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Biology of Pulse Beetle, *Callosobruchus chinensis* L. (Coleoptera: Chrysomelidae) on Pigeonpea, *Cajanus cajan* L. Seeds

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ABSTRACT: Biological attributes of pulse beetle, *Callosobruchus chinensis* L. was carried out on pigeonpea seeds in laboratory during 2020-21. The bruchid *C. chinessis* deposited their eggs singly on pigeonpea seeds. Incubation period varied from 4.95 ± 0.76, 5.23 ± 0.63 and 5.25 ± 0.67 days during September to December. Grub moulted three times and thus had four larval instars wherein, the durations of instars were 19.35 ± 1.43, 18.95 ± 1.33 and 20.00 ± 1.14 days during September to October, October to November and November to December, respectively. The mean pupal period of *C. chinensis* from September to December was 4.40 to 4.57 days. Mean adult longevity was 8.00 to 8.77 days during September to December. Sex ratio (Female: Male) was 1:1.33. As certain the pulse beetle biology which helps to understand the week stage of the menace and to develop the effective management strategies against this insect to protect the pigeonpea seed during storage.

Keywords: *Callosobruchus chinensis*, biology, *Cajanus cajan*, seeds.

INTRODUCTION

Pigeonpea, *Cajanus cajan* L. is an major pulse crop in India and it is the main source of protein for vegetarians. Pigeonpea belongs to the family Leguminosae. The root nodules of pigeonpea plants contain *Rhizobium* bacteria, which have ability to fix atmospheric nitrogen. Pigeonpea pods are longer and contain 4 to 5 seeds, which are important source of energy as they are rich in several essential amino acids, minerals, vitamins and protein. In India, pigeonea is grown in an area of 4.42 m ha with a production of 3.57 million tons and productivity of 760.33 kg/ha (Anonymous, 2019). *C. cajan* is stored in the form of seed and these seeds are prone to several insect pests during storage. The bruchids have been observed as most important insect pest in pigeonpea seeds during storage (Sharma *et al.,* 2010). In India, 117 species of bruchids belonging to 11 genera have been recorded (Arora, 1977). The *Callosobruchus* spp. infests pigeonpea seeds during both at pre and post-harvest stages (Augustine and Balikai, 2018; Pokharkar and Mehta, 2011). The *C. chinensis* completes their immature life stages in individual pigeonpea seeds and as a result of this seed weight loss, decreased seed germination potentiality and reduces the market value as well as nutritional status of the seeds (Dalal *et al*., 2020; Singh and Kumari, 2000). Hence, it is named as "Pulse beetle". The pulse beetle *C. chinensis* can damage the seed upto 30 per cent quickly (Keita *et al.*, 2000). With this background, research was conducted to study the biology of *C. chinensis* which helps to understand the week stage of the menace and to develop the effective management strategies against this insect to protect the pigeonpea seed during storage.

MATERIAL AND METHODS

Laboratory investigations were executed at the National Seed Project (NSP), University of Agricultural Sciences, Bangalore (12°58′N and 77°35′E, 930 m AMSL), South India during 2020-2021.

Maintenance of insect culture

The pulse beetle, *C. chinensis* adults were collected from infested seeds of pigeonpea from the NSP, UAS, Bangalore godowns. The insect culture was reared on pigeonpea seeds by releasing 10 pairs of freshly emerged beetles separately in plastic jars and lids were covered with muslin cloth and fastened by rubber band. Healthy seeds of pigeonpea were provided periodically for the oviposition by the *C. chinensis* beetles. The

insect culture was reared in the laboratory during research period. The insect culture was used to study the biological parameters of *C. chinensis*.

The adults of *C. chinensis* were recognized by using the taxonomic characters given in literature by various authors. The culture of *C. chinensis* was maintained by infesting healthy pigeonpea seeds with freshly emerged pair of *C. chinensis* beetles in glass test tubes. The biology of *C. chinensis* in laboratory was studied on the pigeonpea variety BRG-5 seeds and recorded various developmental stages during three generations like pre-oviposition, oviposition period, incubation period, egg, grub and pre-pupal, pupal period, total developmental period, adult longevity and total life cycle.

RESULTS AND DISCUSSION

Pre-oviposition period. The pre-oviposition period was took in 5 to 8 hours, with an average of 7.12 ± 0.98 hours, 4 to 8 hours with mean of 6.35 ± 0.96 hours and 5 to 8.5 hours with a mean of 6.85 ± 0.95 hours during September to October, October to November and November to December, respectively (Table 1). The pre-oviposition period observed in the current study is in settlement with the observations of Chakraborty *et al.,* (2015); Singh *et al.,* (2017) on green gram seed and Jaiswal *et al.,* (2018) on chickpea seed.

Oviposition period. The egg laying period was continued for 5 to 7 days with an average of 5.95 ± 0.55 days, 4 to 8 days with an average of 5.95 ± 0.65 days and 4 to 7.5 days with an average of 5.35 ± 0.55 days during September to October, October to November and November to December, respectively (Table 1). Earlier workers Siddaraju, (1994); Vidyashree and Thirumalaraju (2015) on pigeonpea seeds were reported the similar observations on oviposition period of *C. chinensis*. Highest number of eggs were deposited on the second day of oviposition period. Subsequently, the number of eggs deposited was declined gradually till the end of oviposition period.

Fecundity. The total fecundity by the gravid female of *C. chinensis* on pigeonpea seeds ranged from 78 to 102 eggs with a mean of 91.60 ± 6.88 eggs, 86 to 118 eggs with a mean of 100.2 ± 11.52 eggs and 87 to 120 eggs with a mean of 101.80 ± 10.89 eggs during September to October, October to November and November to December, respectively (Table 1). The present record of fecundity of pulse beetle is similar to the results of Vidyashree and Thirumalaraju (2015) on pigeonpea; Ahoviya, (2017) on different legume seeds.

Incubation period. The incubation period of the eggs of *C. chinensis* on pigeonpea seed under laboratory condition was ranged 4.00 to 6.00 days with an average of 4.95 ± 0.76 days, 4.00 to 6.50 days with a mean of 5.23 ± 0.63 days and 4.00 to 6.00 days with a mean of 5.25 ± 0.67 days during September to October, October to November and November to December, respectively (Table 1). The hatching of eggs were determined by the change in colour of the eggs. Hatched eggs turned to creamish white colour due to the buildup of frass inside the egg. These observations are in confirmative with the reports of Singh *et al.,* (2017) in chickpea seeds, Siddaraju, (1994); Vidyashree and Thirumalaraju (2015) on pigeonpea seeds.

Table 1: Life cycle of *C. chinensis* on pigeonpea seeds.

Life stages (Days)	Months (Three generations)					
	September - October		October - November		November –December	
	Range	Mean±SD	Range	Mean±SD	Range	Mean±SD
Pre-oviposition	5.00-8.00	7.12±0.98	4.00 -8.00	6.35± 0.96	5.00 -8.50	6.85±0.95
Oviposition period	5.00 -7.00	5.95±0.55	4.00 -8.00	5.95± 0.55	4.00-7.50	5.35 ±0.55
Incubation period	4.00 -6.00	4.95±0.76	4.00 -6.50	5.23±0.63	4.00 -6.00	5.25±0.67
Fecundity	78.00-102	91.60±6.88	86.00-118.0	100.2±11.52	87.00-120.0	101.80±10.89
Grub period						
I Instar	3.00 -5.00	3.70 ±0.65	3.00 -5.00	3.60 ±0.65	3.00- 4.50	3.40 ±0.51
II Instar	3.00 - 6.00	4.80± 0.92	3.00 - 6.00	4.80 ±0.98	4.00 - 6.00	4.70± 0.82
III Instar	4.00 -6.00	5.05± 0.61	4.00 - 6.00	5.00± 0.74	5.00- 6.00	5.40± 0.40
IV Instar	5.00 - 7.00	5.75± 0.65	4.00 - 7.00	5.80± 0.97	5.00- 7.50	6.40± 0.77
Total	15.00-24.00	19.35±1.43	15.00-20.00	18.95±1.33	18.5 -22.00	20.00±1.14
Pre-pupal period	1.50 - 2.00	2.45± 0.43	2.00 -3.00	2.42 ±0.40	2.00 - 3.00	2.60 ±0.41
Pupal period	6.00 -8.00	6.45 ±0.64	5.00 - 7.00	6.55±0.68	6.00 - 7.00	6.55 ±0.43
Adult longevity						
Male	6.00 -7.00	6.80±0.43	5.00 -7.00	6.02 ±0.50	6.00-11.00	7.85 ±1.70
Female	9.00 -11.00	9.95±0.83	7.00-11.50	9.85±1.31.	8.00-11.00	9.70±0.94.
Total life cycle	35.00 -51.5	47.41±1.40	35.50-47.50	46.88±1.31	38.5-49.00	48.53±1.98
Sex ratio	1:1.13					

Grub. As the post embryonic development progressed, the prothoracic plate was seen on the fourth day. The grub used this plate to bore into the seed through the egg shell. During grub period, the grub moulted three times and has four instars. Dyar's law was used to differentiate instars and head capsule width of grub by geometric progression (Table 2 & 3). The duration of each instars were recorded along with their size. The duration of the grub recorded during the studies are in

compatible with the studies of Sibi, (2003); Patel *et al.*, (2005).

First instar grub. The first instar grub was smaller, opaque and creamish yellow in appearance. The grub length was ranged from 0.47 to 0.58 mm with a mean of 0.52 ± 0.04 mm and breadth of head was 0.30 to 0.33 mm with an average of 0.31 ± 0.01 mm. Head capsule length ranged 0.11 to 0.15 mm with mean of 0.13 ± 0.01 mm and head width was 0.24 to 0.28 mm with a mean of 0.25 ± 0.01mm (Table 2 & 3). The data recorded during the present studies are comparable to the observations made by Vidyashree and Thirumalaraju, (2015); Dalal *et al*., (2020).

The duration of first instar grub was ranged 3 to 5 days with an average of 3.70 ± 0.65 days, 3 to 5 days with an average of 3.60 ± 0.65 days and 3 to 4.5 days with an average of 3.40 ± 0.51 days during September to October, October to November and November to December, respectively (Table 1). These observations are in concurrence with the reports of Sibi, (2003); Vidyashree and Thirumalaraju (2015).

Second instar grub. The second instar grub was similar to the first instar except for body size and absence of pro thoracic plates. Grub length was ranged 0.78 to 0.85 mm with a mean of 0.82 ± 0.02 mm. Whereas, breadth of the grub was 0.55 to 0.60 mm with an average of 0.57 ± 0.01 mm. It was identified by the presence of casting of head capsule of the first instar grub. The head capsule length was 0.25 to 0.33 mm with a mean of 0.27 ± 0.02 mm. Head capsule width was 0.33 to 0.38 mm with a mean of 0.36 ± 0.01 mm (Table 2 & 3). Morphometric measurements were corborate to the results obtained by Vidyashree and Thirumalaraju (2015); Augustine and Balikai (2018).

The duration of the second instar grub was ranged from 3 to 6 days with a mean of 4.80 ± 0.92 days, 3 to 6 days with an average of 4.80 ± 0.98 days and 4 to 6 days with an average of 4.70 ± 0.82 days during September to October, October to November and November to December, respectively (Table 1). These explanations are in conformity with the reports of Sibi, (2003) on soybean seeds.

Third instar grub. The third instar grub resembled the second instar grub except for its size. It was identified based on the presence of castings of head capsules of the first and second moults which were seen sandwiched by fecal pellets. The grub length ranged 1.09 to 1.40 mm with an average of 1.23 ± 0.11 mm. Breadth of grub was 0.78 to 0.98 mm with a mean of 0.83 ± 0.06 mm. Head capsule length was 0.32 to 0.35 mm with mean of 0.33 ± 0.09 mm and width of 0.43 to 0.58 mm with a mean of 0.50 ± 0.05 mm (Table 2 & 3).

Third instar grub duration was ranged 4 to 6 days with a mean of 5.05 ± 0.61 days, 4 to 6 days with a mean of 5.00 ± 0.74 days and 5 to 6 days with a mean of 5.40 ± 0.40 days during September to October, October to November and November to December, respectively (Table 1).

Fourth instar grub. Morphologically fourth instar grub was similar to the previous instars except for its size. The final stage of grub was measured 2.06 to 3.25 mm long with a mean length of 2.58 ± 0.45 mm. Breadth of fourth instar grub ranged 1.25 to 2.10 mm with an average of 1.76 ± 0.29 mm (Table 2 & 3). Head capsule length was 0.44 to 0.50 mm with mean of 0.47 ± 0.18 mm and width of 0.65 to 0.78 mm with a mean of 0.72 ± 0.04 mm.

Grub was identified on the basis of the presence of three castings of head capsules sandwiched between the faecal pellets of the preceding and existing instars. The grub fed deeper into the seed spreading up to the seed coat, it left a thin layer of test a appearing like a circular hole. The fourth instar grub constructed a pupal chamber at the end of larval period which was oval in shape and prepared by compacting the faecal matter against the walls of the tunnel. Finally, it stops feeding and became inactive facing the circular hole facilitating adult emergence. The duration of fourth instar grub was 5 to 7 days with a mean of 5.75 ± 0.65 days, 4 to 7 days with mean of 5.80 ± 0.97 days and 5 to 7.5 days with a mean of 6.40 ± 0.77 days during September to October, October to November and November to December, respectively (Table 1). The earlier workers Raina, (1970) reported the similar duration of fourth instar larva.

Total grub period. In the laboratory conditions, the duration of the grub of pulse beetle was ranged 15.00 to 24.00 days with a mean of 19.35 ± 1.43 days, 15.00 to 20.00 days with a mean of 18.95 ± 1.3 days and 18.5 to 22 days with a mean of 20.00 ± 1.14 days during September to October, October to November and November to December, respectively (Table 1). The grub periods observed during investigations are in confirmative with the observations made by Hosamani *et al.*, (2018) on redgram seeds.

Pre-pupal period. The pre-pupa was quiescent. Body divisions were distinct. Abdominal portion was broarder than thoracic portion in comparison to instars of the grub. The pre-pupa moulted into an exarate pupa. Pre-pupal length was 3.80 to 4.25 mm with a mean of 3.96 ± 0.13 mm and breadth was 1.98 to 2.12 mm with a mean of 2.05 ± 0.05 mm, respectively (Table 2). Morphometric measurements are in confirmation with the reports of Prabhakara, (1979); Vidyashree and Thirumalaraju (2015). The pre-pupal stage occupied a period 1.50 to 2.00 days with a mean of 2.45 ± 0.43 days, 2.00 to 3.00 days with a mean of 2.42 ± 0.40 days and 2.00 to 3.00 days with a mean of 2.60 ± 0.41 days during September to October, October to November and November to December, respectively (Table 1). Hosamani *et al.,* (2018) recorded similar pre-pupal duration on redgram seeds.

Table 2: Morphometric measurements of different life stages of *C. chinensis* on pigeonpea seeds.

Insect stages	Length (mm)		Width (mm)	
	Range	Mean±SD	Range	Mean±SD
Egg	0.53 -0.60	0.55±0.02	0.30 - 0.35	0.33±0.01
I Instar	0.47 - 0.58	0.52 ± 0.04	0.30 - 0.33	0.31 ±0.01
II Instar	0.78 - 0.85	0.82 ± 0.02	0.55 - 0.60	0.57 ± 0.01
III Instar	1.09 - 1.40	1.23 ±0.11	0.78 - 0.98	0.83 ±0.06
IV Instar	2.06 -3.25	2.58 ± 0.45	1.25 - 2.10	1.76 ± 0.29
Prepupa	3.80 -4.25	3.96 ±0.13	1.98 - 2.12	2.05 ± 0.05
Pupa	2.80 - 3.80	3.27 ± 0.34	1.80 - 2.15	1.97 ±0.13
Adult female	3.25 -3.95	3.55 ±0.24	1.65 - 2.08	1.84 ± 0.14
Adult male	4.02 - 4.60	4.17 ± 0.21	1.85 - 2.12	1.94 ± 0.09

n= 10 grubs in each instar SD= Standard deviation

Table 3: Head capsule length and width of *C. chinensis* grub.

Instar	Head capsule				Ratio*
	Length (mm)		Width (mm)		
	Range	Mean±SD	Range	Mean±SD	
I	0.11- 0.15	0.13±0.01	0.24 to 0.28	0.25±0.01	–
II	0.25- 0.33	0.27± 0.02	0.33 to 0.38	0.36±0.01	1.44
III	0.32 - 0.35	0.33±0.09	0.43 to 0.58	0.50 ± 0.05	1.42
IV	0.44 - 0.50	0.47±0.18	0.65 to 0.78	0.72 ±0.04	1.44

N = 10 grubs in each instar, SD= Standard deviation; *Ratio calculated for head capsule width only

Pupal period. The pre-pupa moulted converted into an exarate pupa which was cream coloured. Length of the pupa ranged 2.80 to 3.80 mm with a mean of 3.27 ± 0.34 mm. Whereas, breadth ranged 1.80 to 2.15 mm with a mean of 1.97 ± 0.13 mm (Table 2). The appendages were free but held close to the body. The pupa was brown colour at the end of pupal period. Pupal development ranged from 6 to 8 days with a mean of 6.45 ± 0.64 days, 5 to 7 days with mean of 6.55 ± 0.68 days and 6 to 7 days with a mean of 6.55 ± 0.43 days during September to October, October to November and November to December, respectively (Table 1).The pupal periods recorded during the study are in conformity with the results of Ramesh (1993); Hosamani *et al.,* (2018).

Adult emergence. The adults emerged out of the seed through the hole made by the fourth instar grub. It made a circular cut along the peripheral margin of hole and then pushed the circular lid out by head which comes out first. The body length of adult males were 3.22 to 4.00 mm with a mean of 3.50 mm and the breadth ranged from 1.76 to 2.90 mm with a mean of 1.81 mm. Whereas size of female adults were 3.52 to 4.60 mm long with an average length of 4.00 mm and were 1.60 to 2.09 mm broad with a mean breadth of 2.01 mm (Table 2).

Adult longevity. It was found that the female pulse beetle survived longer than the male beetles. The female beetle survived for a period of 9 to 11 days with a mean of 9.95 ± 0.83 days, 7 to 11.5 days with an average of 9.85 ± 1.31 days and 8 to 11 days with an average of 9.70 ± 0.94 days during September to October, October to November and November to December, respectively. Whereas, the male beetle lived for 6 to 7 days with an average of 6.80 ± 0.43 days, 5 to 7 days with an average of 6.02 ± 0.50 days and 6 to 11 days with an average of 7.85 ± 1.70 days during September to October, October to November and November to December, respectively (Table 1).

Observations made regarding the longevity of males and female beetles documented with the findings of Mandal and Konar, (2006) they observed that longer female longevity compared to male beetles (Table 3).

Sex ratio. The present study revealed a sex ratio (Female to Male) of 1:1.33 indicated the dominance of male over female (Table 1).

Total life cycle. The *C. chinensis* completed its one life cycle in 35.00 to 51.50 days with mean of 47.41 ± 1.40 days, 35.00 to 47.50 days with a mean of 46.88 ± 1.31 days and 38.50 to 49.00 days with a mean longevity of 48.53 ± 1.98 days during September to October, October to November and November to December, respectively (Table 1). The data with respect to total life cycle of *C. chinensis* is in agreement with the observations of Jaiswal *et al.,* (2018). They recorded the total life cycle of female and male ranged 36 to 52 and 35 to 51, respectively. Similar results were also published by Gowda, (1984); Hosamani *et al.,* (2018); Varma and Anandhi, (2010).

CONCLUSION

Pigeonpea is one of the pulse crops and the most preferred hosts of *C. chinensis* in storage conditions. The incubation period in laboratory was ranged from 4 to 6 days. The grubs moulted three times thus completed four instars which were identified based on the size of grub and head capsule castings. The total life cycle of the beetle was completed in 35 to 51.5, 35.5 to

47.5 and 38.5 to 49 days during September to October, October to November and November to December respectively. The fecundity of female ranged 72 to 120. Ascertain the pulse beetle biology which helps to understand the week stage of the menace and to develop the effective management strategies against this insect to protect the pigeonpea seed during storage.

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Conflict of interest. Nil.

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