BIOLOGICAL PARAMETERS OF COWPEA BEETLE (*Callosobruchus maculatus* (Fabricius) ON MUNG BEAN (*Vigna radiata* (L.) R. Wilczek) ACCESSIONS

Timothy, M. I. J.[1], Akeem, T. O.[2], *Alabi, O. Y. [2] and Olasoji J. O. [1]

[1]Institute of Agricultural Research and Training, Moor Plantation, Ibadan.
[2]Department of Crop Protection and Environmental Biology, University of Ibadan, Ibadan.

*Corresponding author: alabi.jummy@gmail.com

ABSTRACT

The biological characteristics of *Callosobruchus maculatus* on different mung bean (*Vigna radiata)* accessions was investigated under laboratory conditions, with the goal of identifying potential sources of resistance to infestation. Three mung bean accessions and Ife brown cowpea which served as the check were evaluated in a completely randomized design with six replicates. Survival rate, fecundity, population growth rate, and adult longevity, were recorded. Results indicated significant variation among the accessions in their response to *C. maculatus*. Accessions TVr 111 and TVr 110 were more susceptible to beetle infestation, supporting higher development and reproduction rates than the control. TVr 33 exhibited characteristics similar to Ife brown, suggesting moderate susceptibility. This study highlights the variability in host status among mung bean accessions and underscores the potential of screening for less susceptible varieties as a strategy for managing *C. maculatus* in storage.

KEYWORDS: Mung bean, *Callosobruchus maculatus,* Underutilized legume, Storage pest, Population growth.

Introduction

Climate change continues to pose a significant threat to global food production, impacting crop yields, livestock productivity, and the overall stability of agricultural systems (Prajapati *et. al*., 2024). In response, farmers and agricultural stakeholders are increasingly adopting climate-resilient practices to mitigate these adverse effects. Notable strategies employed include precision agriculture, which leverages data and technology to optimize resource use and increase efficiency (Adewuyi *et. al.,* 2024); integrated pest management, which combines biological, cultural, mechanical, and chemical tools to manage pests in an environmentally sustainable manner (Angon *et. al.*, 2023); and the cultivation of improved crop varieties that are more resistant to drought, pests, and diseases (Pixley *et. al.,* 2023). Mung bean are among the crops that are hardy and able to withstand adverse environmental conditions and the effects of climate change (Pataczek *et al.,* 2018; Ray *et al.*, 2019).

Mung (*Vigna radiata* (L.) Wilczek) bean also known as green gram is an underutilized legume crop in Nigeria, as well as most parts of the world. It is adapted to tropical and subtropical lowlands and relatively tolerant to abiotic stresses, like drought and heat (Chankaew *et al.*, 2014). Mung bean is a multipurpose plant, the grains are highly nutritious having protein, dietary fiber, minerals, vitamins, and significant amount of bioactive compounds (Gan *et al.*, 2017; Hou *et al.*, 2019); harvested residues are used as livestock feed or manure; mung bean incorporated in a crop production system as a catch crop is a soil management strategy. Also diversification of local production systems through inclusion of mung bean as a catch crop provides additional income to farmers and has potential to improve soil fertility.

According to FAO (2017), Nigeria's mung bean production has been steadily increasing over the years, from 12,000 metric tons in 2010 to 24,000 metric tons in 2020. In Nigeria, mung beans are primarily grown in the northern regions, where the climate is suitable for their cultivation. States such as Kano, Katsina, and Jigawa are known for mung bean production due to their favorable agro-ecological conditions. Storage of mung bean after production is threatened by various insect pests, including the cowpea beetle *Callosobruchus maculatus* (Fabricius) (Singh *et. al.*, 2024). The adult females of *C. maculatus* lays eggs on the surface of the beans, and the larvae feed on the seed coats and endosperm, causing significant damage to stored mung bean grains, which later result to substantial economic losses (Singh *et. al.*, 2020). Farmers often rely on inorganic chemical pesticides to control pests due to their rapid and effective results. However, the continuous and indiscriminate use of these chemicals has been associated with numerous health and environmental risks (Elumalai *et. al.*, 2025). There is an urgent need for alternative, sustainable pest management strategies that reduce chemical dependence while maintaining effective control of *C. maculatus*. Varietal resistance is pivotal in minimising losses caused by *C. maculatus* during storage because it is easy to utilize, cost effective and is compatible with other control methods.

The biological parameters of insects provide invaluable insights into its demographic characteristics, including survival rates, fecundity and reproductive rates and these vary according to the suitability of their host grain. Calculated survival rates (Iϰ) directly affect how quickly insect populations can grow. High survivorship means more adults emerge and potentially reproduce, increasing pest pressure in storage systems (War *et. al.*, 2017). There is no known released variety of mung bean in Nigeria, hence this study investigates how different mung bean accessions influence the population dynamics of *C. maculatus*, which may help identify resistance traits that can be integrated into pest management programmes, ultimately reducing post-harvest losses and promoting food security.

Materials and Methods

The study was carried out at the Entomology Research Laboratory, Department of Crop Protection and Environmental Biology, University of Ibadan, Nigeria, under ambient temperature of 23 ± 5°C and relative humidity of 64.2 ± 5%. This study was conducted from September to December 2024.

Sources of grains

Mung bean accessions, TVr 110, TVr 111, and TVr 33, were collected from the Genetic Resource Center, International Institute of Tropical Agriculture, Ibadan. Mung bean grains experimental discards were collected from the Institute of Agricultural Research and Training (IAR&T), Moor Plantation, Ibadan.

Insect rearing

A colony of *C. maculatus* was collected from infested mung bean experimental discard from IAR&T. Five male and female pairs of *C. maculatus* were introduced into five different Kilner jars each containing 50 g of clean mung bean seeds; Male *C. maculatus* are smaller with a narrower, tapering abdomen and lack an ovipositor whereas females are larger with a broader, rounded abdomen adapted for egg laying. The elytra of the male is a uniform light brown colour while the female has two patches on it. The jars were covered with muslin cloth fastened with rubber bands for ventilation and escape proof. Adults were allowed to mate and oviposit for five days, after which they were sieved out of the jars and the seeds observed for emergence. Newly emerged cowpea beetles of 0-24 hours old were used for this study.

Experimental layout

The experiment was laid out in a completely randomised design with four treatments; three mung bean accessions, TVr 110, TVr111, TVr 33, and Ife brown cowpea variety as the susceptible check. Treatments were replicated six times. The methodology was adapted from Boeke *et. al* (2004).

Adult oviposition on mung bean and cowpea seeds

Twenty (20) seeds of each mung bean accession and cowpea check were placed into ventilated plastic containers (7.5cm diameter; 4.5cm depth). A pair of male and female *C. maculatus* were introduced into each ventilated plastic container and left for 96 hours to mate and oviposit. Twenty-four hours after adult infestation, mung bean seeds with eggs were removed from the ventilated containers and placed singly into a small ventilated plastic vial (4.7cm diameter; 3.3cm depth). Every seed removed was replaced with clean seeds in the oviposition chamber. Seeds were observed daily for adult emergence. Data were collected on the number of eggs laid per female, number of days to adult emergence and number of successful emergence, adult longevity, and sex ratio. Adult emergence in this study represents the number of F_1 adults that successfully completed development and emerged from the host seeds. It is a success indicator that reflects egg hatchability, larval survival within the seed, pupal survival, and the ability to exit the seed coat. Adult longevity represents the mean number of days that emerged adults survived following emergence.

Survivorship was calculated using the formula:

$$\mathbf{I}_{\chi} = \frac{\mathbf{n}_{\chi}}{\boldsymbol{n}_0}$$

I_χ = Survivorship

n_χ is the number alive at age χ (Adult stage)

n_0 is the initial cohort size (number of eggs)

Data Analysis

All count data were transformed to achieve normality, using square root transformation then analyzed with general linear model analyses of variance using SAS System for Windows 9.0 software. Significant means were separated using Tukey's Honestly Significant Difference method at 95% confidence interval level. Pearson's Correlation analysis was carried out among the biological parameters of *C. maculatus* and Cluster analysis based on the arithmetic mean of all measured parameters was performed to generate a dendrogram using the Palaeontological Statistics software (PAST v2.17) (Hammer *et al.*, 2001).

Results

Variation in the biological performance of *Callosobruchus maculatus* was observed among mung bean accessions (TVr110, TVr111, and TVr33) and the susceptible Ife brown cowpea check, based on fecundity, developmental period, adult emergence, longevity, mortality, survivorship, and sex ratio.

Number of Eggs Laid per Female Bruchid (Fecundity)

Table 1 shows the developmental parameters of *C. maculatus* on mung bean accessions and Ife brown cowpea**.** Fecundity differed significantly across the mung bean accessions and the Ife brown cowpea check (Table 1). The highest number of eggs (6.10 eggs / female) was recorded on Ife brown variety, highlighting its high susceptibility to infestation. Among mung bean accessions, TVr110 supported relatively higher oviposition (4.86 eggs/female) compared to TVr111 (4.41 eggs/female) and TVr33 (3.80 eggs/female). The developmental period of *C. maculatus* was similar across all accessions, ranging from 5.07 to 5.28 days, indicating that host type did not significantly influence developmental time

Table 1: Developmental parameters of *Calosobruchus maculatus* on mung bean accessions and Ife brown cowpea

Parameters	TVr110	TVr111	TVr33	Ife brown
Fecundity (Eggs/Female)	$4.86^{ab} \pm 0.56$	$4.41^{\mathbf{b}} \pm 0.42$	$3.80^{\mathbf{b}} \pm 0.23$	$6.10^{a} \pm 0.30$
Developmental period (days)	$5.11^{a} \pm 0.10$	$5.23^{a} \pm 0.03$	$5.07^{a} \pm 0.07$	$5.28^{a} \pm 0.07$
No of Adult (n_{χ})	$2.19^{b} \pm 0.27$	$4.22^{a} \pm 0.48$	$3.18^{\mathbf{ab}} \pm 0.60$	$2.86^{\mathbf{b}} \pm 0.34$
Adult longevity (days)	$3.14^{a} \pm 0.42$	$3.48^{\mathbf{a}} \pm 0.17$	$3.47^{\mathbf{a}} \pm 0.07$	$3.18^{\mathbf{a}} \pm 0.17$

Means followed by the same superscript across the rows are not significantly different from each other at p> 0.05

Adult Longevity, Mortality, and Survivorship

Table 2 shows the performance of *C. maculatus* on mung bean accessions and Ife brown cowpea

Adult emergence was highest on TVr111 (4.22), whereas Ife brown (2.86) and TVr110 (2.19) permitted lower emergence. TVr33 had an intermediate emergence rate (3.18). Longevity ranged from 3.14 to 3.48 days and did not differ significantly among treatments. Significant differences in mortality rates were observed among the accessions.

Mortality was lowest on TVr111 (2.01%), supporting the highest survivorship (0.614), while the highest mortality was recorded on Ife brown (5.30%), followed by TVr110 (3.70%) and TVr33 (3.20%). The total life span of *C. maculatus* was longest on TVr110 (36.50) and shortest on TVr33 (24.80) and Ife brown (24.74) (Table 2). Survivorship was notably lower on Ife brown (0.209).

Table 2: Performance of *Callosobruchus maculatus* on mung bean accessions and Ife brown cowpea

Parameters	TVr110	TVr111	TVr 33	Ife brown
Mortality	$3.70^{b} \pm 0.44$	$2.01^{c} \pm 0.41$	$3.20^{bc} \pm 0.20$	$5.30^{a} \pm 0.23$
Total Life Span (days)	$36.50^{a} \pm 0.44$	$32.20^{ab} \pm 2.01$	$24.80^{b} \pm 0.51$	$24.74^{b} \pm 0.61$
Survivorship (I_{χ})	0.426	0.614	0.558	0.209

Means followed by the same superscript across the rows are not significantly different from each other at $p > 0.05$

Correlation among bruchid life cycle parameters on mung bean accessions and cowpea

Pearson's correlation analysis (Table 3) showed that the number of eggs laid was strongly positively correlated with mortality rate ($r = 0.62$, $p < 0.01$), suggesting that increased egg laying often led to higher larval competition and mortality. Weak positive correlations were also noted between fecundity and adult emergence ($r = 0.28$) and between fecundity and days to adult emergence ($r = 0.32$). Mortality rate correlated moderately with sex ratio ($r = 0.56$).

Table 3: Pearson's Correlation Coefficient of life-cycle Parameters of *Callosobruchus maculatus*

Parameters	No. of Eggs	No. of Adults	Days to adult Emergence	Mortality	Sex Ratio	Adult Longevity
No. of Eggs	1.00	0.28	0.32	0.62**	-0.12	-0.16
No. of Adults		1.00	0.25	-0.40	-0.25	0.12
Days to adult Emergence			1.00	0.09	0.19	-0.22
Mortality				1.00	0.56	-0.24
Sex Ratio					1.00	0.25
Adult Longevity						1.00

** Significantly at $p < 0.01$

Sex Distribution

The sex distribution of emerging F1 adults showed no significant differences across accessions (Figure 1). However, slight variations were observed, with TVr111 and Ife brown tending toward a higher male proportion, and TVr110 and TVr33 showing a higher female proportion. Although these differences were not statistically significant, observed differences could influence long-term population growth and pest pressure in storage.

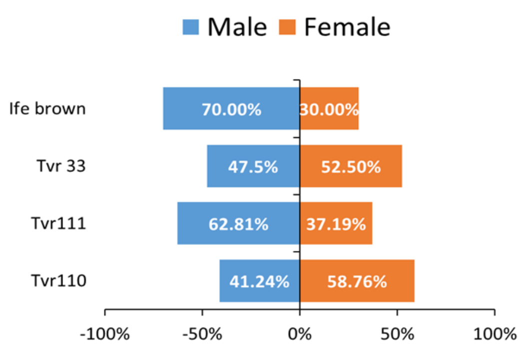

Figure 1: Sex distribution of F_1 *Callosobruchus maculatus* adults emerging from mung bean Accessions.

Cluster Analysis of Mung Bean Accessions

Cluster analysis grouped the mung bean accessions based on their impact on *C. maculatus* biological performance (Figure 2). TVr110 and TVr111 clustered together, suggesting similar levels of susceptibility, while TVr33 grouped closer to Ife brown, despite exhibiting better pest control traits.

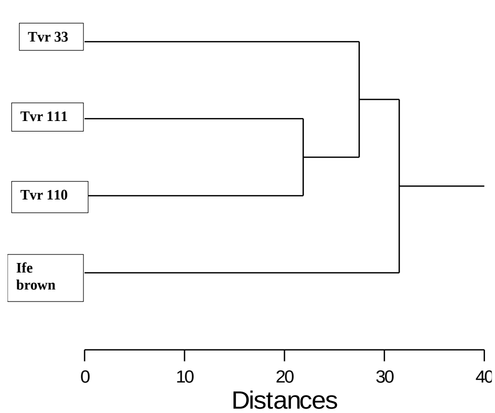

Figure: Dendrogram showing the clustering of mung bean accessions and Ife brown cowpea variety based on *Callosobruchus maculatus* biological response.

Discussion

Biological parameters refer to measurable characteristics or attributes of living organisms, population, or ecosystem. These parameters are used to describe, analyze, and understand the biological processes, structures, and functions of organisms. They are essential in understanding the ecology, behaviour, and population dynamics of *C. maculatus,* which is crucial for developing effective management strategies for this pest species. In this study biological parameters such as growth rate, reproductive rate, mortality rate, sex ratio, adult longevity and survivorship were established.

The findings indicate that while Ife brown allows for high fecundity, confirming its role as a highly susceptible check, TVr33 mung bean accession seemed less favourable for oviposition. Ife brown also exhibited lower survivorship, possibly due to resource depletion (Zahra *et al*., 2023) In contrast, TVr33 exhibited a balance of moderate fecundity and lower survivorship, suggesting a better resistance status to *C. maculatus.* Higher fecundity observed on Ife brown is consistent with findings by Mansouri *et al*. (2022) who reported that susceptible legume varieties tend to stimulate greater oviposition, due to their nutritional quality, and softer seed coat structure. Conversely, the significantly lower fecundity on TVr33 suggests that physical or chemical seed barriers may have deterred egg laying, aligning with the observations by War *et al.* (2017), who emphasized the role of antixenosis (non-preference) mechanisms in mung bean against *Callosobruchus* spp.

While the developmental period of *C. maculatus* was similar across all accessions, differences in adult emergence and mortality rates were notable. TVr111 supported the highest number of adults, whereas TVr33 and Ife brown recorded lower emergence. Mortality rates were highest on Ife brown, despite its high fecundity; this could be attributed to intraspecific larval competition, as supported by Chen *et. al.* (2019), who found that high egg loads, can lead to increased larval mortality in confined seed spaces. The relatively moderate mortality on TVr33 could be a combination of small seed size, physical seed defenses and biochemical properties that impact larval survival, hence the survivorship patterns observed in the study.

Food availability plays a critical role in shaping the population dynamics of *Callosobruchus maculatus* during the larval stage (Mansouri *et al.,* 2022). Insights from Chen *et al.* (2019) highlighted that high oviposition rates on susceptible hosts often result in larval overcrowding. The observed correlation between mortality and the number of eggs laid implies that increased egg deposition corresponds with higher mortality. When more eggs are laid on a seed, the available food may become insufficient to support all larvae. As food resources become limiting, larval competition intensifies, leading to either escape attempts or, in enclosed systems like stored seeds, death. Ehisianya *et al*. (2022) reported direct density-dependent evidence where higher initial egg densities on seeds produced altered adult emergence and seed damage. These findings reinforce the complexity of host-pest interactions, where resistance is not solely defined by reduced oviposition but also by impaired development and survival as a result of the unique characteristics of the host grains that makes it unfavorable for insect development and survival. In a similar study by Rosemond and Khan (2013) on pigeon pea cultivars B9, B35, B52, B59, demonstrated lower larval penetration, longer developmental periods, and decreased survival rates, highlighting resistance at the larval and emergent stages.

Although sex ratios did not significantly differ among accessions, slight male or female dominance was observed depending on the host. This suggests that host seed quality could subtly affect sex ratios in bruchid populations, potentially influencing long-term infestation dynamics (Srisakrapikoop *et al.*, 2022). The clustering patterns indicate that TVr110 and TVr111 were more closely related, while TVr33 shares some features with the susceptible check Ife brown. This presents a less favourable environment for *C. maculatus* development and could be further explored for resistance breeding.

Conclusion

Traits such as lower larval penetration, longer larval developmental periods, and decreased survival rates, highlighting resistance at the larval and emergent stages can be used to indicate resistance in mung bean against *Callosobruchus maculatus.* Similarly, in our study, TVr33 deterred oviposition, so through multiple breeding cycles, this trait can be combined to develop mung bean varieties with enhanced resistance to storage pests. This could reduce reliance on chemical insecticides, promote safer grain storage, and contribute to improved food security in mung bean-producing regions.

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