

# Cowpea Weevil *Callosobruchus maculatus* (Fabricius 1775) (Insecta: Coleoptera: Bruchidae)<sup>1</sup>

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## Introduction

The cowpea weevil, *Callosobruchus maculatus* (Coleoptera: Bruchidae), is an important pest of legume (Fabaceae) seeds both in the field and in storage. The infestation of the crops starts in the field (Prevett, 1961), while most damage occurs during storage. *Callosobruchus maculatus* is the most destructive on cowpeas, *Vigna unguiculata* (L.), causing over 90% yield reduction (Caswell 1981). The population of *Callosobruchus maculatus* can grow exponentially, leading to significant loss in seed weight, germination viability, and the market value of the crop. (Caswell 1968, Singh 1977, Southgate 1979, Beck and Blumer 2014).

## Distribution

*Callosobruchus maculatus* is a cosmopolitan pest. Biogeographically, the species originated in Africa. It later spread to tropical and sub-tropical parts of the world (Beck and Blumer 2014).



Figure 1. Female *Callosobruchus maculatus* feeding on Mung bean (*Vigna radiata*) at magnification 50X.

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## Related Species

There are 20 species in the genus *Callosobruchus* i.e. *C. analis*, *C. chinensis*, *C. dolichosi*, *C. imitator*, *C. latealbus*, *C. nigripennis*, *C. phaseoli*, *C. pilcher*, *C. rhodesianus*, *C. semigriseus*, *C. subinnotatus*, *C. theobromae*, *C. utidai*. (Tuda et al. 2006). They are all considered economically important on legumes.

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## Description and Life Cycle

*Callosobruchus maculatus* is a holometabolic insect with life stages including egg, larva, pupa, and adult.

*Callosobruchus maculatus* adults are polymorphic with two morphs, i.e., a sedentary or flightless morph and a flight or dispersal morph. The life history of both morphs is different with regard to their morphology, physiology, and behavior. The lifespan of the sedentary morph is shorter, and the fecundity is higher than the dispersal morph. The male and female are more easily distinguished in sedentary morph than dispersal morph. High larval density inside the seed, increased temperature, bean host's water content, and photoperiod lead to the flight morph formation (Utida 1972, Beck and Blumer 2014).

The most critical variables influencing the generation time from egg to adult are temperature and relative humidity while rearing *Callosobruchus maculatus* on the preferred host (Howe and Currie 1964, Schoof 1941). The increase in temperature can decrease generation time. *Callosobruchus maculatus* can complete one generation within 3-4 weeks at 30°C and average relative humidity of 30% in the laboratory (Beck and Blumer 2014).

Generation time also depends on the species of legume. The generation time on mung beans (*Vigna radiata*) and black-eyed peas (*Vigna unguiculata* subsp. *unguiculata*) is 3-4 weeks compared to adzuki beans (*Vigna angularis*), where it takes seven weeks at 30°C (Beck and Blumer 2014).

### Eggs

A single female *Callosobruchus maculatus* lays more than 100 eggs during its lifetime and deposits one egg per seed. Eggs are transparent, oval, or spindle-shaped (Figure 2) and glued to the seed surface (Beck and Blumer 2014). These are small, 0.74 mm in length, and 0.38 mm in width at 50X. Mitchell (1975) suggested that the female bean beetle's life cycle duration increases if the female lays multiple eggs on each seed.

### Larva

The egg hatches, and the larva (whitish color; Figure 3) bores inside the seed. Once the larva gets inside, the eggshell turns opaque as it gets filled with the larval frass (Devereau et al. 2003). It has four larval instars before turning into the pupa.



Figure 2. Eggs of *Callosobruchus maculatus*. (Pointed by yellow arrow at magnification 50X.

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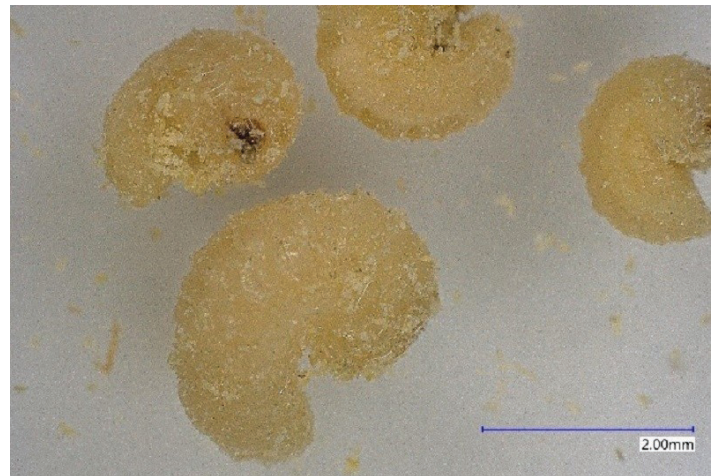


Figure 3. Larva of *Callosobruchus maculatus* at magnification 50X.

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### Pupa

The pupa is whitish, about 3.87 mm long and 1.76 mm wide at 50X (Figure 4). When the larva starts to pupate, the seed's shell starts turning thinner (Beck and Blumer 2014).



Figure 4. Pupa of *Callosobruchus maculatus* at magnification 50X.

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## Adult

The adult *Callosobruchus maculatus* chews the seed coat and emerges out of the seed. The adult is metallic in color with some pale spots/stripes. The head of the male and female is black, and the wings are brown with black patches. The male (Figure 5) and female (Figure 6) can be distinguished by the plate's color at the abdomen's end. In the female, the plate is large and colored black on the sides with a white longitudinal line, while in the male, it is smaller and lacks strips. The adults become sexually mature after 24- 48 hours of emergence. The adult lives for two-three weeks. (Beck and Blumer 2014).



Figure 5. Male *Callosobruchus maculatus*, red circle is showing the abdominal plate at magnification 50X.

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Figure 6. Female *Callosobruchus maculatus*, red circle is showing the abdominal plate at magnification 50X.

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Male *Callosobruchus maculatus* beetles have spines in genital organs, and they tend to puncture females' genital tract during copulation (Edvardsson and Tregenza 2005). Males and females are both polygamous. Female *Callosobruchus maculatus* mating with multiple virgin males live longer, lay

more and larger sized eggs throughout life (Wasserman and Asami 1985, Fox 1993) than females mating only once. The number of eggs laid by the female depends on the hosts' availability to decrease the larval competition (Credland 1986, Messina and Slade 1999).

## Economic Importance

*Callosobruchus maculatus* is a serious economic pest of stored legumes and seed infestation starts in the field. Feeding injury by the developing *Callosobruchus maculatus* larvae reduces the amounts of carbohydrates and proteins of the grain, leading to the degradation of the nutritional quality and forcing the growers to sell their commodity with low economic value after harvest (Allotey and Oyewo 1993, Murdock et al. 2003). It is estimated that the economic losses caused due to *Callosobruchus maculatus* infestation in stored grain legumes are 35%, 7–13%, and 73% in Central America, South America, and Kenya, respectively (Nahdy 1994 and Hu et al. 2009). Legume seeds stored for six months can experience 70% seed infestation and about 30% yield loss, leaving them unacceptable for human consumption (Singh and Jackai 1985). However, there is not enough information about the economic injury level (EIL) of *Callosobruchus maculatus* under storage conditions (Hamdi et al. 2017). *Callosobruchus maculatus* is used for rearing biocontrol agents such as the hymenopteran *Catolaccus hunteri* of pepper weevil (*Anthonomus eugeni*). (Vásquez et al. 2005).



Figure 7. Damage of *Callosobruchus maculatus* at magnification 20X.

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## Management Chemical Control

Environmental risk and development of resistant traits leave the synthetic insecticides inconvenient for managing stored grain pests like *Callosobruchus maculatus* (Odeyemi et al. 2006). Different botanical extracts exhibited the

insecticidal activity on *Callosobruchus maculatus* (Sanon et al. 2010). Rahman and Talukder (2006) reported that the powdered leaves extract of nishinda (*Vitex negundo* L.), eucalyptus (*Eucalyptus globules* Labill.), and bankalmi (*Ipomoea sepiaria* K.) were blended with black gram seeds at a rate of 3% mixture (w/w) had reduced insect oviposition, adult emergence and infestation rate. They also found the bablah (*Acacia arabica* L.) ash is more effective than the powdered leaves of nishinda, eucalyptus, and bankalmi. Treated seeds with plant oils of mustard, safflower, castor, coconut, cotton, groundnut, and soybean provided surface protection from *Callosobruchus maculatus* infestation by reducing the seed damage rate and the number of emerged adults (Ketker 1989, Shaaya et al. 1997, Ahmed et al. 1999). Ilboudo et al. (2010) reported higher mortality of adult *Callosobruchus maculatus* with the essential oils extracted from *Ocimum amricanum*, *Hyptis suaveolens*, *Hyptis spicigera* and *Lippia multiflora*. The seed storage jute bags for cowpea seeds treated with plant leaf extracts of *A. indica*, *V. negundo*, *C. collinus*, and *J. curcas* reduced egg-laying rate, adult emergence and seed infestation by *Callosobruchus maculatus* (Raja et al. 2000). Several research findings suggested that botanical extract oil treatment did not reduce the seed quality and germination rate (Das 1986, Onu and Aliyu 1995, Keita et al. 2001).

More than 60% of the newly emerged adult mortality has been recorded by exposing them to essential oils from sweet basil, *Ocimum basilicum*, and African basil, *O. gratissimum*, (Labiatae) in Guinea (Kéita 2001). The essential oil extracted from *Mentha piperita* and *Salvia officianalis* result in 100% mortality (Fabricius 2010). Cashew kernel extracted from the water was also toxic to *Callosobruchus maculatus* (Adedire et al. 2011). Seeds treated with clove and black pepper showed effectiveness against cowpea weevil (Mahdi and Rahman 2008). Seeds treated with neem (*Azadirachta indica*) extract proves effective in repelling cowpea weevil (Elhag 2000).

## Biological Control

Hymenopteran ectoparasitoids i.e. *Uscana lariophaga* (Stefan), *Dinarmus basalis* (Rondani), and *Eupelmus vuilleti* (Crawford) are promising biocontrol agents for *Callosobruchus maculatus* (Monge and Huignard 1991, Sanon et al. 1998). A higher *Callosobruchus maculatus* mortality can be achieved by releasing the ectoparasitoid *D. basalis* combined with essential oil extracted from *Cymbopogon schoenanthus*. However, the oil should be applied before releasing the parasitoid. Parasitoid adults are also susceptible to oil (Ketoh et al. 2005).

Entomopathogenic fungi (Beauvarin®) effectively reduced the population of *Callosobruchus maculatus* in stored cowpea and wheat (Shams et al. 2011). *Bacillus thuringiensis* (at 4x 10<sup>8</sup> cells/ml) can target the larval and pupal stages and result in 100% mortality of *Callosobruchus maculatus* (Malaikozhundan and Vinodhini 2018).

Sterile insect technique (SIT) and autocidal control methods effectively manage stored grain pests (Bakri et al. 2005, Fetoh 2011). Ionizing radiation (gamma rays, cobalt-60 source) between 50 and 100 Gy can prevent the development of all stages of *Callosobruchus maculatus* (Diop et al. 1997, Bhalla et al. 2008). The use of gamma-irradiated sub sterilized males in over flooding ratio can stop the multiplication of been beetle. The application of a low dose of 20 Gy can induce semi-sterility in adults of *Callosobruchus maculatus* (Ibrahim et al. 2017).

## Physical Control

Freezing the whole storage area for a long time can control *Callosobruchus maculatus* (Johnson and Valero 2000). Also, lowering the temperature to 10°C can effectively reduce the beetle's infestation as development ceases below 12°C.

The high temperature and low humidity or solar heating effectively inhibit egg-laying, embryonic development of *Callosobruchus maculatus* causing mortality of the emerging adults (Murdock et al. 1991, Adebayo and Anjorin 2018). Barbosa et al. (2017) found the microwave radiation (240 W microwave power level at frequency 2450 MHz for 120 and 150 s) was lethal to *Callosobruchus maculatus*. They also found reducing emerging adults and increased developmental period (egg - adult) with the increased microwave exposure (30, 60, 90, 120, and 150 s). Loganathan et al. (2011) reported the lethal time for eggs, larvae, pupae, and adults at 42°C were 18, 57, 78, and 71 h respectively and at 0° were 3, 8, 10, and 4 days. The low temperature (-14±1°C) effectively controls all developmental stages, including adults (Bhalla et al. 2008).

Light spectra are an important source to reduce the damage caused by *Callosobruchus maculatus*. Kehinde et al. (2019) reported that the highest mortality of *Callosobruchus maculatus* under white light while red and blue lights are also lethal by using electric bulbs at 25 Watts. Pandiselvam et al. (2018) revealed increased mortality of different life stages of *Callosobruchus maculatus* with the high gaseous ozone concentration and exposure time when exposed to 500-1500 ppmv ozone.



Storage of the cowpea grain in the sealed metal drum (Seek and Gasper 1992) and the use of triple plastic bagging provided effective control over *Callosobruchus maculatus* infestation. Within these sealed environments, the developmental stages of *Callosobruchus maculatus* are impacted by the depletion of oxygen and the elevation of carbon dioxide (Seek et al. 1996). Modified storage environment by increasing carbon dioxide (CO<sub>2</sub>) levels (hypercarbia) and decreasing oxygen (O<sub>2</sub>) levels (anoxia), and lowering the humidity significantly affected *Callosobruchus maculatus* with high egg and adult mortality (Navarro and Calderon 1980, Ofuya and Reichmuth 2002).

## Cultural Control

*Callosobruchus maculatus* is unable to infest the legume pods with hairy and thick walls. The genetically modified adzuki beans producing amylase inhibitors (alphaAL), making them resistant to *Callosobruchus maculatus* attack (Ishimoto et al. 1996). The cowpea varieties with trypsin inhibitors (Shade et al. 1996), tannins (Oigiangbe and Onigbinde 1996), chitinases and beta -1,3-glucanases (Gomes et al. 1996) and insecticidal lectins (Murdock et al. 1990, Zhu et al. 1996, Omitogun et al. 1999) are resistant to *Callosobruchus maculatus* infestation.

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