common by the borers and they cause damage to rice throughout the crop growth period. The damage is manifested as 'dead heart' due to the death of the growing point in the vegetative phase and 'white ears' at the reproductive stage Katti et al. (2011); Karthikeyan & Purusothaman (2000) and Kasniya et al. 2022. 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*. As *Scirpophaga fusciflua* appears earlier than other borers, a comparative biological aspect and morphometries are needed to predetermine the time of maximum infestation and population pressure to decide management strategies for these severe pests.

Material and Methods

The comparative biology of yellow and white stem borer on rice cultivar CSR 30 (Basmati) was studied at Chaudhary Charan Singh Haryana Agricultural University, Rice Research station, Kaul, Haryana, India. The culture was initiated by collecting the egg masses, larvae and adults from paddy fields. Adults were released on 40-50 days old plants for egg laying. Ten egg masses laid on leaves were kept individually in test tubes to record the incubation period and the number of larvae that emerged per egg mass was recorded. After hatching, each egg mass was dipped in 70 per cent alcohol for 15 minutes and the hairs on the eggs were separated with the help of soft camel hair brush to count per cent hatching and their number in each egg mass. The larval period was studied by rearing fifty newly hatched larvae in test tubes on cut stem of 40-45 days-old plants individually. Fresh food of tender stem was provided to larvae at two days intervals. The duration of different larval instars, pupal period, per cent pupation pupal weight, per cent adult emergence, ovipositional periods, fecundity, longevity, behavior of both the sexes and egg masses/ adult 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 a muslin cloth. The duration of the above parameters was recorded separately for each pair and

Department of Entomology, CCS Haryana Agricultural University, Hisar 125004

[#]Corresponding author: A Kumar, E-mail: ankitood522@gmail.com

the average duration was computed. Larval length, pupal length, wing expanse and size of egg masses were measured with a digital vernier calliper and head capsule width by using calibrated ocular micrometer in a binocular dissecting microscope (Haldhar 2017; Haldhar et al. 2015 & 2021).

Result and Discussion

Site of oviposition, incubation period and hatchability

The female moths of *S. incertulas* and *S. fusciflua* preferred to lay eggs in masses on the dorsal side of the leaf during night hours with 84 and 71 per cent eggs, respectively supported by the findings of Panigrahi & Rajamani (2008). These findings are in strong conformity with Brar et al. (2001), and Hugar et al. (2010), who

reported that 45.65 to 92.86 per cent of egg masses alone were laid in the upper surface of leaves. The maximum number of eggs of *S. incertulas* hatched on 7th day (76.75%), whereas *S. fusciflua* eggs hatched on 5th day (93.62%) (Table 1). The eggs were creamy white in colour after separating hairs from egg masses (Plate 3). The findings on per cent hatchability have been supported by Panigrahi and Rajamani (2008) and Malhi & Brar (1998), who reported that 99.25 per cent eggs were hatched on the 6th day. The present findings are in accordance with Banerjee and Pramanik (1967), Hugar et al. (2010) and Jadhao & Khurad (2012), who reported the incubation period of *Scirpophaga* sp. varied from 4-9, 5-7 and 5-8 days, respectively.

Table 1. Incubation period and per cent hatchability of eggs in *Scirpophaga fusciflua* and *Scirpophaga incertulas* on rice cultivar CSR 30

<i>S. fusciflua</i>	Egg masses laid on dorsal surface (%)	Incubation periods (days)	Per cent hatching 5 th	Per cent hatchability
Average	71	5.25	93.62	92.31
Range	-	5-7	-	-
<i>S. incertulas</i>			7 th	
Average	84	7.25	76.75	86.97
Range	-	7-9	-	-

Average min. temperature range (°C) = 16.8

Average max. temperature range (°C) = 29.0

Relative humidity (%) = 72.0 – 78.0

Relative humidity (%) = 62.0 – 77.0

depending upon the temperature and availability of quality food. The results on *S. fusciflua* have five larval instars supported by DRR (2012). Jadhao & Khurad (2012) reported mean larval duration of 25-30 days strongly supports the present results. The larval duration of the present finding at mean minimum and maximum temperatures of 26.5 and 32.0 °C are in accordance with Manikandan et al. (2013), who observed the larval duration of *S. incertulas* 28.75, 26.75, 25.50, 23.00 and 21.50 days at a different incubation temperature of 28.3⁰ C, 30.6⁰ C, 32.7⁰ C, 34.3⁰ C and 36.0⁰ C, respectively.

Table 2. Duration of various larval instars of *Scirpophaga fusciflua* and *Scirpophaga incertulas* rice cultivar CSR 30

Larval instars	Average duration and range (days)	
	<i>S. fusciflua</i>	<i>S. incertulas</i>
First	4-5	3-4
Second	5-6	4-5
Third	4-5	4-6
Fourth	6-7	4-5
Fifth	7-8	5-6
Sixth	-	5-8
Total larval duration	26-31	25-34

Average min. temperature range (°C) = 26.4

Average max. temperature range (°C) = 32.1

Larval instars

The data revealed that the larvae passed through five instars in *S. fusciflua* and six instars in *S. incertulas*. The characteristics of different instars are given below:

First instar

The neonate larvae of *S. fusciflua* was green in colour with a black head. The larvae of *S. incertulas* was grey in colour with black head and dark brown prothoracic shield as well as white bands before mesothorax was present in comparison of *S. fusciflua* which has no white bands and prothoracic shield

Second instar

The second instar larvae of *S. fusciflua* were light green in colour with brown heads, whereas the larvae of *S. incertulas* are dirty white in colour with transparent bands on the body. Just after moulting, the colour of the head is lighter than the body colour and turns light brown after some time with a prominent prothoracic shield.

Third instar

The third instar larvae of *S. fusciflua* was dirty white in colour and distinguished from *S. incertulas* as the presence of an inverted 'V' shape notch and two brownish dots on the prothorax. Brownish rings also mark each body segment. In comparison, the *S. incertulas* larvae were dirty white with light brown heads. The white

transparent bands of second instar larvae are replaced by a space between each body segment marked by a dark ring.

Fourth instar

The fourth instar larvae of *S. fusciflua* were light yellow in colour with a brown head. The anal segments are white, and the inverted 'V' shape notch is also present on the prothorax. The rings are also on the body, discolouring from brownish to dirty yellowish. The posterior region of the prothorax is mottled, however anterior region is white in colour. A curved shape mark is on the antero-lateral side of the prothorax just above the prothoracic legs. The larvae of this instar start to make a silken web of white colour and feed inside it. In comparison, the fourth instar larvae of *S. incertulas* are dirty white in colour with light brown head. The intersegmental membrane is marked by two rings of light yellow colour on each body segment.

Fifth instar

The fifth and final instar of *S. fusciflua* were greenish yellow in colour with orange head. The larvae feed inside the silken web and the crochets were clearer than *S. incertulas*. The larvae of *S. incertulas* were also greenish yellow with orange-yellow head with a prominent prothoracic shield and numerous dots on head. Two brownish marks structured the anal segments. The crochets were lighter in colour than white stem borer.

Sixth instar

The sixth instar larvae of *S. incertulas* were greenish yellow to yellowish white in colour with orange head. The crochets were short and stout and circled by 'C' shaped black colour circle arranged in a single narrow ellipse. The colour characteristics of different larval instars conform with the description reported by Panigrahi & Rajamani (2008), Banerjee & Pramanik (1967) and Nishida & Tori (1970).

Pre pupal and pupal period

The pre-pupal and pupal stages lasted for 1-2 days and 7-9 days, respectively, in both species. Pupation occurs in the stem near ground level, and before pupation, the larvae make an exit hole for adult could emerge (Plate 9). The present finding is in accordance with earlier researchers, Pathak & Khan (1994), Banerjee & Pramanik (1967). The duration of pre pupal period are in conformity with Malhi and Brar (1998), Korat and Patel (1998) and Hugar et al. (2010), who reported the average pre-pupal period of 1.15 days, 1 day, and 1.2 days, respectively. The pupae were observed pale white in colour at first and then gradually turned dark brown and the female pupa were slightly larger and heavy in weight than the male pupae (Plate 5-6). In the present study, the pupae were partly exarate and the tips of their appendages were free. The similar colour characteristics and result on pupal period duration are in agreement with Panigrahi & Rajamani (2008), Hugar et al. (2010), Jadhao & Khurad (2012) and Manikandan et al. (2013), who reported the average pupal period of 7.52-8.06, 7.6-8.6, 8.0 and 7.25 days, respectively.



Plate 9. Pupation of *Scirpophaga* spp. larvae near water/ground level



Plate 5. Exarate pupae of *Scirpophaga* spp.



Plate 6. *Scirpophaga* spp. pupae with white thin silken case
Adults

The male moths of *S. fusciflua* were smaller than females. The forewings were ochreous white in colour with prominent wing venation in both the sexes. The abdomen is wide and tip of abdomen is covered with a tuft of yellow hairs in females (Plate 3). The length and breadth of male and females of *S. fusciflua* were smaller in size than *S. incertulas*. The colour characteristics of *S. fusciflua* were very close *S. virginia* except the differences in the subteguminal process, bilobed in *S. fusciflua* and rounded in *S. virginia* as observed by Saini et al. (2017). The adult female of *S. incertulas* was bright yellowish brown or straw coloured with a conspicuous single black spot at centre towards lower angle of the forewing and hindwings are pale straw coloured. The tip of abdomen of female is covered with tuft of yellowish silken hairs forming a circle around a ventral opening. The male moth has numerous small dark spots near the tip of brown coloured forewing. The spots on the forewing are not

conspicuous. Male moth is smaller than female with devoid of hairs on the tip of abdomen (Plate 7-8). The abdomen is slender and the anal end has a thin hair

covering dorsally are supported by Korat & Patel (1998), Malhi & Brar (1998) and Panigrahi & Rajamani (2008).



Plate 3. Eggs after separation of Hairs from egg masses and *S. fusciflua* female with yellowish tuft of hairs



Plate 7. Adult of *S. incertulas*



Plate 8. Female & male of *S. incertulas*

Ovipositional periods and adults' longevity

The pre-oviposition, oviposition, post-oviposition period and longevity of *S. fusciflua* and *S. incertulas* adults were almost similar in both species (Table 3). The present findings are in support with Panigrahi & Rajamani (2008). The present result is almost in accordance with Hugar *et al.* (2010), who observed that the pre-oviposition, oviposition and post oviposition period were 1.28, 1.15 and 1.01 days. The present findings are strongly supported by the findings of Korat & Patel (1988) that the pre-oviposition period of 1.13 days with an oviposition period of 1.33 days. The data on longevity indicates that the males were short-lived than the females, supported by Korat & Patel (1988), Malhi & Brar (1998) and Hugar *et al.* (2010), who reported the longevity of male and female was 2.27 and 2.80, 2.50 and 2.78, and 2.95 and 3.44 days, respectively.

Egg masses and fecundity

The number of egg masses laid by female ranged from 1-3 and 1-4 in *S. fusciflua* and *S. incertulas*, respectively (Table 3). The number of eggs varied from female to

female and mainly the fecundity depends upon life span which is influenced by several factors like temperature, humidity and rainfall intensity at the time of the ovipositional period of moths. The present finding are in agreement of Panigrahi and Rajamani (2007 and 2008) who reported that the number of egg masses laid by *S. incertulas* ranged from 1-3 egg masses/ female. The lepidopterous laid eggs in masses are in accordance with Khan et al. (1991), Pathak & Khan (1994) and

Manikandan et al. (2013). The number of eggs laid per female of *S. fusciflua* ranged from 64-212 eggs and 92-187 eggs in *S. incertulas*. The results are strongly in agreement with the findings of Korat & Patel (1988), Bora et al. (1994), and Harinkhere & Aggarwal (1994), who reported the average fecundity of *S. incertulas* were 118.67 ± 42.58 , 133.4 ± 12.47 and 134.66 ± 14.44 , respectively.

Table 3. Duration of different developmental stages of *Scirpophaga fusciflua* and *Scirpophaga incertulas* on rice cultivar CSR 30

S. No.	Insect stage/ Duration	Range (days)	
		<i>S. fusciflua</i>	<i>S. incertulas</i>
1	Pre pupal period	1-2	1-2
2	Pupal period	7-9	7-9
	Adult		
3	Preoviposition	1-2	1-2
4	Oviposition	1-2	1-3
5	Postoviposition	0-1	0-1
6	Male longevity	2-3	2-4
7	Female longevity	2-4	2-4
8	Total developmental period	40-55	40-53
9	Fecundity (No. of eggs laid/ female)	64-212	92-187
10	No. of egg masses/female	1-3	1-4
11	No. of eggs/egg mass	62-153	89-171
12	Hatching (%)	81.44-93.60	77.17-93.87

Average min. temperature range ($^{\circ}$ C) = 19.5

Average max. temperature range ($^{\circ}$ C) = 32.5

Relative humidity (%) = 62.0 – 79.0

Morphometrics on different stages of *S. fusciflua* and *S. incertulas* larval instars

In present study, the average measurement on length of 1st, 2nd, 3rd, 4th and 5th larval instars was 2.30, 5.10, 9.00, 13.90 and 17.80 mm with mean head capsule width of 0.18, 0.35, 0.49, 0.63 and 0.78 mm in *S. fusciflua*, while in six larval instars of *S. incertulas* mean larval length was 2.45, 5.60, 8.30, 12.10, 17.40 and 19.80 mm with mean head capsule width of 0.24, 0.43, 0.73, 0.91, 0.99 and 1.19 mm, respectively (Table 4, Plate 4). The results of the study are in conformity with the findings of Korat and Patel (1988), who reported that the average length and head capsule width of first, second, third, fourth and fifth larval instars was 2.03 ± 0.13 mm, 5.92 ± 0.83 mm, 10.25 ± 1.67 mm, 14.97 ± 1.64 mm and 21.18 ± 1.80 mm with head capsule width of first, second, third, fourth and fifth larval instars was 0.26 ± 0.26 mm, 0.49 ± 0.53 mm,

0.77 ± 0.61 mm, 0.96 ± 0.05 mm and 1.24 ± 0.09 mm, respectively are also in strong accordance with findings of Satpathi et al. (2012).

Table 4. Morphometrics of *Scirpophaga fusciflua* and *Scirpophaga incertulas* larvae

Larval stage	Larval length and head capsule width (mm) (Mean)			
	<i>S. fusciflua</i>		<i>S. incertulas</i>	
	Larval length	Head capsule width	Larval length	Head capsule width
First	2.30	0.18	2.45	0.24
Second	5.10	0.35	5.60	0.43
Third	9.00	0.49	8.30	0.73
Fourth	13.90	0.63	12.10	0.91
Fifth	17.80	0.78	17.40	0.99
Sixth	-	-	19.80	1.19

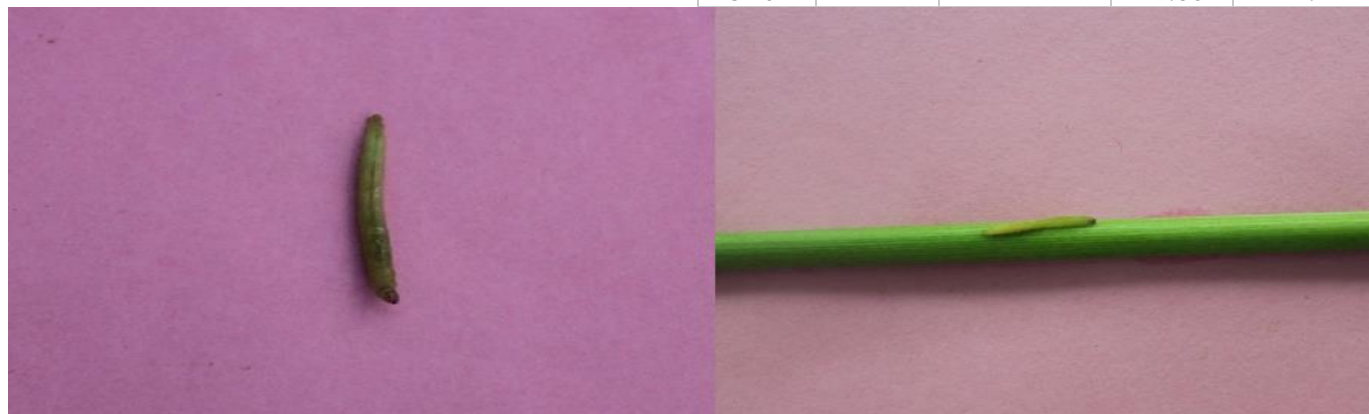


Plate 4. Larvae of *S. fusciflua* and *S. incertulas*

Morphometrics on pupae of *S. incertulas* and *S. fusciflua*

The length and breadth of male and female pupae were almost similar in both species. The *S. incertulas* pupae were slightly bigger in size than *S. fusciflua*, while the breadth was recorded more in *S. incertulas*. The female pupae were slightly larger and heavier than male pupa in both species (Table 5). The present findings are in accordance with the findings of Malhi & Brar (1998), Hugar et al. (2010) and Harinkhere & Aggarwal (1994).

Morphometrics on adults of *S. incertulas* and *S. fusciflua*

Table 5. Morphometrics of pupae, adults, egg masses and pupal weight in *Scirpophaga fusciflua* and *Scirpophaga incertulas*

Pupal length and breadth (mm) (Mean)								
<i>S. fusciflua</i>					<i>S. incertulas</i>			
	Length		Breadth		Length		Breadth	
	Male	Female	Male	Female	Male	Female	Male	Female
Mean	9.50	11.10	1.60	1.79	9.60	11.80	1.91	1.97
Range	9-10	11-12	1.59-1.62	1.75-1.82	9-10	11-13	1.90-1.93	1.96-1.98
Pupal weight (mg) (Mean)								
	Male		Female		Male		Female	
Mean	0.022		0.024		0.022		0.032	
Range	0.021-0.024		0.023-0.027		0.021-0.023		0.031-0.033	
Adult length and breadth (mm) (Mean)								
	Male	Female	Male	Female	Male	Female	Male	Female
Mean	9.40	11.00	16.60	19.0	12.10	15.40	18.70	27.50
Range	9-10	10-12	16-18	18-20	11-13	15-16	18-19	27-29
Egg masses length and breadth (mm) (Mean)								
Mean	12.80		3.20		8.10		4.05	
Range	8-17		3.0-3.5		7-9		3.5-4.5	

Morphometrics on egg masses of *S. incertulas* and *S. fusciflua*

The length and breadth of *S. incertulas* ranged from 7-9 mm with an average of 8.10 mm and 3.5-4.5 mm with an average of 4.05 mm, respectively. Whereas the length and breadth 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 in *S. fusciflua*, respectively (Plate 1-2). The egg masses of *S. fusciflua* were larger in size (12.80 mm) and smaller in breadth (3.20 mm) as compared with *S. incertulas* length (8.10 mm) and breadth (4.05 mm) (Table 5). The present findings are in accordance with Malhi and Brar (1998), while the short difference in size of egg masses was reported by Hugar et al. (2010). The difference in the sizes of egg masses may be due to varying conditions under which the insect was reared/studied.



Plate 1. Egg masses of *Scirpophaga incertulas*

The average length and breadth of *S. incertulas* males were 12.10 and 18.70 mm, whereas those of female were 15.40 and 27.50 mm, respectively. The average length and breadth of *S. fusciflua* males were 9.40 and 16.60 mm, whereas those of female were 11.00 and 19.00 mm, respectively. The male moth was smaller than female in both species (Table 5). The present findings conform with the findings of Malhi & Brar (1998), Korat & Patel (1988), Harinkhere & Aggarwal (1994) and Khan et al. (1991).



Plate 2. Egg masses of *Scirpophaga fusciflua*

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Declarations of interests

All authors of this manuscript declare that they have no conflict of interest.

Data sharing

All relevant data are within the manuscript.

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