REVISTA BRASILEIRA DE FRUTICULTURA
Published by the Brazilian Society of Fruit Crops
ISSN 0100-2945

Plant Protection

Revision - Edited by: Everaldo Antonio Lopes

Dynamics of borer infestation in atemoya fruit in two production periods

Adriana Barbosa do Nascimento[1]*, Marlon Cristian Toledo Pereira[1], Patrícia Cristina do Carmo Oliveira[1], Teresinha Augusta Giustolin[1], Clarice Diniz Alvarenga[1]

[1] State University of Montes Claros, Janaúba, Minas Gerais, Brazil.
* Corresponding author: *adriana7nascimento@gmail.com*

Abstract: *Cerconota anonella* (fruit borer) and *Bephratelloides pomorum* (seed borer) are the main pests of Annonaceae and knowing their population dynamics is essential to establish their management in orchards of these crops. The objective of this study was to evaluate the influence of native vegetation on the population of fruit and seed borers in two production seasons in an atemoya orchard in the semiarid region. The study was carried out in a commercial atemoya orchard in Janaúba, MG. The experimental area was divided into two parcels and, in each of them, the distance from the experimental plots to the surrounding vegetation, of approximately 10m, 33m, 57m and 81m, was recorded. The sampling of insects was carried out at different periods, spring and summer, through the collection, every two weeks, of atemoya fruits containing attack signs by the borers. The intensity of infestation of each borer species was determined. The intensity of borer infestation varies between seasons, with fruit borer infestation in summer and seed borer infestation in spring. The distance from the orchard to the adjacent vegetation does not interfere with the infestation intensity of fruit and seed borers.

Index terms: *Annona squamosa* x *Annona cherimola*, edaphoclimatic conditions, *Bephratelloides pomorum*, *Cerconota anonella*, pest management.

Revista Brasileira de Fruticultura, v.45, e-021. DOI: *https://dx.doi.org/10.1590/0100-29452023021*
Received 15 Mar, 2022 • Accepted 07 Nov, 2022 • Published Jan/Feb, 2023.

Dinâmica da infestação de brocas em frutos de atemoieira em duas épocas de produção

Resumo: *Cerconota anonella* (broca-do-fruto) e *Bephratelloides pomorum* (broca-da-semente) são as principais pragas das anonáceas, e conhecer sua dinâmica populacional é essencial para se estabelecer seu manejo nos pomares dessas culturas. Objetivou-se avaliar a influência da vegetação nativa de entorno sobre a população das brocas-dos-frutos e das sementes em duas épocas de produção, em pomar de atemoieira no Semiárido. O trabalho foi realizado em pomar comercial de atemoieira em Janaúba-MG. A área experimental foi dividida em dois talhões e, em cada um deles, registrada a distância das parcelas experimentais até a vegetação de entorno, que foram de aproximadamente 10 m, 33 m, 57 m e 81 m de distância. As amostragens dos insetos foram realizadas em épocas distintas, primavera e verão, por meio da coleta, quinzenalmente, de frutos de atemoieira contendo sinais de ataque das brocas. Foi determinada a intensidade de infestação de cada espécie de broca. A intensidade de infestação das brocas variou entre as estações do ano, sendo maior a infestação da broca-do-fruto no verão e da broca-da-semente na primavera. A distância do pomar até à mata adjacente não interferiu na intensidade de infestação das brocas-dos-frutos e das sementes.

Termos para indexação: *Annona squamosa x Annona cherimola*, condições edafoclimáticas, *Bephratelloides pomorum*, *Cerconota anonella,* manejo de pragas.

Introduction

Atemoya tree is a hybrid of the cross between cherimoya and custard apple. It has great commercial acceptance for producing fruits of excellent flavor, texture, and important nutritional properties. In semi-arid regions, the cultivation of annonaceae, especially custard apple and atemoya, has achieved high productivity, especially because they are produced in different periods of the year. Thus, obtaining up to two annual harvests under irrigated conditions in the same plants (PEREIRA et al., 2011). Despite the edaphoclimatic conditions favorable to the cultivation of these annonaceaes, there are some phytosanitary problems, especially those related to pest insects, which have been causing losses to producers and discouraging the establishment of commercial planting. The main annonaceae pests are the fruit borer, *Cerconota anonella* (Sepp.) (Lepidoptera: Oecophoridae), and the seed borer, *Bephratelloides pomorum* (Fabr.) (Hymenoptera: Eurytomyidae) (BRAGA SOBRINHO et al., 2021).

The fruit borer has limited the cultivation of annonaceae throughout the tropical region due to the expressive damage caused in the fruit, which has reduced the production of these crops. Females perform the postures randomly on the fruit peel at different stages of development, although they prefer the greener. Newly hatched caterpillars penetrate the fruit and feed on the pulp forming galleries. Its attack favors the entry of pathogens and other insects, which leaves the fruits unfit for marketing (GALLO, 2002).

The seed borer also causes fruit damage and reduces production. Adult wasp lays its eggs in the young fruits and the larva, after hatching, feeds and destroys the endosperm. When emerging, the adult builds a gallery to the surface of the fruit. The orifice that the emerging adult leaves allows the entry of microorganisms that cause the necrosis of this region and depreciates the commercial value of the fruit, besides causing the fall of these when still young (BRAGA SOBRINHO et al., 1999).

Chemical control, especially in a preventive way, is still the most used method for the borer control, because it is the least costly, despite causing damage to the environment and to human health. Currently, due to the changes observed in the profile of fresh fruit consumers regarding the concern with the environment and the demands for food free from pesticide residues, researchers have proposed alternative methods. A strategy that adapts to this consumers paradigm change is biological control. The use of this method can optimize and even increase the efficiency of pest control (VENZON et al., 2005).

Agro-ecosystems are subject to various types of management, so that the crop arrangements and spontaneous vegetation change continuously in time and space (ALTIERI et al., 2003; CHAY-HERNANDEZ et al., 2006). Demite and Feres (2005) found that agro-ecosystems biodiversity is very important to stabilize the population dynamics of pest insects and their natural enemies. The authors verified this fact in a rubber plantation located in São José do Rio Preto, SP, where they observed that the mite fauna present in the rubber plantation was influenced by the surrounding vegetation. The authors' suggestion was to include the surrounding areas in the rubber plantation pest management programs.

Thus, it can be inferred that areas of surrounding vegetation provide favorable conditions for the survival and refuge of natural enemies and pests. Given the above, it is believed that the native vegetation adjacent to the orchard positively influences the population of insects present in the atemoya orchard, since the pest insects would have more difficulty finding and colonizing host plants in diverse systems.

In this sense, the objective was to evaluate the influence of the surrounding vegetation on the infestation of the fruit borer and the seed borer in atemoya orchard in two production periods in the semiarid region.

Material and Methods

The study was conducted in a commercial orchard located in the municipality of Janaúba, North region of Minas Gerais (15.00° 52.00' 5.02" - S and 43.00° 19.00' 46.51" - O), with cultivation of 6 ha of atemoya 'Gefner' and 0.4 ha of custard apple. The orchard is mainly surrounded by a large extension of native forest in the North, East and West directions, and by a pasture area in the South direction (Figure 1).

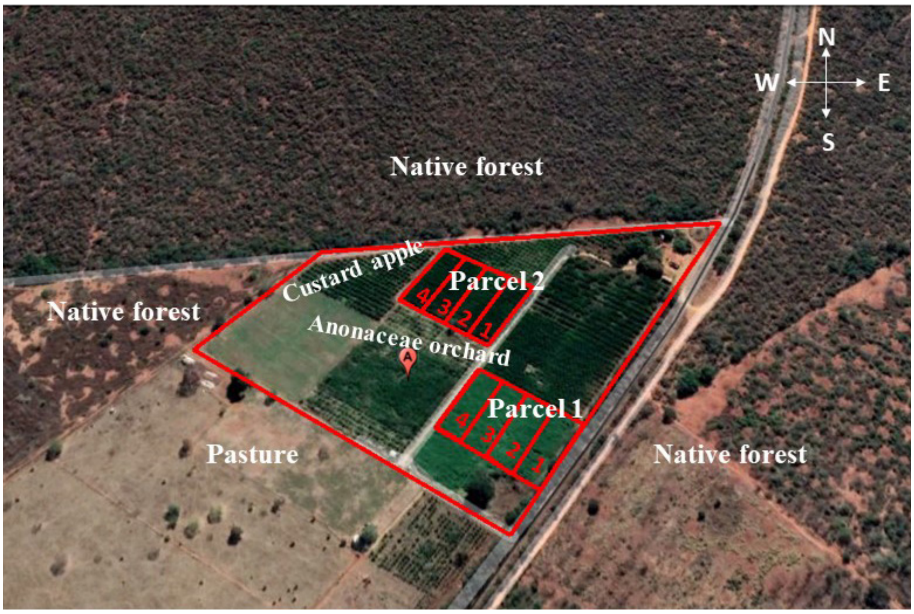

Figure 1 - Sketch of the commercial Annonaceae orchard and the representation of the experimental area with the plot location within parcel 1 and parcel 2. Janaúba, MG.

The management adopted in the orchard occurred in a traditional way, with the use of pesticides, micro-sprinkler irrigation, and regular pruning for fruiting. Weekly insecticides applications (thiamethoxam and lambda cyhalothrin) were performed for borers' control (*C. anonella* and *B. pomorum*) in the orchard. The study region is characterized as semi-arid with type Aw climate, according to the Kõpper classification, with dry winter and rainy summer. The region native vegetation comprises a deciduous forest, called Dry Forest (SANTOS; VIEIRA, 2006).

Because it is an atemoya orchard, managed with pruning to schedule the harvest, the area was divided into two parcels and the samplings performed in different periods. During the samplings were carried out the climatic data collections obtained at the automatic meteorological station in Nova Porteirinha, MG, installed at the Empresa de Pesquisa Agropecuária de Minas Gerais/ Epamig (15.00° 80.00' 18.90" - S and 43.00° 29.00' 79.70" - O), located about 10 km from the orchard.

In parcel 1 (15.00° 52.00' 07.30" - S and 43.00° 19.00' 43.64" - O), the collections started on August 13 and finished on November 12, 2019. This period was mainly understood by the spring, which in the region was characterized by being a dry season, with cumulative precipitation recorded during the collections of 71.2 mm, average temperatures of 29 °C, maximum of 35 °C and minimum of 19 °C and relative air humidity with an average of 46% (INMET, 2020). Parcel 1 was surrounded on three sides, North, East and South directions, by atemoya plants, and in the West direction by a native dry forest, distant about 10 m from parcel 1 (Figure 1).

In parcel 2 (15.00° 52.00' 3.52" - S and 43.00° 19.00' 43.76" - O), the collections started on November 26, 2019 and finished on February 18, 2020. This period was mainly understood by the summer season, when the rainfall in the region were more concentrated, with cumulative precipitation of 473 mm, average temperatures of 26°C, maximum of 33 °C and minimum of 21 °C and relative air humidity with an average of 65% (INMET, 2020). Parcel 2, with approximately 0.60 hectares, was divided into four plots of approximately 60 m x 24 m. This parcel 2 was surrounded by atemoya plants on three sides, in the North, South and West directions, and in the East direction by custard apple plants. Additionally, in one of parcel 2 corners there was a native dry forest, located at an approximate distance of 10 m (Figure 1).

The plots position in each of the parcels was defined based on the distances to the adjacent native forest, aiming to evaluate the influence of this type of vegetation on the population of the insects that attend the orchard. The distances of the plots from the two parcels to the surrounding vegetation were similar and of approximately 10 m, 33 m, 57 m and 81 meters.

The samplings were performed every week, with the collection of five atemoya fruits in each of the plots of the two parcels. The collected fruits had attack signs of the fruit and/ or the seed borers. The fruits were brought to the Biological Control Laboratory of the State University of Montes Claros, UNIMONTES, where they were counted and weighed. The fruits collected in each plot were individualized in order to evaluate the borers' infestation intensity, placed in plastic containers containing a thin layer of vermiculite and sealed with a "voil" fabric type. All the samples collected were properly identified (collection date, site and sample number) and kept in air conditioned room at 26 ± 3°C and RH of 65±10% for a period of 15 days.

The experimental design for each plot was completely randomized, and in parcel 1 the treatments were considered the four distances, and the repetitions the fruits collected, being seven collections in the spring period; in parcel 2, the treatments were also considered as the four distances, and the repetitions the fruits collected, being seven collections in the summer period.

After the necessary period for the emergence of the pest insects, the fruits were carefully dissected with the aid of a stylet and a tweezers, and the vermiculite sieved. The caterpillars/larvae and the borers pupae obtained were transferred to other plastic containers (500 mL) containing vermiculite and closed with a “voil” fabric type, aiming the emergence of adults. The adult insects obtained in the samples were properly accounted for, and the borers (of the seeds and the fruits) assembled using entomological pins for subsequent identification.

To obtain the infestation intensity, the number of borers emerged from the fruits that were individualized was accounted. Thus, the intensity of infestation was obtained for each of the borers through the division between the number of emerging borers (fruit or seed borer) and the fruit mass from where they emerged. The borers’ identification was performed based on the adults, according to Gallo et al. (2002).

The data were submitted to the Shapiro-Wilk test and the Bartlett test, both $p < 0.05$, for the verification of the data normality and homogeneity of the variances, respectively. In order to adjust the assumptions for an Anova, the data was transformed by Root of X+1. With the confirmation, a joint Anova was performed, with a probability of 5% of error. Only for the variable intensity of the seed borer infestation an Anova was not recommended. Thus, this variable was submitted to the nonparametric test of Kruskal Wallis ($p < 0.05$). All the statistical analyses were performed using the Genes software (CRUZ, 2016).

Results and Discussion

In this study, the fruit collection was directed to those who had borer attack symptoms however, in only 57.5% of these was found the presence of larvae and/or adults in the interior, and in 5%, the two borers occurred simultaneously (Table 1).

In the others, probably the insects had already come out of the fruit, that is, more than half of the fruits were infested by one or two borers, regardless of the sampling period and the plant distance to the vegetation around the orchard.

Braga Filho et al. (2007), evaluating the damage of *C. anonella* and *B. pomorum* in araticum (*Annona crassiflora* Mart.), observed that the damage occurs simultaneously in the same seed. The fruit borer when penetrating the fruit makes it more susceptible to pathogens entrance and opportunistic insects. The orifices caused by the seed borer are performed when the adults leave the fruit, also facilitating the entrance of insects and microorganisms. The attack of these borers results in rottenness and fruit mummification, making it impossible for both marketing “in natura” and for industrial processing. According to Braga Sobrinho et al. (1999), the losses caused by these pests can vary from 60 to 100% of the production, depending on the species of annonaceae, since, intended for commercialization “in natura”; a single caterpillar can cause a loss of 100%.

The infestation intensity of *C. anonella* and *B. pomorum* in atemoya fruits was not influenced by the distance in which the parcels were from the surrounding vegetation ($F = 0.6451$ and $p = 0.58984$), with an average of 3.25 and 1.66 borers/Kg of infested fruit, respectively. Less pest infestation was expected to be found in the atemoya plots located closer to the surrounding vegetation, but the infestations were similar in all plots. This result may be related to several factors, such as the absence of natural enemies, cultural

Table 1 - Number of atemoya fruits infested by *Cerconota anonella* and/or *Bephratelloides pomorum* borers harvested in a commercial orchard. Janaúba, MG. August/2019 to February/2020.

Number of fruits	Infested Fruits			
	Cerconota anonella	*Bephratelloides pomorum*	*C. anonella + B. pomorum*	Total
280	124	23	14	**161**

treatments, plant age, temperature, humidity and microclimate. It was believed that the forest diversity could contribute to the increase of natural enemies that would act on the orchard margin, since the conservation of natural areas associated with the cultivation area can assist in the natural pest control, because it provides shelter to natural enemies (ALTIERI et al., 2003). Climate factors can directly affect the physiology (for example, the development rate and water regulation) or the behavior (locomotion, orientation and dispersion) of the insect (TUELHER et al., 2003).

With semi-arid climate and irregular rainfall, the predominant vegetation in the study region is characterized by being of dry forest. The vegetation that occurs in the surroundings of an agroecosystem contributes to the presence, development and permanence of pest insects and, even, to new infestations. This happens mainly when plant species considered primary insect host are present. However, the surrounding vegetation, in this case, did not directly contribute to the borer infestation. Although *B. pomorum* and *C. anonella* are stenophagous insects, that is, have a less rigid diet, are still restricted for a small number of host species (PEÑA; BENNETT, 1995), having food preference for the *Annona* species. In the study region, the surrounding vegetation is very variable, but does not contain hosts for the borers, because in it there are higher trees, which form a continuous canopy, besides xerophytic shrubs, composed of lower and sparse trees, with denser shrub stratum, most with deciduousness of their leaves (FERNANDES; QUEIROZ, 2018).

Although the presence of the surrounding vegetation in the studied orchard was indifferent for the fruit infestation by the pests, Demite and Feres (2005), evaluating the influence of a native forest fragment on the distribution and occurrence of mites in a rubber tree orchard, observed that the greater diversity and uniformity were observed in the boundary line with the forest. Roschewitz et al. (2005) found higher densities of wheat aphids (*Sitobion avenae* F., *Metopolophium dirhodum* Walk. and *Rhopalosiphum padi* L.) in complex landscapes such as native forest, compared to simple landscapes, due to the high availability of hosts, contributing to the increase of aphids' establishment. However, in this case, the aphids are polyphagous insects, that is, develop in a host range different from the annonaceae borers.

According to Jeanneret (2000), the environmental conditions of the orchard margins can change the internal conditioning, especially with regard to the insects' mobility. Non-agricultural habitats can not only act as reservoirs for natural enemies, but also for pest species that invade the plantations. Native vegetation influences the diversity and abundance of herbivorous insects and their natural enemies in the agroecosystem, and can present positive, null or negative effects on the community of natural and herbivores enemies (STRAUB et al., 2008; TSCHARNTKE et al., 2016; BISSELEUA et al. 2017). Besides the borers are more restricted regarding to the hosts, due to the production scheduling in the studied orchard, the borers had food availability all the time. Thus, there was no need to seek food in the surrounding vegetation, which can also explain the infestation uniformity among the most distant and closer plots to the surrounding vegetation.

In this study, it was found that *C. anonella* and *B. pomorum* borers equally infested the atemoya fruits in the two seasons of the year, spring and summer, drier and wet periods, respectively. Annonaceae fruits infestation can vary according to the study region, the availability of hosts and environmental factors. In a *C. anonella* survey conducted in Trairi-CE, in the period of October/2010 to July/2011, region with tropical climate, 27 °C average temperature and precipitation around 106 mm, the average of soursop tree bored fruits found per plant was of 26.7% (MESQUITA et al., 2012). In a survey of borer fruit carried out in Anagé-BA, in the period from February/2011 to June/2011, semi-arid climate region, the average of infested custard apple fruits (*Annona squamosa*) reached 18.44% (OLIVEIRA et al., 2017).

Cerconota anonella infested more atemoya fruits in the summer than in the spring (F = 18.2221 and p = 0.009). The opposite was observed for *B. pomorum*, whose infestation was higher in the spring.

The intensity of fruit borer infestation rose with the increase of precipitation, while the seed borer infestation was reduced. In the dry period, when there were no rainfall or they were reduced, the *B. pomorum* infestation intensity was higher (Figure 2). In this study, the intensity of atemoya fruit infestation by the borers can be mainly related to climate factors, such as temperature and precipitation, which seem to play a fundamental role in the population dynamics of these pests. Besides these factors, others can also be cited influencing the infestation, such as the harvest conduction system, which was on scales. The crop scheduling may have allowed the orchard always to have flowering and fruiting plants, thus contributing to the survival of the pest throughout the period.

In the summer, a concentrated precipitation was recorded, and with about 420 mm of rain, temperature varied less in this period, with an average of 27 °C, which may have favored the fruit borer population increase (Figure 2). According to Pereira and Berti-Filho (2009), the range of 25 °C to 30 °C is the most suitable for the development of *C. anonella*, due to the high feasibility values of the observed development phases. For

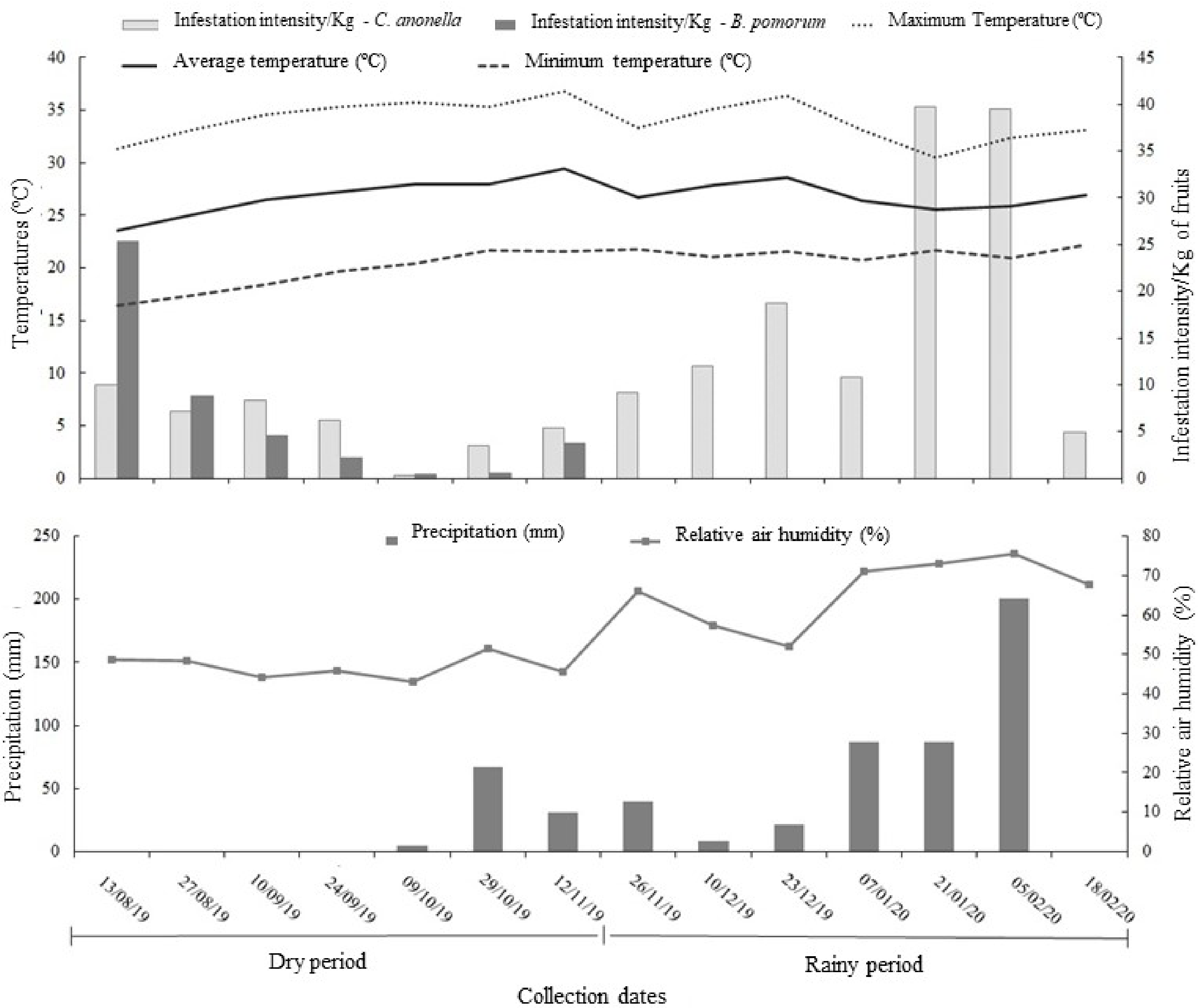

Figure 2 - *Cerconota anonella* and *Bephratelloides pomorum* infestation, maximum, minimum and average temperatures, precipitation and relative air humidity recorded during the collection period in the atemoya orchard. August/2019 to February/2020. Janaúba/MG.

all phases of an insect life, the development rate has significant linear relationships with the temperatures (JARAMILLO et al., 2009). Usually, the largest attack of the fruit borer is observed in the rainfall season (ARAÚJO et al., 1999; TOKUNAGA, 2000), since the high relative air humidity influences directly on the multiplication and survival of the insect. Lemos (2014) found that in the semi-arid regions of the Northeast and North of Minas Gerais, the fruit borer attack is reduced when there is low relative air humidity and high temperatures. This evidences the importance of temperature in the borer development and in the number of generations during the harvest. The complete biological cycle of this pest is approximately 30 days (MELO, 1991), collaborating that a greater number of generations can occur in a single plant cycle, because the fruits, after flowering, take about 100 to 120 days for maturation.

The presence of fruits all the time in the orchard, combined with the ideal temperature and precipitation conditions recorded in this period may have been determining factors for the occurrence of fruit borer infestation peaks. According to Kavati (1992), the atemoya fruit fixation is higher in mild temperatures conditions (27 °C) and high relative air humidity (80%), which does not happen in high temperatures (30 °C). Thus, the rainy season was favorable for the emergence of new atemoya fruits, which ended up being a food source for the fruit borer, since, according to Mesquita et al. (2012); this insect has preference for younger fruits. Mendes and Trevisan (1991) also verified that the largest larvae infestations of *Conotrachelus humeropictu* (Fiedler) (Coleoptera: Curculionidae) in cocoa plantations were directly related to the fruiting peaks.

In the case of seed borer, the infestation intensity was higher in the spring period, which may also have been the result of climate conditions (Figure 2). In the North region of Minas Gerais the spring is characterized by being a dry season, with high temperatures and scarce rainfall. The average temperatures of the region in the sampling period were considered high, around 29 °C. High temperature has a primordial role in seed borer infestation. A study conducted by Nadel and Peña (1991), evaluating *Bephratelloides cubensis* infestation (Ashmead) in atemoya in Florida, demonstrated an increase occurrence in pest infestation in the summer period, that is, a preference for higher temperatures. Peña et al. (1984) observed, in atemoya orchards in Florida, that the adult activity peaks occurred at 3:00 pm, when the average temperature floated around 31 °C to 33 °C, including the oviposition, emergency and adult rest in the tree canopy, being the most frequent oviposition between 3:00 and 4:00 pm, in temperatures of 25 °C and 26.5 °C, respectively. Fazolin and Ledo (1997) reported that in soursop tree, in the Rio Branco region, AC, the population peak of *B. pomorum* occurred in the month of September, dry period and high temperatures, on average of 33 °C, causing losses of more than 70%.

Six *Annona* species and an atemoya hybrid have already been registered as *B. pomorum* hosts (GRISSELL; SCHAUFF, 1990). Nadel and Pena (1991) comment that there is no evidence that wasp prefers any of these fruits however; there are those that are suitable for the oviposition of both species.

In this study, it was observed that the fruits collected in the spring were larger and were in advanced maturation stadium, which allowed observing the adults exit holes of the most evident seed borer. The total seed borer cycle is 46 to 113 days, depending on the temperature (GALLO et al., 2002). Thus, the chances of finding one of the insect development phases in the interior of mature fruit are large, since it passes the larval and pupal phase in the fruit, because it emerges in its interior. Probably, the borer attacked the collected fruits when they were still small. In atemoya tree the borer prefers to lay eggs in small fruits (1.5 cm to 5.5 cm in diameter) and, despite "tasting" larger fruits, it usually does not lay eggs in them. It is believed that seed hardness and pulp thickness of ripe fruits are important for the occurrence of oviposition (PEÑA et al., 2002). Larger fruits are attacked when the seed borer population is very high.

Understanding how *Cerconota anonella* and *Bephratelloides pomorum* infestation dynamics works in annonaceae in semi-arid is of paramount importance, so that we can trace more efficient management forms, since it is known in which climate condition and year period occurs the largest infestation of both borers.

Conclusion

The surrounding vegetation to atemoya orchard does not influence fruit and seed borer infestation. *Cerconota anonella* infests atemoya fruits with higher intensity in the summer, period with higher precipitation, while in the spring, drier and warm period, the fruits are more infested by *Bephratelloides pomorum*.

References

ALTIERI, M.A.; SILVA, E.N.; NICHOLLS, C.I. **O papel da biodiversidade no manejo de pragas**. Ribeirão Preto: Holos, 2003. 226 p.

ARAÚJO, J.F.; ARAÚJO, J.F.; ALVES, A.A.C. **Instruções técnicas para o cultivo da pinha (*Annona squamosa L.*)**. Salvador: EBDA, 1999. 44 p. (Circular Técnica, 7).

BISSELEUA, D.H.B.; BEGOUDE, D.; TONNANG, H.; VIDAL, S. Ant-mediated ecosystem services and disservices on marketable yield in cocoa agroforestry systems.**Agriculture, Ecosystems and Environment,** Amsterdam, v.247, p.409-17, 2017.

BRAGA FILHO, J.R.; VELOSO, V.D.R.S.; NAVES, R.V.; NASCIMENTO, J.L.D.; CHAVES, L.J. Danos causados por insetos em frutos e sementes de araticum (A*nnona crassiflora* Mart, 1841) no Cerrado de Góias. **Bioscience Journal**, Uberlândia, v.23, n.4, p.21-8, 2007.

BRAGA SOBRINHO, R.B.; BANDEIRA, C.T.; MESQUITA, A.L.M. Occurrence and damage of soursop pests in northeast Brazil. **Crop Protection**, Amsterdam, v.18, n.8, p.539-41, 1999.

BRAGA SOBRINHO, R.; MESQUITA, A.L.M.; HAWERROTH, F.J.; SILVA, K.S.; KAVATI, R. Manejo de pragas. *In*: PEREIRA, M.C.T.; BOREM, A. **Anonáceas**: do plantio à colheita.Viçosa, MG: Ed. UFV, 2021. p.143-63.

CHAY-HERNANDEZ, D.A.; DELFIN-GONZALEZ, H.; PARRA-TABLA, V. Ichneumonoidae (Hymenoptera) community diversity in an agricultural environment in the state of Yucatan, Mexico. **Environmental Entomology**, College Park, v.35, p.1286-97, 2006.

CRUZ, C.D. Genes Software estendido e integrado com R, Matlab e Selegen. **Acta Scientiarum. Agronomia**, Maringá, v.38, n.4, p.547-52, 2016.

DEMITE, P.R.; FERES, R.J.F. Influência de vegetação vizinha na distribuição de ácaros em seringal (*Hevea brasiliensis* Muell.Arg., Euphorbiaceae) em São José do Rio Preto, SP. **Neotropical Entomology**, Dordrecht, v.34, n.5, p.829-36, 2005.

FAZOLIN, M.; LEDO, A.S. **Épocas de ocorrência e medidas de controle dos insetos associados aos frutos da gravioleira, em Rio Branco, Acre**. Rio Branco: Embrapa, 1997. 20 p. (Circular Técnica)

FERNANDES, M.F.; QUEIROZ, L.P. de. Vegetação e flora da Caatinga. **Ciência e Cultura**, São Paulo, v.70, n.4, p.51-6, 2018.

GALLO, D.; NAKANO, O.; SILVEIRA NETO, S.; CARVALHO, R.P.L.; BAPTISTA, G.C.; BERTI FILHO, E.; PARRA, J.R.P.; ZUCCHI, R.A.; ALVES, S.B.; VENDRAMIN, J.D.; MARCHINI, L.C.; LOPES, J.R.S.; OMOTO, C. **Entomologia agrícola**. Piracicaba: FEALQ, 2002. p.920.

GRISSELL, E.E.; SCHAUFF, M.E. A synopsis of the seed-feeding genus *Bephratelloides* (Chalcidoidea: Eurytomidae). **Proceedings of the Entomological Society**, Washington, v.92, n.2, p.177-87, 1990.

INMET - Instituto Nacional de Meteorologia. Disponível em: *https://portal.inmet.gov.br/*. Acesso em: 24 mar. 2020.

JARAMILLO, J.; CHABI-OLAYE, A.; KAMONJO, C.; JARAMILLO, A.; VEGA, F.E.; POEHLING, H.M.; BORGEMEISTER, C. Thermal tolerance of the coffee berry borer *Hypothenemus hampei*: predictions of climate change impact on a tropical insect pest. **PloS One**, San Francisco, v.4, n.8, p.e6487, 2009.

JEANNERET, P. Interchanges of a common pest guild between orchards and the surrounding ecossistems. *In*: EKBOM, B.; IRWIN, E, M.; ROBERT, Y. **Interchanges of insects between agricultural and surrounding landscapes**. Dordrecht: Springer, 2000. p.85-107.

KAVATI, R. O cultivo da atemóia. *In*: DONADIO, L.C.; MARTINS, A.B.G.; VALENTE, J.P. **Fruticultura tropical**. Jaboticabal: FUNEP, 1992. p.39-70.

LEMOS, E.E.P. de. A produção de anonáceas no Brasil. **Revista Brasileira de Fruticultura**, Jaboticabal, v.36, p.77-85, 2014. Edição especial

MELO, G.S. de. **Manejo integrado de pragas e doenças de anonáceas**. Recife: IPA, 1991. 13 p. (Comunicado Técnico, 37).

MENDES, A.C.de B.; TREVISAN, O. **Flutuação populacional de *Conotrachelus humeropictus* Fiedler, 1940 (Coleoptera: Curculionidae), broca dos frutos do cacaueiro *Theobroma cacao* L.** Belém: CEPLAC, 1991. p.27-9. (Informe de Pesquisas, 1989/1990)

MESQUITA, A.L.M.; BRAGA SOBRINHO, R.; MARTINS, M.V.V. **Metodologia de monitoramento e níveis de infestação e de controle da broca-do-fruto da gravioleira**. Fortaleza: Embrapa Agroindústria Tropical, 2012 (Comunicado Técnico, 201).

NADEL, H.; PEÑA, J.E. Seasonal oviposition and emergence activity of *Bephratelloides cubensis* (Hymenoptera: Eurytomidae), a pest of *Annona* species in Florida. **Environmental Entomology**, College Park, v.20, n.4, p.1053-7, 1991.

OLIVEIRA, A.D.S.; CASTELLANI, M.A.; MOREIRA, A.A.; NASCIMENTO, A.S.D.; AZEVEDO, M.S.; OLIVEIRA, V.G. Eficácia de inseticidas no controle da broca-do-fruto e de resíduos em frutos de pinha. **Revista Ceres**, Viçosa, MG, v.64, n.2, p.132-7, 2017.

PEÑA, J.E.; BENNETT, F.D. Arthropods associated with *Annona* spp.in the Neotropics. **Florida Entomologist**, Gainesville, v.78, n.2, p.329-49, 1995.

PEÑA, J.E.; GLENN, H.; BARANOWSKI, R.M. Important insect pest of *Annona* spp. in Florida. **Proceedings of the Anual Meeting of the Florida State Horticulture Society,** Bradenton, v.97 p.337-40, 1984.

PEÑA, J.E.; NADEL, H.M.; PEREIRA, B.; SMITH, D. Pollinators and pests for *Annona* species. *In*: PEÑA, J.E.; SHARP, J.L.; WYSOKI, M. (ed.). **Tropical fruit pests and pollinators**: biology, economics, natural enemies and control. Oxon: CABI, 2002. p.197-221.

PEREIRA, M.C.T.; NIETSCHE, S.; COSTA, M.R.; CRANE, J.H.; CORSATO, C.D.A.; MIZOBUTSI, E.H. Anonáceas: pinha, atemoia e graviola. **Informe Agropecuário,** Belo Horizonte, v.32, n.264, p.26-34, 2011.

PEREIRA, M.J.B.; BERTI-FILHO, E. Exigências térmicas e estimativa do número de gerações da broca-do-fruto *Annona* (*Cerconota anonella*). **Ciência Rural**, Santa Maria, v.39, n.8, p.2278-84, 2009.

ROSCHEWITZ, I.; HÜCKER, M.; TSCHARNTKE, T.; THIES, C. The influence of landscape context and farming practices on parasitism of cereal aphids. **Agriculture, Ecosystems & Environment**, Amsterdam, v.108, n.3, p.218-27, 2005.

SANTOS, R.M.; VIEIRA, F.A.Similaridade florística entre formações de mata seca e mata de galeria no Parque Municipal da Sapucaia, Montes Claros-MG. **Revista Científica Eletrônica de Engenharia Florestal**, Garça, v.7, p.2-10, 2006.

STRAUB, C.S.; FINKE, D.L.; SNYDER, W.E. Are the conservation of natural enemy biodiversity and biological control compatible goals? **Biological Control**, San Diego, v.45, n.2, p.225-37, 2008.

TOKUNAGA, T. **A cultura da atemoia**. Campinas: CATI, 2000. 80p. (Boletim Técnico, 223).

TSCHARNTKE, T.; KARP, D.S.; CHAPLIN-KRAMER, R.; BATÁRY, P.; DECLERCK, F.; GRATTON, C.; HUNT, L.; IVES, A.; JONSSON, M.; LARSEN, A.; MARTIN, E.A.; MARTÍNEZ-SALINAS, A.; MEEHAN, T.D.; O'ROURKE, M.; POVEDA, K.; ROSENHEIM, J.A.; RUSCH, A.; SCHELLHORN, N.; WANGER, T.C.; WRATTEN, S.; ZHANG, W. When natural habitat fails to enhance biological pest control – Five hypotheses. **Biological Conservation**, Amsterdam, v.204, p.449-58, 2016.

TUELHER, E.S; OLIVEIRA, E.E.; GUEDES, R.N.C.; MAGALHÃES, L.C. Ocorrência de bicho-mineiro do cafeeiro (*Leucoptera coffeella*) influenciada pelo período estacional e pela altitude. **Acta Scientiarum. Agronomy**, Maringá, v.25, n.1, p.119-24, 2003.

VENZON, M.; ROSADO, M.C.; EUZÉBIO, D.E.; PALLINI, A. Controle biológico conservativo. *In*: VENZON, M; PAULA JÚNIOR, T.J.; PALLINI, A. (ed.). **Controle alternativo de doenças e pragas**.Viçosa: EPAMIG, 2005. p.1-22.