Doi: http://dx.doi.org/10.17584/rcch.2017v11i2.6269

First record of *Chloridea* (*Heliothis*) subflexa (Lepidoptera: Noctuidae: Heliothinae) on cape gooseberry (*Physalis peruviana*) in Brazil

Primer registro de *Chloridea* (*Heliothis*) subflexa (Lepidoptera: Noctuidae: Heliothinae) en uchuva en Brasil

Chloridea (Heliothis) subflexa

Photo: A.P.C. de Melo

ANIELA PILAR CAMPOS DE MELO[1, 5]
PAULO MARÇAL FERNANDES[2]
CARLOS DE MELO E SILVA-NETO[3]
GISLENE AUXILIADORA FERREIRA[2]
ALEXSANDER SELEGUINI[4]

ABSTRACT

Chloridea (Heliothis) subflexa (Guenée) (Lepidoptera: Noctuidae: Heliothinae) is a frugivorous and monophagous species with plant hosts in the genus *Physalis*. In the last few years, the subflexus straw moth became the main pest-insect in tomatillo crops (*Physalis ixocarpa* Brotero) in Mexico and cape gooseberry (*Physalis peruviana* L.) crops in Argentina. The objective was to provide the first record of *C. subflexa* on *P. peruviana* in Brazil. The specimens were collected in the larval stage and kept on a natural diet until reaching the adult stage. Species identification was carried out based on morphological criteria. Damage from *C. subflexa* on *P. peruviana* fruits cultivated in an organic system were recorded. This is the first record in Brazil.

Additional key words: exotic fruit, subflexus straw moth, organic system.

RESUMEN

Chloridea (Heliothis) subflexa (Guenée) (Lepidoptera: Noctuidae: Heliothinae) es una especie frugívora y monófoga con hospederos que consta de las plantas del género *Physalis*. En los últimos años, gusano del tomato

[1] Institute of Biological Sciences, Department of Botanic, Federal University of Goiás, Goiânia-GO (Brazil). ORCID Campos de Melo, A.P.: 0000-0002-5687-5928
[2] School of Agronomy, Phytosanitary Sector, Federal University of Goiás, Goiânia-GO (Brazil). ORCID Fernandes, P.M.: 0000-0003-3442-6539; ORCID Ferreira, G.A.: 0000-0002-1159-0005
[3] Department of Agroecology, Federal Institute Goiás, Cidade de Goiás Goiás-GO (Brazil). ORCID Silva Neto, C.d.M.: 0000-0001-8624-3836.
[4] Federal University Triângulo Mineiro, Iturema-MG (Brazil). ORCID Seleguini, A.: 0000-0002-5762-9278
[5] Corresponding author. aniela.pcdmelo@gmail.com

de cascara se convirtió en la principal plagas-insectos en cultivos de tomatillo (*Physalis ixocarpa* Brotero de México) y cultivo de la uchuva (*Physalis peruviana* L.) en Argentina. El objetivo fue reportar el primer registro de *C. subflexa* en *P. peruviana* en Brasil. Los especímenes se recogieron en la fase larvaria y se mantuvieron en una dieta natural hasta llegar a la etapa adulta. La identificación de especies se realizó en base a criterios morfológicos. Se registraron la presencia y daños causados por *C. subflexa* en frutos de *P. peruviana*, producidos en un sistema orgánico. Este es el primer registro para Brasil.

Palabras clave adicionales: fruta exótica, gusano del tomato de cáscara, sistema orgánico.

Received for publication: 05-02-2017 Accepted for publication: 30-09-2017

INTRODUCTION

The subflexus straw moth, scientifically named *Chloridea (Heliothis) subflexa* (Guenée) (Lepidoptera: Noctuidae: Heliothinae), is native to North America (Baker *et al*., 2004; Pogue, 2013). It occurs in tropical and subtropical regions of the American continents in the following countries: United States, Canada, Mexico, Jamaica, Puerto Rico, Cuba, Nicaragua, Costa Rica, Panama, Trinidad and Tobago, Colombia, Ecuador, Venezuela, Peru, Argentina, Bolivia and Brazil (Heath *et al*., 1990; Poole *et al*., 1993; Bado *et al*., 2005; Groot *et al*., 2007; Groot *et al*., 2009; Pogue, 2013; De Souza *et al*., 2015). The areas of occurrence in Brazil include the Amazon, Northeastern region (Pernambuco, Paraíba), Southeastern (Rio de Janeiro) and Midwestern regions (Mato Grosso do Sul; Goiás) (Poole *et al*., 1993; De Souza *et al*., 2015).

Chloridea subflexa is a frugivorous and monophagous species with plant hosts in the genus *Physalis* (Oppenheim and Gould, 2002 a; Benda *et al*., 2011). Until now, the principal interest in this species consisted of studies on hybridization under laboratory conditions using *C. virescens*, naturally reducing population sizes of this pest-insect by inducing sterility of the males (Mitchell and Heath, 1987). However, in the last few years, the subflexus straw moth became the main pest-insect in tomatillo crops (*Physalis ixocarpa* Brotero) in Mexico (Groot *et al*., 2007; Pogue, 2013; Bautista-Martínez *et al*., 2015) and cape gooseberry (*Physalis peruviana* L.) crops in Argentina (Bado *et al*., 2005).

Therefore, the objective was to provide the first record of damage from *C. subflexa* on *P. peruviana* in Brazil.

MATERIAL AND METHODS

The observations were made on an organic cape gooseberry plantation in Hidrolândia (16°57'51.79" S and 49°11'02.09" W; 865 m altitude) - west central region of Brazil, from 2014 to 2015. Damaged fruit with the presence of larvae in different instars was observed in 100 plants each year (Fig. 1).

The specimens were collected in the larval stage and kept on a natural diet until reaching the adult stage (Fig. 2). Species identification was carried out based on morphological criteria (head, thorax, forewing, male and female genitalia) (Poole *et al*., 1993). The identification was performed by the entomologist Vitor Osmar Becker (Serra Bonita Reserve). The adult individuals were stored at the Insectarium of the School of Agronomy of the Federal University of Goiás, Brazil.

RESULTS AND DISCUSSION

The fruits were not harvested in the two years of cape gooseberry cultivation because of the attack from *C. subflexa*. The plants flourished in a period similar to that reported in the Southeastern region (Rodrigues *et al*., 2013) and earlier than the Southern region (Betemps *et al*., 2014). Flowering took place 35 days after transplanting in 2014 (01/07/2014), and, earlier, 25 days after transplanting in 2015 (25/05/2015).

The moths have a shiny body and green-olive spots in the abdomen and wings (Pogue, 2013). There are medial lines preceded by light brown (cream color),

Figure 1. Larvae of *Chloridea (Heliothis) subflexa* in *Physalis peruviana* fruit.

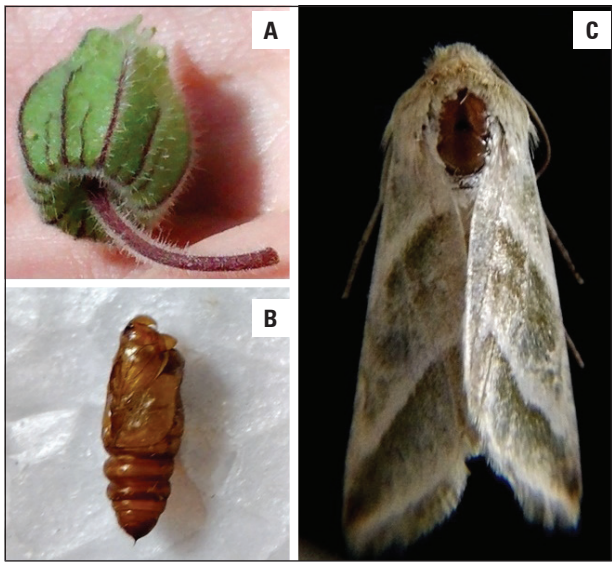

Figure 2. *Chloridea (Heliothis) subflexa* eggs (A), pupae (B) and adults (C), found on *Physalis peruviana*.

specifically in the wings where the basal region has a lighter color than the medial region (Poole *et al*., 1993). The key traits in distinguishing *C. subflexa* from *C. virescens* are related to the prothoracic tibia and palps (Poole *et al*., 1993).

Oviposition is more frequent in vegetative (stem and leaves) than in reproductive structures (bud, flowers, fruit) (Benda *et al*., 2011). The vegetative areas are preferred because of the higher surface area. It is noteworthy that oviposition may also occur in non-host plants from different genera, such as: *Digitaria*, *Cyperus*, *Gossipium* and *Tagetes* (Benda *et al*., 2011).

Newly emerged larvae infiltrate the calyx, where *Physalis* berries may be found, and begin feeding. The larvae feed on the mesocarp of the fruit. This damage may occur superficially or the larvae may consume the entire mesocarp, leaving only the epicarp of the fruit. The aforementioned damage pattern is common to larvae in more advanced instars. In addition, damage is more common in green fruit than in ripe ones (characterized by the yellowish or orange color of the epicarp).

Feeding is usually restricted to fruit of the same plant, where at least three berries are necessary for the larvae become pupae (Benda *et al*., 2009). The damage hinders *in natura* consumption and industrial use of *Physalis* fruit.

The calyx provides an enclosure for the larvae, creating a structural refuge that reduces its detection by parasitoids and predators (Baumann and Meier, 1993; Sisterson and Gould, 1999; Oppenheim and Gould, 2002a). This structure acts as a mechanical barrier and has withanolides and glycosides that are feed deterrents (Baumann and Meier, 1993; Dinan *et al*., 1997) for other phytophagous insects.

The only parasitoid associated with *C. subflexa* in the United States is *Cardiochiles nigreceps* Vierick (Hymenoptera: Braconidae). The rates of parasitism are very low (1 to 4%) (Sisterson and Gould, 1999; Oppenheim and Gould, 2002a; Oppenheim and Gould, 2002b) and are not only related to the presence of the calyx.

De Moraes and Mescher (2004) reported that regurgitations of *C. subflexa* do not have volicitin. Volicitin is a key substance in inducing the responses of the plant to herbivory (via volatile compounds) and its absence is associated with the lack of linoleic acid in *Physalis* fruit. Linoleic acid is key for normal development and insect metamorphosis, especially for the order Hymenoptera (e.g., *C. nigreceps*) (De Moraes and Mescher, 2004). Thus, *C. subflexa* has the ability to grow in fruit that are not nutritionally suitable for other insects and, as a consequence, it is an improper host for natural enemies (De Moraes and Mescher, 2004).

Some *Physalis* species have defense mechanisms against attacks from *C. subflexa*. These can be related to mechanical damage such as fruit abscission in *P.*

angulata and *P. pubescens* (Petzold *et al*., 2009) or egg desiccation in *P. angulata* as a consequence of the release of chemical substances (Petzold *et al*., 2009; Petzold-Maxwell *et al*., 2011).

This high degree of specialization of *C. subflexa* for *Physalis* plants (Barthel *et al*., 2016) hinders the implementation of management strategies in commercial areas, especially in the case of tomatillo and cape gooseberry. Groot *et al*. (2007) suggested that monitoring with traps using pheromones is a key strategy for integrated *C. subflexa* management programs. It is noteworthy that chemical management must be focused on the adult insect once the caterpillars are protected by the calyx in the larval stage. In organic systems, the removal of other *Physalis* species is recommended, such as the angular winter cherry (*P. angulata*), along with cultivation in a protected environment in areas of high infestation.

We reiterate that cape gooseberry cultivation is expanding in Brazil, especially in the southern (Lima *et al*., 2009; Muniz *et al*., 2011; Betemps *et al*., 2014) and southeastern regions (Rodrigues *et al*., 2012). Brazilian production does not meet domestic demand, so importation from Colombia, the largest world producer, becomes necessary (Muniz *et al*., 2014). The fruits are eaten raw or processed (via juices, jellies, dehydrated) (Puente *et al*., 2011). The berries stand out because of their exotic taste and high mineral content, antioxidants, and medicinal and bioactive substances (Puente *et al*., 2011; Ramadan, 2012; Rop *et al*., 2012; Rutz *et al*., 2012; Namiesnik *et al*., 2013; Bravo *et al*., 2014; Fischer *et al*., 2014; Moneim *et al*., 2014; Al-Olayan *et al*., 2014; Ahmed, 2014).

CONCLUSION

The occurrence of *Chloridea (Heliothis) subflexa* in *Physalis peruviana* production areas can derail organic production because of the damage that is caused. Therefore, studies related to the biology and ecology of this insect, its host and the natural control agent are needed to support strategies for integrated management under the Brazilian conditions.

Conflict of interests: the manuscript was prepared and reviewed with the participation of the authors, who declare that there exists no conflict of interest that puts in risk the validity of the presented results.

BIBLIOGRAPHIC REFERENCES

Ahmed, L.A. 2014. Renoprotective effect of Egyptian cape gooseberry fruit (*Physalis peruviana* L.) against acute renal injury in rats. Scientific World J. 2014(4), 1-7. Doi: 10.1155/2014/273870

Al-Olayan, E.M., M.F. El-Khadragy, A.M. Aref, M.S. Othman, R.B. Kassab, and A.E.A. Moneim. 2014. The potential protective effect of *Physalis peruviana* L. against carbon tetrachloride-induced hepatotoxicity in rats is mediated by suppression of oxidative stress and downregulation of MMP-9-expression. Oxid. Med. Cell Longev. 2014, 1-13. Doi: 10.1155/2014/381413

Bado, S.G., A.M. Cerri, and F. Vilela. 2005. Fauna insectil asociada a cultivos de dos especies de *Physalis* (Solanaceae) en Argentina. Bol. Sanid. Veg. Plagas. 31(3), 321-324.

Barthel, A., H. Vogel, Y. Pauchet, G. Pauls, G. Kunert, A. Groot, W. Boland, D.G. Heckel, and H.M. Heidel-Fischer. 2016. Immune modulation enables a specialist insect to benefit from antibacterial withanolides in its host plant. Nat. Commun. 7(7), 1-11. Doi: 10.1038/ncomms12530

Baker, T.C., S.A. Ochieng, A.A. Cossé, S.G. Lee, J.L. Todd, C. Quero, and N.J.A. Vickers. 2004. A comparison of responses from olfactory receptor neurons of *Heliothis subflexa* and *Heliothis virescens* to components of their sex pheronome. J. Comp. Physiol. 190(2), 155-165. Doi: 10.1007/s00359-003-0483-2

Baumann, T.W. and C.M. Meier. 1998. Chemical defence by withanolides during fruit development in *Physalis peruviana*. Phytochem. 33(2), 317-321. Doi: 10.1016/0031-9422(93)85510-X

Bautista-Martínez, N., E. López-Bautista, and H.V. Madriz. 2015. Percentage damage to tomatillo crops by *Heliothis subflexa* (Lepidoptera: Noctuidae) at various altitudes. Fla. Entomol. 98(2), 790-791. Doi: 10.1653/024.098.0261

Benda, N.D., C. Brownie, C. Schal, and F. Gould. 2009. Fruit abscission by *Physalis* species as defense against frugivory. Entomol. Exp. Appl. 130(1), 21-27. Doi: 10.1111/j.1570-7458.2008.00792.x

Benda, N.D., C. Brownie, C. Schal, and F. Gould. 2011. Field observations of oviposition by a specialist herbivore on plant parts and plant species unsuitable as larval food. Environ. Entomol. 40(6), 1478-1486. Doi: 10.1603/EN09335

Betemps, D.L., J.C. Fachinello, C.S.M. Lima, S.P. Galarça, and A.R. Rufato. 2014. Época de semeadura, fenologia e crescimento de plantas de físalis no sul do Brasil. Rev. Bras. Frutic. 36(1), 179-185. Doi: 10.1590/0100-2945-292/13

Bravo, K., S. Sepulveda-Ortega, O. Lara-Guzman, A.A. Navas-Arboleda, and E. Osorio. 2015. Influence of

cultivar and ripening time on bioactive compounds and antioxidant properties in Cape gooseberry (*Physalis peruviana* L.). J. Sci. Food Agr. 95(7), 1562-1569. Doi: 10.1002/jsfa.6866

De Moraes, C.M. and M.C. Mescher. 2004. Biochemical crypsis in the avoidance of natural enemies by an insect herbivore. PNAS 101(24), 8993-8997. Doi: 10.1073/pnas.0403248101

De Souza, B.R., W.T. Tay, C. Czepak, S. Elfekih, and T.K. Walsh. 2015. The complete mitochondrial DNA genome of a *Chloridea (Heliothis) subflexa* (Lepidoptera: Noctuidae) morpho-species. Mitochondrial DNA A DNA Mapp Seq. Anal. 26(11), 1-2. Doi: 10.3109/19401736.2015.1101549

Dinan, L.N., S.D. Sarker, and V. Sik. 1997. 28-Hydroxywithanolide E from *Physalis peruviana*. Phytochem. 44(3), 509-512. Doi: 10.1016/S0031-9422(96)00553-5

Fischer, G., P.J. Almanza-Merchán, and D. Miranda. 2014. Importancia y cultivo de la uchuva (*Physalis peruviana* L.). Rev. Bras. Frutic. 36(1), 1-15. Doi: 10.1590/0100-2945-441/13

Groot, A.T., R.G. Santangelo, E. Ricci, C. Brownie, F. Gould, and C. Schal. 2007. Differential attraction of *Heliothis subflexa* to synthetic pheromone lures in Eastern US and Western Mexico. J. Chem. Ecol. 33(2), 353-368. Doi: 10.1007/s10886-006-9233-6

Groot, A.T., O. Inglis, S. Bowdridge, R.G. Santangelo, C. Bianco, J.D. López, A.T. Vargas, F. Gould and C. Schal. 2009. Geographic and temporal variation in moth chemical communication. Evolution 63(8), 1987-2003. Doi: 10.1111/j.1558-5646.2009.00702.x

Heath, R.R., E.R. Mitchell, and J.C. Tovar. 1990. Effect of release rate and ratio of (Z)-11-Hexadecen-1-ol from synthetic pheromone blends on trap capture of *Heliothis subflexa* (Lepidoptera: Noctuidae). J. Chem. Ecol. 16(4), 1259-1268. Doi: 10.1007/BF01021024

Lima, C.S.M., R. Manica-Berto, S.J.P. Silva, D.L. Betemps, and A.R. Rufato. 2009. Custos de implantação e condução de pomar de *Physalis* na região sul. Rev. Ceres. 56(5), 555-561.

Mitchell, E.R. and R.R. Heath. 1987. *Heliothis subflexa* (GN.) (Lepidoptera: Noctuidae) demonstration of oviposition stimulant from groundcherry using novel bioassay. J. Chem. Ecol. 13(8), 1849-1858. Doi: 10.1007/BF01013234

Moneim, A.E.A., A.A. Bauomy, M.M. Diab, M.T. Shata, E.M. Al-Olayan, and M.F. El-Khadragy. 2014. The protective effect of *Physalis peruviana* L. against cadmium-induced neurotoxicity in rats. Biol. Trace Elem. Res. 160(3), 160-399. Doi: 10.1007/s12011-014-0066-9

Muniz, J., A.A. Kretzschamar, L. Rufato, T.R. Pelizza, A. Rufato, and T.A. Macedo. 2014. General aspects of physalis cultivation. Cienc. Rural. 44(6), 964-970. Doi: 10.1590/S0103-84782014000600002

Namiesnik, J., K. Vearasilp, M. Kupska, K.S. Ham, S.G. Kang, Y.K. Park, D. Barasch, A. Nemirovski, and S. Gorinstein. 2013. Antioxidant activities and bioactive components in some berries. Eur. Food Res. Technol. 237(5), 819-829. Doi: 10.1007/s00217-013-2041-7

Oppenheim, S.J. and F. Gould. 2002a. Behavioral adaptations increase the value of enemy-free space for *Heliothis subflexa*, a specialist herbivore. Evolution 56(4), 679-689.

Oppenheim, S.J. and F. Gould. 2002b. Is attraction fatal? The effects of herbivore-induced plant volatiles on herbivore parasitism. Evolution 83(12), 3416-3425.

Petzold, J., C. Brownie, and F. Gould. 2009. Effect of *Heliothis subflexa* herbivory on fruit abscission by Physalis species: the roles of mechanical damage and chemical factors. Ecol. Entomol. 34(5), 603-613. Doi: 10.1111/j.1365-2311.2009.01109.x

Petzold-Maxwell, J., S. Wong, C. Arellano, and F. Gould. 2011. Host plant direct defence against eggs of its specialist herbivore, *Heliothis subflexa*. Ecol. Entomol. 36(6), 700-708. Doi: 10.1111/j.1365-2311.2011.01315.x

Pogue, M.G. 2013. Revised status of *Chloridea* Duncan and (Westwood), 1841, for the *Heliothis virescens* species group (Lepidoptera: Noctuidae: Heliothinae) based on morphology and three genes. Syst. Entomol. 38(3), 523-542. Doi: 10.1111/syen.12010

Poole, R.W., C. Mitter, and M. Huettel. 1993. A revision and cladistic analysis of the *Heliothis virescens* species-group (Lepidoptera:Noctuidae) with a preliminar morphometric analysis of *Heliothis virescens*. Mississippi Agricultural and Forestry Experiment Station, Mississipi State University, Bost North, MS, USA.

Puente, L.A., C.A. Pinto-Munoz, E.S. Castro, and M. Cortés. 2011. *Physalis peruviana* Linnaeus, the multiple properties of a highly functional fruit: A review. Food Res. Inter. 44(7), 1733-1740. Doi: 10.1016/j.foodres.2010.09.034

Ramadan, M.F. 2012. *Physalis peruviana* pomace suppresses high-cholesterol diet-induced hypercholesterolemia in rats. Grasas Aceites 63(4), 411-422. Doi: 10.3989/gya.047412

Rodrigues, F.A., E.S. Penoni, J.D.D. Soares, and M. Pasqual. 2012. Caracterização do ponto de colheita de *Physalis peruviana* L. na região de Lavras, MG. Biosci. J. 28(6), 862-867.

Rop, O., J. Micek, T. Jurikova, and M. Valsikova. 2012. Bioactive content and antioxidant capacity of Cape gooseberry fruit. Cent. Eur. J. Biol. 7(4), 672-679. Doi: 10.2478/s11535-012-0063-y

Rutz, J.K., G.B. Voss, A.C. Jacques, P.B. Pertuzatti, M.T. Barcia, and R.C. Zambiazi. 2012. Geleia de *Physalis peruviana* L.: Caracterização bioativa, antioxidante e sensorial. Alim. Nutr. 23(3), 369-375.

Sisterson, M.S. and F.L. Gould. 1999. The inflated calyx of *Physalis angulata*: a refuge from parasitism for *Heliothis subflexa*. Ecol. 80(3), 1071-1075.