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Research Article

BIOLOGY OF PULSE BEETLE *Callosobruchus chinensis* IN STORAGE CONDITION IN GRAM

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Abstract- *Callosobruchus chinensis* (L.) (Coleoptera: Bruchidae) is a major stored pest of pulses in India. Biology of pulse beetle was studied during 2015-16 and 2016-17 in the laboratory. The average incubation period, larval + pupal period, and adult longevity of male and female were 4.0, 16.4, 11.0 and 9.6 days respectively. The average of total developmental period (egg to adult) was 25.2 days, and pre-oviposition, oviposition and post-oviposition period were 0.4, 8.0 and 2.2 days, respectively. The average fecundity of the females was 85.6 eggs and its viability 94% during its life time.

Key words- *Callosobruchus chinensis,* Chickpea, Biology.

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Introduction

Pulses are important component of our daily diet as they are the cheapest source of proteins, vitamin, energy and minerals. Production of pulse has increased at a much slower rate compared to cereal, oil seeds and other crops over the last two decades. However, with the increase of population per capita availability of pulses has declined. For nutritional security and also for sustainable agriculture, pulses play a significant role [1]. The demand of protein is increasing by about 3% annually. Pulses add atmospheric nitrogen in the soil, besides meeting their own requirement of nitrogen. The pulse crops are attacked by than 150 insect pests. It is recorded that 55- 60 percent loss in seed weight and 45.50 to 66.30 percent loss in protein content of pulses is due to infestation caused by pulse beetle in *Pisum sativum* (pea), *Vigna unguiculata* (cowpea), *Cajanus cajan* (pigeonpea), *Vigna unguilaris* (adzuki bean), *Lens culinaris* (lentil). It is distributed throughout the tropics and subtropics. Synonyms of *C. chinensis* are *Mylabris chinensis* and *Bruchus chinensis* and common English names are Chinese bruchid, Oriental cowpea bruchid and Adzuki bean weevil. The pulse beetles assume serious proportions usually during July-August in the stores. Biology of pulse beetle in different pulses were reported by [2]. For the management purpose we should require the biology of pulse beetle.

Material and Methods

The investigation entitled "Studies on pulse beetle, *Callosobruchus chinensis.* Linnaeus and its management with edible oils" was carried out at Shri Satya Sai University of Technology and Medical Science, Sehore, Madhya Pradesh during the year 2015-16 and 2016-17. The experiments were carried out at room temperature of 28^0 to 33^0C and relative humidity of 68 to 75 per cent. An adult beetle of less than 24 hours of age was released singly in a glass tube containing a gram seed. The tubes covered with muslin cloth on the top tied with rubber bands including the control. The bottles were suitably labeled and kept in incubator at a temperature of 28±1o C and 70±5 relative humidity. Oviposition was recorded daily and Grains containing eggs were separated out by examining under microscope and were used for further study. After the death of the beetle oviposition, oviposition period and survival were recorded. The total developmental period from egg to adult was also recorded. Observations were recorded at 2, 4 and 6 days after release of adult beetle. The data obtained were statistically analyzed by adopting suitable transformation [3].

Egg: Eggs were examined under microscope for the study of incubation period and hatchability of the eggs, counted number of freshly laid eggs was observed daily till hatching. Average incubation period was then calculated. The eggs were considered as hatched when larva emerged out from it. Hatching percentage was calculated from the number of eggs hatched, out of total number of eggs kept under observation.

Larva: On hatching, the larvae of pulse beetle were allowed to feed individually inside the grains in specimen tube (diameter 1.5 cm; length 7.5 cm) containing gram grains. Two days later, grains were dissected carefully to see the different stages of the larvae. The dissection of grains was made till larva reached the pupal stage. The period between egg hatching and pupation was recorded as larval period.

Pupa: The pupal period was studied by observing the larvae for pupation inside the grains. This was maintained and the observations were made till the adult emergence. The period between formations of pupae till the adult emergence was noted as pupal period.

Ovipositional studies: A pair of emerged beetle was collected in specimen tube (diameter 1.5 cm; length 7.5 cm) and such thirty specimen tubes were maintained. The beetle was allowed to mate. To determine the fecundity, eggs laid by each female were counted daily in the morning till the death of the female. The grains with eggs were discarded. A period between the time of emergence of the female and the time of starting the egg laying was considered as pre-ovipositional period. Period between starting of egg laying and stopping of egg laying was noted as ovipositional period, while period between stopping of egg laying and death of female was considered as post ovipositional period.

Adult longevity: The ability of the adults of pulse beetle to live in the presence or absence of food was determined by enclosing male and female adults obtained from the culture separately. Thirty such vials were maintained for each of the male and female with and without food.

Results and Discussion

During the studies on various aspects of biology of *C. chinensis* under laboratory condition, the duration of different stages recorded and described below. The study on biology of *C. chinensis* was carried out on gram variety JG-16 at laboratory condition during 2016 and 2017. The average room temperature was 23.5° C to 31.6° C, while the relative humidity was 56.8 to 74.2 per cent during the study period. Initial culture was successfully established on stock culture by collecting the adult beetles from the infested gram grains [4].

Egg: The females of *C. chinensis* laid the eggs on the gram grains. Eggs were cigar shaped and shiny bright yellow. They were attached singly to developing grain, often with several eggs on each grain. Freshly laid eggs were translucent and white and became opaque before hatching. It is clear from the [Table-1] that incubation period of eggs of *C. chinensis* was short and it varied from 3.78 to 6.12 day with an average of 4.87 ± 0.31 day at 25.20 to 31.55°C temperature and 77.10 to 87.50 per cent relative humidity. It can be seen from [Table-1] that the hatching percentage of eggs of *C. chinensis* varied from 66.00 to 82.00 per cent with an average of 74.95 ± 5.50 per cent. The incubation period as reported to be 5 to 9 day [5] is more or less in confirmation with present findings.

Table-1 *Incubation period and hatching percentage of eggs of C. chinensis*

Date	No. of Egg observed	Incubation period (Days)			No. of Egg hatch	Hatching (%)
		Min.	Max.	Av. ± SD		
	50	3.75	4.25	4.00 ± 0.23	33	66.00
	50	3.50	4.50	4.11 ± 0.31	40	80.00
	50	3.25	4.75	3.99 ± 0.46	38	76.00
	50	4.25	6.25	5.54 ± 0.65	33	66.00
	50	4.50	5.75	5.02 ± 0.75	38	76.00
	50	3.75	5.25	4.59 ± 0.65	40	80.00
	50	3.75	5.50	4.49 ± 0.75	40	80.00
	50	3.50	4.75	3.99 ± 0.56	41	82.00
	50	3.25	4.75	3.78 ± 0.46	35	70.00
	45	3.50	4.25	3.97 ± 0.39	32	71.11
	50	4.50	6.25	5.54 ± 0.89	33	66.00
	48	5.25	6.75	6.05 ± 0.63	34	70.83
	50	5.50	6.75	6.12 ± 0.45	38	76.00
	50	4.75	6.25	5.49 ± 0.76	40	80.00
	50	4.25	6.50	5.45 ± 0.92	41	82.00
	50	5.25	6.75	5.99 ± 0.52	41	82.00
	43	3.75	6.25	4.45 ± 0.94	32	74.42
	50	3.75	5.50	4.51 ± 0.64	38	76.00
	50	4.25	5.75	4.97 ± 0.59	35	70.00
	50	4.50	5.25	5.04 ± 0.27	34	68.00
	50	4.00	5.50	4.89 ± 0.43	33	66.00
	50	3.75	5.75	4.12 ± 0.54	39	78.00
	50	4.25	5.50	4.99 ± 0.39	36	72.00
	50	4.25	5.25	4.46 ± 0.34	38	76.00
	50	4.50	5.75	5.01 ± 0.43	40	80.00
	50	5.25	6.75	6.07 ± 0.51	41	82.00
	50	3.75	6.25	4.98 ± 0.67	35	70.00
	50	3.75	5.50	4.44 ± 0.53	37	74.00
	50	4.50	5.75	5.08 ± 0.47	38	76.00
	50	4.25	5.75	5.01 ± 0.38	41	82.00
Min.	**-**	**-**	**-**	**3.78 ± 0.46**	**32**	**66.00**
Max.	**-**	**-**	**-**	**6.12 ± 0.45**	**41**	**82.00**
Av. ± SD	**-**	**-**	**-**	**4.87 ± 0.31**	**37.13± 3.10**	**74.95 ± 5.50**

Larva: During the present study it was observed that the larva of *C. chinensis* moulted three times to attain maturity. Grub was apodous, short, stout, yellowish white and brown colored head. Grub development took place inside the grain. There were 13 segments with nine pairs of spiracles, one pair was on thoracic region and the rest were on abdominal segments. Body was covered with small setae. The body length of first instar larvae measured from 0.26 to 0.33 mm with an average of 0.30 ± 0.02 mm and breadth from 0.09 to 0.11 mm with an average of 0.10 ± 0.01 mm. Duration of first instar larvae was 5.50 to 7.00 day with an average of 6.17 ± 0.53 day at 24.80 to 31.40°C temperature and 75.50 to 85.10 per cent relative humidity. The second instar larva was larger than first instar larva. The length of second instar larvae ranged from 0.42 to 0.48 mm with an average of 0.44 ± 0.02 mm and breadth from 0.14 to 0.16 mm with an average of 0.15 ± 0.01 mm [Table-2]. The duration of second instar larvae ranged from 6.00 to 7.50 day with an average of 6.60 ± 0.56 day at 24.50 to 32.60°C temperature and 80.70 to 91.10 per cent relative humidity. The third instar larva was bigger in size than the earlier instars. The body length of third instar larvae ranged from 4.50 to 9.85 mm with an average of 6.17 ± 1.27 mm and breadth from 1.50 to 3.28 mm with an average of 2.06 ± 0.43 mm [Table-2]. The duration of third instar larvae ranged from 7.50 to 9.50 day with an average of 8.42 ± 0.57 day at 25.30 to 31.40°C temperature and 91.00 to 92.50 per cent relative humidity. The body length of fourth instar larvae ranged from 1.25 to 1.45 mm with an average of 1.39 ± 0.05 mm and breadth from 0.42 to 0.48 mm with an average of 0.46 ± 0.02 mm [Table-2]. The duration of fourth instar larvae ranged from 4.50 to 6.50 day with an average of 5.20 ± 0.57 day at 23.00 to 31.80°C temperature and 81.40 to 89.00 per cent relative humidity [Table-2]. Similar observations have also been reported by Quazi, 2007[6]. The total larval period varied from 24.50 to 28.50 day with an average of 26.39 ± 1.24 day [Table-2]. The current findings are in agreement with Mishra *et al.*, 2013 [7] who reported that botanicals gave control of *C. chinensis* by

reducing oviposition and delaying developmental period may be by affecting the overall physiology of the insect.

Table-2 *Duration of different stages of C. chinensis*

Sr. No	Duration of larval development (days)				Total larval period (days)	Pupal period (days)	Longevity of adult (days)		Total life cycle (days)	
	I instar	II instar	III instar	IV instar			Male	Female	Male	Female
1	7.00	6.00	7.50	5.00	25.50	7.00	55.00	82.00	91.50	118.50
2	6.00	7.00	8.00	5.00	26.00	6.75	60.00	83.00	96.86	119.86
3	6.50	7.50	8.50	6.00	28.50	7.00	58.00	85.00	97.49	124.49
4	5.50	7.00	9.00	6.50	28.00	6.85	57.00	86.00	97.39	126.39
5	5.50	7.00	7.50	5.00	25.00	6.25	59.00	89.00	95.27	125.27
6	6.00	7.50	8.00	4.50	26.00	6.00	60.00	90.00	96.59	126.59
7	7.00	7.00	8.00	5.00	27.00	6.75	60.00	92.00	98.24	130.24
8	7.00	6.00	7.50	5.00	25.50	6.45	55.00	100.00	90.94	135.94
9	6.00	6.00	9.00	5.50	26.50	6.85	58.00	92.00	95.13	129.13
10	6.00	6.00	9.00	5.50	26.50	6.95	59.00	95.00	96.42	132.42
11	6.00	6.60	9.00	5.00	26.60	7.00	57.00	93.00	96.14	132.14
12	5.50	6.00	8.50	5.00	25.00	6.95	60.00	85.00	98.00	123.00
13	5.50	6.00	8.50	5.00	25.00	7.00	59.00	84.00	97.12	122.12
14	5.50	6.00	8.00	5.00	24.50	6.90	60.00	81.00	96.89	117.89
15	6.00	6.00	8.00	4.50	24.50	6.50	55.00	83.00	91.45	119.45
16	6.00	6.00	8.00	4.50	24.50	6.65	58.00	84.00	95.14	121.14
17	6.00	6.00	8.00	6.00	26.00	7.00	59.00	85.00	96.45	122.45
18	6.00	7.00	9.00	5.00	27.00	6.75	58.00	85.00	96.26	123.26
19	7.00	7.00	9.50	4.50	28.00	6.85	57.50	84.50	97.32	124.32
20	6.50	7.50	9.00	5.00	28.00	6.90	57.00	85.00	96.94	124.94
21	6.50	7.00	8.50	5.00	27.00	6.80	55.00	86.00	93.69	124.69
22	6.50	7.00	8.50	5.00	27.00	7.00	56.00	87.00	94.12	125.12
23	6.00	7.00	8.00	5.00	26.00	6.90	58.00	87.00	95.89	124.89
24	7.00	7.50	9.00	5.00	28.50	7.00	60.00	101.00	99.96	140.96
25	5.50	6.00	9.50	4.50	25.50	6.95	55.00	89.00	92.46	126.46
26	6.00	6.50	8.00	5.00	25.50	6.90	56.00	88.00	94.47	126.47
27	5.50	6.00	8.00	6.00	25.50	6.65	55.00	82.00	92.13	119.13
28	6.00	6.50	8.50	6.50	27.50	7.00	59.00	82.00	97.94	120.94
29	7.00	6.50	8.00	6.00	27.50	6.95	60.00	81.00	99.53	120.53
30	6.50	7.00	9.00	5.50	28.00	7.00	56.50	83.00	96.51	123.01
Min.	**5.50**	**6.00**	**7.50**	**4.50**	**24.50**	**6.00**	**55.00**	**81.00**	**91.45**	**117.89**
Max.	**7.00**	**7.50**	**9.50**	**6.50**	**28.50**	**7.00**	**60.00**	**101.00**	**99.96**	**140.96**
Av. ± SD	**6.17 ± 0.53**	**6.60 ± 0.56**	**8.42 ± 0.57**	**5.20 ± 0.57**	**26.39 ± 1.24**	**6.82 ± 0.24**	**57.73 ± 1.84**	**86.98 ± 5.17**	**98.81 ± 2.33**	**125.06 ± 5.24**

Pupa: Pupa was white to yellowish white; excrete with clearly visible head thorax and abdomen. Pupa measured 3.25 to 3.50 mm in length with an average of 3.34 ± 0.09 mm and the width measured 1.63 to 1.75 mm with average of 1.67 ± 0.04 mm. Pupal period occupied 6 to 7 days with an average of 6.82 ± 0.24 day at 25.20 to 36.40°C temperature and 68.50 to 88.10 per cent relative humidity. The variation could be due to the difference in temperature, relative humidity and change in the host. The findings are in conformity with Mandal and Konar, 2006 [8] who reported 6 to 16 days of pupal period. **Adult:** Newly emerged adults were reddish brown which become black at the time of egg laying. Adults were elongated, sub-cylindrical with four orange colored patches on elytra. Male and female adults look alike externally but on closer observation, the rostrum of the male was comparatively thick, closely punctured roughs curved, while in female it was elongate, slender smooth, shining slightly curved and sparsely punctured. Head was prolonged into snout at the tip of which mouth parts are situated. Antennae were short and geniculate type. Male measured 3.15 to 3.45 mm in length with an average of 3.32 ± 0.10 mm and 1.26 to 1.38 mm width with an average of 1.33 ± 0.04 mm. While, female measured 3.50 to 3.75 mm in length with an average of 3.62 ± 0.10 mm and 1.40 to 1.50 mm width with an average of 1.45 ± 0.04 mm.

Longevity: The data presented in [Tables-4] showed the longevity of males and females. In case of adult longevity, adult females survived for 81 to 101 days with an average of 86.98 ± 5.17 day while males survived for 55 to 60 days with an average of 57.75 ± 1.84 day at 25.60 to 38.40°C temperature and 65.20 to 88.50 per cent relative humidity. Thus, males lived shorter than females. Thus, males lived shorter than females. The present findings draw the support of Kiran *et al.,* 2005 [9] who observed adult longevity ranging from 14 to 16 days and 7 to 11 days with and without food, respectively. Mukhaerjee *et al.,* 1970 [10] reported that longevity of adult weevil ranging from 16 to 172 days with food.

Total life cycle: In the present study, the total life cycle of males of *C. chinensis* observed to be ranged from 91.45 to 99.96 (Av. 98.81 ± 2.33) day with food, while in case of without food it was ranged from 40.94 to 45.89 (Av. 43.47 ± 1.29) day. The total life cycle of female with food was ranged from 117.89 to 140.96 (Av. 125.06 ± 5.24) day, while in case of without food it was ranged from 44.50 to 50.46 (Av. 47.57 ± 1.58) day [Table-4]. The findings are in agreement with [4] who reported 21 to 46 days. But these results do not agree with observation of [3] who reported 38 to 53 days of total life cycle on sorghum hybrid CSH-5. The difference may be attributed to variation in genotype and different climatic conditions.

Pre-oviposition, oviposition and post-oviposition periods: The data presented in [Table-3] revealed that pre-oviposition, oviposition and post-oviposition periods varied from 3 to 7 (Av. 4.95 ± 0.89), 33 to 61 (Av. 52.21 ± 8.16) and 18 to 37 (Av.29.81 ± 4.52) day, respectively at 23.80 to 34.90°C temperature and 63.80 to 92.00 per cent relative humidity. Sharvale and Borikar, 1996 [11] have made similar kind of observations.

Table-3 *Pre-oviposition, oviposition, post-oviposition period and fecundity of female of C. chinensis*

Sr. No.	Pre-oviposition period (days)	Oviposition Period (days)	Post-oviposition period (days)	Total no. of eggs laid/female
1	3.00	59.00	32.21	125.00
2	3.50	58.00	33.63	265.00
3	3.75	45.00	33.00	145.00
4	4.95	46.00	22.00	156.00
5	5.00	33.00	27.00	178.00
6	5.00	33.50	19.00	133.00
7	4.65	59.00	18.00	198.00
8	4.85	53.25	29.00	154.00
9	4.80	61.00	37.00	176.00
10	5.95	58.00	28.00	167.00
11	4.15	54.00	34.75	156.00
12	4.95	45.00	28.00	187.00
13	4.65	55.25	29.33	159.00
14	5.00	48.00	35.55	155.00
15	4.95	49.50	26.00	187.00
16	7.00	48.00	29.95	163.00
17	4.35	59.95	29.00	177.00
18	4.55	61.00	35.00	188.00
19	4.75	49.00	29.00	145.00
20	4.95	60.25	31.00	165.00
21	4.85	59.95	29.00	132.00
22	4.90	48.00	27.00	178.00
23	4.90	52.00	31.00	144.00
24	7.00	33.00	35.90	153.00
25	4.85	58.58	32.00	177.00
26	4.55	59.00	31.00	145.00
27	6.38	55.00	31.00	122.00
28	6.55	54.00	28.00	165.00
29	4.95	56.00	29.00	178.00
30	4.85	55.00	34.00	143.00
Min.	**3.00**	**33.00**	**18.00**	**122**
Max.	**7.00**	**61.00**	**37.00**	**265**
Av.± SD	**4.95 ± 0.89**	**52.21 ± 8.16**	**29.81 ± 4.52**	**163.87 ± 27.37**

Table-4 *Summary of entire life cycle from egg to death of C. chinensis*

Stage	No. of observations	Range (days)		Mean (days)
		Min	Max	
Egg	30	3.78	6.12	4.87 ± 0.31
Egg hatching (%)	30	66.00	82.00	74.95± 5.50
Larva				
1st instar	30	5.50	7.00	6.17 ± 0.53
2nd instar	30	6.00	7.50	6.60 ± 0.56
3rdinstar	30	7.50	9.00	8.42 ± 0.57
4th instar	30	4.50	6.50	5.20 ± 0.57
Total larval period	30	24.50	28.50	26.39 ± 1.24
Pupa	30	6.00	7.00	6.82 ± 0.24
Adult longevity				
Male	30	55.00	60.00	57.73 ± 1.84
Female	30	81.00	101.00	86.98 ± 5.17
Pre-oviposition	30	3.00	7.00	4.95 ± 0.89
Oviposition	30	33.00	61.00	52.21 ± 8.16
Post-oviposition	30	15.00	37.00	29.81± 4.52
Fecundity	30	122.00	265.00	163.87 ± 27.37
Total life cycle				
Male	30	91.45	99.96	98.81 ± 2.33
Female	30	117.89	140.96	125.06 ± 5.24
Temperature (°C)	180 days	23.5	31.6	29.41 ± 1.62
Humidity (%)	180 days	56.8	74.2	59.43 ± 2.53

Fecundity: The fecundity of each female was recorded by counting the eggs within the cavity of grains laid during different periods of oviposition by each female. The data revealed that the fecundity ranged from 122 to 265 with an average of 163.87 ± 27.37 eggs per female during its entire life cycle.

Table-5 *Measurements of different stages of C. chinensis (Mean of 30 observations)*

Stages	Length (mm)			Breadth (mm)		
	Min.	Max.	Av. ± SD	Min.	Max.	Av. ± SD
Egg	0.35	0.39	0.37 ± 0.01	0.15	0.19	0.17 ± 0.01
Larva						
I instar	0.26	0.33	0.30 ± 0.02	0.09	0.11	0.10 ± 0.01
II instar	0.42	0.48	0.44 ± 0.02	0.14	0.16	0.15 ± 0.01
III instar	4.50	9.85	6.17 ± 1.27	1.50	3.28	2.06 ± 0.42
IV instar	1.25	1.45	1.39 ± 0.05	0.42	0.48	0.46 ± 0.02
Pupa	3.25	3.50	3.34 ± 0.09	1.63	1.75	1.67 ± 0.04
Adult						
Male	3.15	3.45	3.32 ± 0.09	1.26	1.38	1.33 ± 0.04
Female	3.50	3.65	3.62 ± 0.10	1.40	1.46	1.45 ± 0.04

Conclusion

In the present study, the total life cycle of males of *C. chinensis* observed to be ranged from 91.45 to 99.96 (Av. 98.81 ± 2.33) day with food, while in case of without food it was ranged from 40.94 to 45.89 (Av. 43.47 ± 1.29) day. The total life cycle of female with food was ranged from 117.89 to 140.96 (Av. 125.06 ± 5.24) day, while in case of without food it was ranged from 44.50 to 50.46 (Av. 47.57 ± 1.58) day.

Application of Research: Research is applicable for farmers and extension worker of the state for minimizing pulse beetle damage in storage conditions. Also applicable for understanding the biology of pulse beetle.

Research Category: Biology of Pulse Beetle

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***Research Guide: Dr Deepak Kumar Mittal**

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Conflict of Interest: None

Ethical Approval: This is the research work of Ph. D. student and approval has been taken from ethical committee constituted by Shri Satya Sai University of Technology and Medical Sciences, Sehore, 466 001, M.P.

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