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Biology of Pulse Beetle on Stored Chickpea

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ABSTRACT

The present study investigates the life cycle and reproductive biology of Callosobruchus maculatus, a major pest of stored pulses, with a focus on its development on chickpea (Cicer arietinum). The experiment was conducted under controlled laboratory conditions at 30 ± 1°C. The results revealed that the total developmental period, from egg to adult emergence, averaged 35.79 ± 1.81 days. The incubation period lasted 5.93 ± 0.63 days, while the larval and pupal stages combined took 27.79 ± 0.83 days. The adult sex ratio was recorded at 1:0.93 (male to female), with males living an average of 6.65 ± 1.3 days and females surviving 7.68 ± 1.29 days. Reproductive parameters showed that the pre-oviposition period lasted 5.27 ± 1.34 hours, the oviposition period spanned 6.98 ± 1.33 days, and the post-oviposition phase continued for 2.14 ± 0.57 days. On average, a single female laid 70.47 ± 3.65 eggs. The findings highlight the pest's high reproductive potential and rapid developmental cycle, emphasizing the importance of effective management strategies to prevent infestations and minimize post-harvest losses in stored chickpea.

Keywords: *Life cycle, infestation, storage pest, damage, economic loss, binomics*

1. INTRODUCTION

Legumes are a crucial diet component for low-income populations worldwide, particularly in tropical and subtropical regions. They are an affordable source of protein, vitamins, complex carbohydrates, and fibre (Stagnari *et al*., 2017). Additionally, legumes contribute significantly to the agricultural economy of many developing nations (Parveen *et al*., 2022). *Callosobruchus maculatus* (F.) (Coleoptera: Chrysomelidae) is a widely distributed, oligophagous pest that infests a diverse range of stored legumes from approximately 15 different genera, including chickpea, cowpea, mung bean, adzuki bean, pea, pigeon pea, soybean, and lentil (Kashyap *et al*., 2020), leading to significant economic losses by reducing grain weight and quality (Khashaveh *et al*., 2011; Badii *et al*., 2013; Castro *et al*., 2013). Originally native to West Africa, *Callosobruchus maculatus* has since spread across tropical and subtropical regions worldwide (Southgate, 1979). Infestation often begins in the field before harvest, causing minimal damage initially, but escalates significantly during storage, leading to severe losses. The insect undergoes complete metamorphosis, with eggs and adults present on the grain, while the larvae and pupae develop inside the seed (Devi and Devi, 2014). The most damaging stages of this pest are the larval (grub) stages. In storage, females lay single-ovate eggs on the surface of cowpea grains, and upon hatching, the larvae burrow into the inner endosperm, where they complete their development. The larvae and pupae remain enclosed within a single grain(Furk and Hines, 1993). The feeding damage caused by this pest creates entry points for secondary pests and fungal infections, further degrading the grain's nutritional quality (Hagstrum *et al*., 2012; Mutalikdesai and Lolage,2023). Due to its rapid development, high reproductive potential, short life cycle, and continuous generations, *C. maculatus* can lead to the complete loss of stored grains within a few months (Turaki, 2012). Upon reaching adulthood, the insect chews and removes a circular section of the seed coat, creating a "window hole" through which it emerges. Adult beetles do not require food or water and can begin reproduction immediately after exiting the seed. Since *Callosobruchus maculatus* is an internal feeder, its infestation is difficult to detect in the early stages, making control measures challenging for farmers. The use of insecticides is ineffective, as the beetle develops resistance over time (Jain and Yadav, 1989). Another major concern is the unintentional spread of this pest from infested to uninfested areas through commercial crop transportation. Therefore, effective management requires a comprehensive understanding of the insect's behaviour and biology. Therefore, the objective of the present experiment is to gain a deeper understanding of the life history of *Callosobruchus maculatus*.

2. MATERIALS AND METHODS

The present investigation was conducted at the Bio-Control Laboratory, Department of Entomology, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut (U.P.), College of Agriculture, during 2022–2023. A laboratory culture of Callosobruchus maculatus was established under controlled conditions. The initial culture was maintained on disinfected seeds at 30±1° C and Relative humidity of 70±5% in a BOD incubator before release, the required amount of chickpea grains will be disinfested by fumigation with aluminium phosphide (celphos) @three tablets 9 (g) per tonne for 72 hours and then left in open for 24 hours to eliminate the hidden infestation. Fifteen pairs of one day old beetles from the initial culture were released in cylindrical jars measuring (25x15 cm) containing 500 g seeds. The food was replaced every month, and the culture in the previous rearing jar was gently stirred. Small white paper strips (10 × 2.5 cm) were placed on the surface of the culture to allow insects to crawl onto them. After a few minutes, the strips with insects were carefully collected and transferred using a camel hairbrush into a fresh, sterilized glass jar containing new food for further study. The jars were covered with muslin cloth and tied with rubber bands for aeration purposes as well as to prevent the larva from escaping and insects were allowed to mate. To facilitate the observations, seeds containing one egg were separated and kept individually in plastic vials (4.5x2cm) and different biological parameters were studied under laboratory conditions. Due to destructive sampling, supplementary numbers of infested samples (100) were taken recording the incubation period, and larval pupal periods. Observations on developmental period, longevity of males and females, preoviposition, oviposition, and oviposition period were worked out on infested grain samples. For hatchability and ratio of female eggs, 100 adults were observed respectively. The fecundity of females was observed by exposing 25 gm. of chickpea grain.

3. RESULT AND DISCUSSION

Freshly laid eggs were oval-shaped, broader at the anterior end and narrower at the posterior end. Initially, they appeared translucent, smooth, and milky-white, but as they aged, they flattened and turned pale yellowish or greyish-white. As summarized in Table 1, the incubation period ranged between 5 to 8 days, with an average of 5.93 ± 0.63 days on chickpeas. The egg viability rate was recorded at 87%. The newly hatched larva was cylindrical, white in colour, and had a brown head. Upon emergence, the larvae burrowed directly into the cotyledons after creating an entrance hole at the base of the egg capsules. The pupal stage was characterized by a white, conically shaped body at both ends. Both the larval and pupal stages developed within the seed, lasting between 26 to 30 days, with an average duration of 27.79 ± 0.83 days on chickpeas. The entire developmental cycle, from oviposition to adult emergence, ranged from 32 to 37 days on chickpea variety GG-2, with an average duration of 35.67 ± 1.81 days under laboratory conditions (30 ± 1°C). Developmental mortality was recorded at 19%, primarily occurring in the egg and larval stages. The adult beetles were small, with a dark brown to black body. The head was black, elongated, and had carinate frons. Antennae were testaceous, dark brown to black, and sub-serrate in females, while males had longer and more serrate antennae. The elytra appeared dull, and males lacked distinct C-shaped white pubescent markings. The pygidium was covered with golden setae, whereas in females, the elytra had two C-shaped white pubescent areas facing each other, along with a pair of black posterolateral spots on the pygidium (Khare, 1993). Males and females could be distinguished based on abdominal structure. Males had shorter abdomens with the terminal dorsal segment sharply curved downward and inward, while females had longer abdomens with only a slight downward curve (Bandaara & Saxena, 1995). The sex ratio was influenced by the type of host pulse. On chickpea, a higher number of males were recorded, resulting in a male-to-female ratio of 1:0.86 (Table 1). Females had a longer lifespan than males. On chickpea, males lived between 5 to 11 days, averaging 6.65± 1.3 days, while females survived between 6 to 10 days, with an average lifespan of 7.68 ± 1.29 days. Adults initiated mating within an hour of emergence, usually on the surface layer of the grains, likely to facilitate movement. Mating lasted between 6 to 11 minutes, and adults mated multiple times. The pre-oviposition period ranged from 3 to 9 hours, with an average duration of 5.27 ± 1.34 hours on chickpea. According to the data in Table 1, the oviposition period lasted between 6 to 11 days, with an average duration of 6.98 ± 1.33 days on chickpea. The post-oviposition period varied between 1 to 4 days, with an average of 2.14 ± 0.57 days on chickpea (Table 1). The reproductive potential of *C. cephalonica* was evaluated in terms of egg production. On average, a single female laid 70.47 ± 3.65 eggs, with the number ranging between 64 and 75 eggs per female (Table 1). The result of the present study revealed that the egg period duration was 5.93±0.63, Larval +Pupal (27.79±0.83), Total developmental period (egg to adult emergence) (35.79±1.81), Adult Sex ratio (Male: Female) (1:0.93), Male (6.65±1.3). Female (7.68±1.29), Pre-oviposition Period (hours) (5.27±1.34), Oviposition period (6.98±1.33), post-oviposition period (2.14±0.57), Fecundity (eggs/female) (70.47±3.65). The findings are in agreement with Raina (1970) reported that *Callosobruchus maculatus* females laid an average of 128 eggs, with a range of 109 to 157 eggs for 9 days. Similarly, Singh and Rina Kumari (2000) documented an average fecundity of 70 eggs per female in *Callosobruchus chinensis*. Sharma *et al.* (2007) found that a single female of *C. chinensis* laid between 65 to 72 eggs, averaging 59.5 eggs on soybean. The present study aligns with the findings of Bhargava *et al*. (2008), who recorded fecundity in cowpea, with an average of 75.60 ± 6.87 eggs per female. Raina (1970) reported a 4-day incubation period for *Callosobruchus maculatus*, which was consistent with the findings of Zalavadia (1971). In the present study, the incubation period on chickpea averaged 5.91 ± 0.62 days, ranging from 5 to 7 days, closely aligning with the observations of Vyas (2004) for *C. chinensis*. Patel *et al*. (2005) documented an incubation period of 4.10 days for *C. chinensis*, while Patil (2007) recorded an average incubation period of 5.03 ± 0.11 days for chickpea. Additionally, Bhargava *et al*. (2008)

and Borude *et al.* (2012a) reported an incubation period of 4.40 ± 0.54 days on cowpea and 7.20 ± 0.44 days on *C. chinensis*, respectively. The first instar larva possesses a large spine on either side of the first abdominal segment and two groups of smaller spines dorsally on the tergal plate of the pronotum. These spines likely aid the larva in securing itself to the eggshell while using its mandibles to penetrate the seed coat. The frass produced by the larva accumulates within the eggshell, giving it a white appearance. Upon entry, the larva initially bores vertically into the seed before turning at a right angle and progressing horizontally while continuously feeding on the cotyledons. It undergoes four moults before pupation. Before pupation, the larva chews a circular hole near the seed coat, leaving only a thin layer of the testa intact, which appears as a dark spot, indicating the onset of pupation (Raina, 1970). In the present study, the combined larval and pupal duration varied between 19.66 to 38.29 days across different hosts. Raina (1970) previously reported a 20-day larval + pupal period for *C. maculatus*. Similarly, Singh and Kumari (2000) recorded an incubation period of 18 to 20 days for *C. chinensis*. Raina (1970) recorded a total developmental period of *Callosobruchus maculatus* lasting 24 days, with a range of 23 to 27 days. These findings were consistent with previous studies by Zalavadia (1971) and Srivastav & Pant (1989). The shortest developmental duration was observed on cowpea, averaging 22.14 ± 1.02 days, as reported by Wijenayake & Karunaratne (1999). Vyas (2004) documented a mean larval + pupal duration of 16.11 ± 0.88 days, with a complete life cycle (egg to adult) lasting 20.09 ± 0.91 days. Similar observations were made by Patel *et al.* (2005) and Sharma *et al.* (2007), aligning with the present study. Additionally, research has shown that legumes with the highest mean egg count exhibited the shortest developmental period, whereas those with the lowest egg count had the longest developmental period. This trend has been reported by Bhargava *et al*. (2008), Kazemi *et al*. (2009), Swella & Mushobozy (2009), Shivanna *et al*. (2011), Malaikozhundun & Raj (2012), and Borude *et al*. (2012a), further supporting the findings of this study. The sex ratio of emerging adults varied across different host seeds. In chickpea, the male-to-female ratio was 1:0.93. Raina (1970) observed that males were slightly more prevalent than females, with a recorded ratio of 7:6. Similar findings were reported by Singh and Kumari (2000) for *Callosobruchus chinensis* on cowpea. Mandal and Konar (2006) also noted that the sex ratio tended to favour males over females. Significant variations were observed in the longevity of male and female *Callosobruchus maculatus* across different host seeds. The lifespan of males ranged from 6.60 to 9.72 days, with the recorded on chickpea. Raina (1970) documented that male lived for 7–10 days and females for 6–10 days, with average lifespans of 8.2 and 7.6 days, respectively. Similar findings were reported by Zalavadia (1971), while comparable longevity patterns in *Callosobruchus* spp. were also observed by Vyas (2004), Patil (2007), Sharma *et al*. (2007), Bhargava *et al.* (2008), and Borude *et al.* (2012a). In the present study, the pre-oviposition period was longest in chickpea (5.27 ± 1.34 hours, ranging from 3 to 9 hours). Similar trends were noted for the oviposition and post-oviposition periods. These findings align with previous studies on *Callosobruchus* spp. across different pulses, as reported by Zalavadia (1971), Vyas (2004), and Patil (2007). The slight variations observed between the present findings and previous studies may be attributed to differences in diet composition, temperature, and relative humidity across various study locations. Environmental factors play a crucial role in insect development, influencing parameters such as incubation period, longevity, fecundity, and overall mortality. Differences in experimental conditions, including the nutritional quality of host seeds and climatic variations, could account for the discrepancies in results when compared to earlier reports.

Table 4.1 Biology of Pulse beetles, *Callosobruchus maculates* (Fabricius) in chickpea

S. No.	Biological parameters of (*Callosobruchus maculates*)	Number of individuals observed	Range in days		Duration (mean ±SD)
			Minimum	Maximum	
1	Egg period	100	5	8	5.93±0.63
2	Larval +Pupal	87	26	30	27.79±0.83
3	Total developmental period (egg to adult emergence)	81	32	37	35.67±1.81
4	Adult Sex ratio (Male: Female)	81	1:0.93		
Adult Longevity					
5	Male	26	5	11	6.65±1.3
6	Female	25	6	10	7.68±1.29
7	Pre-oviposition Period (hours)	24	3	9	5.27±1.34

8	Oviposition period	24	6	11	6.98±1.33
9	Post-oviposition period	24	1	4	2.14±0.57
10	Fecundity (eggs/female)	24	64	75	70.47±3.65

4. CONCLUSION

The findings of this study provide valuable insights into the life cycle and reproductive potential of *Callosobruchus maculatus* on chickpea. The results indicate that the total developmental period, from egg to adult emergence, averaged 35.79 ± 1.81 days, with an incubation period of 5.93 ± 0.63 days and a combined larval and pupal duration of 27.79 ± 0.83 days. The adult sex ratio was recorded as 1:0.93 (male to female), with males living an average of 6.65 ± 1.3 days and females surviving slightly longer, averaging 7.68 ± 1.29 days. The reproductive parameters showed that females underwent a pre-oviposition period of 5.27 ± 1.34 hours, an oviposition period lasting 6.98 ± 1.33 days, and a post-oviposition period of 2.14 ± 0.57 days. The fecundity of *C. maculatus* on chickpea was recorded at an average of 70.47 ± 3.65 eggs per female. These findings highlight the rapid reproductive rate and developmental adaptability of *C. maculatus*, emphasizing the need for effective management strategies to control its infestation in stored pulses.

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