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Damage caused by *Rhyzopertha dominica* (Fabricius, 1792) (Coleoptera: Bostrichidae) in stored Brazil nuts

E. M. Pires, R. M. Nogueira

Federal University of Mato Grosso - Campus Sinop

Author for correspondence: evaldo.pires@gmail.com

Abstract. *Rhyzopertha dominica* is an insect that attacks several grains and seeds and is considered the main pest found in stored products in Brazil. This insect is classified as an internal primary pest being a borer. It develops effectively in the grain mass due to its adaptability and high biotic potential. The objectives of this study were to verify if *R. dominica* adults and larvae feed on Brazil nuts, and also to characterize the damage caused by this Coleoptera. The injuries inflicted by this insect appear as scratched surfaces, which evolve into deep holes, in almonds. As it has the ability to cause considerable damage with consequent losses in the market value of the product, this beetle can be included among the many pests of this product, and even be considered an internal primary pest of the stored *Bertholletia excelsa*.
Keywords: Borer; new pest; internal primary pest; type of lesion.

Introduction

The Brazil nut is a fruit of *Bertholletia excelsa* HBK, a native tree from the Amazon rainforest, which includes the following countries: Bolivia, Ecuador, French and British Guianas, Peru and Brazil (Loureiro & Silva, 1968; Loureiro *et al.*, 1979; Souza *et al.*, 2008). Its kernels (seeds) are protected by a woody shell with a triangular shape, encapsulated by a domed carapace, known as the "hedgehog", which consists of a thick, very resistant, woody material, that protects the seeds from the weather and physical or chemical damage (Scussel *et al.*, 2014).

In 2014, Brazil was responsible for the production of 37.5 tons of nuts (Instituto Brasileiro de Geografia e Estatística, 2014). All the steps in the production chain are economically and socially significant, as extractivism fosters the attachment and income of thousands of families to the processing and commercialization steps that generate several sources of employment, and simultaneously ensure conservation of the species (Maciel & Reydon, 2008).

Demand from national and international markets for a high quality Brazil nut is increasing the level of quality control along the production chain. A number of researchers are currently seeking to develop new extraction, handling, and storage technologies.

As efforts are being made to promote quick removal of the product from the forest, storage facilities are being built for adequate storage until it is processed. Among the issues involved in the storage of agricultural products, the main one is pests in stored grains, which are responsible for huge losses in rice, corn, sorgum and the like (Alencar *et al.*, 2011; Alves *et al.*, 2008; Caneppele *et al.*, 2003; Elias *et al.*, 2009; Faroni & Silva, 2008; Martins *et al.*, 1985; Silva *et al.*, 2003; Santos *et al.*, 2002).A few species have been found to attack stored Brazil nuts. Amongst these, *Plodia interpunctella* larvae (Lepidoptera: Pyralidae) were observed damaging this product, causing galleries in almonds (Gomes et al, 2015). Another report described the occurrence of Curculionidae larvae in chestnuts, damaging the bast and leading to the appearance of grooves in the mesocarp (Castrillón & Purchio, 1988). However, this investigation does not specify the type(s) of species found, nor describe if the attack occurs in the almond, since the mesocarp of the Brazil nut constitutes part of the chestnut and not the nut. "Broca-do-café" beetle, *Hypothenemus hampei* (Ferrari, 1867) (Coleoptera: Scolytidae) was reported attacking the almond of *Bertholletia excelsa* (Gumier-Costa, 2009). There are also reports of the

association of *Tribolium confusum* Jaquelin Du Val, 1868 and *Tribolium ferrugineum* (Fabricius, 1781) in Brazil nut warehouses, (in this work referred to as Pará nut), but without characterizing or describing the attack or possible damage (Bondar, 1942). Sefer (1961) reports in the Technical Bulletin of the North Agronomic Institute that *T. castaneum* attacks Pará nut, however, there were no reports characterizing the damage. The report mentions only that the species can be considered somewhat harmful to this Amazon product. Other authors report an association with the insect as potentially causing damage to the Brazil nut, however there is no identification of the species (Scussel et al., 2014).

Among the insects, the beetle *R. dominica* (Fabricius, 1792) (Coleoptera: Bostrichidae), is considered the main pest of stored grains, worldwide (Faroni & García-Mari, 1992; Edde, 2012).

Problems related to the occurrence of *R. dominica* have been associated mainly with tropical and subtropical regions, although it may develop in temperate zones during warm seasons, when ideal conditions for its development prevail, such as, a temperature of 30 ± 2°C and relative humidity of 70% (Athiê & De Paula, 2002; Edde, 2012).

Adults have a cylindrical body, with a color varying from nut-brown to brown, measuring about 2.0 to 4.0 mm in length (Gallo *et al.*, 2002; Edde, 2012). The head is considered large, however, it is difficult to see when viewed dorsally (Athiê & De Paula, 2002; Gallo *et al.*, 2002). It has antennae with 10 antennomeres, the last three forming a clavus; the pronotum is anteriorly rounded with a protuberance similar to a tooth in the anterior part and resembling a flattened tubercle in the central and posterior parts. The scutellum is quadrangular and the elytrum strongly convex apically (Athiê & De Paula, 2002; Edde, 2012).

Rhyzopertha dominica belongs to the family of Poaceae. It is a pest found in grains (for example: rice, wheat, oat, millet, barley and corn), Leguminosae (for example: chickpea, peanut and bean) and other products (pharmaceuticals, leather, woody materials, paper, books and cork), which can be contaminated by its presence (Athiê & De Paula, 2002; Edde, 2012). It causes huge losses in grains and seeds, as it has the capacity to damage intact and healthy grains (Athiê & De Paula, 2002).

Thus, in this study the objective is to verify if *R. dominica* feeds on Brazil nuts and characterize the damage caused by this Coleoptera in this product from the Amazon.

Material and methods

This study was undertaken in the Laboratory of Energy and Pests of Stored Grains (LEPGA) in the Federal University of Mato Grosso, Campus of Sinop.

Intact unshelled almonds (almonds with a fully brown skin) of the Brazil nut (*Bertholletia excels*) were offered to *R. dominica* adults and larvae, to identify and characterize the damage caused by this insect.

Ten adults were put in contact with one intact Brazil nut almond inside a covered plastic pot with a volume of 250 mL (9.5 cm in diameter and 7.5 cm in height) and, the same procedure was used for the larvae of this Coleoptera.

For adults, the occurrence and type of damage caused to the Brazil nut was evaluated over a 24-hour period, with the nuts being checked after seven and thirty days of infestation to characterize and describe the type of damage caused by this beetle.

For the larvae, the occurrence of damage was evaluated after 24 hours of infection and five, 10 and 15 days after contact.

Almonds exposed to attack by *R. dominica* adults and larvae were evaluated using a stereoscopic microscope, to enable the characterization and description of the damage caused by this insect.

Results

In the tests conducted, using unshelled Brazil nuts, it was confirmed that *R. dominica* adults feed on Brazil nut, qualifying this beetle as a pest capable of generating losses in this product, under storage conditions. The damage caused in intact Brazil nut by *R. dominica* classifies it as a primary pest for this product from the Amazon. After 24 hours of infestation of the intact unshelled Brazil nut by the *R. dominica* adults, damage such as superficial scrapes were observed in some parts of the almonds (Figure 1 A and B).

Figure 1. (A and B) Damage caused by adult *Rhyzopertha dominica* (Fabricius, 1792) (Coleoptera: Bostrichidae) in intact Brazil nuts after 24-hours of infestation.

In the almonds exposed to attacks for seven days, these insects were observed excavating the brazil nut surface, and a considerable quantity of brown pellets or particles was detached near the place where the insects were observed (Figure 2A).

After 30 days of infestation, few insects were visible on the surface of Brazil nut. After removing particles with a brush, the specimens were observed digging or already inside the nut mass (Figure 2 B). Several deep holes were observed over the entire surface of the almond (Figure 2 C).

No lesions on the surface of the almond caused by the larvae were observed after 24 hours of contact (Figure 3 A). On the fifth day of exposure, the onset of lesions can be noted through superficial scrapes (Figure 3 B). On the tenth day there was a greater amount of residue and the larvae initiate penetration into oval cavities constructed as a result of feeding (Figure 3 C). On the fifteenth day, the damage increased and there was a larger quantity of granules or particles of loose chestnut near the place where the larvae entered the almond (Figure 3 D). On the sixteenth day the pupal stage was initiated and it was observed in the pupal chamber.

Figure 2. (A) *Rhyzopertha dominica* adults (Fabricius, 1792) (Coleoptera: Bostrichidae) excavating the surface of the Brazil nut after seven-days of infestation. (B) Insects drilling into the Brazil nut and (C) detail of hole in a Brazil nut 30-days after infestation.

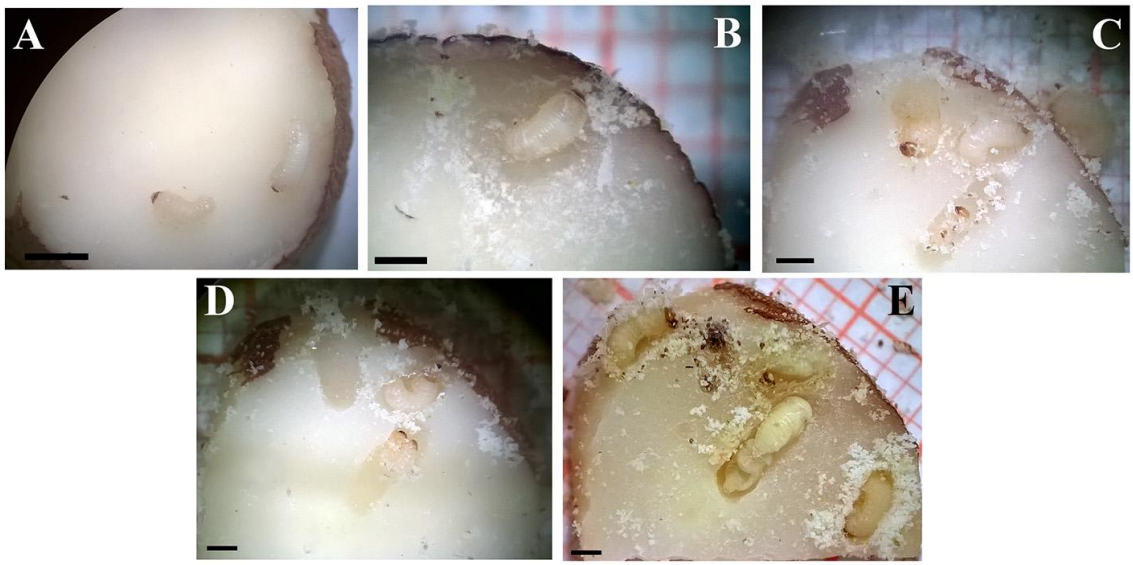

Figure 3. Damage caused by *Rhyzoperta dominica* larvae (Coleoptera: Bostrichidae) on the almond surface of the brazil nuts with: (A) 24 hours after contact. (B) On the fifth day after contact. (C) On the tenth day after contact. (D) On the fifteenth day after contact. (E) Detail of the pupae in the pupal chamber observed on the sixteenth day after contact.

Discussion

The capacity of the beetle *Rhyzopertha dominica* to feed on Brazil nut shows that this product may figure in the list of stored products that deserve special care, with regard to the attack on this pest in storage facilities. Thus, in-depth studies must be carried out to promote more effective techniques to handle and safely store this product from the Amazon, as well as to develop specific managment strategies to conduct an integrated management program for pests that attack stored products, for example, Brazil nut.

R. dominica adults and larvae can be classified as an internal primary pest for Brazil nut that presents the characteristics of a borer, responsible for causing damage to almonds. Initially

they cause superficial scrapes, with consequent holes and galleries that shelter the insects. In accordance with the behavior of this insect, it can drill holes in other grains and seeds, such as, corn, rice, wheat or other cereals containing starch (Edde, 2012).

The holes observed on the surface of the almonds are lightly rounded, measuring approximately 1 mm in diameter, which is in line with the characterization of the damage caused in other products (Breese, 1960).

Considering the quantitative and qualitative parameters and the type of damage caused by *R. dominica* in Brazil nut, this insect can be classified as a pest for this product, capable of promoting losses. With regard to the first parameter, the evident loss in the dry mass by insect feeding concurs with the problems associated with other grains exposed to attack by pests in storage facilities (Ventrakao *et al.*, 1958, Caneppelo *et al.*, 2003). In the second instance, the damage affects seed germination, depreciation in the rate of the almond, and causes nutritional losses. These are the main characteristics of the pest attack in stored products.

Thus, it can be concluded, from this study that *R. dominica* should be included in the list of pests that attack and have significant potential to inflict huge losses on stored Brazil nut, and may even be considered as internal primary pests of this product. The damage observed began as shallow scrapings, which can develop into holes and consequently galleries in the almonds of Brazil nut.

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