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Studies on biology of *Sitotroga cerealella* Olivier. On stored maize

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Abstract
The present investigation entitled "Studies on biology and management of Angoumois grain moth, *Sitotroga cerealella* Olivier on stored Maize" was conducted at Abhilashi University Mandi, Himachal Pradesh during 2021-2022 under laboratory conditions. The Angoumois grain moth, *Sitotroga cerealella* Olivier found to be most serious pest maize crop. The study revealed that the *Sitotroga cerealella* Olivier develops through five larval instars, pupa and adult stages. The ovipositional, incubation, larval and pupal period of Angoumois grain moth maize crop were 3.21±0.014, 4.3±0.016, 24.78±0.042 and 6.4±0.02 days. Respectively male and female longevity of Angoumois grain moth were 5.8±0.019 and 9.1±0.025 days were recorded. Thus, the total life cycle of moth completed in 42.95±0.056 days respectively under laboratory conditions.

Keywords: Biology, *Sitotroga cerealella* Olivier

Introduction
Maize (*Zea mays* L.) belonging to family Poaceae is one of the important cereal crops next to wheat and rice in the world. Maize has high production potential compared to any other cereal crop. Besides its use as food, feed and fodder, maize is now gaining increased importance on account of its potential uses in manufacturing of starch, plastic, rayon, textile, adhesive, dyes, resins, boot polish, syrups, ethanol, etc. The crop has very high genetic yield potential; it is called as the "Queen of cereals" and "King of fodder" (Muthukumar and Ragumoorthi 2017) [11]. Maize grains have great nutritional value as they contain 72% starch, 10% protein, 4.8% oil, 8.5% fibre, 3.0% sugar and 1.7% ash. Maize is very important because of good source of minerals, vitamins, fiber and oil present in maize (rich in embryo). This oil is used for cooking and soap making companies. Maize starch is famous in pharmaceutical Industries as diluents and also used in cosmetics (Huma *et al*. 2019) [9]. The production of maize in, India reported an area about 9.72 million hectares with a production of around 28.64 million tonnes (DAC & FW 2020). In Himachal Pradesh, it occupies an area of 286780 hectare with a total production of 725553 metric tonnes (DLR, H.P. 2019-20).
Angoumois grain moth, *Sitotroga cerealella* Olivier (Gelechiidae: Lepidoptera) is one of the most serious pests of stored maize at post-harvest level (Demissie *et al*. 2014) [6]. Angoumois grain moth attacks various cereals crops such as maize, wheat, rice, barley and jowar. Angoumois grain moth *(Sitotroga cerealella* Olivier) starts infestation in standing field crop and additional damage to the grain. The larva of Angoumois grain moth bore into grains and feed inside the grain at storage level (Basavanjali *et al*. 2020) [4]. Angoumois grain moth, *Sitotroga cerealella* Olivier is a small moth with a slender 5-7 mm long body when wings are folded and 10-16 mm wingspan. The moth attacks many host plants, both in field and storage level. It infests kernels of maize and other crops. A female lay eggs either singly or in batches. The eggs are white but they quickly change to a reddish color with oval shape anterior truncate and having longitudinal ridges. The larvae of Angoumois grain moth having five instars. The larva of staying inside the kernel until pupation. The larva of Angoumois grain moth is rarely seen, because it mostly completes its development within a single grain (Mahmoud *et al*. 2020) [8]. Larval feeding inside the grain caused an appreciable amount of damage to stored grain which has been stated about 8.1% and infested grain become unfit for consumption. Angoumois grain moth reduces weight, germination of seed, nutritional value and market price of maize grains (Basavanjali *et al*. 2020) [4]. So, it is necessary to know the biology of Angoumois grain moth, *Sitotroga cerealella* Olivier.

Material and Method

Maintenance of pure culture

Pure culture of Angoumois grain moth was developed by infesting insect free maize grains with freshly emerged single mating pair. The culture was maintained in the plastic jars. This culture used to study the biology of the *S. cerealella* Olivier.

Recording of Temperature and relative Humidity during experiment

The pure culture was started in BOD incubator to maintain the temperature and relative humidity for the better development of *S. cerealella*. The BOD incubator was 300C and relative humidity was 75% for the growth of weevil.

Duration of different stages of Angoumois grain moth

Study on the biology of Angoumois grain moth, *Sitotroga cerealella* Olivier. The procedure followed to study the different stages of Angoumois grain moth, *S. cerealella* Olivier were as follows.

Egg stage

Thirty Angoumois grain moth were kept with maize grain over black paper in petri plates under ambient conditions. Infested grains were replaced every morning with disinfested grains. The black paper was removed from the petri plates with grains containing eggs were separated out for observing under the microscope and kept for further studies.

Incubation period

The incubation period was studied by collecting egg sample from maize grains maintained in petri plates. A sample of 20 grains with eggs was taken to evaluate egg hatching. Hatching period was noted as intervals in day from incubation to 1st instar larval emergence.

Larval period

After hatching *S. cerealella* were allowed to feed inside in maize grain and twenty maize grains were dissect to check the different larval instars/stages. This whole process of dissection was repeated till pupal period. The period between larvae to pupal stage was observed.

Pupal period

As the pupae appeared, grains containing them transferred into petri plates kept under the same conditions as larvae. They were checked daily until the emerging of adults. The period between formations of pupae up to adult emergence was observed as pupal period.

Adult longevity

The ability of *S. cerealella* Olivier to live in the absence of food was determined by enclosing male and female adults obtained from culture separately. Petri plates were maintained for each of the male and female with food and without food.

Statistical analysis

Data of each experiment will be subjected to suitable statistical methods of analysis. The statistical methods followed in the experiments are Analysis of Variance (ANOVA) technique in CRD (Panse and Sukhame, 1967) and 't' test (Snedecor and Cochran, 1989). Transformation of data will be done whenever necessary.

Result and Discussion

Biology of Angoumois grain moth, *Sitotroga cerealella* Olivier during the month of November to January 2022. The result along with description of brief biology of various development stages are presented as follows:

Eggs: On a black strip of paper the female laid about 70-180 eggs. They laid egg either singly or in groups depending upon season. The newly hatched egg was oval shaped, creamy white but gradually changed to reddish brown with age.

Ovipositional period: The ovipositional period was found to be 2 to 4 days with an average of 3.21±0.014 days. These findings were partially connected with the findings of Akter (2013) was observed ovipositional period 3.67. However, Basavanjali (2014) found ovipositional period of Angoumois grain moth ranged from 2.4-2.60 days.

Incubation period and Fecundity

The incubation period ranged was found to be 3 to 5 days with an average of 4.3±0.016 days. These findings were partially connected with the findings of Akter (2013) observed incubation period ranged from 2 to 3 days in summer and in winter season it ranged from 5 to more on rice grains. However, Saikia (2014) [12] recorded incubation period ranged from 4 to 7 days. Fecundity of *S. cerealella* Olivier observed 70 to 180 days with an average mean of 108±0.09 days.

Larval period

The larvae developed through five instars. The newly hatched were yellowish white in color with light brown head of all instars. The larvae live inside a grain. In the present investigation total larval period found to be 22 to 26 days with an average mean of 24.78±0.042 days. Basavanjali (2020) [4] observed larval period ranged from 23.4 to 27.5 days.

Pupa

Pupa of Angoumois grain moth, *S. cerealella* Olivier is brown colored moth, developed inside silken cocoon. The present investigation found pupal period ranged from 6 to 7 days with an average of 6.4±0.02 days. These findings were partially connected to the findings of Crombie (1943) observed pupal period is 4-7 days. However, Basavanjali (2020) [4] observed pupal period ranged from 6.1 to 6.5 days.

Adult, Adult longevity

The adults was gray or buff colored moth having, darker spots on forewings. The apex of hindwings was sharply pointed towards the tips and widely separated so that the abdomen is partially visible. The female is larger than male.

The adult longevity in the present study was ranged from 5 to 7 days with an average mean of 5.8±0.019 days for males and for female adult longevity ranged from 8 to 10 days with an average mean of 9.1±0.025 days. Saikia (2014) [12] observed adult longevity 6 days for both male and female.

Total life cycle

The total life cycle from egg to adult occupied 36 to 46 days with an average mean of 42.95±0.056 days. The finding report of Saikia (2014) [12] the total life cycle was 37 to 45 days. However, Basavanjali (2020) [4] recorded the total life cycle of Angoumois grain moths, *S. cerealella* Olivier from egg to adult ranged from 35 to 45.

Table 1: Biology of Angoumois grain moth, *Sitotroga cerealella* Olivier under laboratory conditions**.**

Development stages	Duration mean of life cycle (days)	
	Mean ± SE	Range
Oviposition period	3.21 ± 0.014	2.0-4.0
Incubation period	4.3 ± 0.016	3.0-5.0
Larval period		
1st instar	2.7 ± 0.012	2.0-3.0
2nd instar	3.5 ± 0.014	3.4-3.6
3rd instar	9.58 ± 0.026	9.0-11.0
4th instar	4.2 ± 0.016	3.9-4.5
5th instar	4.8 ± 0.017	4.6-5.0
Total larval period	24.78 ± 0.042	22.0-26.0
Pupal period	6.4 ± 0.02	6.0-7.0
Adult longevity		
Male	5.8 ± 0.019	5.0-7.0
Female	9.1 ± 0.025	8.0-10.0
Fecundity (Number)	108 ± 0.09	70-180
Total life cycle	42.95 ± 0.056	36-46

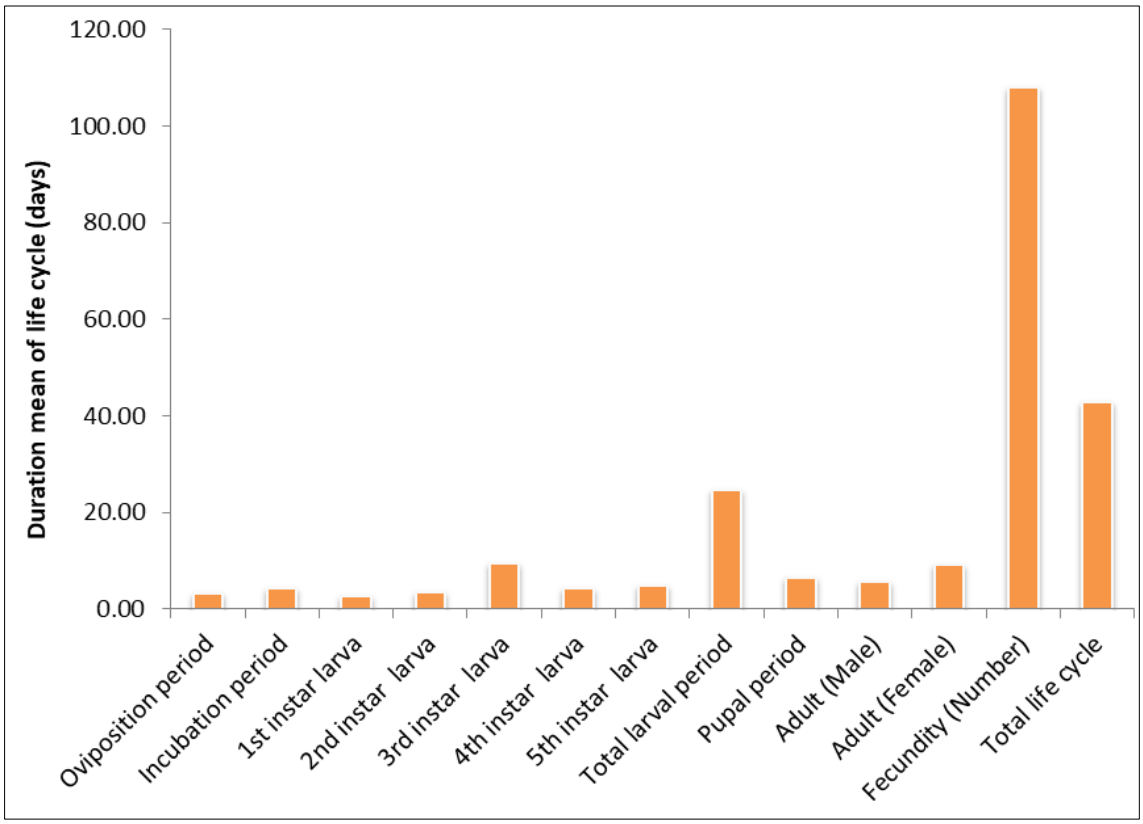

Fig 1: Show the duration mean of life cycle

Summary and Conclusion

Biology of the Angoumois grain moth, *Sitotroga cerealella* Olivier on under laboratory conditions during winter 2021-2022(Nov.-Jan.) was carried out and it was observed that the ovipositional period of Angoumois grain moth, *Sitotroga cerealella* Olivier varied from 2-3 days with an average mean of 3.21±0.014 days during winter. The incubation and larval period were ranged from 3-5 days and 22-26 days with an average mean 4.3±0.016, 24.78±0.042. The period of first, second, third, fourth and fifth instars ranged from 2-3 days, 3.4-3.6 days, 9-11 days, 3.9-4.5 days and 4.6-5.0 days with mean of 2.7±0.012, 3.5±0.014, 9.58 ±0.026, 4.2±0.016 and 4.8±0.017 days. The pupal period observed 6-7 days with an average of mean of 6.4±0.02 days. The total life cycle from egg to adult during winter season ranged from 36-46 days with an average mean of 42.95±0.056 days.

The Angoumois grain moth, *Sitotroga cerealella* Olivier was most destructive pest among cereals and most serious pest of maize crop. The biology of *Sitotroga cerealella* Olivier concluded that the ovipositional, incubation, larval and pupal period having mean of 3.21±0.014, 4.3±0.016, 24.78±0.042 and 6.4±0.02 days and the total life cycle completed in 42.95±0.056 days respectively.

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