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Biology of Red Flour Beetle *Tribolium castaneum* (Hbst.) (Coleoptera: Tenebrionidae) on Stored Sesame

B. Sundar[1], Vishwakarma Rashmi[1], P. Duraimurugan[2], Navya Matcha[1] and K. Ramesh[2]*
[1]Department of Entomology, JNKVV, Jabalpur, (Madhya Pradesh), India.
[2]Crop Protection Division, ICAR-Indian Institute of Oilseeds Research, Hyderabad, (Telangana), India.

(Corresponding author: B. Sundar)*
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ABSTRACT: Storage insects in sesame play a major role in the deterioration of harvested seeds causing both quantitative and qualitative losses. Red flour beetle, *Tribolium castaneum* is one of the major pests of sesame seed under storage conditions. Biology of the red flour beetle on three different coloured sesame varieties *viz*., white (cv. Swetha), black (cv. GT-10) and brown (cv. YLM-17) was studied in the laboratory. Among the varieties evaluated GT-10 was least preferred one recorded with longest incubation period (6.48 days), longest larval duration (37.22 days), and longest adult longevity (33.20 days). Whereas Swetha is highly preferred genotype recorded with shortest incubation period (4.70 days), shortest larval duration (32.83 days), and shortest adult longevity (22.74 days). The width of head capsule was recorded lowest on GT-10 at each moult 0.15, 0.17, 0.25, 0.31, 0.36 and 0.39 mm respectively. The mean observed and estimated progression factor was obtained to the tune of 1.223 and 1.227. Which indicate that an increase in head width during successive instars was close proximity to the Dyar's law and followed a geometric progression in growth. The study of morphometric parameters of *Tribolium castaneum* as a result of feeding on three varieties (Swetha, GT-10, and YLM-17) of sesame seed showed statistically significant effects on length, breadth and head capsule width of different larval instars. The results of this study indicated that black coloured variety, GT-10 was the least suitable for development of *Tribolium castaneum* as compared to white colored variety, Swetha.

Keywords: *Tribolium castaneum*, biology, morphometrics, varieties, storage, sesame seed.

INTRODUCTION

Post-harvest food losses during storage are substantial and have various causes (Kitinoja and Gorny, 1999; Musa, 1984; Tindall and Proctor, 1980). Losses in stored cereals, pulses and oilseeds depend on the crop, the storage conditions and the type of postharvest processing. Sesame seed is one of the oldest oilseeds crops known, domesticated well over 3000 years ago. "Sesame is called the queen of oilseed crops" by the oil it produces. It is drought-tolerant and can grow where other crops fail. Sesame has one of the highest oil contents of any seed. With a rich nutty flavour, it is a common ingredient in cuisines across the world. Seed coat has significant antioxidant activity against various lipid per-oxidation processes. The oil was found to be cyanide free, so appropriate for human consumption. Sesame oil boosts tocopherol and also increases vitamin E activity that is supposed to aid in cancer and other heart disease prevention (Asghar *et al.,* 2014). The state of Madhya Pradesh contributes an area of 315 ha with a production of 126 tonnes and productivity of 400 kg/ha (Anon, 2019). It occupies an important position within the world as the fourth leading oilseeds producing countries lacking solely the USA, China, and Brazil.

Sesame is prone to attack by some stored pests in storage. The red flour beetle *Tribolium castaneum* (Hbst.) (Coleoptera: Tenebrionidae) is an important pest of different stored products in tropics. *Tribolium castaneum* is frequently referred to as a secondary pest since it is unable to feed on or attack sound grains (Howe, 1956). *Tribolium castaneum* prefers the embryo and may feed on whole kernels. Moreover, it is a polyphagous and cosmopolitan pest and presents an extreme adaptation, supported by the presence of a cryptonephridial kidney-like organ, in its body, that allows its establishment in extreme low humidity conditions (Richards *et al.,* 2008). These insects cause damage by reducing the mass and/or volume, reducing the physiological quality and germination capacity, and increasing the temperature and water content of the grains (Padin *et al.,* 2002; Faroni and Sousa, 2006). Where these pests are present in large numbers the flour becomes greyish and discoloured and will mould more quickly than clean flour. Sometimes the disagreeable, pungent odour given off by the insect scent glands (Quinones) is incorporated into the flour, giving it a disgusting taste and odour (Good, 1936). Quinone chemical secretions accumulate in the medium in proportion to time and density in a process known as 'conditioning', and these chemical secretions are used by the beetles as indicators of demographic parameters, such as population density (El-Desouky *et al*., 2018). Latest work exhibit that females evaluate current and future competitive conditions when making oviposition decisions (Halliday *et al.*, 2019). The information on the biology of red flour beetle on sesame is meager and hence the present investigation was conducted.

It is necessary to first determine the basic life cycle of this pest, including the number of larval instars, in order to develop rational pest management strategies, one method for determining the number of larval instars is to measuring the width of the larval head capsule throughout development and applying Dyar's rule (Panzavolta, 2007; Cazado *et al.*, 2014). This method is based on the assumption that the size of the head capsule remain constant throughout an instar but increase geometrically as the larva progresses from one instar to the next (Dyar, 1890).

MATERIALS AND METHODS

Studies on the biology of *Tribolium castaneum* was conducted in the Entomology Laboratory, ICAR-IIOR, Hyderabad during 2019-2020. The biology of the beetle on three different coloured sesame varieties *viz*., white (cv. Swetha), black (cv. GT-10) and brown (cv. YLM-17) was studied d in a Completely Randomized Design with five replications. Biology of *Tribolium castaneum* studied under laboratory conditions. The laboratory temperature and relative humidity during the period of studies were in the range of 25°C to 30°C and 60 to 70 per cent, respectively. Five gram cleaned sesame seed of each genotype were placed in fifteen plastic boxes. Later freshly hatched ten first instar grub/replication were introduced by using camel hairbrush. The open end of the box was closed with a muslin cloth and fastens with a rubber band. Observations were taken on the duration, length and breadth of different stages of insect were also recorded. Measurements of the larval instars, pupae and adults were made using a standardized ocular micrometer.

RESULTS AND DISCUSSION

Red flour beetle *Tribolium castaneum* life cycle involved egg, larva, pupa and adult stages (Figs. 1-9). The larval stage passed through six instars. Observations on incubation period, larval duration; pupal duration, adult longevity; length and breadth of different immature stages and adult were recorded.

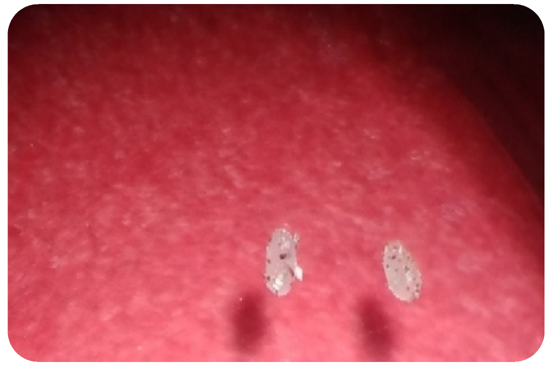

Fig. 1. Eggs of *T. castaneum.*

Fig. 2. First instar grub of *T. castaneum.*

Fig. 3. Second instar grub of *T. castaneum.*

Fig. 4. Third instar grub of *T. castaneum.*

Fig. 5. Fourth instar grub of *T. castaneum.*

Fig. 6. Fifth instar grub of *T. castaneum.*

Fig. 7. Sixth instar grub of *T. castaneum.*

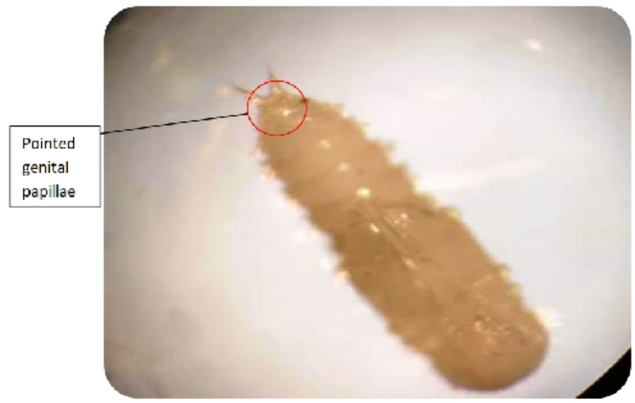

Fig. 8. Female pupae of *T. castaneum.*

Fig. 9. Adult of *T. castaneum.*

Duration of different larval instars in the Table 2, manifested that the first, second, third, fourth, fifth, sixth instars exhibited significant differences between the varieties. The larval period range of the first instar varied significantly between 5.07 to 6.02 with the lowest and highest 5.07 and 6.02 days on Swetha, and GT-10 respectively. The larval period of the second instar significantly lowest on Swetha (4.48 days) and the highest on 6th instar GT-10 (7.48 days). There is a significant difference observed in the duration of all the instars. Total larval period showed significant difference among the varieties of sesame. The genotype GT-10 recorded longest development period on GT-10 (37.22 days) and shortest on Swetha (32.83 days).

Pupal period in the Table 2, shows that among the different sesame varieties significantly ranged from 5.68 to 6.48 days. There was a significant relation in pupal duration among GT-10, YLM-17 and Swetha.

The pupal period was highest on GT-10 (6.48 days), which was significantly deferred with YLM-17 (6.18 days). The lowest pupal period was recorded on Swetha (5.68 days). The present findings are in accordance with (Chitrangad, 2012; Evaldo, 2019; Adil, 2002) as they reported it to be in the range of 5.30 to 6.50 days. Adult longevity in the Table 2 revealed that male and female adult longevity exhibited significant differences among the varieties. The lowest adult longevity was observed on Swetha (22.74 days) significantly deferred with YLM-17 (24.10 days). The highest adult longevity was recorded on GT-10 (33.20 days). The findings are agreement with those of (Chitrangad, 2012) 22.00 days and (Adil, 2002) 36.80.

There was a non-significant relation between length of first and sixth instars observed on YLM-17 (1.09 mm and 5.06 mm) and GT-10 (1.07 mm and 5.05) respectively, the highest significant difference was observed in Swetha (1.13 mm) and (5.44) in first and sixth instar. These findings are contrast with (Devi and Devi, 2015; Patil, 2014; Namrata, 1993; Adil, 2002) they reported as length was 1.16 mm and incase of 6th instar similar findings have been reported by (Devi and Devi, 2015; Patil, 2014) (5.27 mm), (4.6 mm) and variance with (Adil, 2002) 4.28 mm and (Park, 1932) 6.00 mm. Whereas the length of second, third, fourth, fifth instar showed significant difference varied from 1.68 to 1.76, 2.42 to 2.55, 3.19 to 3.28 and 3.90 to 4.17 mm, respectively (Table 1).

The breadth of the larvae significantly differed in all the instars, ranging from 0.14 to 0.20, 0.30 to 0.41, 0.4 to 0.50, 0.56 to 0.63, 0.66 to 0.74 and 0.84 to 1.06 mm. Significantly, the highest was observed when reared on Swetha, while the lowest was observed in GT-10 (Table 1).

Table 1: Morphometrics of different larval instars of *T. castaneum* on sesame varieties.

Varieties	First instar #			Second instar #			Third instar #			Fourth instar #			Fifth instar #			Sixth instar #		
	Length (mm)	Breadth (mm)	HCW (mm)	Length (mm)	Breadth (mm)	HCW (mm)	Length (mm)	Breadth (mm)	HCW (mm)	Length (mm)	Breadth (mm)	HCW (mm)	Length (mm)	Breadth (mm)	HCW (mm)	Length (mm)	Breadth (mm)	HCW (mm)
Swetha	1.13 (1.45)	0.20 (1.09)	0.18 (1.09)	1.76 (1.66)	0.41 (1.19)	0.20 (1.10)	2.55 (1.89)	0.50 (1.22)	0.30 (1.14)	3.28 (2.07)	0.63 (1.28)	0.37 (1.17)	4.17 (2.27)	0.74 (1.32)	0.47 (1.21)	5.44 (2.54)	1.06 (1.43)	0.63 (1.28)
GT-10	1.07 (1.44)	0.14 (1.07)	0.15 (1.07)	1.68 (1.64)	0.30 (1.14)	0.17 (1.08)	2.42 (1.85)	0.44 (1.20)	0.25 (1.12)	3.18 (2.04)	0.56 (1.25)	0.31 (1.15)	3.90 (2.21)	0.66 (1.29)	0.36 (1.16)	5.05 (2.46)	0.84 (1.36)	0.39 (1.18)
YLM-17	1.09 (1.44)	0.17 (1.08)	0.16 (1.08)	1.72 (1.65)	0.34 (1.16)	0.20 (1.10)	2.52 (1.88)	0.47 (1.21)	0.29 (1.13)	3.25 (2.06)	0.60 (1.27)	0.33 (1.15)	4.16 (2.27)	0.72 (1.31)	0.41 (1.19)	5.06 (2.46)	0.94 (1.39)	0.48 (1.21)
S.Em	0.007	0.006	0.003	0.005	0.007	0.004	0.005	0.006	0.006	0.004	0.007	0.005	0.001	0.007	0.008	0.004	0.009	0.007
CD (5%)	0.021	0.019	0.010	0.014	0.023	0.013	0.014	0.017	0.019	0.013	0.021	0.016	0.033	0.023	0.024	0.011	0.027	0.022
CV(%)	1.07	1.25	0.68	0.62	1.43	0.87	0.55	1.02	1.22	0.45	1.221	1.003	1.08	1.27	1.46	0.33	1.39	1.33
# Figures in the parenthesis are square root transformed values. All the values are mean of five replications																		

Table 2: Duration of life cycle of *T. castaneum* reared under different sesame varieties.

Varieties	Incubation period (days)#	Larval period (days)#						Total larval period (days)#	Pupal period (days)#	Adult longevity (days)#	Total development period (days)#
		First instar	Second instar	Third instar	Fourth instar	Fifth instar	Sixth instar				
Swetha	4.70 (2.39)	5.07 (2.46)	4.48 (2.34)	5.34 (2.55)	5.40 (2.53)	5.68 (2.58)	6.50 (2.74)	32.83 (5.82)	5.68 (2.58)	22.74 (4.87)	65.95 (8.18)
GT-10	6.48 (2.73)	6.02 (2.65)	5.72 (2.59)	5.54 (2.52)	5.76 (2.60)	6.72 (2.78)	7.48 (2.91)	37.22 (6.18)	6.48 (2.73)	33.20 (5.85)	83.38 (9.19)
YLM-17	5.70 (2.59)	5.62 (2.57)	5.30 (2.51)	5.52 (2.55)	5.74 (2.60)	6.64 (2.76)	6.79 (2.79)	35.27 (6.02)	6.18 (2.68)	24.10 (5.01)	71.25 (8.50)
S.Em±	0.031	0.011	0.014	0.010	0.02	0.02	0.01	0.02	0.017	0.005	0.02
C.D(5%)	0.095	0.034	0.043	0.030	0.06	0.07	0.04	0.06	0.052	0.016	0.07
# Figures in the parentheses are square root transformed values. All the values are mean of five replications											

The head capsule width did not differ significantly in first and fourth instars feed on YLM-17 and GT-10 and significant on Swetha (0.18 mm and 0.37 mm) respective instars. However, the second, third, fifth and sixth instars significant difference observed among Swetha, YLM-17 and GT-10 varieties (Table 1). The growth rate of all instars in the respected varieties followed geometric progression. The average values are closely following the (Dyar, 1890) law rules. The head capsule width of present study is similar to those observed by (Patil, 2014).

The pupal length and breadth of *Tribolium castaneum* revealed in the Table 3 which exhibited significant differences among the varieties.

The highest pupal length was observed on GT-10 (3.63 mm), which is significantly differed from YLM-17 (4.25 mm) and Swetha (4.67 mm). The breath of pupa was highest recorded on Swetha (1.34 mm) followed by YLM-17 (1.19 mm) and lowest on GT-10 (1.08 mm). The results are closely related to (Devi and Devi, 2015) who reported a length and width of 3.18 to 4.12 mm and 1.07 to 1.15 mm respectively. The body length and breadth of male and female adult moths of *Tribolium castaneum* showed significant differences among the varieties (Table 3).

The male moth body length significantly ranged from 3.20 mm to 3.81 mm. The longest body length was observed in Swetha (3.81 mm), followed by YLM-17 (3.49 mm) and shortest body length (3.20 mm) was on GT-10 which is significantly differed from the other varieties. The breadth of the male moth recorded shortest in GT-10 (1.01 mm) significantly differed from

YLM-17 (1.12 mm) and longest breadth was observed in Swetha (1.22 mm). The female moth body length reared on GT-10 (3.25 mm) was significantly lower compare to Swetha (3.89 mm) and YLM-17 (3.54 mm). The breadth of female moth found to be longest on Swetha (1.33 mm), significantly different from YLM-17(1.20 mm) and lowest on GT-10 (1.07 mm)

Table 3: Morphometrics of pupa and adult stages of *T. castaneum* on different sesame varieties.

Varieties	Pupa #		Adult #			
			Male		Female	
	Length (mm)	Width (mm)	Length (mm)	Width (mm)	Length (mm)	Width (mm)
Swetha	4.67 (2.38)	1.34 (1.53)	3.81 (2.19)	1.22 (1.49)	3.89 (2.21)	1.33 (1.53)
GT-10	3.63 (2.15)	1.08 (1.44)	3.20 (2.05)	1.01 (1.42)	3.25 (2.06)	1.07 (1.44)
YLM-17	4.25 (2.29)	1.19 (1.48)	3.49 (2.12)	1.12 (1.46)	3.54 (2.13)	1.20 (1.48)
S.Em±	0.003	0.007	0.005	0.007	0.007	0.008
C.D(5%)	0.010	0.022	0.014	0.023	0.021	0.025
C.V(%)	0.320	1.050	0.484	1.138	0.700	1.221

 # Figures in the parentheses are square root transformed values. All the values are mean of five replications

Table 4: Comparison of observed and estimated values (mm) of mean measurements of head capsule width of *T. castaneum* on GT-10.

Details	Mean values of head capsule width (mm) in different instars						Progression factor
	First	Second	Third	Fourth	Fifth	Sixth	
Observed	0.14±0.04	0.17±0.015	0.28±0.009	0.32±0.02	0.41±0.03	0.34±0.02	
Growth ratio		1.21	1.65	`1.14	1.28	0.83	1.223
Estimated	0.15	0.18	0.23	0.28	0.34	0.42	1.227
Difference	-0.01	-0.02	0.05	0.04	0.06	-0.09	

The genotype GT-10 recorded longest development period in all the instars of *Tribolium castaneum*. Delay in the duration of the larval phase is normally verified by reduced intake of feed, frequently due to one or more inhibitors in the food or to nutritional inadequacy of the feed substrate (Martinez & Emden, 2001). The unsuitability of varieties also may be a result of the presence of some secondary biochemicals in these varieties, which act as antibiotic agents or absence of primary nutrients necessary for the development of larvae. According to (Janzen, 1977) the testa may be so thick that the newly hatched larva dies before it reaches the cotyledon, or the cotyledon may be poisonous. *Tribolium castaneum* had varying numbers of larval instars at the different uncontrolled laboratory conditions tested. The number ranged from six to seven instars. In current study six instars was observed. (Bahram *et al.*, 2009) reported that the variation in the number of larval instars may be attributed to the quality of the seed, which has different nutritional value for grub or differences in geographic population of *Tribolium castaneum* or different temperature.

CONCLUSION

In conclusion, studying the biology of insects to better understanding of how insects grow and develop has contributed greatly to their management. Among the three tested varieties, the egg, grub, pupa and adult period of *Tribolium castaneum* on white seeded variety of Swetha was observed to be the shortest, whereas the longer duration was on GT-10, which is black seeded. This suggests that the GT-10 has become unsuitable for insect development and has evolved into a *Tribolium castaneum* resistant variety.

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Conflict of interest. The authors do not have any conflict of interest.

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