




TWO STUBBORN STORAGE INSECT PESTS, *Callosobruchus maculatus* AND *Sitophilus zeamais*: BIOLOGY, FOOD SECURITY PROBLEMS AND CONTROL STRATEGIES

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ABSTRACT

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This review work contributes to the biology, food security problems and control strategies of two stubborn storage insect pests, the cowpea bruchid (*Callosobruchus maculatus* Fabricius) and the maize weevil (*Sitophilus zeamais* Motschulsky). The beetles have high destructive capacity and therefore require control tactics that are rapidly effective and at the same time safe for man and his environment. The biology will evoke inspirations to devise efficient control tactics. The *C. maculatus* adult is small and measures 2.5 to 3.5 mm in length, compact, brownish, possesses serrated and un-clubbed antennae, relatively long legs, a pair of distinct and toothed ridges on the ventral side of each hind femur. Whereas, *S. zeamais* adult measures between 3.0 to 3.5 mm long and it is easily identified by its prominent protruded snout or rostrum. Cowpea varieties most common for *C. maculatus* to lay their eggs are black eyed peas, mung beans and adzuki bean and when more than one host is available; the insect chooses its host depending on the variety- size of the bean and texture of the seed coat. It was revealed that under certain storage conditions, *S. zeamais* shows preference to products which are not maize. Application of the efficient control tactics will ensure food security of cowpea seeds and maize grains in storage.

Contribution/Originality: This review work discusses the biology, food security problems and control strategies of two stubborn storage insect pests, the cowpea bruchid and the maize weevil.

1. INTRODUCTION

The introduction of this review work begins with this important question, why contribute to *Callosobruchus maculatus* Fabricius (Coleoptera: Chrysomelidae) and *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae)? The justification is presented as follows. Reports of *C. maculatus* infestations of cowpea seeds and *S. zeamais* infestations of maize grain are on the increase. High multiplication and destructive capacities of the storage insects raise alarm and require attention especially in this period of global food crises. Moreover, the affected stored-products, cowpea (*Vigna unguiculata* L. Walp) seeds and maize (*Zea mays* L.) grains are staples and used industrially in the manufacture of indispensable products [1, 2]. Unequivocally, apart from their roles in food security and poverty alleviation, cowpea and maize possess other high level economic values. Therefore, any contribution that will provide useful information in cowpea and maize protection against these destructive insect species is worthwhile.

2. BIOLOGY OF *Callosobruchus maculatus* FABRICIUS

The morphology, distribution and host range, life history and host preference of *C. maculatus* are discussed here. Good knowledge of the pest's biology is unquestionably important in the development of control strategies for stored product pests [3].

2.1. Morphological Description

The *C. maculatus* adult is characteristically small (measuring 2.5 to 3.5 mm in length), compact, brownish, possessing serrated and un-clubbed antennae, relatively long legs, a pair of distinct and toothed ridges on the ventral side of each hind femur [4]. It lacks the snout of a true weevil and the absence of the snout otherwise called rostrum places this beetle outside the family Curculionidae. Curculionids are the true weevils distinguishable by the presence of a rostrum which *C. maculatus* lacks and so it is wrong to address *C. maculatus* as weevil. The insect is more elongated in shape than other members of the leaf beetle family, Chrysomelidae. The chrysomelid is easily identified by an overall reddish-brown body colouration, with black and gray elytra marked with two central black spots and of course, the last segment of the abdomen (also possessing two black spots) extends out from the short elytra and this is notable. The insect is sexually dimorphic especially in the markings of the elytra and males are easily distinguished from females [4, 5]. Briefly, the dorsal spots are more prominent in the females which are also larger in body size than in the smaller males. In other words, females are darker overall, while males are brown. The plate covering the end of the abdomen is large and dark in colour along the sides in females and smaller without the dark areas in males. According to Raina [6] male and female *C. maculatus* adults are morphologically different. Adults with longer antennae and dull-coloured elytra are identified as male while those possessing shorter antennae and bright-spotted elytra are characterized as female. The egg of *C. maculatus* is clear, shiny and oval to spindle-shaped and about 0.75 mm long. The insect larva is white in colour.

2.2. Distribution and Host Range

Callosobruchus maculatus originated in West Africa and has attained a tropico-politan distribution [4]. It has been rated the most important insect pest of stored cowpea and bambara groundnut in the tropics. It is responsible for substantial weight loss and production of dust in the products it attacks. Infestation of these products commences in the field; however proliferation occurs in storage where conditions are optimum for its development.

2.3. Life History

The life history of *C. maculatus* has been summarized by Ofuya [5] and Lale [4] and presented as follows. The *C. maculatus* adult female oviposits between 70 and 100 eggs singly on the surface of the seed. The optimum temperature and relative humidity for egg-laying and development to adulthood are 30 – 35 °C and 70 – 90 %, respectively. Egg hatches in about 6 days after it has been deposited on the seed surface and each scarabaeiform larva spends its entire life of 20 days (mean value) within a single seed. As the larva feeds and gets nourished, it prepares a chamber covered with a flap of testa/ window prior to pupation. The window is the hole with a thin membrane of testa covering it, excavated by the larva and which serves as an exit for the eventual emergence of the adult *C. maculatus*. Pupation occurs in this chamber and the pupal period is about 7 days. When the diet is suitable and environmental conditions are favourable, it takes adults 3 – 4 weeks after oviposition to emerge.

2.4. Host Preference

The varieties of cowpea which are most common for *C. maculatus* individuals to lay their eggs are black eyed peas, mung beans and adzuki beans [7]. If more than one host is available, the insect will choose its host depending on the variety- size of the bean and texture of the seed coat [8]. It has also been demonstrated that *C. maculatus* will choose host depending on the geographical region it inhabits [9]. The beetles will switch hosts if a new host

becomes available and over time, the insect starts specializing on the new host and will lose preference for the ancestral host [10].

3. FOOD SECURITY PROBLEMS CAUSED BY *C. maculatus*

Several workers have reported that *C. maculatus* causes severe losses in stored host legume seeds in Africa [1, 4, 5]. The huge losses resulting from *C. maculatus* infestation in cowpea during seed storage expose farmers and other consumers to different degrees of food shocks. Activities of *C. maculatus* culminate in seed nutritional and agronomic problems. Part of the consequences is loss of visual appeal and rejection at markets [4]. Infestations have been reported to cause substantial reduction in quality and quantity of affected seeds -within 3 to 5 months of storage for affected cowpea seeds [11]. Preservation of seeds of cowpea and bambara groundnut for planting during the next cropping season is often sabotaged by *C. maculatus* which reduces the viability of seeds through its biological activities. The great seed, food, financial, agronomic losses and economic losses constitute food insecurity problems.

4. CONTROL STRATEGIES OF *C. maculatus*

Use of resistant varieties, botanical powders, hermetic storage, biological control, freezing whole storage area and use of chemical insecticides are options available for the post-harvest control of *C. maculatus* [4, 12-17]. The application of synthetic insecticides is the major means of controlling bruchid infestations in stored legume seeds. This could be in form of fumigation of stored product with phosphine or carbon disulphide and or dusting with carbaryl, pirimiphos methyl or permethrin [11]. Proteinaceous inhibitors or other plant proteins that show insecticidal activities and interfere with the digestive biochemistry of insect pests, such as *C. maculatus* are one of the naturally-occurring defense mechanisms in plants which should be explored to control insect pests [18].

5. BIOLOGY OF *Sitophilus zeamais* MOTSCHULSKY

The biology of the maize weevil insect pest is presented as follows to enable readers have holistic information that will assist in the design of efficient control measures of the pest.

5.1. Morphological Description

The *S. zeamais* adult is characteristically small in size, measuring between 3.0 to 3.5 mm long [19] and about 0.8 mm width. The weevil is easily identified by its prominent protruded snout or rostrum. The rostrum is usually dark brown or reddish brown in colour and it is used for chewing and boring into the grain. The elytra (sclerotized wing) and prothorax are densely pitted with rows of tiny holes which characteristically appear circular. The body appendages (legs and wings) are markedly developed [19-21] and these attributes have giving them the opportunity to be good fliers. The larva of the insect commonly called grub is white in colour, without legs, but with brown head and strong jaws and appears thick [20, 22]. The eggs are white in colour, oval in shape and measure about 0.7 and 0.3 mm in length and width respectively [19, 20]. It is sometimes difficult to distinguish between *S. zeamais* and another closely related species of the genus, such as *Sitophilus oryzae* [23]. Apart from being a better flier, the adult *S. zeamais* is comparatively larger and the patches on its elytra are more conspicuous [21]. The rostrum of the female *S. zeamais* is longer, narrower or slenderer, smoother and shinier when compared with that of the male that is shorter, wider and rougher in appearance [24] indicating sexual dimorphism.

5.2. Distribution and Host Range

Sitophilus zeamais is of global occurrence, infesting most cereals in storage [25]. As a cosmopolitan pest of intact and whole grains [23] the weevil operates in both tropical and temperate environment of the world, probably causing greater problems in the former than in the latter, because in the former, there are optimal conditions of temperature and relative humidity for pest development. It is the predominant storage pest in large warehouses and

local storage conditions. Notably, it is a primary pest of maize grain, but secondarily found attacking a wide range of other crops such as wheat, oats, barley, rye, buckwheat, cowpea, millet, rice, groundnut, guinea corn (sorghum), yam, cassava products, cocoyam and beniseed in the tropics [19, 23].

5.3. Life Cycle

In storage, the adult female *S. zeamais* orally makes tiny hole in the grain, deposits eggs singly in it and protects or seals it with a mucilaginous or waxy substance which it has secreted [23, 26]. The female individual can lay up to 5 eggs in a day, producing up to a total of about 400 eggs during its life span of about 5 months [26, 27]. In about 4 to 9 days after oviposition, the deposited eggs hatch into larvae, the most voracious stage of the weevil. Under suitable environmental conditions (temperature 30 °C and relative humidity 70 %), larval development lasts about 25 days [28]. However, Mattah [29] has stressed that when ambient conditions are unfavourable, the larval stage may over-stretch to 98 days. The larva pupates within the grain and this pupation duration last for about 5 days, being followed by emergence of new progenies through a round hole. Chilio, et al. [22] reported that after emergence of virgin adults, they tend to remain inside the grain for a few days before they push out. It takes *S. zeamais* between 30 to 40 days to develop from egg to adult when laboratory conditions are optimal (temperature 31°C and 14 % grain moisture) while temperature and grain moisture of greater than 32 °C and less than 14 % respectively adversely affect its development, overstretching it to about 110 days [20]. It has been reported that the adult weevil is usually unable to survive when temperature rise above 32 °C [22].

5.4. Host Preference

Research has demonstrated that the maize weevil pest has shown preference to other products other than maize under certain storage conditions. Wheat and polished rice were most preferred to maize, buckwheat and paddy while rice paddy and buckwheat were least preferred [30]. In a different study on Italian diets, superfine and parboiled rice were more preferred than other rice categories and on the contrary, pre-cooked rice and enriched rice were less attractive to *S. zeamais* adults. When eight different types of cereal pasta were compared, namely barley, buckwheat, durum wheat, five cereals (a mixture of durum wheat, barley, spelt, oat and rye), kamut, corn, rice and spelt, results showed that corn pasta was most attractive whereas the five cereals pasta were less preferred to maize weevil adults [31].

6. FOOD SECURITY PROBLEMS CAUSED BY *S. zeamais*

Sitophilus zeamais adult appears on maize in the field immediately it reaches the roasting ear stage. However, egg laying and infestation do not begin until the grain ear becomes firm. In the store, the weevil continues to proliferate and causes damage to the grains. Both the adult and larva are internal feeders and the whole developmental activities of the insect lead to severe tunneling, powdering and tainting of the grains with their waste [23, 32, 33]. Increase in temperature and moisture caused by weevil appearance on the maize grain results in increase in respiration and these lead to loss in quantity and quality of the grain. Thus, the stored grain is exposed to secondary attack by pathogens such as the mycotoxin-producing fungi [32]. Caking and mould infestation (with characteristic foul odor), make the grain undesirable for consumption [32] and invariably reduce the market value [23]. Damaged grains are not adequately viable and successful planting by farmers is impaired, nutritional value of the staple food is reduced; perforations and weight loss also affect market value adversely [34]. In unprotected stored maize, *S. zeamais* causes 20 to 90 % loss [35] and this suggests serious food security problems and vehemently challenges the realization of global food security because damage and loss caused by this obnoxious species is irreversible.

7. CONTROL STRATEGIES OF *S. zeamais*

In order to meet the demand for maize, it is necessary to tackle the problem of maize grain loss due to *S. zeamais* activity and when successful, economic growth will be greatly stimulated [36]. Reportedly, control strategies against the maize weevil include the use of conventional synthetic insecticides, resistant varieties, botanical insecticides, animal-derived insecticides, hermetic storage, biological control, cultural measures, controlled atmosphere and inert dusts [23]. The most effective and commonly used of these control measures is synthetic insecticides [37]. The chemicals are either used as dust or as fumigants. However, chemical insecticides have bad effects on consumers and the environment [38]. Their use have led to health and ecological hazards, resistance, insect resurgence and deleterious impact on non-target organisms Development of resistance to chemical applications by the weevil is one major limitation to sustainable use of conventional synthetic insecticides.

8. CONCLUDING REMARKS

This review work contributes to the biology, food security problems and control tactics of *C. maculatus* and *S. zeamais*. These storage insects are primarily still too destructive and therefore, attention of the International Community should be drawn to it through scientific contributions like this. Much as effective control tactics remain operational, efforts should be continued towards augmenting on their efficacy and environmental friendliness through further scientific studies. The information presented here will evoke inspirations to devise efficient control tactics against the cowpea bruchid and maize weevil pest. Integrated insect pest management is highly viable and should be applied because it provides the farmer with economic benefits.

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