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Avani Hirapara
M.Sc. Scholar, Department of
Entomology, NAU, Navsari,
Gujarat, India

Dr. PB Patel
Assistant Research Scientist,
Main Rice Research Station
NAU, Navsari, Gujarat, India

Dr. LS Chaudhary
Research Associate
(Entomologist), Gujarat
Natural Farming Science
University, Halol, Gujarat,
India

Dhara Vankar
M.Sc. Scholar, Department of
Entomology, NAU, Navsari,
Gujarat, India

Biological studies on pulse beetle, *Callosobruchus maculatus* (Fabricius) (Coleoptera: Chrysomelidae) infesting stored cowpea

Avani Hirapara, PB Patel, LS Chaudhary and Dhara Vankar

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Abstract

A laboratory study was conducted during 2025-26 at Navsari Agricultural University, Navsari, Gujarat, to study the biology of pulse beetle, *Callosobruchus maculatus* (Fabricius) on stored cowpea (*Vigna unguiculata* L.) variety GVC 9. Freshly emerged adults were released on healthy, uninfested seeds under laboratory conditions and biological parameters were recorded. Mean fecundity was 84.70 ± 12.05 eggs/female. Incubation period averaged 4.24 ± 0.89 days (range 3-6 days) with $93.42 \pm 2.30\%$ egg hatchability. The larval-pupal period and total developmental period averaged 19.19 ± 2.01 and 23.43 ± 1.80 days, respectively, with $86.15 \pm 2.57\%$ adult emergence. Adult longevity averaged 6.75 ± 1.05 days (male) and 9.45 ± 1.60 days (female), while total lifespan averaged 30.30 ± 1.59 days (male) and 32.76 ± 1.37 days (female). The sex ratio (male: female) was 1:1.06.

Keywords: *Callosobruchus maculatus*, cowpea, biology, fecundity, developmental period, GVC 9

1. Introduction

Cowpea (*V. unguiculata* L.), also known as black-eyed pea or lobiya, is a multipurpose kharif pulse crop grown for food, fodder and green manuring across India, particularly in the arid and semi-arid tracts of Punjab, Haryana, Delhi, western UP, Rajasthan, Karnataka, Kerala, Tamil Nadu, Maharashtra and Gujarat (Kaur and Rawat, 2020) [10]. In Gujarat, it occupies 0.32 lakh hectares with a production of 3.30 lakh MT and productivity of 10.32 MT ha⁻¹ (Anon., 2025) [1].

Often called "vegetable meat" for its high protein content, mature cowpea seed contains 28% protein, 63.4% carbohydrate, 0.3% fat and 18% dietary fiber (Dixit *et al.*, 2024) [3], making it an affordable and nutritious food source, especially in African countries, where it also contributes to food security (Idoko and Ileke, 2020; Obembe *et al.*, 2020) [6, 12].

Over 200 insect species infest stored pulses in India (Srivastava and Sagar, 2016) [18], among which *Callosobruchus* spp. are restricted specifically to stored grains (Chakraborty and Mondal, 2016) [2]. The pulse beetle, *C. maculatus*, along with *C. chinensis*, is a major storage pest causing grain losses of 20-60% (Gupta and Apte, 2016; Tarver *et al.*, 2007) [4, 19], with damage often exceeding 60% seed loss during storage (Ileke *et al.*, 2021) [7]. Such infestation remains a key constraint to the large-scale storage of cowpea.

A sound understanding of pest biology is fundamental to developing effective, cost-efficient management strategies, as it helps identify the vulnerable life stages responsible for maximum grain damage.

2. Materials and Methods

2.1 Location and duration of study

The laboratory experiments to study biology of pulse beetle, *Callosobruchus maculatus* (Fabricius) on cowpea were carried out during 2025-2026 in the Post Graduate Laboratory, Department of Entomology, Navsari Agricultural University, Navsari, Gujarat, India, under ambient laboratory conditions.

2.2 Host material

Healthy, uninfested seeds of cowpea (*Vigna unguiculata* L.) variety GVC 9, free from any prior insect infestation or chemical treatment, were procured and used as the host medium

Corresponding Author:
Avani Hirapara
M.Sc. Scholar, Department of
Entomology, NAU, Navsari,
Gujarat, India

throughout the study. Seeds were checked for uniformity in size and moisture content before use and were surface-sterilized/oven-treated (as applicable) to eliminate any hidden infestation prior to the start of the experiment.

2.3 Maintenance of culture

A stock culture of *C. maculatus* was established and maintained on cowpea seeds (variety GVC 9) in glass jars under laboratory conditions to obtain a uniform-age population of beetles for use in the biology study. Freshly emerged (0-24 hour old), unmated adults were carefully picked from this culture using a camel-hair brush to avoid injury, and used for setting up the biological studies.

2.4 Experimental setup

For studying the biological parameters, one pair (one male and one female) of freshly emerged adult beetles was released into separate glass jars (of suitable size, e.g., 250 ml capacity) containing a known, pre-weighed quantity of healthy cowpea seeds. The mouth of each jar was covered with a piece of fine muslin cloth secured with a rubber band to permit aeration and prevent the escape of insects. The experiment was replicated ten times, with each replication representing one pair of beetles in an individual jar.

2.5 Observations recorded

The following biological parameters were recorded for each replication:

2.5.1 Fecundity: The eggs laid by each female were counted daily from the day of pairing until the death of the female and the total number of eggs laid per female over her lifetime was recorded as fecundity.

2.5.2 Incubation period and egg hatchability: Freshly laid eggs (glued to the seed coat) were observed daily under a hand lens/stereo-binocular microscope for the change in colour/translucency, which indicates embryonic development. The period from egg-laying to hatching of the larva was recorded as the incubation period (days). The number of eggs hatched out of the total eggs observed was recorded, and hatchability percentage was calculated using the formula:

Hatchability (%) = (Number of eggs hatched/Total number of eggs observed) × 100

2.5.3 Larval-pupal period: Since the neonate larva bores into the seed immediately after hatching and completes both larval and pupal development inside the grain, the two stages could not be observed or recorded separately without cutting open the seed and disturbing normal development. Hence, the period from egg hatching to adult emergence from the seed, encompassing both larval and pupal stages, was recorded jointly as the "larval-pupal period" (days).

2.5.4 Total developmental period: The total duration from the day of egg-laying to the day of emergence of the adult beetle from the seed was recorded as the total developmental period (days).

2.5.5 Adult emergence: The number of adults successfully emerging out of the total number of eggs laid/observed was recorded, and percent adult emergence was calculated as:

Adult emergence (%) = (Number of adults emerged/Total number of eggs laid) × 100

2.5.6 Sex ratio: Adults emerging from each replication were separated into males and females based on morphological differences (size and shape of the last abdominal segment/elytra pattern), and the male: female sex ratio was worked out.

2.5.7 Pre-oviposition, oviposition and post-oviposition periods: After pairing, the period from adult emergence to the initiation of egg-laying by the female was recorded as the pre-oviposition period. The period during which the female actively laid eggs was recorded as the oviposition period and the period from cessation of egg-laying to the death of the female was recorded as the post-oviposition period.

2.5.8 Adult longevity: The number of days survived by the male and female adults from the day of emergence to their natural death was recorded separately as adult longevity (days) for each sex.

2.5.9 Total lifespan: The total lifespan of male and female beetles was calculated as the sum of the total developmental period (egg to adult emergence) and the respective adult longevity, and was recorded separately for males and females.

2.6 Statistical analysis

The data recorded on various biological parameters were compiled, tabulated and the mean values along with their standard error (Mean ± SEM) were computed using appropriate statistical software (e.g., MS Excel/OPSTAT) for interpretation of results.

3. Results and Discussion

The findings on the life cycle stages and reproductive potential of *C. maculatus* reared on cowpea variety GVC 9 are detailed below.

3.1 Egg Stage and Fecundity

Freshly emerged adults mated within an hour of emergence. Females laid their eggs singly, gluing them onto the surface of the cowpea grains. Freshly laid eggs were small, oval to spindle-shaped, broader at the anterior end and tapering posteriorly. They appeared smooth, shiny, translucent, and milky white with a faint yellow tinge. As the embryo developed, the egg colour gradually changed to a distinct opaque white on the grain surface.

The fecundity of *C. maculatus* ranged from 67 to 112 eggs/female, with a mean of 84.70 ± 12.05 eggs/female (Table 1). These findings closely agree with those of Kashyap *et al.* (2021) [9], who recorded a fecundity of 84.20 ± 1.28 eggs/female on chickpea, and Jaiswal *et al.* (2018) [8], who reported 84.15 ± 8.44 eggs/female, also on chickpea.

The incubation period ranged from 3 to 6 days, averaging 4.24 ± 0.89 days. This result is in close agreement with the findings of Sharma *et al.* (2018) [15] on pigeon pea (4.20 ± 0.20 days) and Jaiswal *et al.* (2018) [8] on chickpea (4.15 ± 0.87 days).

3.2 Hatching Percentage

Out of a total of 881 observed eggs, 823 hatched successfully, establishing a mean hatchability percentage of

93.42 ± 2.30%. The present findings were in close agreement with those reported by Harsh *et al.* (2023) ^[5] who observed 93.0 ± 1.80 percent egg hatchability of *C. chinensis* on pigeon pea var. BDN-711.

3.3 Larval and Pupal Stage

The newly hatched larva was found to be apodous, short, stout, and creamy-white with a characteristic brown head and a C-shaped scarabeiform body structure. Upon hatching, the larva bored directly through the egg shell into the endosperm. As it fed internally, the empty egg shell on the seed coat became filled with white fecal waste (frass), rendering the shell opaque and easily visible to the naked eye.

The larva molted three times inside the seed, progressing through four distinct larval instars. Before transitioning into a pupa, the fourth-instar larva chewed a circular cavity moving upward toward the seed coat, leaving only a thin, translucent layer of seed testa intact. This created a characteristic dark spot known as a "window spot," signifying the initiation of pupation. The pupa was stout, compact, white, and free from hairs.

Because both internal stages are completed entirely within the seed, they were recorded as a single larval-pupal developmental block. This period ranged from 16 to 24 days, with an average of 19.19 ± 2.01 days. The obtained results are closely supported by observations of Sindhura and Godhani (2020) ^[16] on cowpea (19.88 ± 1.59 days).

3.4 Total Developmental Period and Adult Emergence

The total developmental period (from the day of oviposition to adult emergence) varied between 20 and 27 days, yielding a mean of 23.43 ± 1.80 days. The present findings were in close confirmation with the results obtained by Prajapati *et al.* (2022) ^[13] who reported an average developmental period of 23.96 ± 2.23 days on cowpea and 22.92 ± 2.88 days on red gram, respectively. Once fully developed, the adult emerged by chewing and lifting the circular piece of seed coat at the window spot, creating a neat, round exit hole. The average adult emergence rate was recorded at 86.15 ± 2.57%, ranging between a minimum of 82.29 percent and a maximum of 90.11 percent. The results were in close agreement with the findings of Sharma *et al.* (2016) ^[14] who recorded average adult emergence of *C. maculatus* 85.80 ± 1.60 percent from cowpea.

3.5 Adult Longevity, Lifespan, and Sex Ratio

The female adult reproductive phases began immediately upon emergence. The pre-oviposition period ranged from 2.5 to 5.3 hours, with a mean of 3.98 ± 0.68 hours. Mutalikdesai and Lolage (2023) ^[11] recorded an average pre-oviposition period of 4.30 ± 0.70 hours on cowpea. The active oviposition period lasted between 5 to 8 days, with an average of 6.92 ± 0.85 days. This result was confirmed with the results of Harsh *et al.* (2023) ^[5] on pigeon pea var. BDN-711 (6.80 ± 0.13 days). The post-oviposition period was short, varying from 1 to 4 days with a mean of 2.12 ± 0.72 days. Sowdhamini *et al.* (2021) ^[17] recorded an average post-oviposition period of 2.30 ± 0.70 days on cowpea.

Adult longevity trials indicated that females lived longer than males. The mean longevity of adult males was 6.75 ± 1.05 days (range: 5-9 days), whereas adult females lived for an average of 9.45 ± 1.60 days (range: 7-12 days). The results were in close conformity with the findings of Sindhura and Godhani (2020) ^[16] on chickpea who recorded an average male longevity of 6.64 ± 1.11 days. Similarly, Sowdhamini *et al.* (2021) ^[17] in cowpea and Kashyap *et al.* (2021) ^[9] in green gram recorded an average female longevity of 9.43 ± 1.04 days and 9.40 ± 0.24 days, respectively. Consequently, the total lifespan (including developmental stages) averaged 30.30 ± 1.59 days for males and 32.76 ± 1.37 days for females. Out of 759 successfully emerged adults evaluated, 369 were identified as males and 390 as females, establishing a sex ratio of 1:1.06, indicated the dominance of females over males. These findings were confirmed by the study of Prajapati *et al.* (2022) ^[13] who reported sex ratio of 1:1.07 on cowpea.

Table 1: Life period of *C. maculatus* on stored cowpea

Sr. No.	Stage/Parameter	Duration	
		Range	Av. ± SD
1	Incubation period (Days)	3 to 6	4.24 ± 0.89
2	Larval + pupal period (Days)	16 to 24	19.19 ± 2.01
3	Developmental period (Days)	20 to 27	23.43 ± 1.80
4	Adult longevity (Days)		
4.1	(a) Male	5 to 9	6.75 ± 1.05
4.2	(b) Female	7 to 12	9.45 ± 1.60
5	Life span (Days)		
5.1	(a) Male	26 to 34	30.30 ± 1.59
5.2	(b) Female	29 to 35	32.76 ± 1.37
6	Pre-oviposition period (Hours)	2.5 to 5.3	3.98 ± 0.68
7	Oviposition period (Days)	5 to 8	6.92 ± 0.85
8	Post-oviposition period (Days)	1 to 4	2.12 ± 0.72
9	Fecundity (No. of eggs)	67 to 112	84.70 ± 12.05
10	Hatching percentage	88.54 to 96.81	93.42 ± 2.30
11	Adult emergence (%)	82.29 to 90.11	86.15 ± 2.57

3.6 Sexual Dimorphism (Male-Female Differences)

Clear morphological markers were recorded between the adult sexes:

3.6.1 Adult Males: Visually smaller, oval in shape, and dull to light brown. They possessed long, deeply serrated antennae. The abdomen was blunt at the posterior end, and the pygidium remained completely hidden underneath the elytra. The male elytra displayed distinct reddish-brown stripes with small white spots on the thorax, lacking broad patches of white pubescence. Behaviorally, males were highly active compared to females.

3.6.2 Adult Females: Noticeably larger, elongated, and black in color. They possessed sub-serrate antennae and an elongated, pointed abdomen specialized for egg laying. Their pygidium was enlarged, exposed beyond the elytra, and marked by a pair of large black spots at its posterior tip along with a white band across the center. The female elytra displayed white pubescence forming two distinct C-shaped patches facing each other.

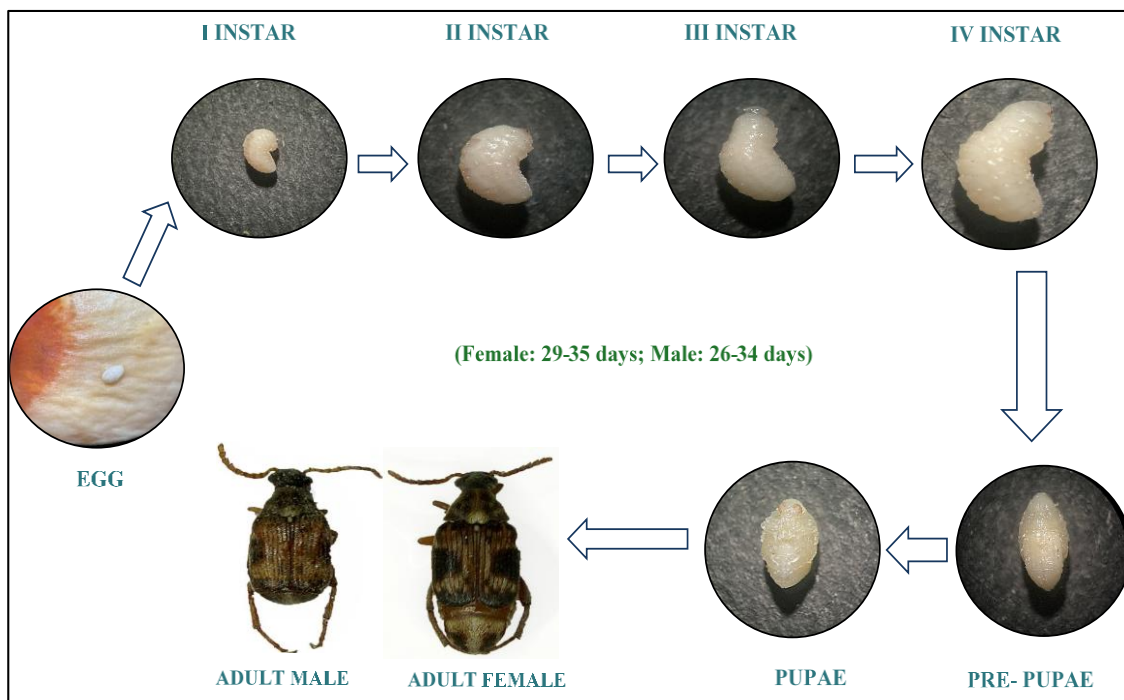


Photo 1: Life cycle of *C. maculatus* on stored cowpea

4. Conclusion

The present investigation revealed that *C. maculatus* successfully completed its entire life cycle on stored cowpea variety GVC 9 under laboratory conditions, confirming the suitability of this variety as a favourable host for the pest's development. The beetle exhibited high fecundity, high egg hatchability, and successful adult emergence, along with a short developmental period, indicating its strong reproductive potential and multiplication ability on this host. Female adults were found to live longer and outnumber males slightly in the emerging population, a pattern generally consistent with earlier reports on this species. The biological parameters recorded in the present study were largely comparable with those documented by earlier workers on related pulse crops, further validating the findings.

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