Biological and Reproductive Parameters of Tribolium castaneum in Brazil Nut

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Biological and reproductive parameters of *Tribolium castaneum* in Brazil nut

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**Abstract**

Brazil nut is used widely in the food industry because the nutritional content of this commodity contains a variety of lipids, proteins, and essential minerals, as well as vitamin A which is used in the cosmetic industry. Agricultural products such as grains, seeds, and nuts often are adversely affected by numerous organisms, including *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae), that cause significant losses during storage. Therefore, the objective of the present study was to investigate the biological and reproductive parameters of *T. castaneum* on Brazil nut. Pre-oviposition, egg incubation, and oviposition lasted an average of 7.4, 4.2, and 28.4 d, respectively, with 79.4% egg viability. Oviposition began on the seventh d after mating and the last occurrence of laying was on the 46th d. An average of 1.2 eggs per d per female was produced during the first 20 d. The mean number of eggs per female produced during a lifetime was 28.9. The larval stage exhibited 8 instars during a period of about 86 d. The pupal stage averaged 6.5 d and the adult stage 40.8 d. Survival rate was 44.7% on d 40 and 22.7% on d 60 after adult emergence.

**Key Words:** red flour beetle; *Bertholletia excelsa*; food substrate; survival; stored product pests

Brazil nuts are produced by the Brazil nut tree (*Bertholletia excelsa* HBK) (Lecythidaceae) and are native to the Amazon rainforest, which includes the countries Bolivia, Ecuador, French Guiana, English Guiana, Peru, and Brazil (Loureiro & Silva 1968; Loureiro et al. 1979; Souza et al. 2008). The nuts (seeds) are protected inside by a triangular-shaped woody bark encapsulated by a bulging carapace called “ouriço” (the popular name for the fruit of Brazil nut tree). An outer covering is composed of a woody, thick, resistant material that protects the seeds from harsh climates, as well as physical and chemical damage (Scussel et al. 2014).

Brazil produced 37,664 tons of Brazil nuts in 2016 (Instituto Brasileiro de Geografia e Estatística 2017). Brazil nut production benefits the income of thousands of families that harvest the commodity. Postharvest processing of Brazil nuts is of considerable additional economic importance by providing employment along the production chain (Maciel & Reydon 2008).

The most significant efforts in Brazil nut research focus on the nutritional values of this product on human health (González & Salas-Salvadó 2006; Berno et al. 2010; Colpo et al. 2013). In Brazil, there are few species of insect pests that are reported attacking Brazil nut, including coffee berry borer, *Hypothenemus hampei* (Ferrari) (Coleoptera: Curculionidae) (Gumier-Costa 2009), and *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae). *Tribolium castaneum* is popularly known as the “red flour beetle” and is considered a cosmopolitan insect found mainly in the tropics (Rees 1996; Faroni & Sousa 2006). It is classified as a secondary pest because adults and immature stages feed on grains previously cracked, broken, or damaged by primary pests. However, White (1982) reported the insect’s ability to survive in undamaged grains. Because this stored product pest has been reported previously to infest stored Brazil nuts (Pires et al. 2017) we investigated the biological and reproductive capacity of *T. castaneum* to develop in Brazil nuts.

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Material and Methods

Tribolium castaneum used in this study were obtained from a laboratory colony maintained on Brazil nuts for 2 yr in an acclimatized Biochemical Oxygen Demand chamber (Caltech EI-08F1-F, Caltech Ltda. Indústria e Comércio de Equipamentos de Laboratório, Recife, Pernambuco, Brazil) at 30 ± 2 °C and RH of 60 ± 10% situated in the Laboratory of Pests and Vectors of Amazon/Cerrado of the Universidade Federal de Mato Grosso - Campus de Sinop. Periodically, beetles were added to the colony from field collected material because this species has exhibited high mortality when reared on Brazil nuts.

Initially, 150 pupae were obtained from the colony and maintained until adult emergence in 6 × 1.5 cm Petri dishes lined with sheets of 75 g white paper at the bottom. One d after emergence, mating pairs were placed in similar Petri dishes for a total of 25 replications. Half Brazil nuts (cut with a surgical scalpel) were provided to each pair as a food substrate. Brazil nut meal was not provided to adult beetles because in preliminary tests individuals exhibited difficulty in moving about the dish. This was due to the high oil content of the nut meal that accumulated on the surface of the Petri dish from nut debris. This problem was similar to that for T. castaneum in maize meal (Li & Arbogast 1991). On the other hand, T. castaneum is classified as a primary pest for Brazil nuts, experiencing no difficulties when feeding on the intact product (Pires et al. 2017).

Duration of pre- and oviposition periods as well as daily and cumulative T. castaneum egg deposition per female were recorded. Eggs were collected daily with a soft bristle brush from nuts while those deposited on the sulphite papers were placed separately in another set of Petri dishes of the same dimensions as mentioned earlier. Egg hatch was monitored daily. Larvae were fed Brazil nuts. Duration and number of instars were determined by the presence of exuvium that characterizes an instar change. Daily and cumulative survivorship of T. castaneum adults fed Brazil nuts were determined using an additional aliquot of 150 pupae from the Laboratory of Pests and Vectors of Amazon/Cerrado colony and handled similarly as previously mentioned in Petri dishes. In preliminary tests, we found no difference between males and females daily or cumulative survivorship when fed Brazil nuts. Therefore, the sexes were not separated when recording those biological parameters. A regression analysis was performed on mean oviposition data (Ne) and percent adult survival (PS) over time fitted with a quadratic model, $P < 0.05$. All the statistical procedures were performed using Action Stat Pro software (Estatcamp & Digup 2017).

Results

Tribolium castaneum pre-oviposition, egg incubation, and oviposition periods were 7.4 ± 1.7, 4.2 ± 0.4, and 28.4 ± 7.2 d (± SD), respectively (Table 1), and egg viability was 79.4%. Oviposition began on the seventh d after males and females were placed together, and continued until 46 d after mating. Overall, females produced about 29 eggs per individual lifetime.

Generally, we found that egg production declined over time at a decreasing rate ($Ne = 0.0015t^2−0.1233t+2.7824$; $R^2 = 0.8586$) [Fig. 1]. The first four d of egg deposition averaged 1.9 per d while during d 5 to 12, the average was 1.3 eggs per d. After d 13, egg production declined to < 1 egg per d [Fig. 1]. Peak oviposition was reached on d 4 with an average of 2.2 eggs deposited.

Overall duration of the larval stage averaged 85.9 ± 18.8 d, with 8 instars identified (Table 1). The pupal stage averaged 6.5 ± 0.5 d, whereas adult survivorship averaged 40.8 ± 28.5 d. The first occurrence of death was recorded on the second d after emergence and the last was recorded at 129 d [Fig. 2]. Generally, we found that adult T. castaneum survivorship declined over time ($PS = 0.0077t^2−1.7791t+103.25$), with a coefficient of determination ($R^2 = 0.9986$) [Fig. 2]. Approximately 45% of the population was alive at 40 d, then gradually declined to about 23% at 60 d.

Discussion

We found that the length of the pre-oviposition period in T. castaneum was in agreement with other studies, where T. castaneum females usually initiated oviposition about one wk after mating, and that the period from copulation to oviposition was, on average, four d (Good 1936). Also, the incubation period of T. castaneum eggs was similar to that found by Good (1936), Abdelsamad et al. (1988), and Devi and Devi (2015). However, the oviposition period of our beetles, and the number of eggs produced per female fed Brazil nuts, was considerably reduced compared with the same species reared on other diets (at the same temperature) where oviposition continued from 5 to 6 mo (Good 1936; Li & Arbogast 1991). In our study, mean egg viability was considerable lower (79%) than that reported for red flour beetles reared on flour, where egg hatch approached 90% (Good 1936). These results suggest that Brazil nut, when used as a food source for T. castaneum, may adversely affect the fertility and
biotic potential of this insect. This study was conducted under the optimum rearing conditions for *T. castaneum*, previously reported by others to be 30 °C (Good 1936; Howe 1956; Halliday & Blouin-Demers 2014; Halliday et al. 2015).

We also found that Brazil nut, as a food source, delayed larval developmental time in *T. castaneum*. Indeed, other workers have found similar results with whole wheat, corn flour, and bran and wheat flakes (Good 1936; Halliday & Blouin-Demers 2014; Devi & Devi 2015). We identified 8 instars in our rearing studies, which is within the range reported for this species (instar range 5–11 with 7–8 most common) (Good 1936; Devi & Devi 2015). Pupal stage duration was similar to previous reports for this species with other food sources at the same temperature range. Apparently, Brazil nuts provide the necessary nutritional requirements for successful pupation of *T. castaneum* (William 2000; Devi & Devi 2015).

However, survival of adult *T. castaneum* fed Brazil nut was lower than that observed in another study, in which males lived on average 547 d and females 226 d (Good 1936). The survival of adults on Brazil nuts, in our study, can be considered low given >50% of adults died within 40 d after emergence and 75% within 60 d. Only 1 individual lived to 129 d. One might suggest that *T. castaneum* adults do not feed on Brazil nuts, but this hypothesis can be discarded because Good (1936) previously reported that this beetle can survive only 18 d with no food at a temperature of 30 °C. In summary, we found that the biological and reproductive parameters of *T. castaneum* were adversely affected when reared on Brazil nuts, reflected by production of fewer eggs, a considerable increase in larval stage, and short survivorship of adults compared with the results of other workers when reared on other food sources but under the same environmental conditions. This information suggests that even though *T. castaneum* may be considered a potentially important pest of stored Brazil nuts, it does not thrive on this commodity as a food substrate.

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**Reference Cited**

Abdelsamad RM, Elhay EA, Eltayeb YM. 1988. Studies on the phenology of *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae) in the Sudan Gezira. Journal of Stored Products Research 24: 101–105.

Berno LJ, Poeta PT, Júnior MRM. 2010. Effects of selenium derived Pie Brazil-nut on the concentration of reduced glutathione (GSH) in Wistar rats. Feeding and Nutrition 21: 231–239.

Colpo E, Dalton C, Vilanova DA, Gustavo L, Reetz B, Maria M, Frescura M, Luiza J, Farias G, Muller EJ, Lima A, Muller H, Marlon E, Flores M, Wagner R, Battista J. 2013. A single consumption of high amounts of the Brazil nuts improves lipid profile of healthy volunteers. Journal of Nutrition and Metabolism. DOI: 10.1155/2013/653185.

Devi MB, Devi NV. 2015. Biology of rust-red flour beetle, *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae). Biological Forum - An International Journal 7: 12–15.

Faroni LR, Sousa AH. 2006. Aspectos biológicos e taxonômicos dos principais insetos-praga de produtos armazenados, pp. 371–402. In Almeida FAC, Duarte MEM, Mata MERM [eds.], Tecnologia de Armazenagem em sementes. Campina Grande, Paraíba, Brazil.

González CA, Salas-Salvadó J. 2006. The potential of nuts in the prevention of cancer. British Journal of Nutrition 96: S87–S94.

Good NE. 1936. The flour beetles of the genus *Tribolium*. USDA Technical Bulletin 498. Washington, D.C., USA.

Gurnier-Costa F. 2009. First record of the coffee berry borer, *Hypophemus hampeyi* (Ferrari) (Coleoptera: Scolytidae), in Pará nut, *Bertholletia excelsa* (Lecythidaceae). Neotropical Entomology 38: 430–431.

Halliday WD, Blouin-Demers G. 2014. Red flour beetles balance thermoregulation and food acquisition via density-dependent habitat selection. Journal of Zoology 294: 198–205.

Halliday WD, Thomas AS, Blouin-Demers G. 2015. High temperature intensifies negative density dependence of fitness in red flour beetles. Ecology and Evolution 5: 1061–1067.

Howe RW. 1956. The effects of temperature and humidity on the oviposition rate of *Tribolium castaneum* (Hbst.) (Coleoptera, Tenebrionidae). Bulletin of Entomological Research 53: 301–310.

**Instituto Brasileiro de Geografia e Estatística. 2017. Pes 2016: produção da silvicultura e da extração vegetal. 2017. https://agenciadenoticas.ibge.gov.br/agencia-noticias/2013-agencia-de-noticias/releases/16981-pes-2016-producao-da-silvicultura-e-da-extracao-vegetal-alcancara-r-18-5-bilhoes.html (last accessed 6 Feb 2018).**

Li L, Arbogast RT. 1991. The effect of grain breakage on fecundity, development, survival, and population increase in maize of *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae). Journal of Stored Products Research 27: 87–94.

Loureiro AA, Silva MF. 1968. Catálogo de madeiras da Amazônia. 2nd edition. SUDAM, Belém, Pará, Brazil.

Loureiro AA, Silva MF, Alencar JC. 1979. Essências madeireiras da Amazônia. 2nd edition. INPA, Manaus, Amazonas, Brazil.

Maciel RCG, Reynold BP. 2008. Produção de castanha-do-brasil certificada na Resex Chico Mendes: impactos e avaliações, pp. 1–21 In XVI Congresso Brasileiro da Sociedade de Economia, Administração e Sociologia Rural. Campinas, São Paulo, Brazil.

Pires EM, Souza EQ, Nogueira RM, Soares MA, Dias TKR, Oliveira MA. 2017. Damage caused by *Tribolium castaneum* (Coleoptera: Tenebrionidae) in stored Brazil nut. Scientific Electronic Archives 10: 1–5.

Rees BP. 1996. Coleoptera, pp. 1–39 In Subramanyam B, Hagstrom DW [eds.]. Integrated management of insects in stored products. Marcel Dekker, New York, USA.

Scussel VM, Manfio D, Savi GD, Moecke EHS. 2014. Stereoscopic and scanning electron microscopy of Brazil nut (Bertholletia excelsa H.B.K.) shell, brown skin, and edible part: part one — healthy nut. Journal of Food Science 79: 1443–1453.

Souza CR, Azevedo CP, Rossi LMB, Lima RMB. 2008. Castanha-do-brasil (*Bertholletia excelsa* Humb. & Bonpl). 1st edition. Embrapa Amazônia Ocidental. EMPRAPA, Manaus, Amazonas, Brazil.

White GG. 1982. The effect of grain damage on development in wheat of *Tribolium castaneum* (Herbst) (Cole., Tenebr.). Journal of Stored Products Research 18: 115–119.

William FL. 2000. Confused and red flour beetles. Ohio State University Extension Fact Sheet Entomology, HYG-2087-97. http://www.pestcontrolsydney.com.au/insects/Confused and Red Flour Beetles, HYG-2087-97.htm (last accessed 16 Mar 2018).