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Biology of *Sitotroga cerealella* (Olivier) (Lepidoptera: Gelechidae) on Stored Wheat, *Triticum aestivum* L.

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Abstract
The investigation was conducted to study the biology of *Sitotroga cerealella* Olivier on stored wheat, *Triticum aestivum* L. in the laboratory of the Department of Entomology, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India, during 2021-22 at 30.25 ± 0.25 ºC temperature and 75.00 ± 5.06% relative humidity. The mean oviposition, incubation and larval-pupal period of *S. cerealella* were 3.5 ± 0.61, 4.2 ± 1.01 and 26.7 ± 1.38 days, respectively. The male and female longevity were 10.25 ± 0.97 and 7.60 ± 0.75 days, respectively. The average length and breadth of eggs were 0.61 ± 0.05 and 0.31 ± 0.02 mm, respectively. The average length and breadth (across the wings expanded) of male were 3.82 ± 0.26 and 7.70 ± 0.31 mm, respectively, whereas, the female moth measured on an average 4.25 ± 0.26 mm in length and 9.61 ± 0.46 mm in breadth. The mean total life cycle of male and female of *S. cerealella* was 38.5 ± 1.79 and 41.15 ± 1.87 days, respectively.

Keywords: *Sitotroga cerealella*, biology, stored wheat

Introduction
Wheat, *T. aestivum*, belongs to the family Poaceae and widely cultivated in India. In India, It ranked second after rice in terms of area and production. During 2020-21, the wheat production reached to 108.75 million tonnes with an average national productivity of 3424 kg/ha (Annual Report, 2020-21) [3]. In India, annual storage losses were estimated as 14 million tonnes of food grains worth $16,000 million every year. Food grain losses due to insects alone accounted for a monetary loss of $300 million (Ghizdavu and Diec, 1994) [7]. Among the different insect pests attacking wheat grains, *S. cerealella* is one of the most destructive internal pests and has a great potential as a pre-harvest and post-harvest threat to grain crops (Agrawal *et al.* 1977; Singh *et al.* 1978) [1, 18]. The infestation of *S. cerealella* in wheat starts from the field as females lay their eggs singly or in groups on grains (Ghizdavu and Diec, 1994) [7]. The destructive stage is larva that feeds on the endosperm of the host grains and may cause considerable damage to them (Weston *et al.* 1993) [21]. Larval feeding inside the grain cause an appreciable amount of damage to stored grain which has been stated about 8.1% and infested grain becomes unfit for consumption. Sedlacek *et al.* (1998) [16] and Weston & Rattlingourd (2000) [20] reported additional indirect damage to the grains through the attacks of certain secondary insect pests. *S. cerealella* reduces weight, germination of seed, nutritional value and market price of maize grains (Srivastava and Subhramanian, 2016; Basavanjali *et al.* 2020; Sachin *et al.* 2022) [17, 5, 14]. The infested grains smell and taste unpleasant (Kossou and Et Aho, 1993) [8]. Infestation is hidden and cannot be easily assessed in the early stages. The data on the biology of *S. cerealella* on stored wheat is scarce. Moreover, there is the need to know the biology of *S. cerealella* as it helps in the easier management of the pest. Therefore, the present experiment was attempted to study the biology of *S. cerealella* on stored wheat under Laboratory Condition.

Materials and Methods
The study was undertaken in the laboratory of the Department of Entomology, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India, during 2021-22. Male and female adults of *S. cerealella* were collected from the infested stored wheat grain and sorted out under a simple microscope by observing their abdominal tergites. When *S. cerealella* adults were viewed from the ventral side of the abdomen of males, it was narrower, pointed and blackish while the abdomen was broad and long in females with no blackish

shades, and the body length of males were smaller than females. The biology of *S. cerealella* was studied on wheat grains under laboratory conditions by maintaining 30.25 ± 0.25ºC temperature and 75.00 ± 5.06% relative humidity. The collected adult moths were enclosed for mating and oviposition in plastic jars covered with muslin cloth. The adults were kept in the glass cylinder for mating and subsequent egg laying. Eggs were collected by brushing the wall of cylinder and stored in refrigerator to ensure supply for future study.

To study the egg stage, freshly laid eggs of *S. cerealella* were taken individually in the plastic container from the laboratory culture to record the incubation period. The incubation period was considered as the period between the date of egg laying and the date of egg hatching. By cutting infested grains from the pure culture with the use of blade, the morphological characters of larva and pupa were examined. Developmental stages of *S. cerealella,* larval-pupal period and adult longevity were recorded. Larval-pupal period was worked out by recording period between the date of hatching of larva and adult emergence. The emerged adults of *S. cerealella* were kept in the plastic jar until the death and the adult longevity was recorded. Reproductive parameters, oviposition period and fecundity were observed and recorded. The morphological characters of different stages of *S. cerealella* were observed under a stereoscopic trinocular microscope.

Results and Discussion

Mating and Oviposition

The *S. cerealella* adults started mating 30-35 minute after the emergence. The mating took place in tip-to-tip position (Fig. 1). The copulation period varied from 50 to 210 minute with an average of 126 minute. On wheat grains, a single female *S. cerealella* laid about 39 to 175 eggs with an average of 90.65 ± 34.32 eggs throughout its life (Table 1). The eggs were laid singly or in batches of 2 to 10 eggs generally on the crease of wheat grain (Fig. 2). The average fecundity of *S. cerealella* on maize, ranged from 106.7 to 146.3 numbers (Pandey *et al.* 1976) [12]. The fecundity of *S. cerealella* was observed to be 109 ± 57.23 eggs per female on rice (Akter *et al.* 2013) [2] and 93.3 ± 2.1 eggs per female on stored maize (Demissie *et al.* 2014) [6]. Singh *et al.* (2014) [19] found that the mean fecundity was 100.57 eggs per female. The mean oviposition and incubation period was found to be 3.5 ± 0.61 and 4.2 ± 1.01 days, respectively (Table 2). Newly hatched eggs were white in colour, but gradually changed to reddish brown at the time of hatching and oval to elongate in shape (Fig. 3). The average length and breadth of eggs were found to be 0.61 ± 0.05 and 0.31 ± 0.02 mm, respectively (Table 3). The incubation period was 3.3 ± 0.5 days in rice and 2.8 ± 0.8 days in maize (Saikia *et al.* 2014) [15]. The Oviposition period and incubation period of *S. cerealella* on paddy were 2.5 ± 0.53 and 4.1 ± 0.70 days, respectively (Basavanjali *et al.* 2020) [5]. The oviposition and incubation period of *S. cerealella* on maize crop were 3.21±0.014 and 4.3 ± 0.016 days, respectively (Sachin *et al.* 2022) [14]. The average fecundity and incubation period of *S. cerealella* on maize, ranged from 106.7 to 146.3 numbers and 4.3 to 5.7 days, respectively (Pandey *et al.* 1976) [12]. Singh *et al.* (2014) reported that the mean incubation period and mean fecundity were 6.23 ± 0.07 days and 100.57 eggs per female, respectively (Singh *et al.* 2014) [19].

Table 1: Number of eggs laid by *S. cerealella* at different days on wheat grains under laboratory condition

Sr. No.	Pairs	Number of eggs laid				Total number of eggs laid
		1st day	2nd day	3rd day	4th day	
1	1st	98.00	45.00	8.00	0.00	151.00
2	2nd	50.00	32.00	4.00	2.00	88.00
3	3rd	28.00	30.00	7.00	0.00	65.00
4	4th	48.00	37.00	10.00	3.00	98.00
5	5th	43.00	32.00	15.00	11.00	101.00
6	6th	30.00	27.00	10.00	0.00	67.00
7	7th	70.00	41.00	6.00	1.00	118.00
8	8th	32.00	56.00	11.00	2.00	101.00
9	9th	45.00	66.00	4.00	0.00	115.00
10	10th	54.00	25.00	11.00	5.00	95.00
11	11th	101.00	50.00	15.00	9.00	175.00
12	12th	12.00	22.00	5.00	0.00	39.00
13	13th	45.00	38.00	11.00	2.00	96.00
14	14th	18.00	22.00	15.00	4.00	59.00
15	15th	32.00	11.00	2.00	0.00	45.00
16	16th	78.00	21.00	10.00	0.00	109.00
17	17th	55.00	20.00	0.00	0.00	75.00
18	18th	15.00	22.00	5.00	0.00	42.00
19	19th	42.00	29.00	11.00	7.00	89.00
20	20th	33.00	41.00	8.00	3.00	85.00
Min.		12.00	11.00	0.00	0.00	39.00
Max.		101.00	66.00	15.00	11.00	175.00
Mean ± SD		46.45 ± 24.67	33.35 ± 13.58	8.40 ± 4.27	2.45 ± 3.27	90.65 ± 34.32

Table 2: Developmental period of life stages of *S. cerealella* on wheat grain in the laboratory

Developmental Stages	Duration (in days) (Av. ± SD)
Pre-oviposition	1.50 ± 0.69
Oviposition	3.5 ± 0.61
Post-oviposition	5.25 ± 1.25
Incubation	4.2 ± 1.01
Larval-pupal	26.7 ± 1.38
Adult longevity	
Male	7.6 ± 0.75
Female	10.25 ± 0.97
Total Life Cycle	
Male	38.5 ± 1.79
Female	41.15 ± 1.87

Table 3: Morphometric of life stages of *S. cerealella* on wheat grain in the laboratory

Life stage	Size (mm)	
	Length	Width
Egg	0.61 ± 0.05	0.31 ± 0.02
Adult wing span		
Male	3.82 ± 0.26	7.70 ± 0.31
Female	4.25 ± 0.26	9.61 ± 0.46

Fig 1: Adults in mating position

Fig 2: Eggs of *S. cerealella*

Fig 3: Microscopic view of eggs

Larval-pupal period

The neonate larva of *S. cerealella* was tiny, elongate and yellowish white to yellowish red in colour which gradually turned white within one or two days of feeding (Fig. 4). The newly emerged larvae remained crawling on the grains and surface of rearing container for about 30 to 60 minute and then started feeding the grain by searching comparatively weaker spot for the entry in the grain (Fig. 5, 6 and 7). The larvae of all other instars were yellowish white in colour with light brown head (Fig. 8, 9 and 10). The freshly formed pupa was yellowish brown in colour which later changed to dark brown (Fig. 12, 13 and 14). Pupa developed inside the silken cocoon (Akter *et al.* 2013) [2]. *S. cerealella* was an internal feeder as the larval and pupal stages developed inside the grain. The mean larval-pupal period was 26.7 ± 1.38 days on wheat grains (Table 2). The total larval and pupal period were 21.74 ± 0.1 days on wheat (Nasseri *et al.* 2017) [11] and 26.31 ± 0.60 days on maize (Demissie *et al.* 2014) [6]. Basavanjali *et al.* (2020) [5] found that the larval and pupal period of *S. cerealella* on paddy were 24.3 ± 2.25 and 6.3 ± 0.95 days, respectively. There was slight variation in larval-pupal duration might be due to nutritional status of hosts.

Fig 4: Teneral of *S. cerealella*

Fig 5: Larva entering in to grain

Fig 6: Larva inside the grain

Fig 7: First instar larva

Fig 8: Second instar larva

Fig 9: Third instar larva

Fig 10: Fourth instar larva

Fig 11: Pre-pupa

Fig 12: Pupa dorsal side

Fig 13: Pupa ventral side

Adult period: The adults of *S. cerealella* were pale golden-yellowish or grey coloured with greyish brown head and thorax (Fig. 15, 16 and 17). The fore wing was trapezoid in shape with one or two blackish dots on it. The hind wing was sharply pointed at the apex with dense fringe of hairs on margin (Fig. 17). Male moth was smaller than female moth in size. The length and breadth (with wing expanded) of female were 4.25 ± 0.26 and 9.61 ± 0.46 mm, respectively. While male length and breadth were 3.82 ± 0.26 and 7.70 ± 0.31 mm, respectively (Table 3). In rice, the length and breadth of female were 4.17 and 9.66 mm while, in male they were 3.51 and 7.55 mm, respectively (Naseri *et al.* 2017) [11]. The length of male and female moth was 10.1 ± 0.29 and 11.2 ± 0.33 mm respectively (Basavanjali *et al.* 2020) [5]. The adult longevity was 7.6 ± 0.75 days for male and 10.25 ± 0.97 days for female (Table 2). The male and female longevity were 6.1 ± 1.10 and 8.5 ± 0.85 days, respectively (Basavanjali *et al.* 2020) [5]. The adult longevity period ranged from 7.2 to 8.4 days for female and 6.8 to 7.6 days for male, respectively on maize (Prakash *et al.* 2004) [13]. The adult longevity was reported to be 8.9 days in male and 9.8 days in female respectively (Ashamo, 2009) [4]. Sachin *et al.* (2022) [14] reported the male and female longevity of *S. cerealella* were 5.8 ± 0.019 and 9.1 ± 0.025 days were recorded.

Fig 14: Male and female pupae

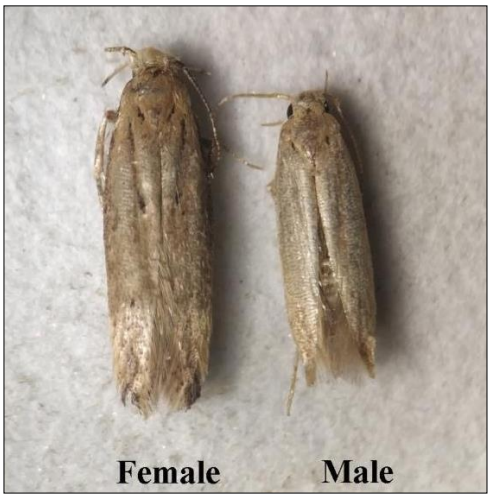

Fig 15: Adult female and male (Dorsal side)

Fig 16: Adult female and male (Ventral side)

Fig 17: Adult spreading wing

Total life cycle

The total life cycle of female and male *S. cerealella* were 41.15 ± 1.87 and 38.5 ± 1.79 days, respectively (Table 2). The development cycle varied from 37 to 45 days on wheat (Koleva *et al.* 2009) [9]. The total life cycle of male and female completed in 47.70 and 49.70 days on rice grains, respectively (Akter *et al.* 2013) [2]. Ghosh and Durbey (2013) [8] reported that the total life cycle was completed in 27 to 40 days. The total life cycle was 41.4 ± 3.54 days (Basavanjali *et al.* 2020) [4] and 42.95 ± 0.056 days, under laboratory conditions (Sachin *et al.* 2022) [14] which are concurrent with the present findings.

Conclusion

The *S. cerealella* was the most destructive internal pests of wheat which developed through egg, different larval instars, pre-pupa, pupa and adult stages. The destructive stage was larva. The male moth was smaller than the female moth in size. The longevity of females was more than that of males. The *S. cerealella* completed its life cycle in 38 to 41 days.

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