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Study on biology of rice weevil, *Sitophilus oryzae* (L.) on stored maize (*Zea mays*).

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Abstract: The present investigation on biology of rice weevil, *Sitophilus oryzae* (L.) on stored maize was conducted during 2020-21. Studies on biology were carried out under laboratory conditions at Department of Entomology, College of Agriculture, Dharwad. The incubation period was 4 to 6 days. There were three moults with four instars and total larval period lasted for 25 to 32 days. Pupal period for 7 to 10 days. Total life cycle of the pest from egg to adult stage was ranged from 32 to 48 days with a mean of 41 days and the average fecundity of adult female was 55.20 eggs per female.

I. INTRODUCTION

Maize (*Zea mays* L.) is referred as queen ofcereals since it has very high yielding potential and one of the largestcultivated cereal crops in tropical and subtropical climatic conditions worldwide. It is being used as food, feed, fodder and raw material in industries like beverage, confectionary, starch, ethanol, oil, cosmetic, pharmaceutical, food processing, textile, gum and paper industries. Apart from that, nutritionally it contains approximately 72,10 and 4 percent of starch, protein and fat, respectively and providing an energy density of 365 Kcal per 100 g. In addition, it has higher content of proteinandfat ascompared to other cereals (Hiruy and Emana, 2018).In the world it occupies an area of 193.74 million hectares with a total production of1147.69 million tonnes and productivity of 5.92tonnes per hectare (Anon., 2021). The top three countries in maize production are United States, China and Brazil whereas India ranks fourth position with 3.0 per cent of total world production. In India, maize is the third most cultivated cereal after rice and wheat with an area of 9.03 million hectare with 27.72 million tonnes production and 3070 kg per hectare of productivity (Anon., 2021). In Karnataka it is cultivated on

an area of 1.34 million hectares with a production of 3.76 million tonnes and productivity of 2.81 tonnes per ha(Anon.,2021).

Though the production of maize has increased to meet the global demand, several biotic as well as abiotic factors are playing an important role in limiting the productivity. It is also overwhelmed with post production storage losses. It has been reported that more than37 species of arthropod insects are associated with stored maize (Abraham,1997). Various life stages of insects cause economic damage and deteriorate the quality of food grains and food products hence post harvest infestation is a very serious problem. Amongthe several insects attacking maize grains during storage, *Sitophilus* spp; lesser grain borer, *Rhyzopertha dominica* Fabricius; redflourbeetle, *Tribolium castaneum* Herbest; ricemoth, *Corcyra cephalonica* Stainton and angumois grain moth, *Sitotroga cerealella* Olivier are of economic importance. However, genus *Sitophilus* is a major group of pest on stored maize all over the world (Grenier *et al*., 1994). Among the two species of *Sitophilus viz*., *Sitophilus zeamais* (Motschulsky) and *Sitophilus oryzae* (Linn.), former could cause considerable losses accounting to18.30 percent(Adams, 1976).Whereas high of 92.40 to 98.30 per cent damage was caused by *S. oryzae* as per the report made by Bitran*et al*. (1978) in different parts of theworld except India. On the other hand, *S. oryzae* is the most destructive insect pest of the stored raw cereal grains in the world (Champ and Dyte,1976) which could cause massive losses up to 100 per cent instored maize in India and in other countries (Irabagon, 1959). This clearly indicates the importance of *S. oryzae* in stored maize in India.

Storage insect pests are difficult to control due to their small size, feeding behavior and ability to attack seeds before harvest. However, prevention of losses due to insects in stored products and their protection fromthem is the most vital aspect to guarantee quality food supply to all over the world. For this, a thorough understanding of the pests life history as well as the knowledge of the weak links in their life cycle is much required which would be advantageous for successful management of storage pests.

II. MATERIAL AND METHODS

Biologyof *S. oryzae*on stored maize was carried out under laboratory condition at Department of Agricultural Entomology, College of Agriculture, Dharwad, Karnataka-India during 2020-21. Culture of the rice weevil was initiated by collecting the adult weevils from the infested seed samples of Seed Unit, University of Agricultural Sciences, Dharwad. The culture was further maintained in a glass jar of 2 kg capacity containing the maize grains. Mouth of the container was closed with muslin cloth and fastened with a rubber band. Fresh grains were introduced periodically for maintenance of the culture and the same was used throughout the period of investigation.

Observations were taken on biological parameters of *S. oryzae* by allowing 30 pairs of rice weevil adults into the glass bottles containing 100 grams of maize seeds. The released weevils were allowed for mating. Maize seeds with rice weevil eggs so obtained were maintained in a glass vials for incubation. Daily 20 grains, from the

day of oviposition to egg hatching were observed to determine the incubation period. After hatching, the larvae of rice weevil were allowed to feed individually inside the seed. 20 grains per day were dissected to observe the different stage of larvae. Larval instars were determined by the range of head capsule width as described by (Sharifi and Mills, 1971). Head capsule width was measured by using stage and ocular micrometer. Dissection of the maize seed was continued till the appearance of pupal stage. 20 seeds with eggs of rice weevil obtained in afore said manner were dissected out daily till the emergence of adults. Pupal period was determined by subtracting incubation and larval period. 10 pairs of adults were released individually in plastic container (10 cm diameter) to observe pre-mating and mating period. The mated females were taken and kept in a plastic container (10 cm diameter) along with the maize seeds to know the pre-oviposition and oviposition periods. The life span of rice weevil adults both in presence and absence of food was observed by enclosing male and female adults in a glass vials. Ten such vials were maintained for each male and female with and without food.

III. RESULTS AND DISCUSSION

3.1 Egg

It was observed from the experiment that gravid female laid single egg inside the grain cavities. The freshly laid egg was glistening, translucent and white in colour and later become opaque before hatching with one end rounded and other end pointed. The larva emerged by biting through the rounded end and moves towards the starchy material of the grain. The incubation period ranged from 4 to 6 days with a mean of 4.90 days (Table 1).The results of the present findings are in accordance with Bhuiyah *et al.* (1990) who recorded 5 to 6 days of incubation period at 23 to 35 ^{o}C temperature and 56 to 88 per cent relative humidity. In the same way, relatively same period of incubation on maize grains was observed at 15 to 34 ^{o}C temperature and 58 to 89 per cent relative humidity by Swamy *et al.* (2014). However, the present findings are in contradictory with the findings of Khan (1948) who noticed 12 days of incubation period on maize grains at 15 ^{o}C temperature and 50 per cent relative humidity. Variation in incubation period could be attributed to the variation in the temperature and relative humidity under which the experiment was carried out and was supported by earlier reports made by Nakakita and Ikenga (1977) who stated that hatching was completely affected with the variation in temperature.

3.2 Larva

Larval development was manifested with three moults and four instars under the laboratory conditions and was observed inside the grains. Grubs were short, stout, apodous and having yellowish white coloured body with brown coloured head with biting jaws. The larva was noticed to be scarabaeiform with three thoracic and ten abdominal segments. Further, whole body was covered with small hair like processes. Totally nine pairs of spiracles were witnessed where, one pair on first thoracic segment and remaining eight on first eight abdominal segments. Larval period ranged from 25-32 days with a mean of 27.40 days(Table 1).These results are in close association with the findings of Yevoor (2003) who reported the total larval period of 25 to 32 days on maize

grains with four larval instars. Similarly, Bheemanna (1986) and Swamy *et al.* (2014) also reported the analogous results on sorghum and maize grains, respectively

3.2.1 First instar (L1)

The first instar grub was appeared to be white with brown coloured head with small spherical body. On hatching grub entered into the grain directly by feeding on starchy material. Duration of first instar was found to be in the range of 5 to 6 days with an average of 5.2 days (Table 1) with a mean head capsule width of 0.31 mm which ranged between 0.28 to 0.33 mm (Table 2). However, body length measured to be 0.53 to 0.60 mm with a mean of 0.57 mm.

3.2.2 Second instar (L2)

As observed in the first instar, second instar grub also appeared to be white in colour with brownish head and capable of moving but not as quickly as in case of succeeding instars. However, compared to L1, there was slight increase in body size with head retracted, appeared more plumpy but resembled to be L1. The duration of L2 was slightly enhanced with a mean of 6.60 days but ranged from 5.00 to 7.00 days with enlargement in the head capsule width with an average 0.39 mm which ranged from 0.35 to 0.44 mm. However, body length was slightly enhanced to an average of 0.85 mm but ranged between 0.82 to 0.91 mm (Table 2).

3.2.3 Third instar (L3)

There was a noticeable increase in the body size of grub as compared to L1 and L2 with well retracted head. The grub resided inside the grain in curved position and its movement was much restricted to grain only. Compared to preceding instars, L3 enhanced its life span with an average of 8.6 days which ranged between 7.00 to 9.00 days. Remarkable enhancement in head capsule width and length of body was noticed compared to its preceding instars with an average of 0.50 and 1.17 mm which ranged between 0.45 to 0.50 and 1.13 to 1.26 mm respectively (Table 2).

3.2.4 Fourth instar (L4)

L4 was relatively similar to L3 except amplification in size. The major portion of the tunnel inside the grain was occupied by the grub. Further, it was quite immobile and remained in curved position inside the grain. Extent of life span was found to be an average of 9.40 days which ranged between 8.00 to 10.00 days (Table 1). However, detectable enhancement in head capsule width was noticed with an average of 0.57 mm which ranged between 0.52 to 0.61 mm. Similarly, body length was enhanced remarkably compared to its preceding instars with an average of 2.01 mm and ranged between 1.82 to 2.38 mm (Table 2).

3.3 Pupa

The colour of the pupa was noticed to be white to yellowish white, exarate type with clearly noticeable head, thorax and abdomen which resembled to adult in all aspects except its inactive posture. Pupation was found inside the grain tunnel and surrounded by the excreta of larval instars. Pupal period occupied 7.00 to 10.00 days with an average of 9.2 day (Table 1). The present findings are in agreement with the earlier reports of Yevoor (2003) who reported total pupal period of 7 to 10 days with an average of 8.75 days and Swamy*et al*. (2014) also recorded an average pupal period of 9.50 days which ranged between 8 to 11 days on maize grains. However, the present findings are in conflict with the findings of Sharifi and Mills (1971) who registered an average pupal period of 6.3 days on wheat grains by radiographic method. This variation might be attributed to variation in temperature, relative humidity and change in the host as well as laboratory conditions.

3.4 Adult

Adult weevil noticed to be reddish brown with four reddish or yellowish spots on elytra and head protruded into snout like projection at the end of which a pair of strong jaws located. Antennae short, geniculate and arised from the mid length of the snout. Externally male and female appeared alike but on closer observation, the rostrum of the male was somewhat thick, closely punctured, rough and less curved, while its counterpart was elongated, slim, smooth, shining, slightly curved and sparsely punctured. Freshly emerged adults were light brown in colourand smaller than normal adults. Adult emerged out from the grain by making circular hole, newly emerged adults were brown in colour which later turns to black. Adult weevils were elongated, sub cylindrical with four orange coloured patches on elytra. Externally both male and female weevils look alike but on closer observation, in males rostrum was thick, closely punctured, rough and less curved as compared to females. Whereas in females, rostrum was thin, elongated, smooth, slender, shining, slightly curved and sparsely punctured. Head prolonged into snout and mouth parts situated at the tip. Antennae were short and geniculate. The description made on adult morphology during the present study is similar to the description made by Khan (1948), Khare and Agarwal (1962) and Halstead (1963). Total life cycle from egg to adult completed from 32 to 49 days with an average of 42.20 days. These results are in line with the findings of Yevoor (2003) who witnessed the total life cycle of rice weevil ranged from 32 to 48 days with an average of 41 days on maize grains. On contrary, Bheemanna (1986) noticed the total life cycle varied from 38 to 53 days on sorghum grains at the temperature of 14 to 34 ºC. Contradictory observations with the present study might be attributed to the change in the host as well as variation in temperature.

3.5 Total life cycle

The total life cycle of the rice weevil was witnessed to be 42.20 days which ranged between 33 to 49 days (Table 1).These results are in line with the findings of Yevoor (2003) who witnessed the total life cycle of rice weevil ranged from 32 to 48 days with an average of 41 days on maize grains. On contrary, Bheemanna (1986) noticed the total life cycle varied from 38 to 53 days on sorghum grains at the temperature of 14 to 34 ºC. Contradictory observations with the present study might be attributed to the change in the host as well as variation in temperature.

3.6 Pre-mating, Mating, Pre-oviposition and Oviposition period

The pre-mating period was registered to be an average of 6.4 days which ranged between 4.00 to 7.00 days (Table 1). The mating was observed during day time from 8.00 am to 6.00 pm. Most of the weevils were found to mate during hot hours with full of sunshine. Under stress condition, that too under lack of food, it was found to occur both during day and night. The mating period was noticed to be 54.00 minutes which ranged between 30 to 65 minutes (Table 1). The pre-oviposition period was witnessed from 7.00 to 10.00 days with an average of 8.60 days (Table 1).The oviposition period was 8.00 to 28.00 days with an average of 24.00 days (Table 1) on maize grains. Before depositing the eggs, female weevil scooped out small portion of grain near the germ region and turned back to deposit the eggs. Such scooped area having eggs was covered by secretion of anal glands. The female weevil preferred grains with soft endocorns. Among the different regions of the grain, the germ region and the area surrounding it was most preferred as compared to other parts. The weevils found to copulate freely under laboratory conditions. Most of the weevils were found to mate during day time with full sunshine hours. Under stress conditions, that too under scarcity of food they found to copulate both during day and night. This observation on mating behavior is in accordance with the findings of Sattigi*et al.* (1987) on sorghum grains.

3.7 Fecundity and Adult longevity

The fecundity of the mated females accounted to be 14 to 80 eggs with an average of 54.20 eggs during April to May 2021. Presence of food grains was quite essential for egg laying by adult female, as witnessed by the weevils enclosed with maize grains laid eggs while weevils without maize grains failed to oviposit. The adult longevity of females with food was measured between 84 to 119 days with an average of 114.40 days whereas males with food survived for 72 to 113 days with an average of 696.20 days. Further it was observed that the adult females without food lived for 6 to 15 days with an average of 10.20 days and males lived for 5 to 10 days with mean of 7.80 days (Table 1).These findings are in line with the findings of earlier workers like Bheemanna

(1986), Sattigi *et al.* (1987), Yevoor (2003), Swamy *et al.* (2014). Adult longevity of female and male with food and without food condition was an average of 114.40 and 10.20 and 96.20 and 7.80, respectively. These observations are in line with the findings of Yevoor (2003) who recorded the longevity of adult female with and without food was 115.76 days (85 to 120 days) and 9.50 days (6 to 15 days) . Whereas, 97.42 days (70-11 days) and 7.32 days (5 to 10 days) was noticed in its counterpart.

The fecundity ranged from 14 to 80 eggs with an average of 54.20 eggs (Table 1). These observations are in agreement with the findings of Yevoor (2003) who recorded an average fecundity of 55.50 eggs per female. Similarly, an average of 56.60 eggs which ranged from 12 to 84 eggs was noticed by Swamy *et al*. (2014). However, the present observations on fecundity are in contradictory with the observations of Sattigi *et al.* (1987) who documented an average fecundity of 64.50 eggs on sorghum grains. These contradictory results might be due to change in host.

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Table 1: Biology of rice weevil, *S. oryzae* on stored maize grains

Sl. No.	Different stages	Duration (Days)	
		Range	Average ± SD
1	Incubation period	4-6	4.90 ± 0.70
2	First instar	5-6	5.20 ± 0.40
3	Second instar	5-7	6.60 ± 0.66
4	Third instar	7-9	8.60 ± 0.66
5	Fourth instar	8-10	9.40 ± 0.80
6	Total larval period	25-32	27.40 ± 1.81
7	Pupal period	7-10	9.20 ± 0.98
8	Total life cycle	33-49	42.20 ± 4.42
9	Pre-mating period(days)	4 – 7	6.40 ± 1.07
10	Mating period(minutes)	30 – 65	54.00 ± 10.28
11	Pre oviposition period(days)	7- 1 0	8.60 ± 1.07
12	Oviposition period(days)	8 – 28	24.00 ± 6.88
13	Adult longevity of female with food (days)	84 – 119	114.40 ± 10.83
14	Adult longevity of male with food (days)	72 – 113	96.20 ± 12.72
15	Adult longevity of female without food (days)	6 – 15	10.20 ± 2.78
16	Adult longevity of male without food (days)	5 – 10	7.80 ± 1.68
17	Fecundity	14 – 80	54.20 ± 21.46

Table 2: Morphometric measurements of different larval instars of *S. oryzae*

Stages	Head capsule width (mm)		Body length (mm)	
	Range	Average ± SD	Range	Average
First instar	0.28 - 0.33	0.31 ± 0.02	0.53 - 0.60	0.57 ± 0.02
Second instar	0.35 - 0.44	0.39 ± 0.02	0.82 - 0.91	0.85 ± 0.03
Third instar	0.45 - 0.50	0.50 ± 0.04	1.13 - 1.26	1.17 ± 0.04
Fourth instar	0.52 - 0.61	0.57 ± 0.02	1.82 - 2.38	2.01 ± 0.21

Egg of *S. oryzae*

1st instar grub

2nd instar grub

3rd instar grub

4th instar grub

Pupa of *S. oryzae*

Adult of *S. oryzae*