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Morphological Characterization of *Callosobruchus maculatus* and *C. chinensis* and Seed Damage Assessment in Monogamous and Polygamous Condition in Mung Bean

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The pulse beetles or bruchids cause serious damage in stored legumes. Two most important bruchids are *Callosobruchus maculatus* and *C. chinensis.* Among the various pulses, the preferred host of these beetles is mung bean. Therefore, an estimation of seed damage and to study the morphological characters of both species, experiment was conducted in the Department of Entomology, Banda University of Agriculture and Technology, Banda. The observations related to

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the body size of *C. chinensis* was smaller in comparison to the *C. maculatus* and *C. chinensis* caused lower seed damage than *C. maculatus*. The weight loss of mung bean seeds caused by *C. maculatus* was 45.39 ± 5.90 % in monogamous condition and 56.11 ± 5.27% in polygamous condition and the seed weight loss caused by *C. chinensis* was 36.44 ± 4.72 % in monogamous condition and 48.02 ± 5.51% in polygamous condition. The maximum seed weight loss caused by the polygamous conditions of *C. maculatus* and *C. chinensis*, respectively, followed by monogamous conditions of *C. maculatus* and *C. chinensis*, respectively.

Keywords: Monogamous; polygamous; seed weight loss; C. maculatus; C. chinensis; mung bean.

1. INTRODUCTION

“Globally, 900 million people are undernourished due to inadequate intake of proteins, vitamins and minerals in their diets” [1]. “Pulses are the important source of nutrients such as carbohydrates, proteins, fats and vitamins” [2]. “Among the pulses, mung bean crop is the third most important pulse crop cultivated throughout India. Mung bean is popular among farmers for its short life cycle and drought tolerance; nitrogen fixation in its root nodules in association with soil rhizobium allows it to thrive in N-deficient soils” [3]. “India is the largest producer and consumer of pulses in the world, accounting for about 25% of global production, 27% of consumption and 34% of food use” [4]. The Food and Agriculture Organization [5] of the United Nations proclaimed the international year of pulses with the goal of enhancing public understanding of the nutritional benefits of pulses in sustainable food production. “India is the largest mung bean producing country, accounting for about 65% of the world acreage & 54% of the production” [6]. “Mung bean alone accounts for 10% of the production and 16% of the area for all pulses in India” [7].

“One of the main constrains of pulse production are the insect pests that cause huge losses in both field and storage. Insect pests account for about 30% of pulse losses in India, which amount to about $815 million in monetary losses” [8]. “Mung bean production is constrained by destructive pests, a notable group of which are the storage pests particularly bruchids. Among the bruchids, commonly called pulse beetles, *Callosobruchus maculatus* and *C. chinensis* are the major pests causing serious damage and are cosmopolitan in distribution. The economic loss of the bruchids in various pulses ranged from 30-40 per cent within a period of six months and when left unattended losses could be up to 100%” [9,10,11]. “The pulse beetle may cause 10-95 per cent loss in the seed weight and 45.5-66.3 per cent loss in protein content of the seeds under normal condition and the severity of damage increases with the duration of storage condition” [12]. “The germination of pulse seed is also reduced to a great extent. Losses caused in storage of mung beans, by *C. maculatus* and *C. chinensis* are 46.70 and 44.08%, respectively” [13,14]. “In mung bean, bruchid infestation occurs both in the field and in storage, for which storage losses are heavy and sometimes total losses occur within few months” [15]. “When left unattended, they can cause up to 100% loss” [2]. “The seed is rendered unfit for human consumption as well as for sowing purposes due to quality loss and mould growth” [16]. *C. maculatus* and *C. chinensis* often occur simultaneously in storage and there may be chances of monogamous and polygamous population of both species. In order to characterize the morphological parameters of both species of bruchids and the losses caused by monogamous and polygamous population, the present study is envisaged.

2. MATERIALS AND METHODS

The experiment was conducted in the Department of Entomology, Banda University of Agriculture and Technology, Banda in 2023. Coordinates of Banda are 24°53' to 25°55' North Latitudes and 80°07' to 81° 34' East Longitudes in Uttar Pradesh (India). The pure culture of *C. maculatus* and *C. chinensis* were obtained from Indian Council of Agricultural Research (ICAR) - Indian Institute of Pulses Research (IIPR), Kanpur and the stock culture was maintained in insect growth chamber. The yield loss of *C. maculatus* and *C. chinensis* on mung bean seeds was studied under controlled conditions at 27 ± 1°C temperature and 65 ± 5% relative humidity (RH) in the insect growth chamber (IGC). This experiment was conducted in Completely Randomized Design (CRD) with three replications. The external morphological character of both the species was observed in the laboratory in three sets and each set consisted of ten replications. Under different mating regimes polygamous and monogamous conditions, the experiment was done with ten seeds of mung bean in a vial (1.5 ml) (each set was under taken separately for *C. maculatus* and *C. chinensis*) and seeds were weighed before the release of one pair *C. maculatus* and *C. chinensis* in separate vials. The percent weight loss by *C. maculatus* and *C. chinensis* in mung bean was determined on the basis of polygamous and monogamous condition. Percent seed infestation by pulse beetles on mung bean were observed after the adult emergences after 30 days in both the species. To work out the weight losses, the beetles, frass, excreta etc. was removed from each compartment and then weighted by using a single pan electronic balance of each condition. The following formula was used to work out the percent seed infestation and seed weight losses [17].

$$\text{Percent of seed weight loss} = I - F/ I \times 100$$

I =Initial weight of seed (gm)
F=Final weight of seed (both sound and damaged seed in g)

The observations were recorded and the data was statistically analysed with the help of an online statistical analysis tool (OPSTAT) developed by Chaudhary Charan Singh Haryana Agriculture University, Hisar (India).

3. RESULTS AND DISCUSSION

Morphological Characters- The adults emerged from the grain through windows, leaving the main evidence of round holes. The adults were fully mature in 24 to 26 hours after emergence. Neither male nor female adults require food or water during their short adult lifetime. Male and female pulse beetles are easily distinguished from one another by their general appearance.

It was also observed that females were bigger than males of both the *Callosobruchus* species. Generally, body colour of both the *Callosobruchus* species were brown in males and somewhat blackish in females. The abdomen is found in obtuse in male and pointed in female in both the *Callosobruchus* species. The antennae were pectinate and larger size in males while in females, the antennae were serrate and smaller than male in both the *Callosobruchus* species (Table 1). Two sets of wings, first set was converted into elytra sheathing that was dark coloured in female than male. Hindwings were membranous and longer than forewings and shield by the elytra. The most distinguishing character was the coloration on the plate covering the end of abdomen.

In the female, *C. maculatus* the plate was enlarged and darkly coloured on both sides two prominent brown spot presents on elytra and in the male, the plate was smaller and lacked stripes two prominent black spot presents on elytra. Pygidium of *C. maculatus* was found two brown spots in male beetle and two black spots on female beetle. In *C. chinensis* pygidium was found broad shiny area spreading over the lateral margin of posterior mid dorsum giving shape of expanded inverted “V” in the male beetle and narrow shiny area confined to the posterior mid dorsum giving a shape of closed inverted “V” in the female beetle (Table 1) [18] reported that the male and female bean beetles are easily distinguished from one another by general appearance. The most distinguishing characteristic was the coloration on the plate covering the end of the abdomen. In the female, the plate was enlarged and was darkly coloured on both sides. In the male, the plate was smaller and lacks stripes. Generally, females were larger in size than males, but there was much variation. In some strains, females were black in coloration and males were brown, but in others both sexes were brown. The present finding also confirms the finding the [19].

Seed weight loss in monogamous and polygamous conditions- The percent seed weight loss by *C. maculatus* in monogamous condition ranged from 37.96 to 52.33 with an average of 45.39 ± 5.90 percent (Graph 1). In polygamous conditions, the range of percent seed weight loss by *C. maculatus* was 47.03 to 63.90 with an average of 56.11 ± 5.27 percent (Table 2) [20] reported that, the seed damage shown by *C. maculatus* a significant variation in damage and differed from 70.0 to 95.3%. The maximum damage was noticed in Pant Mung-2 (95.3%), and the minimum in ML-935 (70.0%). The damage caused by *C. maculatus* varied from 81.6 to 99.3% [21,22] reported that the cowpea weevil, *C. maculatus* is the most destructive on cowpeas, *Vigna unguiculata* causing over 90% yield reduction. The population of *C. maculatus* can grow exponentially, leading to significant loss in seed weight, germination viability, and the market value of the crop [18,23,24].

The percent seed weight loss by *C. chinensis* in monogamous condition ranged from 29.57 to

42.55 with an average of 36.44 ± 4.72 percent (Graph 1). In polygamous conditions the percent seed weight loss by *C. chinensis* was ranged from 39.42 to 53.65 with an average of 48.02 ±5.51 percent (Table 2) [25] observed the loss in seed weight of green gram due to infestation by *C. chinensis.* A significant difference was observed among the genotypes with Ganga-8 with having higher percent weight loss (46.46 percent) and whereas Km12-5 recorded the lowest percent weight loss (5.61 percent). However, [26] reported that the percentage seed weight loss ranged from 19.73 to 29.14 percent. The reports of the present finding are somewhat similar to the reports of previous workers. However, the percent loss variation might be due to the variation in seeds of different crops and the storage conditions too [27].

A B C D

Fig. 1. Adults of [A] *C. maculatus* (Male) [B] *C. maculatus* (Female) [C] *C. chinensis* (Male) [D] *C. chinensis* (Female)

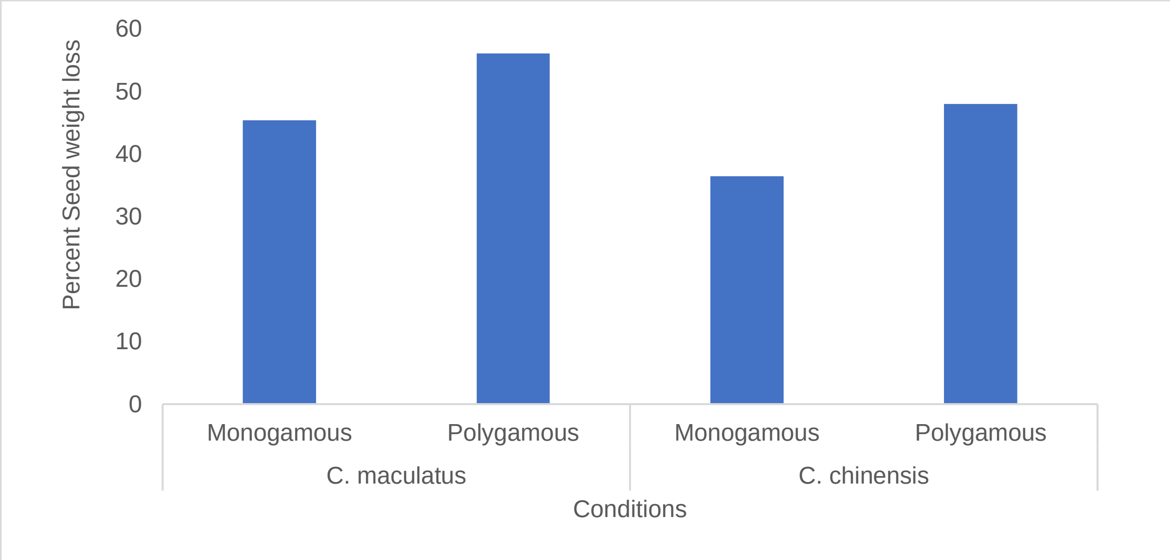
Table 1. Morphological characters of *C. maculatus* and *C. chinensis*

Sr. no.	Morphological characters	*C. maculatus*		*C. chinensis*	
		Male	**Female**	**Male**	**Female**
1.	Body size	Smaller Length-3.40±0.17 mm; Width-2.01±0.13 mm	Larger Length-4.28±0.16 mm; Width-2.20±0.09 mm	Smaller Length-2.26±0.15 mm; Width-1.30±0.11 mm	Larger Length-2.96±0.17 mm; Width-1.60±0.14 mm
2.	Body colour	Brown	Blackish	Brown	Blackish
3.	Abdomen	Obtuse	Pointed	Obtuse	Pointed
4.	Antenna	Pectinate	Serrate	Pectinate	Serrate
5.	Antenna size	Larger (2.09±0.08 mm)	Shorter (1.70±0.08 mm)	Larger (1.35±0.05 mm)	Shorter (1.24±0.03 mm)
6.	Elytral pattern	Two prominent brown spot presents on elytra	Two prominent black spot presents on elytra	Deep vertical & closed stripes, light dark band expanding laterally & tapering in the mid dorsal line (usually two bands)	Stripe present, no such Transvessaly dark band present
7.	Pygidium	Two brown spots	Two black spots	Broad shiny area spreading over the lateral margin of posterior mid dorsum giving shape of expanded inverted "V"	Narrow shiny area confined to the posterior mid dorsum giving a shape of closed inverted "V"

Table 2. Seed weight loss of mung beans caused by *C. maculatus* and *C. chinensis* under monogamous and polygamous condition

Bruchid Species	Mating behaviour	Range (per cent)	Mean* ± SE
C. maculatus	Monogamous	37.96 - 52.33	45.39 ± 5.90
	Polygamous	47.03 - 63.90	56.11 ± 5.27
C. chinensis	Monogamous	29.57 - 42.55	36.44 ± 4.72
	Polygamous	39.42 - 53.65	48.02 ± 5.51

**Mean of three sets and each set consists of 10 replications.*



Graph 1. Seed weight loss in monogamous and polygamous conditions

4. CONCLUSION

As the body size of *C. chinensis* (male 2.26±0.15 mm length, 1.30±0.11 mm width and female 2.96±0.17 mm length ,1.60±0.14 mm width) was smaller than the *C. maculatus* (male 3.40±0.17 mm length, 2.01±0.13 mm width and female 4.28±0.16 mm length 2.20±0.09 mm width) which caused lower seed weight loss in comparison to *C. maculatus*. The males of both species were smaller than females. The antennae of both species of males were small with pectinate and in females it was large sized with serrate type. Both species of male abdomen were stout and in the case of the female it was pointed. The maximum seed weight loss caused by the polygamous condition of *C. maculatus* followed by polygamous condition of *C. chinensis,* monogamous condition of *C. maculatus* and monogamous condition of *C. chinensis*.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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