ENTOMOLOGICAL Communications

Entomological Communications, 4, 2022: ec04016
doi: 10.37486/2675-1305.ec04016
e-ISSN: 2675-1305
Open Access Full Text Article

Scientific Note

Melanaphis sorghi (Theobald, 1904) (Hemiptera: Aphididae), an invasive sorghum pest in the American continent, is a host of *Aphidius platensis* (Brèthes, 1913) (Hymenoptera: Braconidae: Aphidiinae) in Brazil

Marcus V. Sampaio[1], Ricardo F. Domingues[1], Simone M. Mendes[2], Guilherme S. Avellar[2]

[1]Universidade Federal de Uberlândia, Uberlândia, Minas Gerais, Brazil. [2]Embrapa Milho e Sorgo, Sete Lagoas, Minas Gerais, Brazil.
Corresponding author: mvsampaio@ufu.br

Edited by: Rafael M. Pitta

Received: February 22, 2022. Accepted: May 17, 2022. Published: June 03, 2022.

Abstract. *Melanaphis sorghi* (Theobald, 1904) is an invasive species recently introduced in the American continent and has been causing great losses in the sorghum crop. In surveys carried out in the cities of Uberlândia and Sete Lagoas, state of Minas Gerais, Brazil, during the year 2021, mummified specimens of *M. sorghi* were collected on sorghum plants, from which the parasitoid *Aphidius platensis* (Brèthes, 1913) (Hymenoptera: Braconidae: Aphidiinae) and the hyperparasitoids *Syrphophagus* sp. and *Pachyneuron* sp. emerged. This is the first record of *A. platensis* parasitizing *M. sorghi* in Brazil.

Keywords: Aphid, aphid parasitoid, biological control, cereal aphid, hyperparasitoid.

Melanaphis Van der Goot, 1917 is a genus of aphids with approximately 25 species with Palearctic origin (Blackman & Eastop 2000). The sugarcane aphid, *Melanaphis sacchari* (Zehntner, 1897), was the only species of this genus present in the American continent capable of colonizing sorghum, with records since the late 1960s in Brazil (Costa et al. 1972), and the late 1970s in the United States (Bowling et al. 2016). This species preferentially colonizes sugarcane, causing damage as it is a vector of the *Sugarcane yellow leaf virus*, which occurs sporadically and in small populations in sorghum crops (Nibouche et al. 2018). However, in 2013, several occurrences of *M. sacchari* were reported causing losses of up to 50% in sorghum production in regions of the southern United States and northern Mexico (Bowling et al. 2016). In Brazil, *M. sacchari* was not recorded as a pest of sorghum (Mendes et al. 2014), however, events similar to those in the United States and Mexico were observed in 2019 in Brazil, starting in sorghum crops in the regions of Triângulo Mineiro, Brasília and São Paulo (Mendes et al. 2019). Primarily, the species causing damage to sorghum in the American continent was considered a new biotype of *M. sacchari*; however, it was determined by molecular and morphological techniques that it was the cryptic species *Melanaphis sorghi* (Theobald, 1904) (Nibouche et al. 2021).

Asia is the possible center of origin for both *M. sacchari* and *M. sorghi* (Nibouche et al. 2018) and, despite the difficulty in differentiating these species by morphological features (Nibouche et al. 2021), the large populations observed in Brazil and the symptoms in sorghum plants revealed the presence of *M. sorghi* (Fernandes et al. 2021). The presence of this species was confirmed by molecular techniques from a sample of aphids collected on sorghum, in the city of Sete Lagoas, state of Minas Gerais (Nibouche et al. 2021), and as the only aphid species of *Melanaphis* genus (MLL-F *M. sorghi* super-clone) collected on sorghum in 39 samples in 10 cities in the states of Bahia, Goiás, Minas Gerais, Paraná and in the federal district (Brasília) (Harris-Shultz et al. 2022).

Due to the occurrence of large populations of *M. sorghi* on sorghum in Brazil, the assessment of its natural enemies becomes important to understand its population dynamics and propose solutions for the management of this pest. Thus, after the observation of parasitized *M. sorghi* (mummies), collections were carried out to determine the parasitoid species that use this species as a host. Aphids and mummies of *M. sorghi* were collected on sorghum plants in the cities of Uberlândia and Sete Lagoas, in the state of Minas Gerais. In Uberlândia, they were collected in three locations, in Fazenda Capim Branco (18°53'23.677'' S, 48°20'27.089'' W), in Fazenda do Glória (18°56'54.713'' S, 48°13'2.616'' W), and in sorghum plants cultivated in the urban perimeter (18°55'0.371'' S, 48°16'3.136'' W). In Sete Lagoas, aphids were collected at Embrapa Milho e Sorgo (19°44'89.06'' S, 44°17'68.82'' W).

Samples of aphids collected in Uberlândia and Sete Lagoas were kept in 70% alcohol and identified using a stereoscopic microscope. Fourteen apterous specimens collected in Uberlândia were mounted on slides (adapted from Blackman & Eastop 2000) for morphometric analysis. Seven apterous specimens of *M. sacchari* kept on slides and collected on sugarcane in the city of Uberlândia on 15/V/2009 (Fazenda do Glória, 18°56'54.713'' S, 48°13'2.616'' W, 3 individuals), and 18/VI/2009 (Agroteste, 18°53'31.560'' S, 48°8'24.684'' W, 4 individuals) were used as standards. Insects kept on slides had the lengths of the processus terminalis (pt), cauda, siphunculi (siph) and hind tibia (ht) (Fig. 1) measured using a digital camera for microscopy (ScopeTek® model DCM 130). The softwares Scope Photo® and Mini See® were used to determine length. The measurements were used to calculate pt:cauda, pt:siph and ht:pt ratios, the three reliable ratios to identify *M. sacchari* compared to *M. sorghi*, according to Nibouche et al. (2021). The mummies were individualized in plastic centrifuge tubes (5mL) and kept in the laboratory until the emergence of the parasitoids. The emerged insects were kept in 70% alcohol for later identification. Primary parasitoids were identified according to Tomanović et al. (2014) and Santos et al. (2019). The genera of the hyperparasitoids were identified according to Powell (1982).

When analyzing the pt:cauda, pt:siph and ht:pt ratios of *M. sacchari* from Uberlândia (Tab. 1), we observed that the lower limit of pt:cauda was lower than that described for this species, and that the upper limit was higher than that of *M. sorghi* according to what was found by Nibouche et al. (2021). The pt:siph and ht:pt ratios were

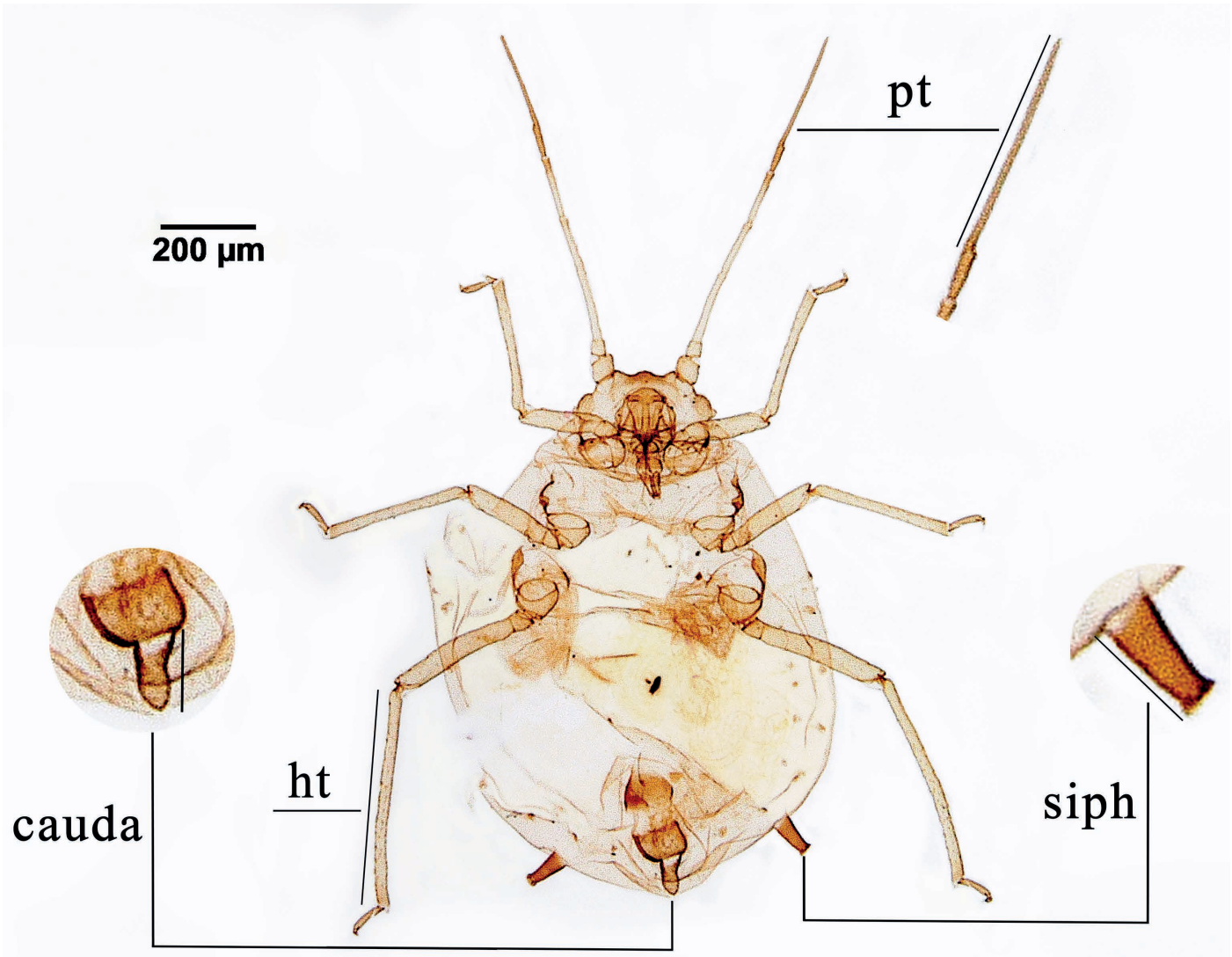

Figure 1. *Melanaphis sacchari* (Zehntner, 1897): pt - processus terminalis; siph - siphunculi; ht - hind tibia. Source: specimen number 1027 from the Aphid Collection (Coleafis) of the Department of Ecology and Evolutionary Biology (DEBE) of Federal University of São Carlos, São Paulo state, Brazil. Aphid collected on sugarcane (January, 03 of 2012), in Ribeirão Preto city, São Paulo state, Brazil.

Table 1. Length (µm) of morphological characters and ratios (unitless) of apterous females (mean values, with range under brackets) of *Melanaphis sacchari* and *M. sorghi* according to Nibouche et al. (2021), and for *M. sacchari* and *M. sorghi* collected in Uberlândia, Minas Gerais, Brazil, on sugarcane and sorghum, respectively.

Length or ratio	Nibouche et al. (2021)		Uberlândia	
	M. sacchari	*M. sorghi*	*M. sacchari*	*M. sorghi*
pt	308 (258-359)	294 (207-345)	328 (296-345)	268 (234-297)
cauda	126 (96-151)	147 (103-180)	143 (129-159)	130 (111-152)
siph	95 (67-123)	108 (77-130)	126 (100-146)	94 (81-122)
ht	530 (413-628)	585 (419-707)	649 (582-701)	489 (428-587)
pt:cauda	2.46 (2.19-2.8)	2.02 (1.72-2.35)	2.30 (2.06-2.54)	2.07 (1.79-2.29)
pt:siph	3.33 (2.71-4.28)	2.75 (2.26-3.19)	2.63 (2.28-2.95)	2.86 (2.21-3.19)
ht:pt	1.73 (1.54-1.93)	2.00 (1.8-2.31)	1.98 (1.89-2.06)	1.83 (1.69-2.17)

pt - processus terminalis length; cauda - cauda length; siph - siphunculi length; ht - hind tibia length; pt:cauda - ratio processus terminalis length/cauda length; pt:siph - ratio processus terminalis length/siphunculi length; ht:pt - ratio hind tibia length/processus terminalis length

not compatible with what was described for this species. Conversely, they were within the lower and upper limits described by Nibouche et al. (2021) for *M. sorghi*. *Melanaphis sorghi* pt:cauda and pt:siph ratios (Tab. 1) were compatible for this species, although the lower limit of pt:siph was slightly lower than that described by Nibouche et al. (2021). The lower limit of the ht:pt ratio of *M. sorghi* (Tab. 1) was a little lower than that found for this species by Nibouche et al. (2021). However, the upper limit was higher than that of *M. sacchari*, being compatible to what was described for *M. sorghi*.

According to Nibouche et al. (2021), the morphological identification of *M. sacchari* and *M. sorghi* is difficult, but it is possible by comparing the pt:cauda, pt:siph and ht:pt ratios of a set of aphids, and is not indicated for the identification of an individual separately. In general, only by the pt:cauda ratio it was possible to identify the individuals of *M. sacchari* and *M. sorghi* from Uberlândia, comparing with the morphometric results indicated by Nibouche et al. (2021). Individuals of *M. sorghi* from Uberlândia presented pt:cauda, pt:siph, and ht:pt ratios compatible with those described for this species by Nibouche et al. (2021). Although specimens collected on sugarcane in Uberlândia one month before (IV/16/2009) than those used in the present work were identified by molecular and morphological techniques as *M. sacchari* (Nibouche et al. 2014; 2021), and were used for the

morphometric analyzes by Nibouche et al. (2021), the individuals of *M. sacchari* from Uberlândia used in this study did not have similar pt:siph and ht:pt ratios than those described for *M. sacchari*.

One species of primary parasitoid and two species of hyperparasitoid were obtained from the mummies of *M. sorghi*. The primary parasitoid *Aphidius platensis* (Brèthes, 1913) (Hymenoptera: Braconidae, Aphidiinae) emerged from the mummies of two of the three sites of Uberlândia and of Sete Lagoas. In Uberlândia, two females were collected in the Capim Branco farm, and 59 females and 46 males were obtained from sorghum plants cultivated within the urban perimeter, in a total of 61 females and 46 males. Eleven females and 8 males of *A. platensis* were collected in Sete Lagoas. The hyperparasitoids *Syrphohagus* sp. (10 females and 5 males from the Glória farm) and *Pachyneuron* sp. (1 female and 2 males – Capim Branco, and 1 female – Glória) emerged from the mummies of *M. sorghi* from Uberlândia.

The parasitoid *A. platensis* is a cosmopolitan species, and probably has a Mediterranean origin (Tomanović et al. 2014). Problems in identifying *A. platensis* make it difficult to determine its host range and geographic distribution. This aphid parasitoid is part of the three species complex called *Aphidius colemani* species group, comprised of *A. colemani* (Viereck, 1912), *Aphidius transcaspicus* (Telenga, 1958), and *A. platensis* (Tomanović et al. 2014). Despite the numerous mentions of *A. colemani* in Brazil and South America (Starý et al. 2007), it is likely that the occurrences are of *A. platensis* (Tomanović et al. 2014). In fact, after the report of Tomanović et al. (2014), only *A. platensis* was reported in Brazil among the species that form the *A. colemani* species group (Souza et al. 2019; Santos et al. 2019; Venâncio et al. 2020; Engel et al. 2021).

There are reports of parasitoids occurring in *M. sorghi* on sorghum plants in North America; however, the authors treat them as *M. sacchari* or as *M. sacchari*/*sorghi* due to the difficult identification of these species (Colares et al. 2015; Bowling et al. 2016; Gárcia-Gonzáles et al. 2018; Rodríguez-del-Bosque et al. 2018; Lahiri et al. 2020; Mercer et al. 2020). However, if we take into account that there are no reports of large populations of *M. sacchari* on sorghum before 2013 in the Americas, the year of the occurrence of *M. sorghi* on the continent, it is likely that all sorghum records are of *M. sorghi*. Therefore, reports of parasitoids of *M. sacchari*, in large populations of this aphid species on sorghum plants after 2013 in North America, were considered as parasitoids of *M. sorghi* in the following paragraph discussion.

Under laboratory conditions, *A. colemani* as well as other parasitoids commercially used to control aphids in North America, *Aphelinus abdominalis* (Dalman, 1820) (Hymenoptera: Aphelinidae), *Aphidius ervi* (Haliday, 1834), and *Aphidius matricariae* (Haliday, 1834) were able to parasitize *M. sorghi* (Mercer et al. 2020). Under field conditions, at least two species of primary parasitoids and three species of hyperparasitoids were recorded in the American continent using *M. sorghi* as a host on sorghum plants. In Texas, United States, it was found in *M. sorghi* the primary parasitoids *Aphelinus* sp. (Hymenoptera: Aphelinidae), as the predominant species, and *Lysiphlebus testaceipes* (Cresson, 1988) with rare occurrences. In addition, the hyperparasitoid *Syrphophagus aphidivorus* (Mayr, 1876) (Hymenoptera: Encyrtidae) was also reported (Bowling et al. 2016). In this same country, but in Georgia, *L. testaceipes* was recorded occurring in greater numbers in greenhouses than in the field (Lahiri et al. 2020), and in Kansas, *Aphelinus* sp. was recorded in *M. sorghi* (Colares et al. 2015). Similarly, in Mexico, the primary parasitoids *Aphelinus* sp. and *L. testaceipes*, and the hyperparasitoids *Pachyneuron aphidis* (Bouché, 1834) (Hymenoptera: Pteromalidae) and *S. aphidivorus* were recorded in Tamaulipas (Rodríguez-del-Bosque et al. 2018). In addition, *Aphelinus varipes* (Förster, 1841) and *L. testaceipes*, primary parasitoids, and *S. aphidivorus*, *P. aphidis* and *Alloxysta* sp. (Hymenoptera: Figitidae), hyperparasitoids, were recorded in Coahuila (Gárcia-Gonzáles et al. 2018). Hence, this is the first occurrence of *A. platensis* parasitizing *M. sorghi* in Brazil.

The occurrence of *A. platensis* in Brazil, and other parasitoid species in the USA and Mexico parasitizing *M. sorghi* contributes to the development of integrated management programs for this aphid, considered a new pest introduced in the American continent.

Acknowledgments

We thank CAPES for a master's degree fellowship (second author). We also thank Dr. Alexandre Kannebley de Oliveira, from the Federal University of São Carlos, for allowing us to use the image of *Melanaphis sacchari*, which was obtained due to the financial support of FAPESP (Process number 11/50213-5).

Authors' Contributions

RFD, SMM and GSA collected the insects in the field. RFD and MVS made the identification of aphid, parasitoid and hyperparasitoid species. MVS, RFD, SMM and GSA proposed and wrote the manuscript.

Conflict of Interest Statement

All authors declare that they have no conflicts of interest.

References

Blackman, R. L.; Eastop, V. F. (2000) *Aphids on the World's Crops: An Identification and Information Guide*. 2nd ed. Chichester: John Wiley and Sons.

Bowling, R. D.; Brewer, M. J.; Kerns, D. L.; Gordy, J.; Seiter, N.; Elliott, N. E.; Buntin, G. D.; Way, M. O.; Royer, T. A.; Biles, S.; Maxson, E. (2016) Sugarcane aphid (Hemiptera: Aphididadae): a new pest on sorghum in North America. *Journal of Integrated Pest Management*, 7(1): 1-13. doi: 10.1093/jipm/pmw011

Colares, F; Michaud, J. P; Bain, C. L; Torres, J. B. (2015) Recruitment of aphidophagous arthropods to sorghum plants infested with *Melanaphis sacchari* and *Schizaphis graminum* (Hemiptera: Aphididae). *Biological Control*, 90: 16-24. doi: 10.1016/j.biocontrol.2015.05.009

Costa, C. L.; Eastop, V. F.; Costa, A. S. (1972) A list of the aphid species (Homoptera: Aphidoidea), Collected in Sao Paulo, Brazil. *Revista Peruana de Entomologia*, 15(1): 131-134.

Engel, E.; Lau, D.; Godoy, W. A. C.; Pasini, M. P. B.; Malaquias, J. B.; Santos, C. D. R.; Pivato, J.; Pereira, P. R. V. da S. (2021) Oscillation, synchrony, and multi-factor patterns between cereal aphids and parasitoid populations in southern Brazil. *Bulletin of Entomological Research*, First View: 1-8. doi: 10.1017/S0007485321000729

Fernandes, F. O.; Souza, C. da S. F.; Avellar, G. S. de; Nascimento, P. T.; Damasceno, N. C. R.; Santos, N. M. dos; Lima, P. F.; Santos, V. M. C. dos; Simeone, M. L. F.; Parrella, R. A. da C., et al. (2021) Manejo do pulgão da cana-de-açúcar (*Melanaphis sacchari/sorgh*i) na cultura do sorgo. *Sete Lagoas: Embrapa Milho e Sorgo*, Comunicado Técnico, 249: 1-24.

Gárcia-Gonzáles, F.; Ramírez-Delgado, M.; Cortez-Madrigal, H.; Ramírez-Ahuja, M. L. (2018) New Reports of Parasitoids and Hyperparasitoides of *Melanaphis sacchari* (Zehntner) in México. *Southwestern Entomologist*, 43(3): 787-790. doi: 10.3958/059.043.0324

Harris-Shultz, K.; Armstrong, J.S.; Carvalho, G., Jr.; Segundo, J.P.; Ni, X. (2022) *Melanaphis sorghi* (Hemiptera: Aphididae) clonal diversity in the United States and Brazil. *Insects*, 13(416): 1-8. doi: 10.3390/insects13050416

Lahiri, S.; Ni, X.; Buntin, G. D.; Toews, M. D. (2020) Parasitism of Melanaphis sacchari (Hemiptera: Aphididae) by Lysiphlebus testaceipes (Hymenoptera: Braconidae) in the Greenhouse and Field. *Journal of Entomological Science*, 55(1): 14-24. doi: 10.18474/0749-8004-55.1.14

Mendes, S. M.; Viana, P. A.; Oliveira, I. R. de; Menezes, C. B. de; Waquil. J. M.; Tompson, W. (2019) Pulgão-da-cana-de-açúcar no sorgo: um velho conhecido, mas um novo problema! *Grão em Grão, Embrapa, Sete Lagoas*, 13(112).

Mendes, S. M.; Waquil, J. M.; Rodrigues, J. A. S.; Sampaio, M. V.; Viana, P. A. (2014) Manejo de pragas na cultura do sorgo. *Informe Agropecuário*, 35(278): 89-99.

Mercer, N. H.; Bessin, R. T.; Obrycki, J. J. (2020) Parasitization of the

sugarcane aphid, *Melanaphis sacchari*, by commercially available aphid parasitoids. *BioControl*, 66: 181-191. doi: 10.1007/s10526-020-10051-w

Nibouche, S.; Costet, L.; Holt, J. R.; Jacobson, A.; Pekarcik, A.; Sadeyen, J.; Armstrong, J. S.; Peterson, G. C.; McLaren, N.; Medina, R. F. (2018) Invasion of sorghum in the Americas by a new sugarcane aphid (*Melanaphis sacchari*) superclone. *PLoS ONE*, 13(4). doi: 10.1371/journal.pone.0196124

Nibouche, S.; Costet, L.; Medina, R. F.; Holt, J. R.; Sadeyen, J.; Zoogones, A. S.; Brown, P.; Blackman, R. L. (2021) Morphometric and molecular discrimination of the sugarcane aphid, *Melanaphis sacchari*, (Zehntner, 1897) and the sorghum aphid *Melanaphis sorghi* (Theobald, 1904). *PLoS ONE*, 16(3). doi: 10.1371/journal.pone.0241881

Nibouche, S.; Fartek, B.; Mississipi, S.; Delatte, H.; Reynaud, B.; Costet, L. (2014) Low Genetic Diversity in *Melanaphis sacchari* Aphid Populations at the Worldwide Scale. *PLos ONE*, 9(8). doi: 10.1371/journal.pone.0106067

Powell, W. (1982) The identification of hymenopterous parasitoids attacking cereal aphids in Britain. *Systematic Entomology*, 7(4): 465-473. doi: 10.1111/j.1365-3113.1982.tb00457.x

Rodríguez-del-Bosque, L. A.; Rodríguez-Vélez, B.; Sarmiento-Cordero, M. A.; Arredondo-Bernal, H. C. (2018) Natural Enemies of *Melanaphis sacchari* on Grain Sorghum in Northeastern Mexico. *Southwestern Entomologist*, 43(1): 277-279. doi: 10.3958/059.043.0103

Santos, C. D. R. D.; Sampaio, M. V.; Lau, D.; Redaelli, L. R.; Jahnke, S. M.; Pivato, J.; Carvalho, F. J. (2019) Taxonomic Status and Populations Oscillations of *Aphidius colemani* Species Group (Hymenoptera: Braconidae) in Southern Brazil. *Neotropical Entomology*, 48: 983-991. doi: 10.1007/s13744-019-00716-2

Souza, I. L.; Tomazella, V. B.; Santos, A. J. N.; Moraes, T.; Silveira, L. C. P. (2019) Parasitoids diversity in organic Sweet Pepper (*Capsicum annuum*) associated with Basil (*Ocimum basilicum*) and Marigold (*Tagetes erecta*). *Brazilian Journal of Biology*, 79(4): 603-611. doi: 10.1590/1519-6984.185417

Starý, P.; Sampaio, M. V.; Bueno, V. H. P. (2007) Aphid parasitoids (Hymenoptera, Braconidae, Aphidiinae) and their associations related to biological control in Brazil. *Revista Brasileira de Entomologia*, 51(1): 107-118. doi: 10.1590/S0085-56262007000100018

Tomanović, Ž.; Petrović, A.; Mitrović, M.; Kavallieratos, N. G.; Starý, P.; Rakhshani, R.; Rakhshanipour, M.; Popović, A.; Shukshuk, A. H.; Ivanović, A. (2014) Molecular and morphological variability within the *Aphidius colemani* group with redescription of *Aphidius platensis* Brethes (Hymenoptera: Braconidae: Aphidiinae). *Bulletin of Entomological Research*, 104(5): 552-565. doi: 10.1017/S0007485314000327

Venâncio, H.; Bianchi, R. A.; Lobato, T. O. S.; Sampaio, M. V.; Santos, J. C. (2020) Tritrophic interaction between the Mexican sunflower, the aphid *Aphis gossypii* and natural enemies in a greenhouse experiment. *Acta Scientiarum, Biological Sciences*, 42: e47120. doi: 10.4025/actascibiolsci.v42i1.47120