Original Article

CU-ID: 2247/v37n1e06

Suitability of *Ephestia kuehniella* (Lepidoptera: Pyralidae) and *Aleurodicus cocois* (Hemiptera: Aleyrodidae) as food sources for *Ceraeochrysa cornuta* (Neuroptera: Chrysopidae)

Idoneidad de *Ephestia kuehniella* (Lepidoptera: Pyralidae) y *Aleurodicus cocois* (Hemiptera: Aleyrodidae) como fuentes de alimento para *Ceraeochrysa cornuta* (Neuroptera: Chrysopidae)

Eliana Maria dos Passos[1*], Adenir Vieira Teodoro[2,3], Danúbia Maria da Costa[3], Lívia de Almeida Lima[4], Marcelo da Costa Mendonça[2,5]

[1]Empresa de Desenvolvimento Agropecuário de Sergipe (Emdagro), Av. Dr. Carlos Rodrigues da Cruz, s/n, 49080-190, Nossa Sra. do Socorro - SE, Brazil.

[2]Embrapa Tabuleiros Costeiros, Av. Beira mar, 3250, 49025-040, Aracaju - SE, Brazil.

[3]Programa de Pós-Graduação em Agroecologia, Universidade Estadual do Maranhão, Cidade Universitária Paulo VI, s/n, 65054-970, São Luís - MA, Brazil.

[4]Departamento de Engenharia Florestal da Universidade Federal de Sergipe, Av. Marechal Rondon, s/n, 49100-000, São Cristóvão - SE, Brazil

[5]Programa de Pós-Graduação em Biotecnologia Industrial, Universidade Tiradentes, Av. Murilo Dantas, 300, 49032-490, Aracaju - SE, Brazil.

ABSTRACT: This study aimed to compare the suitability of *Ephestia kuehniella* (Zeller, 1879) and *Aleurodicus cocois* (Curtis, 1846) as food sources for *Ceraeochrysa cornuta* (Navás, 1925) based on the assessment of the development and reproductive parameters of this predator. For this, *E. kuehniella* eggs or all developmental stages of *A. cocois* were used as prey and the effects were evaluated on developmental time, survival, viability, longevity, and fecundity of *C. cornuta*. *Ceraeochrysa cornuta* completed its development cycle from larvae to adult in 22 d or in 27 d when it preyed on *E. kuehniella* or on *A. cocois*, respectively. This could be explained by longer larval instars for *C. cornuta* feeding on *A. cocois*. The larval survival was higher when *C. cornuta* larvae fed on *E. kuehniella* than when it fed on *A. cocois*, increasing progressively from 79.82 % in the first to 97.56 % in the third instar. Although the diets did not influence female longevity, oviposition period and egg viability, the total number of eggs laid per female of *C. cornuta* was higher when their larvae fed on *A. cocois*. The results indicate that both *E. kuehniella* eggs and *A. cocois* developmental stages are suitable prey for rearing *C. cornuta*. In addition, this predator showed an outstanding potential for controlling *A. cocois*.

Keywords: alternative prey, cashew whitefly, fecundity, lacewing, natural enemies, survival larval.

RESUMEN: Este estudio tuvo como objetivo comparar la idoneidad de *Ephestia kuehniella* (Zeller, 1879) y *Aleurodicus cocois* (Curtis, 1846) como fuentes de alimento para *Ceraeochrysa cornuta* (Navás, 1925), sobre la base de la evaluación de sus parámetros reproductivos y de desarrollo. Para esto, se utilizaron como presa huevos de *E. kuehniella* o todas las etapas de desarrollo de *A. cocois* y se evaluaron sus efectos sobre el tiempo de desarrollo, sobrevivencia, viabilidad, longevidad y fecundidad de este depredador. *C. cornuta* completó su ciclo de desarrollo de larva a adulto en 22 días y en 27 días cuando se alimenta de *E. kuehniella* y *A. cocois*, respectivamente. La supervivencia del período larvario fue mayor cuando las larvas de *C. cornuta* se alimentaron de *E. kuehniella* en comparación con *A. cocois* como fuente de alimento, que aumentó progresivamente del 79,82 % en el primero al 97,56 % en el tercer estadio. Aunque las dietas no influyeron en la longevidad de las hembras de esta especie, el periodo de oviposición y la viabilidad de los huevos, así como el número total de huevos puestos por hembra fueron mayores cuando sus larvas se alimentaron de *A. cocois*. Los resultados indican que tanto los huevos de *E. kuehniella* como los estados inmaduros de *A. cocois* son presas adecuadas para la cría de *C. cornuta*. Adicionalmente, este depredador podría considerarse como un agente de control biológico promisorio para el manejo de *A. cocois*.

Palabras clave: presa alternativa, mosca blanca del anacardo, fecundidad, crisopideo, enemig natural, supervivencia larval.

*Correspondence to: Eliana Maria dos Passos, E-mail: bisologa@hotmail.com

Received: 23/11/2021
Accepted: 4/2/2022

INTRODUCTION

Lacewings (Neuroptera: Chrysopidae) are generalist predators considered important biological control agents due to their high reproductive potential, search capacity, ability to explore several habitats and a wide variety of prey (1, 2). *Ceraeochrysa* (Adams, 1982) is one of the most diverse Chrysopidae genera, distributed from Canada to Argentina, but mainly in the Neotropical region, inhabiting open forests and crops (3, 4, 5, 6). The species *Ceraeochrysa cornuta* (Navás, 1925), synonymous with *C. caligata* (Banks, 1945) (Neuroptera: Chrysopidae), has proved to be an important biological control agent of agricultural pests (7, 8, 9).

The whitefly *Aleurodicus cocois* (Curtis, 1846) (Hemiptera: Aleyrodidae) is a key pest of the cashew crop in Brazil. The presence of this pest affects negatively plant development by the suction of sap and nutrients and photosynthesis impairment due to the development of sooty mold on the leaves (10, 11, 12).

Recently, in the northeastern Sergipe state, Brazil, *C. cornuta* immature stages were found on cashew leaves infested with colonies of *A. cocois*. Reports of natural predation of *A. cocois* by other lacewing species, such as *Ceraeochrysa* sp. and *Chrysoperla externa* (Hagen, 1861) (Neuroptera: Chrysopidae), on cashew leaves in the northeastern state of Ceará, Brazil (12) suggest these predators as potential biological control agents for this whitefly. Nevertheless, no studies have addressed the importance of *A. cocois* as food source for *C. cornuta*.

Eggs of *Ephestia* (*Anagasta*) *kuehniella* (Zeller, 1879) (Lepidoptera: Pyralidae) have been predominantly used as standard food source in biological studies of *Chrysoperla, Ceraeochrysa* and *Leucochrysa* species (McLachlan, 1868) (Neuroptera: Chrysopidae), resulting in an adequate development of these predators (13, 14, 15, 16).

Although studies about suitable food sources for the development and reproduction of *C. cornuta* are important to determine the predatory potential, the biological cycle of this lacewing was only evaluated on aphids and *Spodoptera frugiperda* eggs as food sources (Smith, 1797) (Lepidoptera: Noctuidae) (8, 17, 18). This gap of knowledge about potential food sources and their effects on biological parameters of *C. cornuta* may hamper significant advances regarding its applicability for agricultural pest control.

Therefore, we aimed to compare the suitability of *E. kuehniella* and *A. cocois* as food sources for *C. cornuta,* based on assessment of the development and reproductive parameters of this predator.

MATERIAL AND METHODS

Colonies of *Ceraeochrysa cornuta*

The rearing of *C. cornuta* was established from specimens collected in citrus plantations in the northeastern state of Sergipe (Boquim municipality (11°08'19"S 37° 36'21"W). The specimens were identified by Francisco José Sosa Duque from Federal Rural University of the Amazon. The lacewings used in all experiments had been reared under laboratory conditions (temperature = 26 ± 2 ºC; relative humidity (RH) = 55 ± 10 % and natural photoperiod) for at least five generations. Briefly, adults were kept in PVC tube cages (300 x 300 mm) sitting on plastic plates internally lined with white paper sheets for oviposition. The top of the cage contained a 'voil' fabric wrapped by a rubber band. The adults were supplied with water and an artificial diet (*i. e*., honey and brewer's yeast, 1:1) as food every third day. The paper sheets containing the eggs were transferred to plastic pots in which the newly hatched larvae were fed with *E. kuehniella* eggs as food source until complete development and formation of the pupae. The eggs of *E. kuehniella* were obtained from the company Ecotrix biodefensivos.

Developmental time and larval survival of *C. cornuta* in relation to prey source

Eggs of *C. cornuta* were individually transferred to Elisa plates to avoid larval cannibalism. Subsequently, 137 newly hatched *C. cornuta* larvae were individually placed in plastic Petri dishes (5.5 cm Ø) containing *E. kuehniella* eggs *ad libitum*. Oiti (*Licania tomentosa* Benth) leaves, which are hairy and waxy, were added to each Petri dish to help lacewings to form the cocoon and protect the pupae. Also, 114 newly hatched *C. cornuta* were individually transferred to Petri dishes (as described above) containing field-collected cashew leaves heavily infested with eggs, nymphs, and adults of *A. cocois*. Food sources were daily replaced. The development of each larva, larval survival and pupal viability were daily recorded. The instar change was verified by the presence of exuvias and arrows in the tubers. This experiment was performed under laboratory conditions (temperature = 26 ± 2ºC; relative humidity (RH) = 55 ± 10 % and natural photoperiod).

Longevity and reproduction of *C. cornuta* in relation to prey source

After the emergence of adult predators with either prey sources (*E. kuehniella* or *A. cocois*), the sex ratio was determined and couples were separately kept in cylindrical PVC tube cages (200 x 200mm). These insects fed on artificial diet and water as previously described, which were replaced every two days. Altogether, 76 couples were randomly formed, however, only 13 couples previously fed on *E. kuehniella* and 7 couples previously fed on *A. cocois* remained due to either the absence of viable eggs or early death of females.

Female longevity was daily recorded and males were replaced whenever necessary. Eggs were daily collected, counted, registered, and placed in Elisa plates, and the number of eggs by female, hatching, and egg viability were determined. This experiment was conducted under laboratory conditions (temperature = 28 ± 2ºC; relative humidity (RH) = 50 ± 10 % and natural photoperiod).

Data analysis

The data from each experiment were compared by the t-tests ($P < 0.05$) [Proc TTEST, Method: pooled or *satterthwaite*, considering the equality of variances] using the SAS software (19). The developmental time of each larval instar, larval and pupal periods, female longevity, oviposition and total number of eggs laid per female of *C. cornuta* feeding either on *E. kuehniella* or *A. cocois* were compared. In addition, the percentage of surviving larvae, the pupal and egg viabilities were compared. The sex ratio was determined by the ratio between the number of females and the total number of adults (males and females) (20).

RESULTS AND DISCUSSION

Ceraeochrysa cornuta completed its cycle from larva to adult in 27 d when the prey was *A. cocois* and 22 d when it fed on *E. kuehniella* eggs. The development time in each larval instar lasted longer when *C. cornuta* fed on *A. cocois,* resulting in an increase of 4.76 d in the larval period ($t_{1,204} = -21.81$, $P < 0.0001$). Pupal period also lasted longer when *C. cornuta* fed on *A. cocois* ($t_{1,197} = -2.68$, $P = 0.0079$) (Table 1).

The survival of larval period, however, was higher for *C. cornuta* fed on *E. kuehniella* than on *A. cocois* as food source ($t_{1,249} = 4.85$, $P < 0.0001$), increasing progressively from 79.82 % in the first to 97.56 % in the third instar (Table 2).

The developmental periods of predators may be shortened when they feed on high quality preys (21). Lepidoptera eggs have high nutritional content and foster shorter larval cycles in *Ceraeochrysa* spp. (14, 22, 23), including in *C. cornuta* (17, 18), which is in line with the results of the present study. On the other hand, the development from larva to adult of *C. cornuta* feeding on *A. cocois* was accompanied by high larval survival and pupal viability, indicating that this whitefly was also an appropriate prey. As other lacewing species, *C. externa* also completes its life cycle when it feeds on *A. cocois,* though with a very low larval survival (35 %) (16).

As with other holometabolic insects, the larval developmental time of *C. cornuta* is associated with the type of food, while the survival of each instar is influenced by food availability. In fact, the survival of the larval stage increased progressively with the instars when *A. cocois* was offered as food source. This is because prey consumption by lacewing larvae rely on their search ability and prey handling. For example, the ability of *C. cornuta* to feed upon *Raoiella indica* (Hirst,1924) (Acari: Tenuipalpidae) increased with the larval development of the predator (8). Eggs of *E. kuehniella*, on the other hand, are immobile and do not exhibit antipredator behavior, which results in little effort and less energy lost by predators. The

Table 1. Developmental time of larval instars, and total larval and pupal periods (means ± SE) of *Ceraeochrysa cornuta* fed on *Aleurodicus cocois* developmental stages and *Ephestia kuehniella* eggs. / *Tiempo de desarrollo de los estadios larvarios y períodos totales de larvas y pupas (medias ± SE) de Ceraeochrysa cornuta alimentada con estadios de desarrollo de Aleurodicus cocois y huevos de Ephestia kuehniella.*

Food source	Average time (days)				
	1st instar	2nd instar	3rd instar	Total larvae	Pupae
E. kuehniella	3.24 ± 0.05	3.21 ± 0.04	4.99 ± 0.06	11.36 ± 0.06	10.64 ± 0.07
A. cocois	4.40 ± 0.11	4.86 ± 0.15	7.24 ± 0.14	16.12 ± 0.21	10.95 ± 0.09
P	0.0001	0.0001	0.0001	0.0001	0.0079

Table 2. Survival (%) of larval instars, total larval period and pupal viability (means ± SE) of *Ceraeochrysa cornuta* feeding on *Aleurodicus cocois* developmental stages and *Ephestia kuehniella* eggs. / *Supervivencia (%) de estadios larvarios, período larvario total y viabilidad de pupas (medias ± SE) de Ceraeochrysa cornuta alimentados con estadios de desarrollo de Aleurodicus cocois y huevos de Ephestia kuehniella.*

Food source	Survival			Viability	
	1st instar	2nd instar	3rd instar	Total larvae	Pupae
E. kuehniella	98.54 ± 1.03	99.26 ± 0.74	95.52 ± 1.80	93.43 ± 2.12	96.09 ± 1.72
A. cocois	79.82 ± 3.77	90.11 ± 3.15	97.56 ± 1.71	70.17 ± 4.30	93.75 ± 2.72
P	0.0001	0.0056	0.4121	0.0001	0.4680

pupal viability was not influenced by the diets and the resulting sex ratios for *C. cornuta* feeding on *A. cocois* and on *E. kuehniella* were 0.46 and 0.5, respectively. Adult emergence and the sex ratio are useful parameters to evaluate the suitability of food sources for natural enemies. For this end, both *A. cocois* and *E. kuehniella* are suitable preys to *C. cornuta* emergence. Also, the sex ratios of *C. cornuta* feeding on both food sources approached that of *Ceraeochrysa claveri* (Navás, 1911) (0.42) (9) and the 'ideal' (1 male:1 female) for sexually reproducing insects.

The diets also did not influence the longevity of females, oviposition period and viability of eggs. However, the total number of eggs laid by female was higher for *C. cornuta* feeding on *A. cocois* than on *E. kuehniella* ($t_{1, 18} = -2.54$, $P = 0.0405$) (Table 3). In addition, *C. cornuta* larvae feeding on *A. cocois* laid 823.57 ± 146.58 eggs per female. This high oscillation in the number of eggs laid possibly reflect the nutritional variation of the different biological stages of the whitefly.

The oviposition of *C. cornuta* feeding on *E. kuehniella* (441.92 ± 31.79) are consistent with that found in other species of *Ceraeochrysa*. For instance, *C. claveri* and *Ceraeochrysa cubana* (Hagen,1861) laid 467.7 ± 0.52 and 476.2 ± 3.21 eggs, respectively, when they fed on eggs from other lepidopteran species (22, 23).

Other authors also found an even higher oviposition (1,629.4 ± 200.46) of *Ceraeochrysa everes* (Banks, 1920) feeding on eggs of *E. kuehniella* (14). The oviposition difference between *C. cornuta* and *C. everes* may be related to differential species-specific capacities, as well as the quality of food offered to the prey *E. kuehniella*, which determines eggs nutrition contents. In this regard, changes in diets provided to *E. kuehniella* influenced the developmental time of the larval and pupal stages, sex ratio and pupal viability of *C. cubana* (24).

The food consumed in the larval stage influences oviposition capacity of the predator, which in turn influences predatory success. Larval diets significantly influence ovarian development as oocyte development varies with pupal size from larvae treated with different nutritional diets (25). In this sense, it is noteworthy the high number of eggs laid per female when its larvae fed on *A. cocois*.

Aleurodicus cocois proved to be appropriate for the development of larval and subsequent stages of *C. cornuta,* which emphasizes the potential of this predator as a biological control agent of *A. cocois*. In addition, the whitefly could be used as the main or supplementary diet for mass rearing *C. cornuta*. Similarly, other neotropical lacewing species such as *C. externa* and *C. everes* are promising biological control agents against two exotic mealybugs recently introduced in Brazil, *Ferrisia dasylirii* (Cockerell) and *Pseudococcus jackbeardsleyi* (Gimpel & Miller) (Hemiptera: Pseudococcidae) (14).

The lacewing *C. cornuta* also proved to be suitable for mass rearing due to its relatively short developmental time, high survival larval and pupal viability, and good reproductive potential when it fed either on *E. kuehniella* or *A. cocois*. These traits are important in the production of a biological control agent. In addition, although the sex ratio of *C. cornuta* feeding on *A. cocois* indicates a greater number of males, it may favor fertility by increasing the possibility of female encounters with virgin males, which would result in increased egg production in the field or in the laboratory (26).

CONCLUSION

Our results indicate that eggs of *E. kuehniella* are suitable for the development and reproduction of *C. cornuta*, which corroborates the widespread use of this alternative prey for the mass rearing of lacewings. Also, different biological stages of the whitefly *A. cocois* proved to be adequate for the development and reproduction of *C. cornuta*, indicating its potential as a biological control agent of this pest. This whitefly can also be used either as a main or as a supplementary food source for mass rearing *C. cornuta*.

ACKNOWLEDGEMENTS

We are grateful to Francisco José Sosa Duque from the Universidade Federal Rural da Amazônia (UFRA) for identifying the lacewing species.

REFERENCES

1. Albuquerque GS, Tauber CA, Tauber MJ. *Chrysoperla externa* and *Ceraeochrysa* spp.: potential for biological control in the New World

Table 3. Period of oviposition, female longevity, total number of eggs laid per female (means ± SE) and egg viability (%) (means ± SE) of *Ceraeochrysa cornuta* feeding on *Aleurodicus cocois* developmental stages and *Ephestia kuehniella* eggs. / *Período de oviposición, longevidad de la hembra, número total de huevos puestos por hembra (media ± SE) y viabilidad del huevo (%) (media ± SE) de Ceraeochrysa cornuta alimentada con huevos de Aleurodicus cocois y Ephestia kuehniella*

Food source	Female longevity	Oviposition	Total number of eggs	Egg viability
E. kuehniella	56.92 ± 3.41	43.23 ± 3.33	441.92 ± 31.79	52.45 ± 3.52
A. cocois	63.14 ± 6.61	51.71 ± 6.58	823.57 ± 146.58	57.19 ± 7.21
P	0.3643	0.2140	0.0405	0.5128

tropics and subtropics. In: McEwen PK, New TR, Whittington AE (eds). Lacewings in the crop environment, 1th ed., pp 408-423. Cambridge University Press, 2001.
2. Carvalho CF, Souza B. Métodos de criação e produção de crisopídeos. In VHP Bueno (ed). Controle biológico de pragas: produção massal e controle de qualidade, 2th ed., pp. 77-115. Brasil, Editora UFLA - Universidade Federal de Lavras, 2009.
3. Adams PA. *Ceraeochrysa*, a new genus of Chrysopinae (Neuroptera) (Studies in New World Chrysopidae, Part II). Neuroptera Intl. 1982; 2: 69-75.
4. Brooks SJ, Barnard, PC. The green lacewings of the world: a generic review (Neuroptera: Chrysopidae). Bull Br Mu Nat Hist Entomol. 1990; 59: 117-286.
5. Tauber CA, De León T, Penny N, Tauber MJ. The genus *Ceraeochrysa* (Neuroptera: Chrysopidae) of America north of Mexico: larvae, adults, and comparative biology. Ann Entomol Soc Am. 2000; 93:1195-1221. DOI: 10.1603/0013-8746(2000)093[1195:TGCNCO]2.0.CO;2
6. Freitas S, Penny ND, Adams PA. A revision of the New world genus *Ceraeochrysa* (Neuroptera: Chrysopidae). Proc Calif Acad Sci. 2009; 60: 503-610.
7. Souza JC, Galvão JR, Maia WJMS, Alves Filho PPC, Barbosa AVC. Resposta funcional e capacidade predatória da fase larval de *Ceraeochrysa caligata* alimentada com *Brevicoryne brassicae.* Rev Verde. 2015;10 (3): 61-65. DOI:10.18378/rvads.v10i3.3308
8. Jumbo LOV, Teodoro AV, Rêgo AS, Haddi K, Galvão AS, Oliveira, EE. The lacewing *Ceraeochrysa caligata* as a potential biological agent for controlling the red palm mite *Raoiella indica*. PeerJ. 2019; 7:e7123. DOI:10.7717/peerj.7123
9. Palomares-Pérez MPP, Contreras-Bermúdez Y, Grifaldo-Alcántara PF, García-García R E, Bravo-Núñez M, Arredondo-Bernal, HC. Predation capacity and larval development of *Ceraeochrysa claveri* (Neuroptera: Chrysopidae) fed with *Raoiella indica* (Acari: Tenuipalpidae). Revista De La Facultad De Ciencias Agrarias *UNCuyo* 2021; 53(2): 225-231. DOI:10.48162/rev.39.055
10. Byrne DN, Bellows TS. Whitefly biology. Annu Rev Entomol. 1991; 36: 431-457. DOI:10.1146/annurev.en.36.010191.002243.
11. Mesquita ALM, Braga Sobrinho R. Pragas do cajueiro. In: Araújo, JPP de (ed). Agronegócio caju: práticas e inovações, pp. 195-215. Brasil, Embrapa, 2013.
12. Goiana ESS, Dias-Pini NS, Gomes Filho AAH, Vidal Neto FC, Barros LM, Pastori PL, *et al*. Preferência de clones de cajueiro-anão à mosca-branca e distribuição temporal da praga e seu predador. Brasil, Embrapa Agroindústria Tropical: Boletim de pesquisa e desenvolvimento 123, 2017. http://ainfo.cnptia.embrapa.br/digital/bitstream/item/213060/1/BP-123.pdf
13. Scholtens BG, Solis MA. Annotated check list of the Pyraloidea (Lepidoptera) of America North of Mexico. ZooKeys. 2015; 535: 1-36. DOI: 10.3897/zookeys.535.6086.
14. Tapajós SJ, Lira R, Silva-Torres CSA, Torres JB, Coitinho RLCB. Suitability of two exotic mealybug species as prey to indigenous lacewing species. Biol Control. 2016; 96: 93-100. DOI: 10.1016/j.biocontrol.2016.02.005
15. Costa SS, Broglio SM, Dias-Pini NS, Santos DS, Santos JM, Duque FJ, *et al*. Developmental biology and functional responses of *Leucochrysa* (Nodita) *azevedoi* fed with different prey. Biocontrol Sci Technol. 2020; 30 (1): 42-50. DOI: 10.1080/09583157.2019.1687644
16. Monteiro NV, Saraiva WVA, Dias NS, Maciel GPS, Vasconcelos JF, Duarte, *et al*. Aspectos biológicos de *Chrysoperla externa* visando ao controle biológico da mosca-branca-do-cajueiro. Brasil, Embrapa Agroindústria Tropical: Boletim de Pesquisa e Desenvolvimento 215, 2021. http://www.infoteca.cnptia.embrapa.br/infoteca/handle/doc/1130075
17. Nogueira P, Fernandes A, Dias I, Moreira D, Cruz I. Aspectos biológicos de *Ceraeochrysa caligata* (Banks) (Neuroptera: Chrysopidae) alimentada com ovos frescos de *Spodoptera frugiperda* (Smith) (Lepidoptera: Noctuidae). In: Simpósio de Controle Biológico. Brasília, 2007,1p.
18. Castro ALG, Cruz I, Da Silva I, Paula CDS, Leao ML, Ferreira TE, *et al*. Biologia de *Ceraeochrysa caligata* (Banks, 1945) (Neuroptera: Chrysopidae) Alimentada com *Schizaphis graminum* (Rondani) (Hemiptera: Aphididae). Cadernos de Agroecologia, [S.l.], v 4, n 1, dec 2009. ISSN 2236-7934. Disponível em: http://revistas.aba-agroecologia.org.br/index.php/cad/article/view/4306. Acessado em: 05 de novembro de 2021
19. SAS S, Guide U. SAS Institute Inc. USA; Carry, NC, 2008.
20. Silveira Neto S, Nakano O, Bardin D, Villa Nova NA. Manual de ecologia dos insetos. Brasil; Agronômica Ceres, 1976.
21. Barbosa PRR, Oliveira MD, Giorgi JA, Silva-Torres CSA, Torres JB. Predatory behavior and life history of *Tenuisvalvae notata* (Coleoptera: Coccinellidae) under variable prey availability conditions. 2014; 97(3): 26-34. DOI: 10.1653/024.097.0304
22. Almeida MF, Barros R, Gondim Júnior MGC, Freitas S, Bezerra AL. Biologia de *Ceraeochrysa claveri* Navás (Neuroptera: Chrysopidae) predando *Plutella xylostella* (L.) (Lepidoptera: Plutellidae). Cienc Rural. 2009; 39: 313-318. DOI: 10.1590/S0103-84782009000200001.

23. Oliveira RO, Barbosa VO, Vieira DL, Oliveira FQ, Batista JL, Brito CH. Development and reproduction of *Ceraeochrysa cubana* (Neuroptera: Chrysopidae) fed with *Aleurocanthus woglumi* (Hemiptera: Aleyrodidae). Semina: Ciênc Agrár 2016; 37: 17-24. DOI: 10.5433/1679-0359.2016v37n1p17.
24. Nunes G S, Silva ITFA, Barbosa VO, Dantas TAV, Oliveira R, Batista JL. Influência da alimentação de *Ephestia kuehniella* Zeller (Lepidoptera: Pyralidae) no desenvolvimento de *Ceraeochrysa cubana* Hagen (Neuroptera: Chrysopidae). EntomoBrasilis. 2017; 10 (1): 14-18. DOI: 10.12741/ebrasilis.v10i1.641
25. Al Baki MA, Lee DW, Jung JK, Kim Y. Insulin signaling mediates previtellogenic development and enhances juvenile hormone-mediated vitellogenesis in a lepidopteran insect, *Maruca vitrata*. *BMC Dev Biol* 2019; 19: 1-14. https://doi.org/10.1186/s12861-019-0194-8
26. Medina-Pereyra P, Ordano M, Reguilón C, Salvatore AR, Acosta C, Risso L. El papel de la densidad y la proporción sexual de adultos en la fecundidad de *Diatraea saccharalis* (Lepidoptera: Crambidae) en jaulas de cría masiva. Revista de la Sociedad Entomológica Argentina 2016; 75(3-4): 165-171.

Declaration of conflict of interest: The authors declare that they have no conflict of interest.
Author Contributions: Eliana Maria dos Passos: Conceptualization, Investigation, Methodology, Writing original draft and writhing review. **Adenir Vieira Teodoro:** Data curation, Writing original draft. **Danúbia Maria da Costa:** Writing original draft and writing review. **Lívia de Almeida Lima:** Investigation. **Marcelo da Costa Mendonça:** Writing review.