

Seasonal Variations in Biology of Pulse Beetle (*Callosobruchus Maculatus*) on Bengal Gram under Laboratory Conditions

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ABSTRACT: Laboratory studies on the biology of the pulse beetle *Callosobruchus maculatus* (Linnaeus) (Coleoptera: Chrysomelidae) on stored Bengal gram revealed that the mean incubation period of 7.28, 8.88 and 5.96 days, the mean duration of first instar grub was 6.32, 8.76 and 4.08 days, second instar-7.00, 9.36 and 4.92 days, third instar-8.04, 10.88 and 6.04 days and fourth instar-8.88, 11 and 6.92 days during kharif, rabi and summer seasons, respectively. Pre-oviposition and oviposition period occupied 80 minutes and 7.08 days, respectively. The fecundity was 56-115 eggs with a mean of 90.68 eggs per female. The male and female adult beetles lived for 9.04 and 10.68 days. The mean total life cycle occupied 46.32, 62.4 and 35.28 days during kharif, rabi and summer seasons, respectively. Present study revealed the life cycle changes with the seasons. Longer life cycle was observed during rabi season due to low temperatures and shorter during summer due to ideal temperatures for faster development of the pulse beetle.

Keywords: Chickpea, *C. maculatus*, Life cycle, Dyar's law

INTRODUCTION

Chickpea (*Cicer arietinum* L.) which is also called as bengal gram or gram is the third most important food legume crops belongs to family Fabaceae, is native of South-Eastern Turkey. Chickpea is a cool season legume crop and is grown in several countries worldwide. Seed is the main edible part of the plant and is a rich source of protein, carbohydrates and minerals. The pulse beetle, *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) is a serious cosmopolitan and polyphagous pest of stored pulses such as bean, cowpea, lentil, and other legume grain. The grub of this species feed and develop exclusively on the seed of legumes (Fabaceae) hence the name "bean beetle". The adults do not require food or water and spend their limited lifespan (one-two weeks) mating and laying eggs on beans [1]. The information on life cycle during different seasons on chickpea is not available. However, studies by Venkate Gowda [2] on soyabean revealed lot of variations with respect to grub period during rabi and summer seasons. Hence the studies were carried out at National Seed Project, University of

Agricultural Sciences, GKVK, Bangalore, Karnataka during Kharif, rabi and summer season.

MATERIALS AND METHODS

Chickpea seeds of the variety JG-11 were used in the study. *C. maculatus* culture was maintained on chickpea in a laboratory throughout the study period. A pair of freshly emerged male and female adults were kept in the container for mating and allowed for egg laying. Identification of the sexes were made by employing the method of Raina [3].

Twenty five specimen tubes (5 x 1.5 cm) were taken. In each tube, chickpea seeds with freshly laid eggs of *C. maculatus* were introduced and the open end of the tube was plugged with cotton. The observations on different parameters like incubation, grub, pupal, pre mating, mating, pre-oviposition and oviposition periods, fecundity, adult longevity and total life span were studied during kharif (July-August), rabi (November-December) and summer (April-May) seasons. To determine the number of instars and the duration of each instar, seeds with eggs laid on the same day were segregated. Each day, 3-4

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seeds were carefully dissected and stages of grubs present inside the seed was determined based on the number of castings of head capsules [2].

RESULTS AND DISCUSSION

The eggs were oval, planoconvex in shape and smooth in appearance. The freshly laid eggs were transparent and covered by a secretion with which the eggs fastened to the seed surface. The morphological observations with respect to egg were in confirmation with Kunhikannan [4], Raina [3], Venkate Gowda [2] and Siddaraju [5]. Incubation period of eggs ranged from 6-8, 8-12 and 5-7 days with an average of 7.28, 8.88 and 5.96 days during kharif, rabi and summer season, respectively (Table 1) and seasonal variation of *C. maculatus* life cycle was presented (Fig. 1). The egg stage was shorter during summer (April-May) and longer during rabi/winter (November-December). The results are in confirmation with Venkate Gowda [2] who recorded 7-12 days with a mean of 9.09 days during winter season and 6-9 days with a mean of 7.95 days during summer on soyabean.

As the post-embryonic development progressed, the pro-thoracic plate became visible on the fourth day. The grub used this plate to bore into the seed through the egg shell. As the grub bored into the seed, the colour of the egg changed to white due to accumulation of frass inside the egg. During its grub period, the grub moulted three times and thus has four instars. Dyar's law was used to differentiate instars and head capsule width of grub follows a geometric progression (Table 2). The period occupied by each instars were noted along with their size.

The hatched grub was small, pale yellowish and opaque with clear annulations. The head was brown in colour and the pro-thoracic plates were clearly visible. The first instar grub duration ranged from 5 to 8 days with an average of 6.32 ± 1.14 days, 8-10 days with an average of 8.76 ± 0.72 days and 3-5 days

with an average of 4.08 ± 0.90 days during kharif (July-August), rabi (November-December) and summer (April-May), respectively (Table 1). The present results were in association with Venkate Gowda [2] who recorded first instar period of 6-10 days with a mean of 8.00 days during April-May, 1983. The length and width of first instar was almost similar to that reported by Venkate Gowda [2] who recorded the length ranged from 0.47-0.56 mm with a mean of 0.50 mm and width ranged from 0.28-0.32 mm with a mean of 0.29 mm.

The II stage of the grub was determined by the presence of head capsule, cast by the first instar grub. It resembled the first instar grub except for the size and absence of pro-thoracic plates. The head was not distinct and represented by the presence of mouthparts. The body was curved with the thoracic region enlarged than the posterior end. The second instar grub duration ranged from 6-9 days with an average of 7 ± 0.86 days, 8-10 days with an average of 9.36 ± 0.63 days and 4-6 days with an average of 4.92 ± 0.81 days during Kharif, rabi and summer respectively (Table 1). The length and breadth of second instar larvae varies between 0.75 to 0.85 mm and 0.55 to 0.60 mm with a mean of 0.82 ± 0.03 mm and 0.58 ± 0.02 , respectively (Table 3) with a mean head capsule length of 0.28 ± 0.2 mm and width of 0.36 ± 0.02 (Table 2).

Third instar grub did not differ much from the second instar except for the size. It entered into fourth instar in 7-9 days with an average of 8.04 ± 0.84 days, 10-12 days with an average of 10.88 ± 0.83 days and 5-7 days with an average of 6.04 ± 0.84 days during Kharif, rabi, and summer respectively. The mean head capsule length and breadth were 0.33 ± 0.02 and 0.51 ± 0.05 mm respectively (Table 2). The length and width of third instar grub varies between 1.05 to 1.40 mm and 0.70 to 0.98 mm with a mean of 1.23 ± 0.10 mm and 0.83 ± 0.08 mm, respectively (Table 3). The

Table 1
Developmental period (days) of different stages of *C. maculatus* during different seasons

Insect stages	July-August, 2012		November- December, 2012		April-May, 2013	
	Range	Mean \pm S.D. (n=25)	Range	Mean \pm S.D.	Range	Mean \pm S.D.
Incubation	6-8	7.28 \pm 0.73	8-12	8.88 \pm 1.30	5-7	5.96 \pm 0.78
I instar	5-8	6.32 \pm 1.14	8-10	8.76 \pm 0.72	3-5	4.08 \pm 0.90
II instar	6-9	7.00 \pm 0.86	8-10	9.36 \pm 0.63	4-6	4.92 \pm 0.81
III instar	7-9	8.04 \pm 0.84	10-12	10.88 \pm 0.83	5-7	6.04 \pm 0.84
IV instar	7-10	8.88 \pm 0.83	10-12	11.00 \pm 0.81	6-8	6.92 \pm 0.81
Total Grub period	25-36	31.12 \pm 3.89	36-44	39.44 \pm 2.53	18-26	22.12 \pm 2.45
Pre-pupal	2-3	2.88 \pm 0.33	3-4	3.48 \pm 0.50	1-2	1.44 \pm 0.50
Pupal	7-9	8.08 \pm 0.86	8-10	8.76 \pm 0.72	6-7	6.44 \pm 0.50
Total life cycle	40-56	46.32 \pm 5.85	55-70	62.4 \pm 5.66	30-42	35.28 \pm 4.13

S.D.=Standard deviation; n=Sample size

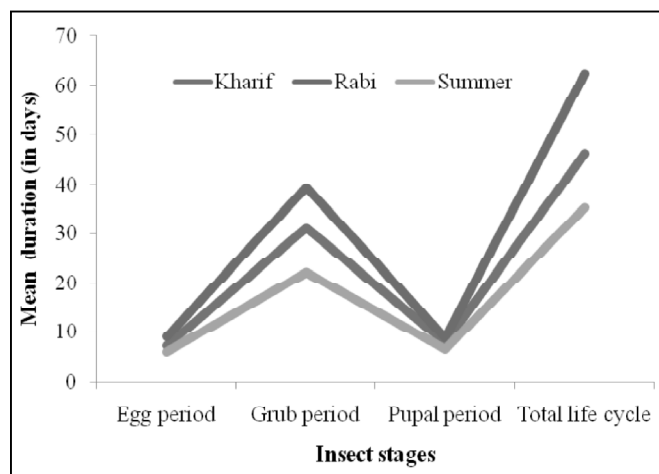


Figure 1: Seasonal variation of *C. maculatus* life cycle

durations were not in confirmity with Venkate Gowda [2] who observed 7-10 days with a mean of 7.90 days during April-May (1983) on soybean the length of first instar grub was 0.48 to 0.58 mm with a mean of 0.52 ± 0.03 mm and the width ranged between 0.20 ± 0.33 mm with a mean of 0.31 ± 0.1 mm (Table 3) but agreed with morphometric measurements.

Table 2

Head capsule length and width of stages of *C. maculatus* grub

Instars	Head capsule				Ratio*
	Length (mm)		Width (mm)		
	Range	Mean \pm S.D.	Range	Mean \pm S.D.	
1	0.10-0.15	0.13 \pm 0.01	0.22-0.28	0.25 \pm 0.02	-
2	0.25-0.30	0.28 \pm 0.02	0.33-0.40	0.36 \pm 0.02	1.44
3	0.30-0.35	0.33 \pm 0.02	0.43-0.60	0.51 \pm 0.05	1.41
4	0.43-0.50	0.47 \pm 0.02	0.65-0.78	0.73 \pm 0.04	1.43

n=10 grubs in each instar; S.D.=Standard deviation;

*Ratio calculated for head capsule width only.

Table 3

Morphometric data of *C. maculatus* on chickpea

Insect stages	Length (mm) (n=20)		Width (mm) (n=20)	
	Range	Mean \pm S.D.	Range	Mean \pm S.D.
Egg	0.50-0.60	0.55 \pm 0.02	0.30-0.35	0.33 \pm 0.01
I instar	0.48-0.58	0.52 \pm 0.03	0.30-0.33	0.31 \pm 0.01
II instar	0.75-0.85	0.82 \pm 0.03	0.55-0.60	0.58 \pm 0.02
III instar	1.05-1.40	1.23 \pm 0.10	0.70-0.98	0.83 \pm 0.08
IV instar	2.05-3.25	2.55 \pm 0.32	1.25-2.20	1.76 \pm 0.28
Pre-pupa	3.80-4.05	3.89 \pm 0.09	1.95-2.12	2.04 \pm 0.07
Pupa	2.83-3.80	3.20 \pm 0.35	1.80-2.15	1.93 \pm 0.13
Adult male	3.25-3.95	3.62 \pm 0.22	1.65-2.00	1.83 \pm 0.12
Adult female	4.05-4.78	4.17 \pm 0.28	1.85-2.12	1.93 \pm 0.11

S.D.=Standard deviation

The fourth instar grub was recognised by the presence of castings of head capsules of the preceding three instars. The tunnelling caused by the feeding of the grub extended up to the seed coat where the grub

fed leaving a thin layer of testa appearing like a circular spot (window). Towards the end, the grub prepared an oval pupal chamber by compressing the faecal matter against the wall of the tunnel. Facing the circular spot (window) on the seed coat, the grub became inactive and stopped feeding. It took 7-10 days with an average of 8.88 ± 0.83 days, 10-12 with an average of 11 ± 0.83 days and 6-8 days with an average of 6.92 ± 0.81 days during Kharif, Rabi, and summer, respectively (Table 1). But the results were contrary with Venkate Gowda [2] who recorded the duration lasted for 7-11 with a mean of 8.85 days during April-May, 1983 however, the morphometric measurements were in confirmation with his finding.

Total grub period ranged from 25 to 36 days with an average of 31.12 ± 3.89 days, 36 to 44 days with an average of 39.44 ± 2.53 days and 18 to 26 days with an average of 22.12 ± 2.45 days during July-August, November-December and April-May, respectively. The obtained results were contrary with the results of Ramesh [6] who recorded that 32.8 days and 34.18 days on soybean in summer (April-May) and Siddaraju [5] recorded 15.15 days on cowpea in the month of May-June. These variations may be due to biochemical constituent or physiology and quality of the seed.

The pre-pupa was quiescent. The body divisions were distinct. The abdominal portion was broader than the thoracic portion in comparison to grub stages. The stage occupied a period of 2-3 days with an average of 2.88 ± 0.33 days, 3-4 days with an average of 3.48 ± 0.50 days and 1-2 days with an average of 1.44 ± 0.50 days during Kharif, Rabi, and summer, respectively. The pre-pupa moulted into an exarate pupa. The length was 3.80 to 4.05 mm with an average of 3.89 ± 0.09 mm and width ranged from 1.95 to 2.12 mm with an average of 2.04 ± 0.07 mm. The present findings were supported by Moreno *et al.*, [7] who recorded pre-pupal period of 3.41 days. The morphometric measurements were in confirmation with Prabhakara [8] who observed in *C. chinensis*. But no literature available on measurements of *C. maculatus* of pre-pupa.

The pupa was light creamy in colour, as the pupa aged its colour changed from creamy to dark brown. The appendages were free but they were held close to the body. The pupal development lasted for 7-9 days with an average of 8.08 ± 0.86 days, 8-10 days with an average of 8.76 ± 0.72 days and 6-7 days with an average of 6.44 ± 0.50 days. However, the pupal period of 8-12 days with a mean of 8.51 days was

reported by Venkate Gowda [2] and 8.68 days by Ramesh [6] on soybean seeds during summer, which were contrasting to the present results. However, the results was in confirmation with Siddaraju [6] who observed 7.40 days pupal period of *C. maculatus* on cowpea seeds.

Adult emergence: The adults emerged out of the seed through the window which was made by the fourth instar grub. It was observed to make a circular cut along the peripheral margin of the window and then pushed the circular lid out by head which comes out first.

Sex ratio: The present study revealed a sex ratio (Female: Male) of 1:1.31 indicating the dominance of males over females (Table 4). Similar results were obtained by Venkate Gowda [2] Ramesh [6] and Siddaraju [5].

Table 4
Adult longevity and fecundity of *C. maculatus* on chickpea

Insect stage	Range	Mean±S.D. (n=25)
Pre-mating period (min)	3- 75	43.00±20.33
Mating period (min)	2-4	3.00±0.82
Pre-oviposition period (min)	45-135	80.00±28.19
Oviposition period (d)	6-9	7.08±1.18
Fecundity	56-115	90.68±17.21
Male adult longevity (d)	7-12	
Female adult longevity (d)	8-15	9.04±1.69
Sex ratio (Female: male)	1: 1.32	10.68±2.15

S.D.=Standard deviation; n=Sample size

The male beetles were brown in colour, antennae long and deeply serrate, elytra without distinct C-shaped areas of white pubescence, pygidium uniformly covered with golden setae and lack stripes. The length of male ranged from 3.25-3.95 mm with a mean of 3.62 ± 0.22 mm, width ranged from 1.65-2.00 mm with a mean of 1.83 ± 0.12 mm.

Females were black in colour; antennae short and sub-serrate; white pubescence on the elytra forming two distinct C-shaped areas with their bases facing each other; pygidium is enlarged with a pair of black postero-lateral spots. The length of female ranged from 4.05-4.78 mm with a mean of 4.17 ± 0.28 mm, width ranged from 1.85-2.12 mm with a mean of 1.93 ± 0.11 mm (Table-3).

Total developmental period: The shortest developmental period (egg to adult emergence) of 30-42 days with an average of 35.28 ± 4.13 days in summer and the longest period of 55-70 days with an average of 62.4 ± 5.66 days in kharif season.

Premating and mating period: The adult male and female beetles were observed to mate in about 3 minutes to 75 minutes (Mean: 43 minutes) after their

emergence from the seed (Table 4). The emerging males were more active compared to female. After emergence, the male chased the female and made number of attempts to mate. The female escaped by pushing it away with the hind legs. After several attempts, the male grasped the female and copulated. In the process, the male climbed over the back of the female and established union. The mating lasted for a period of 2-4 minutes with a mean of 3 minutes. Repeated matings were seen among both sexes which is in confirmity with the observations of Raina [3].

Pre-oviposition and Oviposition period: Pre-oviposition period ranged from 45 to 135 minutes (Mean: 80 minutes). The period of oviposition was spread over 6-9 days (Mean: 7.08 days Table-4). Maximum egg laying was observed during the second day followed by the first day and the number of eggs laid gradually decreased till the last day of oviposition.

The fecundity of *C. maculatus* varied from 56-115 eggs with a mean of 90.68 ± 17.21 eggs. The results were supported by the observations of Venkate Gowda [2], Siddaraju [5] who reported 58-116 eggs with a mean of 92.8 eggs and 74-116 eggs with a mean of 92.20 eggs in soybean and cowpea, respectively.

Adult longevity: Female beetles lived for 8-15 days with a mean of 10.68 days and male beetles for 7-12 days with a mean of 9.04 days. Present results were in confirmation with the results of Venkate Gowda [2] who reported the male and female adult beetles of *C. maculatus* lived for 9.21 days and 9.89 days respectively on soybean and Ramesh [6] observed 9.16 days of male and 9.47 days of females longevity on soybean.

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