International Journal of Environmental & Agriculture Research (IJOEAR)
ISSN: [2454-1850]
[Vol-12, Issue-7, July- 2026]
Website: www.ijoear.com
Journal DOI: 10.25125/agriculture-journal

Biology of Angoumois Grain Moth, *Sitotroga cerealella* Olivier on Sorghum

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Received:- 08 July 2026/ Revised:- 18 July 2026/ Accepted:- 27 July 2026/ Published: 31-07-2026

Abstract— *The Angoumois grain moth, Sitotroga cerealella Olivier is one of the most serious pests of sorghum at post-harvest. The experiment was carried out at Biocontrol Laboratory, Department of Entomology, N. M. College of Agriculture, Navsari Agricultural University, Navsari during the period from June to November, 2025 to study the biology of the Angoumois grain moth, Sitotroga cerealella Olivier on sorghum. The study revealed that the incubation period, total larval and pupal period, pre-oviposition, oviposition and post-oviposition period of Angoumois grain moth were 4.42 ± 1.03 days, 26.00 ± 1.89 days, 1.95 ± 0.78 days, 3.03 ± 0.77 and 4.28 ± 1.01 days, respectively. The average hatching percentage of egg was 87.57 ± 4.74%. The average number of eggs laid by a female moth was 100.23 ± 35.87 eggs per female. The average longevity of female moth was 9.35 ± 1.03 days while male moth lived for 7.10 ± 0.77 days. The total life cycle of female and male of* S. cerealella *were 43.17 ± 2.74 days and 38.30 ± 2.41 days, respectively*.

Keywords— Sorghum, Biology, Angoumois grain moth,* Sitotroga cerealella*, Stored grain pest, Life cycle, Fecundity, Post-harvest loss.

I. INTRODUCTION

Sorghum is a significant cereal crop that is widely cultivated in tropical and subtropical climates worldwide. For millions of people, it is a staple food, especially in Asia and Africa, where it is a vital source of nutrition and energy. Globally, the United States leads in sorghum production with 9,957 MT while India ranks fourth with 4,600 MT (Anonymous, 2025). According to Oganja et al. (2024), it covered over 0.4 lakh hectares in Gujarat and produced 0.5 lakh tonnes annually with a productivity of 1378 kg per ha in 2023-2024. After rice and wheat, sorghum comes in third place in terms of area and production. Nutritionally, sorghum is rich in carbohydrates, protein, fibre, vitamins and minerals and it is gluten-free, making it a valuable food source (Hariprasanna and Patil, 2015).

Storage losses are affected by several factors which can be classified into two main categories: biotic factors (insect pests, rodents and fungi) and abiotic factors (temperature, humidity and rain). Among all the biotic factors, insect pests are considered the most important and cause huge losses in the cereal grains (30% - 40%) (Kumar, 2017). The most important pests affecting grains are found within the order Lepidoptera, *S. cerealella* (Lepidoptera: Gelechiidae) which is a serious pest affecting grains (Boshra, 2007). Infestation of this pest starts in the field itself and immature stages from the field infestation complete their life cycle and emerge as adults in storage (Reed et al., 2002). After entering the grain, the larva feeds internally and subsequently turns around to seal the entry point by spinning a silken web over the opening. Infested grains are typically hollow inside and

filled with larval excreta or silken webs with a circular opening left for the emergence of adult moths. Germination is severely affected after infestation (Ahmad et al., 2021).

II. MATERIALS AND METHODS

The experiment on biology of Angoumois grain moth, *Sitotroga cerealella* Olivier was carried out in Biocontrol Laboratory, Department of Entomology, N. M. College of Agriculture, NAU, Navsari during June to November, 2025.

2.1 Disinfestation of Grains

The required quantity of sorghum seeds (variety GJ-102) was collected, thoroughly cleaned and sieved to eliminate foreign materials. The seeds were sterilized in a hot air oven at 55°C for 4 hrs to ensure disinfection. Following sterilization, the seeds were kept at room temperature for 24 hrs to allow equilibration, making them suitable for pest infestation. These sterilized seeds were subsequently used to maintain cultures for experimental purposes.

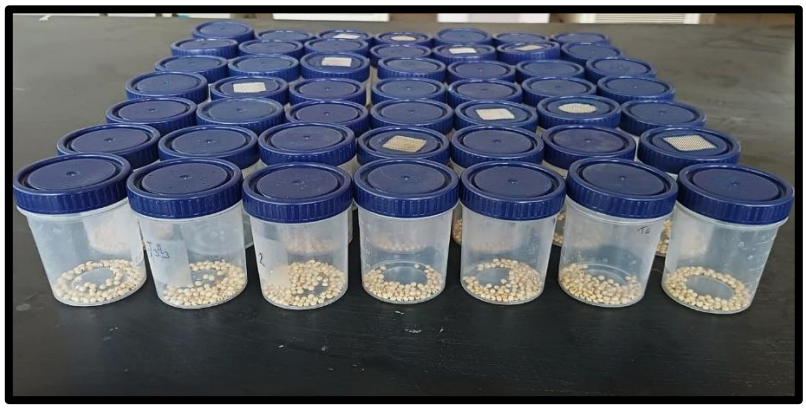
2.2 Maintenance of Laboratory Culture

Male and female adult moths were collected from infested stored sorghum grain sorted out under a simple microscope by observing their abdominal tergites. In males, the abdomen is thinner, pointed and blackish when viewed from the ventral side whereas in females, the abdomen is bulky and long without any blackish coloration and body size of the male is smaller than female.

Adults of *S. cerealella* were collected from infested grains in storage facilities to establish a laboratory stock culture. Ten pairs of adults were introduced into a glass jar (20 × 15 cm) containing 250 g of sterilized sorghum seeds. The jar was covered with muslin cloth secured by a rubber band to prevent adult moths from escaping and to exclude other insects. The culture was maintained at room temperature (Plate 1).

Newly emerged adults from this stock culture were used for subsequent multiplication and experimentation. To ensure a continuous supply of fresh *S. cerealella* adults, cultures were regularly maintained at predetermined intervals following this rearing protocol. Appropriate care was taken in handling both the insects and seeds throughout the process.

Maintenance of stock culture of *S. cerealella*



Laboratory rearing of *S. cerealella*

PLATE 1: Maintenance of stock culture and laboratory rearing of *S. cerealella* on sorghum

2.3 Collection of Eggs of *S. cerealella*

For the collection of fresh eggs, the freshly emerged adults of *S. cerealella* were collected from laboratory culture and were kept in a cylinder for one day for mating and subsequent egg laying on the glass cylinder. The top of the glass cylinder was covered by muslin cloth. In the consecutive days the eggs laid inside the cylinder were collected with the help of camel hair brush. The eggs were cleaned by removing body parts of moth and fresh eggs were obtained. The collected eggs of *S. cerealella* were kept into a glass tube with labelling and stored in a refrigerator to ensure a continuous supply for future study.

2.4 Egg

For egg period, freshly laid 40 eggs were taken individually in the plastic container from the laboratory culture and observed regularly in the morning for hatching purpose. The incubation period was considered as the period between the date of egg laying and date of egg hatching. The percent egg hatchability of *S. cerealella* was calculated by using the following formula:

$$\text{Egg hatchability (\%)} = \frac{\text{Number of neonate larvae hatched out}}{\text{Total number of eggs}} \times 100 \quad (1)$$

2.5 Larva and Pupa

The morphological characters of larva and pupa were studied by cutting infested grains from the pure culture with the help of a blade. With a view to determining the total larval and pupal period, newly hatched 40 larvae were reared separately on sorghum grains into plastic container (7.5 × 5.5 cm). Total larval and pupal period were recorded.

2.6 Adult

The newly emerged adults were observed for their size, colour and sex differences. To make out the morphological difference in male and female adult, mating pairs of the adults were collected and each of the individuals was examined under microscope carefully. For longevity of male and female, freshly emerged 40 individual adults of each were confined in a transparent plastic container (7.5 × 5.5 cm) and observations were recorded from the period between the emergence of adults to the death of adults. Adults confined in the jar for egg laying were closely observed for their mating behaviour. The female was provided with a male immediately after its emergence and the time from the emergence of the female to starting of mating copulation period, frequency of mating and egg laying behaviour were observed. For sex ratio, all the emerged adults were examined critically to determine male or female on the basis of their morphological characters and the ratio (male: female) was calculated.

2.7 Pre-oviposition, Oviposition and Post-oviposition Period

For oviposition, 40 females were reared separately in each plastic vial (7 × 6 cm) containing 10 g conditioned sorghum grain to observe the pre-oviposition, oviposition and post-oviposition periods. The pre-oviposition period was determined by the newly emerged adult pair. The pre-oviposition period was calculated from the date of emergence of adult female to the date of commencing the egg laying. Oviposition period was calculated from the date of commencing the egg laying to the ceasing of the egg laying by an individual female. The post-oviposition period was calculated from the date of the ceasing of egg laying to the death of adult female.

For fecundity of *S. cerealella*, a number of eggs laid by a single female were collected and counted daily in the morning till the death of the female. The eggs laid by a female were stuck to the base of container and were collected and counted daily with the help of moist fine camel hair brush.

2.8 Life Cycle

With a view to determine the total life cycle of *S. cerealella*, counted numbers of adults were reared separately in a transparent plastic container (7.5 × 5.5 cm) on sorghum grains. The period from date of egg laid to the date of adult emergence was calculated as a life cycle. The total life span of male and female was calculated from the date of egg laid to the death of an adult. Observations on *S. cerealella* were calibrated under the trinocular stereo zoom microscope.

III. RESULTS AND DISCUSSION

3.1 Egg

The eggs of *S. cerealella* were placed on sorghum grains either individually or in clusters. The newly laid eggs were creamy-white, soft and oval to elongated in shape. At the time of hatching, the colour changed to a reddish brown. The length of eggs varied from 0.50 to 0.70 mm with an average of 0.60 ± 0.06 mm, whereas the breadth ranged from 0.28 to 0.32 mm with an average of 0.29 ± 0.01 mm (Table 1). The present study is supported by the results of El-Sherif et al. (2008) who reported that the eggs of *S. cerealella* were placed on maize grains either individually or in clusters of two to sixty and average length and breadth of the egg measured was 0.60 mm and 0.30 mm, respectively.

3.2 Incubation Period, Fecundity and Hatching Percentage

The incubation period varied from 3 to 6 days with an average of 4.42 ± 1.03 days. The adult female of *S. cerealella* laid eggs singly or in batches of 2 to 10 eggs. The egg laying capacity of female moth varied from 48 to 170 eggs per female with an average of 100.23 ± 35.87 eggs per female (Table 2). The hatching rate of eggs varied from 77.19 to 95.29% with an average of 87.57 ± 4.74%. Zote (2023) observed that the incubation period of *S. cerealella* was 3 to 7 days with an average of 4.92 ± 1.37 days on rice. The average incubation period of *S. cerealella* recorded by Basavanjali et al. (2020) was 4.10 ± 0.70 days. According to Akter et al. (2013), the single female moth of *S. cerealella* can produce 42 to 213 eggs with an average of 109 eggs per female. Muthukumar et al. (2017) found that the mean number of eggs laid by *S. cerealella* was 94.76 eggs, ranging from 75.60 to 110.60 eggs. The results are in accordance with Patel (2019) who recorded that the hatching rate of egg varied from 71.79 to 97.14% with an average of 89.30 ± 6.09%. El-Sherif et al. (2008) noted that the hatching percentage ranged from 85 to 100% with a mean of 91%.

3.3 Larva

S. cerealella had four different instars. Similar findings of four instars were also reported by El-Sherif et al. (2008) and Saikia et al. (2014). The freshly hatched larva was yellowish white to yellowish red in colour with light brown head. It had three pairs of thoracic legs and four pairs of prolegs. The colour of the larva gradually turned white within one or two days of feeding. Zote (2023) reported that the newly hatched larva was tiny, elongate and creamy white to yellowish red in colour which gradually turned white within two days of feeding. Second instar larva was creamy white in colour with yellowish brown head and strong mandibles. The head was somewhat narrower than the prothorax. The prolegs were poorly developed and white in colour. Three thoracic and 10 abdominal segments observed and it was less active than the first instar larva. Patel (2019) recorded that second instar larva of *S. cerealella* was white in colour with yellowish brown head and strong mandibles. Third instar larva was morphologically similar to second instar larva but slightly larger in size. The head was yellowish brown in colour and slightly narrower than prothorax. The body of larva was whitish in colour. Zote (2023) observed that the appearance of the third instar larva closely resembled to that of second instar. Fourth instar larva was the same as the third instar larva in morphology but bigger in size. The fully grown larva was dirty white in colour with brownish head. Patel (2019) reported that the fourth instar larva of *S. cerealella* was the same as the third instar larva in morphology but bigger in size.

3.4 Pre-pupa and Pupa

The colour of pre-pupa was milky white to pale yellowish and it was formed inside the sorghum grain. It was smaller in size than full grown larva. The freshly formed pupa was yellowish brown in colour which later changed to dark brown and developed inside the delicate silken cocoon. The pupa was obtect type. Abdomen of developing adult was clearly marked into 10 segments in pupal stage. According to Basavanjali et al. (2020), the pupa of *S. cerealella* was brown in colour, developed inside the silken cocoon.

3.5 Total Larval and Pupal Period

The total larval and pupal period varied from 23 to 29 days with an average of 26.00 ± 1.89 days on sorghum grains. The present study is supported by the results of Demissie et al. (2014) who revealed that the total larval and pupal period of *S. cerealella* was 26.31 ± 0.60 days at 30°C temperature and 28.00 ± 0.97 days at 32°C temperatures. Borzoui et al. (2016) observed that the total larval and pupal period was 26.26 ± 0.24 days on sorghum.

3.6 Adult

The moths were pale golden-yellowish or grey-coloured with greyish brown head and thorax. The fore wing was pale greyish-brown in colour and small black dots was located on it. The hind wing was sharply pointed at the apex with dense fringe of hairs on margin. In terms of morphology, the male and female moths were nearly same to each other except the abdomen which was slender and blackish in male while that of female was broader and greyish white in colour. The female moth is larger than male moth in size. Kumar et al. (2022) described the moth as buff or grey in colour with dark markings on the fore wings, pointed hind wings exposing the abdomen and females larger than males in size on stored maize. The results obtained through the present study are in agreement with the results of earlier workers. The body length of female varied from 3.70 to 4.70 mm with an average of 4.20 ± 0.36 mm and breadth with wing expanded varied from 8.50 to 10.50 mm with an average of 9.59 ± 0.64 mm. Whereas, in case of male the length and breadth with wing expanded varied from 3.20 to 4.10 mm and 7.30 to 8.50

mm with an average 3.69 ± 0.28 mm and 7.79 ± 0.43 mm, respectively. These results are in accordance with Patel (2019), who reported that the length and breadth of female and male were 4.25 and 9.61 mm and 3.82 and 7.70 mm, respectively.

3.7 Pre-oviposition, Oviposition and Post-oviposition Period

The pre-oviposition period of *S. cerealella* varied from 1 to 3 days with an average of 1.95 ± 0.78 days. The oviposition period varied from 2 to 4 days with an average of 3.03 ± 0.77 days and post-oviposition period varied from 3 to 6 days with a mean of 4.28 ± 1.01 days (Table 2). Equivalent observations were also reported by Patel (2019) who recorded that the pre-oviposition, oviposition and post-oviposition period of *S. cerealella* for stored wheat were 1.50 ± 0.69 days, 3.50 ± 0.61 days and 5.25 ± 1.25 days, respectively. According to El-Sherif et al. (2008), the pre-oviposition period, oviposition and post-oviposition period were 2.60 days, 4.10 ± 0.28 days and 4.40 ± 0.26 days, respectively on maize grain.

3.8 Adult Longevity and Total Life Cycle

The longevity of female varied from 8 to 11 days with an average of 9.35 ± 1.03 days while male longevity varied from 6 to 8 days with an average of 7.10 ± 0.77 days. It showed that the female adult lived for longer duration than male adult (Table 2). According to Basavanjali et al. (2020), the average longevity of adult female and male of *S. cerealella* was 8.50 ± 0.85 days and 6.10 ± 1.10 days, respectively. Kumar et al. (2022) observed that the longevity of male adult *S. cerealella* ranged from 5 to 7 days with an average of 5.80 ± 0.01 days while female longevity ranged from 8 to 10 days with an average of 9.10 ± 0.02 days. The results of above workers are more or less similar to the present findings. The total life cycle of female varied from 39 to 48 days with an average 43.17 ± 2.74 days while, in case of male it varied from 35 to 42 days with an average of 38.30 ± 2.41 days. Saikia et al. (2014) studied that the average total life cycle of female was 43.20 and 44.30 days on rice and maize, respectively. While in case of male, the average total life cycle was 37.40 and 43.30 days on rice and maize, respectively. According to Basavanjali et al. (2020), the total life cycle of *S. cerealella* was 35 to 45 days with an average of 41.40 ± 3.54 days. The results of above workers are more or less supported with the present results.

TABLE 1

MORPHOMETRY OF EGGS AND ADULT OF *S. CEREALELLA* ON SORGHUM

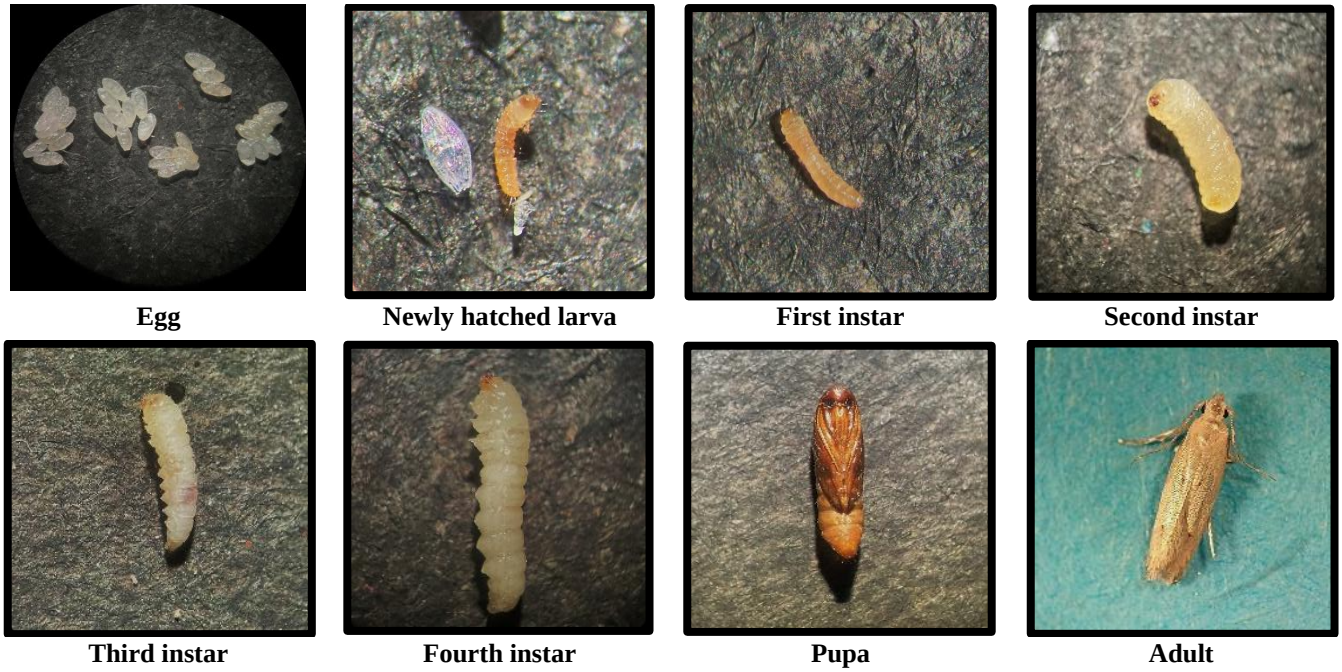
Sr. No.	Life stage	Length (mm)		Breadth (mm)	
		Range	Mean ± SD	Range	Mean ± SD
1	Eggs	0.50-0.70	0.60 ± 0.06	0.28-0.32	0.29 ± 0.01
2	Adult Female	3.70-4.70	4.20 ± 0.36	8.50-10.50*	9.59 ± 0.64*
3	Adult Male	3.20-4.10	3.69 ± 0.28	7.30-8.50*	7.79 ± 0.43*

Breadth with wings expanded

TABLE 2

DEVELOPMENT PERIODS OF DIFFERENT LIFE STAGES OF *S. CEREALELLA* ON SORGHUM

Sr. No.	Particulars	Periods	
		Range	Mean ± SD
1	Incubation period (Days)	03-Jun	4.42 ± 1.03
2	Hatching (%)	77.19-95.29	87.57 ± 4.74
3	Larval + Pupal period (Days)	23-29	26.00 ± 1.89
4	Pre-oviposition period (Days)	01-Mar	1.95 ± 0.78
5	Oviposition period (Days)	02-Apr	3.03 ± 0.77
6	Post-oviposition period (Days)	03-Jun	4.28 ± 1.01
7	Adult longevity (Days) Female	08-Nov	9.35 ± 1.03
	Male	06-Aug	7.10 ± 0.77
8	Fecundity (No. of eggs per female)	48-170	100.23 ± 35.87
9	Sex ratio (male: female)	0.81-1.50	1.12 ± 0.23
10	Total life cycle (Days) Female	39-48	43.17 ± 2.74
	Male	35-42	38.30 ± 2.41



Egg **Newly hatched larva** **First instar** **Second instar**

Third instar **Fourth instar** **Pupa** **Adult**

PLATE 2: Development stages of *S. cerealella* on sorghum

IV. CONCLUSION

Sitotroga cerealella exhibits a complete internal feeding life cycle on sorghum grains. It undergoes four larval instars within the grain, progressing through a concealed developmental phase that includes pre-pupal and obtect pupal stages inside a silken cocoon. Overall, it completes its life cycle in approximately 39 to 48 days with females exhibiting a slightly longer developmental duration and higher longevity, highlighting its strong reproductive potential and significant capacity for internal grain damage under storage conditions.

Recommendations:

1) **Monitoring:** Based on the life cycle duration (39-48 days), monitoring programs should be scheduled at regular intervals to detect early infestations.
2) **Management:** The extended larval period inside the grain (23-29 days) indicates that chemical control measures should target adult stages before oviposition.
3) **Storage Practices:** Since infestation starts in the field, harvest should be done promptly and grains should be properly dried (below 13% moisture) to prevent infestation.
4) **Future Research:** Studies on host preference among different sorghum varieties, impact of temperature and humidity on life cycle parameters, and development of eco-friendly management strategies are recommended.

ACKNOWLEDGEMENT

Authors are greatly thankful to Principal and Dean and Department of Entomology, N. M. College of Agriculture, Navsari Agricultural University, Navsari for providing necessary infrastructures and resources for carrying out the research work.

CONFLICT OF INTEREST

The authors declare no conflict of interest regarding the publication of this manuscript.

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