Biology of *Callosobruchus maculatus* (Fabricius) (Coleoptera: Chrysomelidae) on two commercial beans in Makassar, Indonesia

Asra Asra[1,2], Wardani Syahrani[1,2], Bhintang Maharani[1,2], Laila Al Atsariyah[1,2], Ravindra Chandra Joshi[3,4,5,6], Eirene Brugman[1], Ito Fernando[7] and M. Bayu Mario[1,2,*]

[1] Study Program of Plant Protection, Department of Plant Pest and Disease, Faculty of Agriculture, Universitas Hasanuddin, Indonesia
[2] Stored-Product Insect Research Group, Department of Plant Pest and Disease, Faculty of Agriculture, Universitas Hasanuddin, Indonesia
[3] Senior Consultant, Philippine Rice Research Institute, Philippines
[4] Pacific Coordinator, Tropical Agriculture Association International, United Kingdom
[5] Research Associate, Centre for Agriculture and Bioscience International - Southeast & East Asia Regional Centre, Malaysia
[6] Professor of Practice, Malla Reddy University, Hyderabad, India
[7] Department of Plant Pests and Diseases, Faculty of Agriculture, Universitas Brawijaya, Jalan Veteran Malang 65145, Indonesia

[*] Corresponding author e-mail: bayumario@unhas.ac.id

DOI: https://doi.org/10.36077/kjas/2025/v17i4.18666
Received date: 31/1/2025
Accepted date: 2/11/2025

Abstract

Callosobruchus maculatus (Fabricius) (Coleoptera: Chrysomelidae) is a significant pest of legumes, exhibiting oligophagous feeding behavior. Infestation by this pest during storage can result in substantial economic losses, as its larvae consume the seed endosperm, leaving the seeds hollow and thereby reducing both their quantity and quality. The aim of this study was to investigate the biology of *C. maculatus* and the extent of its damage to commercial mung bean and cowpea in Makassar, Indonesia. The results showed that the population growth of *C. maculatus* was significantly higher in mung bean (228.22 adults) compared to cowpea (190.22 adults). This population growth also affected the average weight of the adults. For females, not significant difference was observed, with an average weight of 1.66 mg/adult in mung bean and 1.73 mg/adult in cowpea. In contrast, a significant difference was observed in males, with an average weight of 1.12 mg/adult in mung bean and 1.06 mg/adult in cowpea. The percentage of damaged beans was significantly higher in cowpea (95.16%) compared to mung bean (78.95%). Similarly, the percentage of weight loss was significantly greater in cowpea (31.69%) than in mung bean (22.65%). This damage and weight loss pose a serious storage problem, reducing both the quality and quantity of beans.

Keywords: Adult weight, Cowpea, Mung bean, Oligophagous, Weight loss

Introduction

Mung bean and cowpea, two essential dietary staples in tropical and subtropical regions such as Indonesia (1), offer significant nutritional benefits. Renowned for their high protein content, mung bean have been extensively consumed by populations worldwide. Their protein content ranges from 20 to 30% (2), making them a valuable dietary protein source. Cowpea, on the other hand, provides a balanced nutritional profile containing approximately 22% protein, 15% fat, and 60% carbohydrates. Despite their nutritional value, these legumes face significant challenges during storage due to the prevalence of insect infestations, such as the cowpea weevil, *Callosobruchus maculatus* (Fabricius) (Coleoptera: Chrysomelidae) (3 and 4).

The cowpea weevil is oligophagous in nature allows it to infest a wide range of legume species, including mung bean, cowpea, adzuki beans, soybeans, pigeon pea, bambara groundnut, and lentils (5). This pest has a cosmopolitan distribution, including Indonesia (6). Infestation by *C. maculatus* in stored legumes can lead to substantial economic losses. The larvae consume the endosperm of the seeds, rendering them hollow and reducing both quantity and quality (7). Severe infestations can also facilitate secondary pest invasions and fungal contamination, further diminishing the economic value of infested seeds (8). Controlling *C. maculatus* is challenging due to its rapid life cycle and the high fecundity of females, which can lay large numbers of eggs, leading to rapid population growth (9).

Losses during storage caused by *C. maculatus* infestation represent a serious problem in legume preservation. Legume seeds stored for six months may experience up to 70% infestation and an estimated yield loss of about 30%, rendering them unsuitable for human consumption (10). Economic losses due to *C. maculatus* infestation in stored legumes have been estimated at 35% in Central America, 7–13% in South America, and 73% in Kenya (11). In Egypt, seed weight loss commonly reaches 50% after only three months of storage (12). This issue warrants special attention given the critical importance of ensuring adequate and sustainable food availability (13).

Pest population growth is influenced by various factors, including host quality. Suitable hosts can enhance insect population growth, survival, and reproduction (14). Host suitability is determined by factors such as nutritional properties (15) and physical characteristics of beans, including size, color, texture, and hardness (12, 13, and 14). This study aimed to investigate the biology of *C. maculatus* on mung bean and cowpea in Makassar, Indonesia, to better understand its impact on stored legume commodities and develop effective pest management strategies.

Material and Methods

Insect infestation, mung bean, and cowpea were obtained from Daya traditional market in Makassar, Indonesia (5°06'46"S

119°30'45"E) (Figure 1). Thirty unsexed adults were introduced into a glass jar (h=9 cm; d=5.5 cm) with thirty grams of mung bean and cowpea, each replicated nine times, under laboratory conditions (28±2 °C; relative humidity (r.h.) 30±10%). Each glass jar was covered by organdy mesh and sealed with rubber band. Insect infestations were removed after seven days, and number of F_1 progeny was counted from first emergence until no adults appeared for five consecutive days (18).

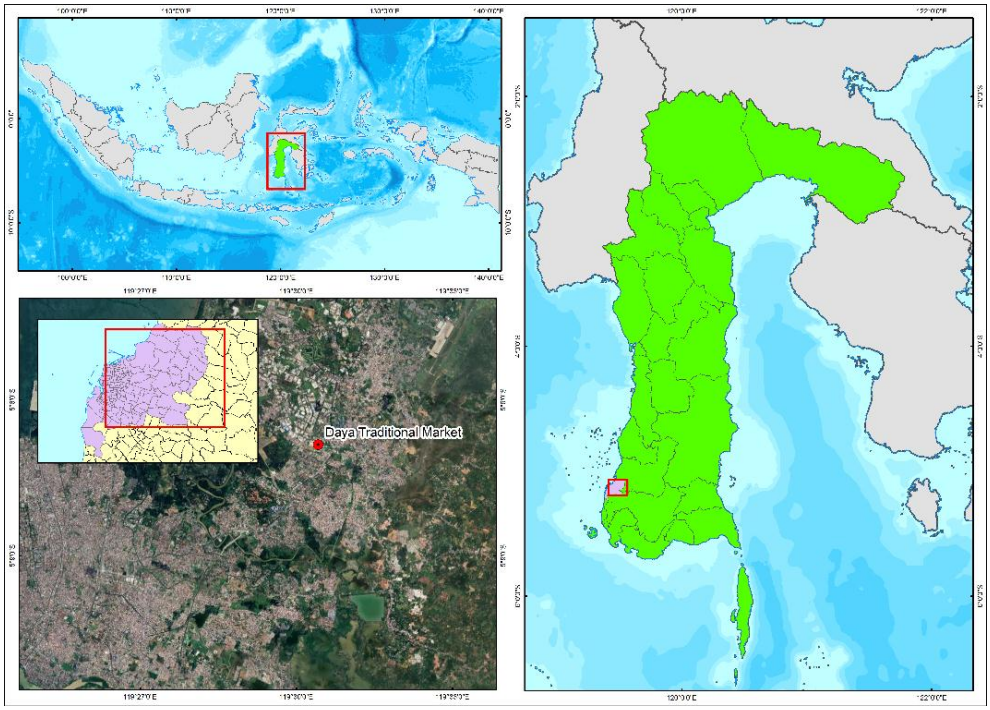


Figure 1. Insect infestation, cowpea, and mung bean source from Daya traditional market, Makassar, Indonesia

Twenty males and females *C. maculatus* of their progeny were weighed separately using an analytical balance (KK-LABR, Panasonic Kenko®, Japan).

The percentage of damaged beans was calculated using the formula (19).

$$\text{Damage bean (\%)} = \frac{Nd}{Nd + Nu} \times 100\%$$

Nd = number of damaged beans
Nu = number of undamaged beans

While the percentage of beans weight loss was calculated from the following formula (20).

$$\text{Weight loss (\%)} = \frac{WI - W}{WI} \times 100\%$$

WI = weight of the beans before the assay
W = weight of the beans at the end of the assay.

All observation parameters were tested for normality using the Shapiro-Wilk test and for homogeneity using Levene's test to meet the assumptions. All analyses were done by Microsoft Office Excel 16.86 version for one-tailed independent T-test and their box plots. Additionally, R-Studio 3.6.0 version 2.0 package was employed

for the creation of heat maps to visualize the relationships between biological parameters (21).

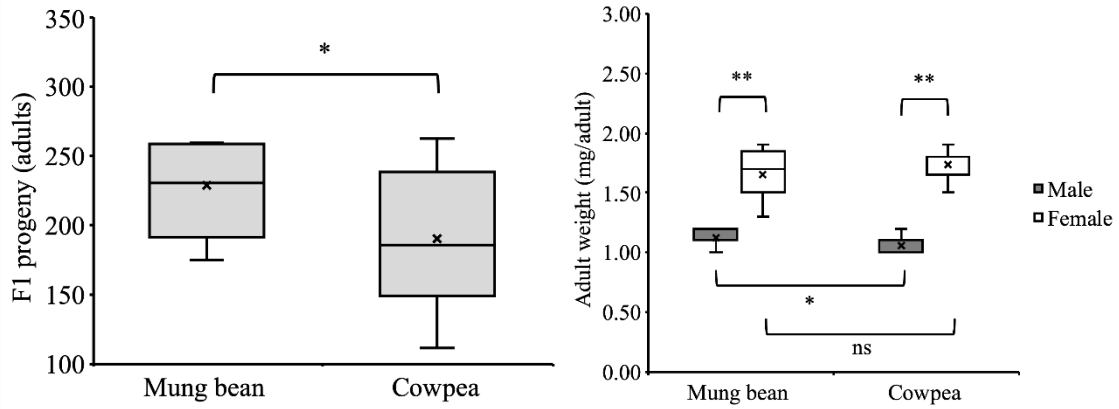
Results and Discussion

Biological Performance of *C. maculatus*

The F_1 progeny of *C. maculatus* on mung bean (228.22 adults) and cowpea (190.22 adults) exhibited a significant difference ($P < 0.05$) (Figure 2a). The number of F_1 progeny was higher on mung bean compared to cowpea. Various factors influence the development and survival of *C. maculatus* on different legume species. Grain characteristics, such as seed surface texture and nutritional content, play crucial roles (6 and 18). Some of the observed variation can be explained by seed texture, for instance, the smooth seed coat of mung bean, which facilitates oviposition and larval development by *C. maculatus* (23 and 24). Additionally, the nutritional balance of the beans significantly impacts insect development. Mung bean contain 30% more protein than cowpea (2), providing a more suitable nutrient composition for *C. maculatus* growth (22).

Population density can also influence insect development. The higher number of beans in the tested mung bean samples resulted in a lower population density. High population density can induce stress in insects, impacting their growth and development (25). Moreover, bean size can affect adult emergence success. Larger beans may allow for more eggs to be laid, but they may also lead to a lower percentage of *C. maculatus* emergence due to increased competition among larvae (26).

The weight of female *C. maculatus* on mung bean (1.66 mg/adult) and cowpea (1.73 mg/adult) did not exhibit a significant difference ($P > 0.05$), while the weight of male *C. maculatus* on mung bean (1.12 mg/adult) and cowpea (1.06 mg/adult) differed significantly ($P < 0.05$) (Figure 2b). Significant differences were also detected for the weight of both male and female *C. maculatus* on the two legumes ($P < 0.01$) (Figure 2b). Adult weight in *C. maculatus* is influenced by various factors. Insect body size, with larger insects tending to be heavier, is one such factor (27). The nutrient content of the host legume also plays a role in adult weight (28). Females, in particular, require a substantial amount of protein for egg maturation, resulting in heavier weights compared to males (29). This explains the observed differences in weight between males and females on both mung bean and cowpea. Male reproduction can also influence weight differences in *C. maculatus*. According to Małek *et al*. (30), reproducing males provide substantial ejaculate to their female partners, ranging from 0.06–0.31 mg, which constitutes about 10% of the male body mass. Additionally, Małek *et al*. (31) found that a single *C. maculatus* ejaculate corresponds to a loss of body mass equivalent to 0.4–2.0 days. In males that mated twice, the combined 'day equivalent' of two ejaculates increased to 1.2–2.5 days of body mass loss.



(a) (b)

Figure 2. Biological ascpect of *Callosobruchus maculatus* on mung bean and cowpea, (a) F_1 progeny and (b) weight of male and female. * = significant at $P < 0.05$, ** = significant at $P < 0.01$, and ns = not significant differences by one-tailed independent T-test. The box plots represent the mean as a cross mark, the median as the center line, the upper and lower whiskers as the maximum and minimum values, and the box limits as the upper and lower quartiles.

Seed Damage and Weight Loss

The percentage of damaged beans attacked by *C. maculatus* revealed a significant difference between mung bean (78.95%) and cowpea (95.16%) ($P < 0.01$) (Figure 3a). Bean size plays a crucial role in *C. maculatus* oviposition and the extent of subsequent damage. Larger beans provide more surface area for egg deposition and can support the development of multiple larvae within a single bean, resulting in higher infestation levels (32). Due to their larger bean size, cowpea experiences a higher percentage of damage compared to mung bean, even though the F1 progeny is higher in mung bean.

Additionally, bean size can influence resistance to *C. maculatus* infestation, with smaller beans generally showing higher resistance than larger ones (33). The damage caused by *C. maculatus* resulted in a decrease in bean weight. This reduction in weight can have significant economic implications for stored legume commodities.

The percentage of weight loss in cowpea (31.69%) was significantly higher than in mung bean (22.65%) ($P < 0.05$) (Figure 3b). *C. maculatus* infestations result in perforated beans, a decrease in nutritional value, and a reduction in bean weight, leading to a decrease in both the quality and quantity of the beans (34). This damage and weight loss pose a severe problem in storage, as they leads to economic losses due to the reduced weight of the beans, thereby affecting their economic value (35). The correlation analysis revealed a significant positive correlation between the percentage of damaged beans and weight loss ($r = 0.650$; $P < 0.01$) (Figure 4). This indicates that a higher percentage of damaged beans is directly associated with a greater loss of weight. Resistant seeds exhibited the lowest weight loss caused by *C. maculatus*

due to their small size, broad and thick seed coat, and well-developed seed coat texture. Furthermore, delayed insect development in such resistant seeds can result in a significant reduction in seed weight loss during grain storage (24 and 36).

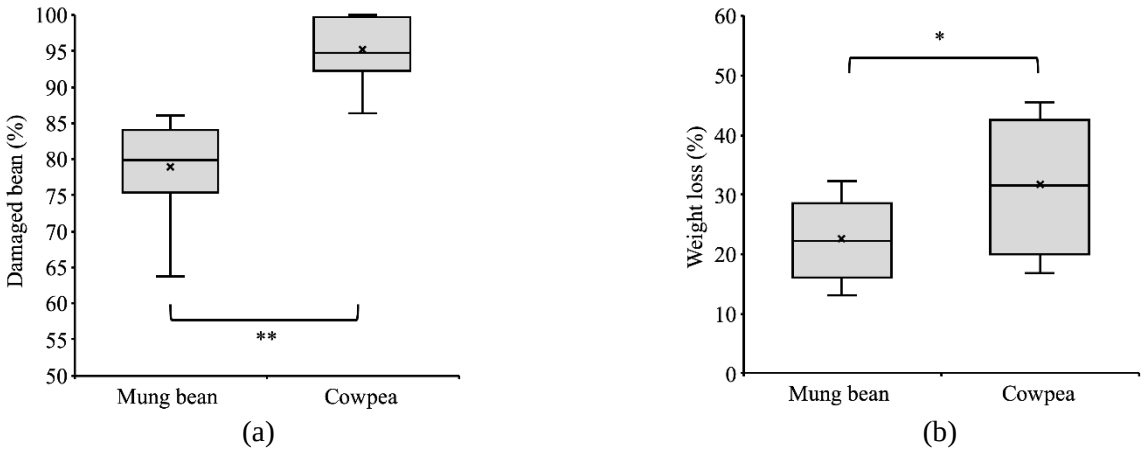


Figure 3. Damaged beans (a) and weight loss (b) of mung bean and cowpea by *Callosobruchus maculatus*. * = significant at $P < 0.05$, ** = significant at $P < 0.01$ by one-tailed independent T-test. The box plots represent the mean as a cross mark, the median as the center line, the upper and lower whiskers as the maximum and minimum values, and the box limits as the upper and lower quartiles.

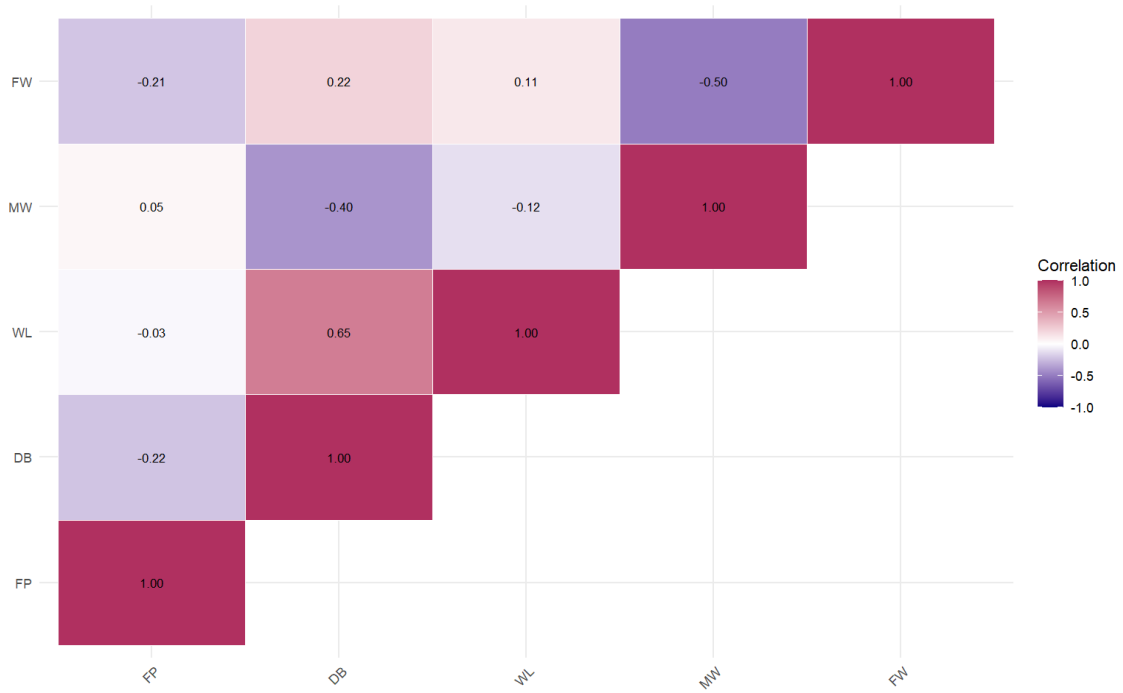


Figure 4. Heat map Pearson's correlation matrix among the observed variables at $P < 0.05$. Strong positive correlations are indicated by darker red shades, and negative correlations by darker blue shades. FP: F_1 progeny, DB: damaged beans, WL: weight loss of beans, MW: male weight, FW: female weight.

Conclusion

This study found that mung bean supported a higher F_1 progeny count compared to cowpea, while cowpea experienced a higher percentage of damage. Infestation by *C. maculatus* results in perforated beans and a reduction in bean weight.

Conflict of Interest

The authors have no conflict of interest.

References

1- **Sun, S; F. Sun; D. Deng; X. Zhu; C. Duan and Z. Zhu. 2020.** First report of southern blight of mung bean caused by *Sclerotium rolfsii* in China. Crop Prot, 130:105055.

2- **Liu, H; H. Liu; L. Yan; X. Cheng and Y. Kang. 2015.** Functional properties of 8S globulin fractions from 15 mung bean (*Vigna radiata* (L.) Wilczek) cultivars. Int J Food Sci Technol, 20;50(5):1206–14.

3- **Martins, S. P; G. N Silva; A. H. de Sousa; D. R. S. Barbosa; R. A. da Silva; K. R. Ducatti, et al. 2024.** Cowpea storage: Can small farmers use polyethylene terephthalate bottles and wood ash as an alternative to avoid damage caused by *Callosobruchus maculatus*? J Stored Prod Res, 106:102301.

4- **Ogunmefun, O. T; P. U. Obi and O. B. Akpor. 2023.**. Bioinsecticidal efficacy of *Eucalyptus camaldulensis* (Dehn) and *Hyptis suaveolens* (L.) Poit. leaf extracts on *Callosobruchus maculatus* (Cowpea weevil). Sci African, 20:e01663.

5- **Hagstrum, D. W; T. Klejdysz; B. Subramanyam and J. Nawrot. 2013.** Atlas of Stored-Product Insects and Mites. AACC International.

6- **Hamzavi, F; B. Naseri; M. Hassanpour; J. Razmjou and A. Golizadeh. 2022.** Biology and life table parameters of *Callosobruchus maculatus* (F.) on *Vigna unguiculata* (L.) Walp. fertilized with some mineral- and bio-fertilizers. J Stored Prod Res, 97:101978.

7- **Mario, M. B; L. P. Astuti; J-L. Hsu and L. Kafle. 2021.** Fumigant activity of four plant powders against cowpea weevil, *Callosobruchus maculatus* (Fabricius)(Coleoptera: Chrysomelidae) in stored adzuki bean. Legum Res Int J, 44(6):667–72.

8- **Mutungi, C. M; H. Affognon; A. W. Njoroge; D. Baributsa and L. L. Murdock. 2014.** Storage of mung bean (*Vigna radiata* [L.] Wilczek) and pigeonpea grains (*Cajanus cajan* [L.] Millsp) in hermetic triple-layer bags stops losses caused by Callosobruchus maculatus (F.) (Coleoptera: Bruchidae). J Stored Prod Res, 58:39–47.

9- **Cherene, M. B; S. R. Ferreira; L. D. A. Santos; R. Rodrigues; A. D. O. Carvalho; A. E. A. Oliveira, et al. 2023.** Insecticidal activity of *Capsicum annuum* L. leaf proteins on cowpea weevil *Callosobruchus maculatus* (Coleoptera: Bruchidae) development. J Asia Pac Entomol, 26(4):102158.

10- **Singh, S. R and K. O. Rachie. 1986.** Cowpea Research, Production and Utilization. Vol. 22, John Wiley and Sons. New York.

11- **Hu, F; G-N. Zhang and J-J. Wang. 2009.** Scanning electron microscopy studies of antennal sensilla of bruchid beetles, *Callosobruchus chinensis* (L.) and *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae). Micron, 40(3):320–6.

12- **Jackai, L. E. N and R. A Daoust. 1986.** Insect Pests of Cowpeas. Annu Rev Entomol, 31(1):95–119.

13- **Kosini, D; E. N. Nukenine; G. A. Agbor; A. T. Tchinda; J. P. Abdou; J. A. G. Yaya et al. 2021.** Fractionated extracts from *Gnidia kraussiana* (Malvales: Thymeleaceae) as bioactive phytochemicals for effective management of *Callosobruchus maculatus* (Coleoptera: Chrysomelidae) in stored *Vigna unguiculata* (Fabales: Fabaceae) seeds. J Insect Sci, 21(1):1–8.

14- **Tahmasebi, M; J. Shakarami; M. Mardani-Talaee and J. E Serrão. 2022.** Evaluation of resistance of six chickpea cultivars to the cowpea weevil, *Callosobruchus maculatus* (F.) (Coleoptera: Chrysomelidae: Bruchinae) with age-stage, two-sex life table. J Stored Prod Res, 99:102014.

15- **Hamdi, S. H; S. Abidi; D. Sfayhi; M. Z. Dhraief; M. Amri; E. Boushih et al. 2017.** Nutritional alterations and damages to stored chickpea in relation with the pest status of *Callosobruchus maculatus* (Chrysomelidae). J Asia Pac Entomol, 20(4):1067–76.

16- **Bidar, F; J. Razmjou; A. Golizadeh; S. A. A. Fathi; A. Ebadollahi and B. Naseri. 2021.** Effect of different legume seeds on life table parameters of cowpea weevil, *Callosobruchus maculatus* (F.) (Coleoptera: Chrysomelidae). J Stored Prod Res, 90:101755.

17- **Murevanhema, Y. Y and V. A. Jideani. 2013.** Potential of Bambara Groundnut (*Vigna subterranea* (L.) Verdc) Milk as a Probiotic Beverage—A Review. Crit Rev Food Sci Nutr, 53(9):954–67.

18- **Mario, M. B; M. Taufik; M. Melina; R. C. Joshi; I Anshar; P. Paridah et al. 2025.** Resistance of several Indonesian cereal grain cultivars to the maize weevil, *Sitophilus zeamais* (Motschulsky) (Coleoptera: Curculionidae). Crop Prot, 190:107105.

19- **Ahmedani, MS; M. I. Haque; S. N Afzal; M. Naeem; T. Hussain and S. Naz. 2011.** Quantitative losses and physical damage caused to wheat kernel (*Triticum aestivum* L.) by khapra beetle infestation. Pakistan J Bot, 43(1):659–68.

20- **Mario, M. B; L. P. Astuti; J-L. Hsu; L. Kafle and I. Fernando. 2023.** Bioefficacy of eight different plant powders applied as fumigants against the adzuki bean weevil, *Callosobruchus chinensis*. Crop Prot, 167:106200.

21- **R Core Team. 2024.** A Language and Environment for Statistical Computing [Internet]. Vienna (Austria): R Foundation for Statistical Computing

22- **Nation, J. L. 2008.** Insect Physiology and Biochemistry. CRC Press.

23- **Nisar, M. S; I. U Haq; H. Ramzan; D, M. Aljedani; M. Qasim; W. Islam et al. 2021.** Screening of different legumes for the developmental preference of *Callosobruchus maculatus* (Bruchidae: Coleoptera). Int J Trop

Insect Sci, 19;41(4):3129–36.

24- **Singh, D and T. Boopathi. 2022.** *Callosobruchus chinensis* (Coleoptera: Chrysomelidae): Biology, life table parameters, host preferences, and evaluation of green gram germplasm for resistance. J Stored Prod Res, 95:101912.

25. **Ramadan, M. M; A. A. A. Abdel-Hady; H. S. Awadalla; R. N. C. Guedes and A. S. Hashem. 2024.** Larval competition in the khapra beetle, *Trogoderma granarium* everts (Coleoptera: Dermestidae). J Stored Prod Res, 106:102278.

26- **Kébé, K; N. Alvarez and A. Espíndola. 2020.** Oviposition choice and larval development of the seed beetle *Callosobruchus maculatus* (F.) (Coleoptera: Chrysomelidae: Bruchinae) on three cowpea varieties. J Stored Prod Res, 86:101578.

27- **Cayetano, L and R. Bondurianský. 2015.** Condition dependence of male and female genital structures in the seed beetle *Callosobruchus maculatus* (Coleoptera: Bruchidae). J Evol Biol, 15;28(7):1364–72.

28- **Astuti, L. P; M. B. Mario and T. Widjayanti. 2018.** Preference, growth and development of *Oryzaephilus surinamensis* (L.) (Coleoptera: Silvanidae) on red, white and black rice in whole grain and flour form. J Entomol Res, 42(4):461.

29- **Yanagi, S and M. Tuda. 2012.** Female size constrains egg size via the influence of reproductive organ size and resource storage in the seed beetle *Callosobruchus chinensis*. J Insect Physiol, 58(11):1432–7.

30- **Małek, D. K; M. J. Dańko and M. Czarnoleski. 2019.** Does seed size mediate sex-specific reproduction costs in the *Callosobruchus maculatus* bean beetle? Chaline N, editor. PLoS One, 14(12):e0225967.

31- **Małek, D; M. J. Dańko and M. Czarnoleski. 2023.** Effect of age, mating history and temperature on male reproductive costs in the bean beetle *Callosobruchus maculatus*. J Stored Prod Res, 102:102110.

32- **Cope, J. M and C. W. Fox. 2003.** Oviposition decisions in the seed beetle, *Callosobruchus maculatus* (Coleoptera: Bruchidae): effects of seed size on superparasitism. J Stored Prod Res, 39(4):355–65.

33- **Southgate, B. J. 1979.** Biology of the Bruchidae. Annu. Rev. Entomo, 24:449—473.

34- **Osman, D. F; S. M. Omara; S. S. M Hassanein; M. S. Ghareb; W. M. Al-Otaibi; M. M. E. Aljameeli et al. 2023.** Varietal susceptibility of certain broad bean seeds to infestation with *Callosobruchus maculatus* (F.) and *Callosobruchus chinensis* (L.) (Coleoptera: Bruchidae). Saudi J Biol Sci, 30(5):103645.

35- **Utono, I. 2013.** Assessment of grain loss due to insect pest during storage for small-scale farmers of Kebbi. IOSR J Agric Vet Sci, 3(5):38–50.

36- **Lambrides, C. J, and B. C. Imrie. 2000.** Susceptibility of mungbean varieties to the bruchid species *Callosobruchus maculatus* (F.), *C. phaseoli* (Gyll.), *C. chinensis* (L.), and *Acanthoscelides obtectus* (Say.) (Coleoptera: Chrysomelidae). Aust J Agric Res, 51(1):85.