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Some Aspects on the Biology of the Groundnut Borer Caryedon Serratus (Olivier) (Coleoptera: Bruchidae)

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Abstract

Groundnut borer, Caryedon serratus (Olivier) (Coleoptera: Bruchidae) is the only insect species known to infest kernels and intact pods of groundnut, thus it potentially becomes the most important major store pest of groundnut. The literature on the biology of C. serratus is scanty and is only available for the other bruchid, Callosobruchus maculatus (F) and the other related species, C. chinensis (L). For this reason, this work aimed at studying the biology of this species. The studies included mating process and frequency, developmental period of the eggs, larvae, pupae and adults of sexes, fecundity of females, preference of the females to oviposit on shelled and unshelled groundnut and the sex ratio of the progeny. The results revealed that: Mating occurred soon after adult emergence, took about 16-18 minutes. Both females and males mated once during their lifespan. The mean incubation period of the eggs was 6.28 and 5.33 days, larval development was completed in 16.71 and 15 days, pupal stage lasts for about 13 and 13.3 days, the mean adult longevity was 13.42 and 12 days and the total life cycle was completed in 50 and 45 days for females and males, respectively. The larvae undergo three moults and the mean larval instars duration were 3, 3.7, 3.8 and 4 days for the first, second, third and fourth instar respectively, while prepupal period took 2 days. Females deposited significantly more eggs on unshelled than on shelled groundnuts (38 and 28/female). The pre-oviposition period was one day, oviposition period ranged between 2-4 days and the post-oviposition period ranged between 3-5 days. The oviposition started on the second day and reached the peak on the third day. The eggs hatched and gave males and females, at 1.17:1 ratio.

Keywords: Groundnut, biology, Borer

Introduction

The legume crops in Sudan have a significant role in the diets of the Sudanese people, because of their high protein content and they contribute substantially to the economy of thecountry. They are equally important as income generating crops for their producers. Food legume crops also play an important role in sustaining the productivity of the farming system in Sudan, because of their beneficial effect on the soil through the fixation of atmospheric nitrogen. The yield of legume crops is known to be sensitive to weather conditions, and reduced by high temperatures, insect pests and diseases [1].

In the Sudan groundnut is infested during storage by several insects such as the Khapra beetle, Trogoderma granarium (Evert), the flour beetle, Tribolium confusum (Dur), the rice moth, Corcyra cephalonica (Stainton) and the saw-toothed beetle, Oryzaephilus surinamensis (L) all occur as secondary pests [2]. However, the most important pest during storage is the groundnut borer Caryedon serratus. It causes about 20% damage to the stored crop and gradually emerging as a major storage pest [3]. The pinkish larvae are internal borers and bore into the kernels causing deterioration of germination. In case of severe damage, the kernel seed with many holes with some powdery masses and the entire inner content is consumed.

Materials and Methods

Insect Culture

The nucleus culture of the groundnut borer was collected from infested pods of groundnut from the Southern Zone of Rahad Agricultural Corporation, storehouses. The stock culture was maintained on groundnut by releasing 10 pairs of freshly emerged beetles separately in plastic jars covered with muslin cloth and fastened by rubber band. Fresh pods were provided periodically for the development of beetles. The pure culture was maintained by infesting insect-free groundnut pods with freshly emerged pairs of beetles in plastic jars. The culture was maintained under room conditions throughout the experimental period. The biology of C. serratus was studied under laboratory conditions which ranged between 18.1 – 20.9oC min and 31.1-40.3oC max and 31 - 77%RH during April to December, 2018.

Mating Duration and Behavior

To obtain virgin females and males, several pupae of C. serratus were collected from the culture, transferred singly to Petri dishes and kept until the adults emerged. The adults were sexed using the characters described by Davey [4]. Ten virgin pairs were randomly taken and each pair was transferred to a Petri-dish (PYREX® reusable glass Petri Dishes 100×15 mm), supplied with unshelled groundnut and observed. When mating occurred, the mating duration and behavior were recorded.

Mating frequency

The aim of the experiment was to determine whether females accept copulation with more than one male. Virgin females and males were collected from the culture and isolated separately to Petri dishes. The females were categorized to three groups. The first group contains one male, the second group two males and the last group three males. All groups were supplied with virgin single female each separately. The females in all groups observed for mating and remoting.

Developmental Periods of the Different Stages of C. serratus

Egg stage

The mated females were transferred to glass jars and supplied with unshelled groundnut for oviposition. Twenty pods, which containing the newly eggs deposited on the same day were randomly selected. The eggs on each pod were reduced to a single egg/pod by surrounding the randomly selected egg with a black circle created by a pen. The remaining eggs in each pod were removed by using a wooden toothpick. The pods containing the single eggs were transferred singly to Petri-dishes using forceps. The Petri-dishes were covered and kept under room conditions and observed every 12 hours until the eggs hatched and the incubation period of the eggs was recorded.

Larval, Pupal and Adult Stages

For larval development, groundnut seeds were crushed into fine granules using an electric blender for ten seconds, crushed groundnut was used as food for rearing. Ten neonate larvae of (0-24 hours) were transferred individually to Petri dishes and supplied with groundnut powder. The larvae were transferred daily to new Petri dishes using camel hair brush and supplied with food. The crushed groundnut harboring the juvenile larvae was examined daily by using intensive light of electric torch and wooden toothpick for exuviae presence. This was continued until the larvae pupate, where number and duration of each instar was determined.

Prepupal Stage

The full-grown larvae were transferred singly to Petri-dishes by using forceps and kept under room conditions until the cocoons were formed, when the prepupal periods were recorded.

Oviposition Rate, Fecundity and Longevity

Nine newly emerged and mated females were collected from the culture. Each female was transferred to a glass jar by using forceps and supplied with 20 pods of unshelled groundnut. The groundnut was removed daily, the eggs deposited were counted and fresh pods of groundnut were provided. This was continued until all the females died, then the total number of eggs deposited was determined. The pre-oviposition, oviposition and post-oviposition periods were recorded. The longevity (age) of both sexes was also recorded.

Preference of the Females of C. serratus for Oviposition on Shelled and Unshelled Groundnut

The aim of the activity was to determine the preference and the fecundity of the females to oviposit when given free choice to oviposit on shelled and unshelled groundnut. Five females, which were emerged on the same day (0-24 hours old), were randomly taken from the culture. They were transferred to glass jar and supplied with a mixture of 50 grams shelled and 50 grams unshelled groundnut, i.e. given a free choice. The jar was covered and left under room condition. The insects were transferred daily to clean glass jars and supplied with the same type and quantity of groundnut. This was continued until all the females died and the number of eggs deposited on each groundnut type was recorded.

Type of Reproduction

Five virgin females were transferred separately to glass jars and provided with 100 grams unshelled groundnut. The groundnut was removed daily; the daily number of eggs deposited was recorded and the females were provided with fresh groundnut. The pods containing the eggs deposited daily by each virgin female were transferred separately to glass jar and observed daily for hatching or otherwise.

Sex Ratio of the Progeny

Four mated females were confined separately in glass jars; each female was supplied with 100 grams of unshelled groundnut. The groundnut containing the daily deposited eggs by each female from the first day of the oviposition period until the female died were transferred using forceps to glass jars until they hatched. Rearing was continued until the adults emerged. The adults were sexed and the sex ratio of the progeny was recorded.

Results and Discussion

Mating Duration and Behavior

The copulation took place soon after emergence. Once introduced, the male immediately held the female and mounted her from behind adopting a male above position. The mean mating time took longer (17 + 0.25 minutes) Table (1), than that reported by other investigators for other species, e.g. Paddock and Reinhard noted a pair of C. maculatus (Fabricius) coupling one minute after emergence and pointed out that the copulation rarely lasted more than 3-4 minutes [9]. However, Raina mentioned that copulation lasted 3-8 minutes also in C. maculatus [10]. The study revealed that unlike other bruchids, C. serratus did not show polyandry. Contrary, females of the bruchid beetle C. maculatus often mate many times per day if males are present [11]

Table 1: Mating duration of Caryedon serratu

Duration/Minutes	Sample (male and female)
17	1
16	2
18	3
16	4
17	5
17	6
18	7
16	8
18	9
17	10
170	Total
16-18	Range
17	Mean
0.25	SE±

Biology of the groundnut borer (C. serratus)

Normally the females started oviposit soon after mating. The first eggs were usually laid within two days. The mean incubation period of the eggs was 6.28 and 5.33 days for females and males, respectively. The mean of the incubation period of the eggs recorded for C. maculatus were 3.2 days under 63% RH, four days at 30oC and 70% RH, 3-8 days at 35oC (Wade, 1919), 3-37 days and 3-27 days [16, 10, 9, 7]. The mean larval development was completed in 16.71 and 15 days for females and males, respectively. The pupal stage lasts for about 13 and 13.3 days for females and males, respectively. The mean adult longevity was 13.42 and 12 days and the life span completed in 50 and 45 days for females and males, respectively. Table (2).

Table 2: Developmental Period of Caryedon Serratus from Egg to the Adult Longevity

No	Development Period (days)									
	Egg incubation		Larval		Pupal		Adult		Total life span	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
1	5	5	16	15	12	12	13	12	46	44
2	7	6	18	15	12	12	15	12	52	45
3	7	5	16	15	13	14	11	12	47	46
4	7	-	15	-	14	-	15	-	51	-
5	6	-	18	-	14	-	12	-	50	-
6	5	-	17	-	12	-	13	-	51	-
7	7	-	17	-	14	-	15	-	53	-
Total	44	16	117	45	91	40	94	36	350	135
Mean	6.28	5.33	16.71	15.0	13.0	13.3	13.42	12.0	50.0	45.0

Larval, Pupal and Adult Stages

The results obtained indicated that, there were four larval instars: the mean of the duration periods of the instars were 3.0, 3.7, 3.8, 4.0 days for the first, second, third and fourth larval instar, respectively (Table 3). This agree with the finding reported for the same pest by Saxena, and, (1970), grubs passed through four instars and emerged out of the pod, leaving a characteristic round hole of about 3 mm in diameter on the pod wall and migrated to the bottom of the heap and constructed oval papery cocoons [10].

Table 2: Developmental Period of Caryedon Serratus from Egg to the Adult Longevity

Sample Instar	1	2	3	4	5	6	7	8	9	10	Mean	SE(±)
1st	3	3	3	3	3	3	3	3	3	3	3.0	-
2nd	3	4	4	3	3	4	4	4	4	4	3.7	0.15
3rd	3	4	3	4	4	4	4	4	4	4	3.8	0.13

4th	4	4	3	4	4	4	4	5	4	4	4.0	0.14
Prepupa	2	2	2	2	2	2	2	2	2	2	2.0	-

Preferences of the Females of c. Serratus to Oviposit on Shelled and Unshelled Groundnuts

When the females of C. serratus given a free choice, they preferred to oviposit on the rough surface than on the smooth surface of the groundnut, i.e. deposited significantly more eggs on unshelled groundnut than on shelled groundnut, eggs deposition was significantly more on unshelled groundnut (38 eggs) than on shelled groundnut (28 eggs) Table (4). Contrarily, Larson and Fisher and Booker found clear preference by C. maculatus to oviposit on smooth than on rough cowpea seeds [7, 2]. The rough surface of the chick pea might determine oviposition and preference of C. maculatus to oviposit is associated with roughness of seed coat [14, 15]. The preference for oviposition may be related to the suitability of the host for larval development, physical characteristics rather than to the chemical composition of the seeds and to several biochemical factors, which may be responsible for resistance of pulse seeds to infestation by bruchids [1, 8].

Table 4: total number of eggs of c. Serratus when given Free Choice to Oviposit on Unshelled or Shelled Groundnut

Number of eggs		
Sample No.	**Shelled**	**Un shelled**
1	52	68
2	42	58
3	27	33
4	15	21
5	7	11
Total	143	191
Mean	28.6 b	38.2 a
SE±	6.33	
Cv%	12.4	
Level of significance	*	

Means followed by same letter are not significantly different according to T test.

Oviposition rate, fecundity and longevity

The females had equal pre-oviposition periods (1 day), the post oviposition period ranged between 2-4 days. The oviposition period ranged between 3-5 days. All females oviposited on the second day from emergence and the oviposition rate was highest on the second and third day of the oviposition period, and then gradually decreased, Table (5) Figure (1).

Table 5: Oviposition Rates, Fecundity and Reproductive Period for C. Serratus

Individuals	Number of eggs / female / days											Adult period			Number of eggs	longevity(days)
	1	2	3	4	5	6	7	8	9	10	11	Pre	Ovi	Post		
1	-	24	20	14	4	-	-	-	D			1	4	3	62	8
2	-	23	17	13	-	-	-	-	-	D		1	3	5	53	9
3	-	22	15	12	4	-	-	-	D			1	4	3	53	8
4	-	20	14	12	5	2	-	-	-	D		1	5	3	53	9
5	-	23	15	10	4	-	-	-	-	D		1	4	4	52	9
6	-	18	15	17	5	4	-	-	D			1	5	2	59	8
7	-	22	20	18	6	-	-	D				1	4	2	66	7
8	-	23	20	14	6	2	-	-	-	D		1	5	3	65	9
9	-	25	17	13	3	1	-	-	-	D		1	5	3	59	9

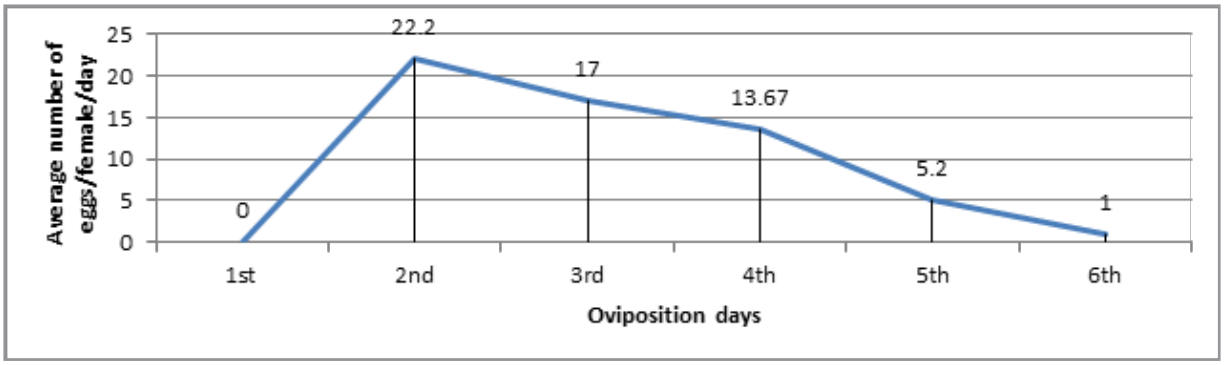

Figure 1: Mean number of eggs/female/days for C. serratus during its life time at Rahad Agricultural Corporation, season 2016/17

Sex Ratio of the Progeny of Mated Females of C. serratus

The progeny produced was a mixture of males and females. The sex ratio was male biased, i.e. the female to male ratio was 1:1.17 Table, (6).

Table 6: Sex Ratio of the Progeny of C. serratus under room conditions at Rahad Agricultural Corporation, season 2016/17

Number of fertilized females	Total number of eggs	Progeny produced		Sex Ratio Female: Male
		Female	Male	
1	41	19	22	1:1.2
2	48	21	27	1:1.3
3	52	25	27	1:1.1
4	49	23	26	1:1.1
Total	190	88	102	4:4.7
Mean				1:1.7

Type of Reproduction of C. Serratus

All the eggs deposited by mated females of C. serratus hatched. Contrarily, the eggs deposited by the unmated females failed to hatch. This indicated that the reproduction of C. serratus is only bisexual. This agrees with the findings of El Kindi and El Sawaf [5, 6].

Conclusion and Suggestions

From the results obtained it was concluded that:

- The generation period in the laboratory during the months (April - December) was 47.2 and 48.6 for females and males, respectively. 34.3% and 34.1% of this period is spent by the larval stage of females and males, respectively which is the most destructive stage.
- Females preferred oviposition on unshelled than on shelled groundnuts.
- Reproduction of C.serratus is only sexual.
- Further research on the biology of this insect under controlled conditions of temperature and humidity are needed to determine the optimum conditions for development and reproduction.
- Assessment of damage caused by this pest in stores needs to be determined. Also developmental periods, number of annual generations and the damage caused under field conditions need investigation.

Temperature and relative humidity during April to December, 2018.

Month	Mean		
	Maximum temperature (oC)	Minimum temperature (oC)	RH (%)
April	40.3	23.7	31
May	39.9	24.7	38
June	36.6	23.0	56
July	32.8	21.5	71
August	31.1	20.9	77
September	33.0	21.2	71

October	37.5	21.8	57
November	34.2	21.0	43
December	32.3	18.1	48

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