Revista Facultad Nacional de Agronomía Medellín
ISSN: 0304-2847
ISSN: 2248-7026
Facultad de Ciencias Agrarias - Universidad Nacional de Colombia

Pezzini, Cleder; Silva, Daniela da Costa e; Köhler, Andreas
Influence of temperature on the occurrence of *Myzus persicae* (Sulzer) (Hemiptera: Aphididae) parasitoids in tobacco crops in Rio Grande do Sul, Brazil
Revista Facultad Nacional de Agronomía Medellín,
vol. 72, no. 2, 2019, May-August, pp. 8801-8808
Facultad de Ciencias Agrarias - Universidad Nacional de Colombia

DOI: https://doi.org/10.15446/rfnam.v72n2.72192

Research article

http://www.revistas.unal.edu.co/index.php/refame

Revista Facultad Nacional de Agronomía

Influence of temperature on the occurrence of *Myzus persicae* (Sulzer) (Hemiptera: Aphididae) parasitoids in tobacco crops in Rio Grande do Sul, Brazil

UNIVERSIDAD NACIONAL DE COLOMBIA

Influencia de la temperatura en la ocurrencia de parasitoides de *Myzus persicae* (Sulzer) (Hemiptera: Aphididae) en cultivos de tabaco en Rio Grande do Sul, Brasil

doi: 10.15446/rfnam.v72n2.72192

Cleder Pezzini[1]*, Daniela da Costa e Silva[2] and Andreas Köhler[2]

ABSTRACT

The aphid *Myzus persicae* (Sulzer) (Hemiptera: Aphididae) is considered one of the main pests in tobacco crops. By knowing their natural enemies, such as parasitoid wasp, is the first step to develop management strategies for the biological control of the aphids using local agents. For the success of using this tool, it must be considered some environmental factors like thermal tolerance. Therefore, the objective of this work was to survey the occurrence of the parasitoids of *M. persicae* associated with tobacco crops in the state of Rio Grande do Sul, Brazil, as well as to evaluate the influence of temperature on the occurrence of these parasitoid species. During four crop seasons, tobacco leaves infested with aphids were collected in 42 cities of Rio Grande do Sul. The leaves with aphids were conditioned in plastic containers for ten days for later screening and verification of parasitoids' emergence. In total, 2963 individuals of two emerging species were sampled: 78% were *Aphidius colemani* Viereck (Hymenoptera: Braconidae), and 22% were *Praon volucre* (Haliday) (Hymenoptera: Braconidae). Among the 42 cities sampled, the occurrence of parasitoids was detected in 25 of them. Under the conditions of this study, it was confirmed the influence of the temperature on the populations of the parasitoids of *M. persicae.* Individuals of *P. volucre* occurred preferably in temperatures below 22 °C, unlike to *A. colemani*, which preferred higher temperatures, above 22 °C, showing a different thermal tolerance between both species.

Keywords:
Aphids
Aphidius colemani
Nicotiana tabacum
Parasitoid
Praon volucre
Temperature

RESUMEN

El pulgón *Myzus persicae* (Sulzer) (Hemiptera: Aphididae) es considerado una de las principales plagas en cultivos de tabaco. Conocer sus enemigos naturales, como las avispas parasitoides, es el primer paso para desarrollar estrategias de manejo para el control biológico de los pulgones utilizando agentes locales. Para el éxito en la utilización de esta herramienta, se debe tener en cuenta algunos factores ambientales como la tolerancia térmica. En ese sentido, este trabajo tuvo como objetivo realizar una evaluación de la ocurrencia de los parasitoides de *M. persicae* asociados al cultivo del tabaco en el estado de Rio Grande do Sul, Brasil, así como, evaluar la influencia de la temperatura en la ocurrencia de estas especies parasitoides. Durante cuatro temporadas de cultivo, se realizaron colectas de hojas de tabaco infestadas con pulgones en 42 ciudades de Rio Grande do Sul. Las hojas con pulgones fueron acondicionadas en recipientes plásticos por diez días, para posterior identificación y verificación de la emergencia de los parasitoides. Se muestrearon un total de 2963 individuos emergidos, de dos especies: 78% a *Aphidius colemani* Viereck (Hymenoptera: Braconidae) y 22% a *Praon volucre* (Holiday) (Hymenoptera: Braconidae). De las 42 ciudades muestreadas, se detectó la presencia de parasitoides en 25 de ellas. En las condiciones en que se realizó el estudio, se constató que la temperatura ejerció influencia directa sobre las poblaciones de parasitoides de *M. persicae*. Los individuos de *P. volucre* ocurrieron preferentemente en temperaturas inferiores a los 22 °C, a diferencia de *A. colemani*, que presentaron preferencia por temperaturas mayores a los 22 °C, observándose una tolerancia térmica diferente entre las dos especies.

Palabras clave:
Áfidos
Aphidius colemani
Nicotiana tabacum
Parasitoide
Praon volucre
Temperatura

[1] Departamento de Fitossanidade. Universidade Federal do Rio Grande do Sul- UFRGS. 7712 Avenida Bento Gonçalves. CEP 91540-000, Porto Alegre, Rio Grande do Sul, Brazil.
[2] Departamento de Biologia e Farmácia. Universidade de Santa Cruz do Sul - UNISC. 2293 Avenida Independência. CEP 96816-501, Santa Cruz do Sul, Rio Grande do Sul, Brazil.
* Corresponding author: <cleder.pezzini@hotmail.com>

Received: May 15, 2018; Accepted: November 24, 2018
Rev. Fac. Nac. Agron. Medellín 72(2): 8801-8808. 2019
ISSN 0304-2847 / e-ISSN 2248-7026

Tobacco (*Nicotiana tabacum* L. Solanaceae) is cultivated for commercial purposes worldwide. In Brazil, its production is concentrated in the South region, and the state of Rio Grande do Sul has the largest planted area (dos Santos *et al*., 2017). This crop has great economic importance in the region due to the high commercial value and the capacity to employ a large number of people in both cultivation and industrialization (de Carvalho *et al*., 2014).

Brazil is now the second largest producer of tobacco leaves, after China, and has maintained a global leadership in export for two decades (Kist, 2014). On average, 85% of the Brazilian crop is shipped to more than a hundred countries in all continents (dos Santos *et al*., 2017).

During the vegetative development of tobacco's field, its leaves can be attacked by a range of pest insects, among them aphids of the *Myzus persicae* (Sulzer) (Hemiptera: Aphididae) species, which are one of the most important pests due to a negative interference with the production and quality of tobacco (Kanavaki *et al*., 2006; Burrack, 2015). This insect presents a high reproductive capacity and dispersion. It can settle in the crop in a short time, causing serious damage by the continuous sucking of the sap and transmission of diseases (Backer *et al*., 2015).

There is a lack of information regarding the level of damage caused by *M. persicae* to tobacco crops. The only data available are for the state of North Carolina, USA, which vary according to the stage of the crop development and whether, or not, viral diseases are considered endemic (Davis and Nielsen, 1999). According to the same source, the level of damage is characterized when 10% of the plants present at least 50 aphids in a leaf from the apical half to the pruning and 20% after, being lower in regions where the virus transmission by *M persicae* is recognized.

Currently, the control strategies for *M. persicae* depend on chemical products in Brazil. However, the indiscriminate use of such substances has diminished their efficiency mainly due to the emergence of a resistant population (Carvalho and Barcellos, 2012). One of the alternatives for the management of aphids is the implementation of biological control using natural enemies, such as parasitoid wasps, chiefly representatives of the Braconidae family, which are important agents of aphids' natural mortality in agricultural and natural environments (Cruz, 2007).

The knowledge about the occurrence of these agents of biotic mortality as well as their distribution in areas of the Neotropical region is fundamental (da Silva and de Brito, 2015). Such knowledge establishes the necessary bases for their importance to biological control studies using these organisms as a pest management tool (González and Burgos, 1997).

Environmental factors such as temperature may act positively or negatively on biological aspects of parasitoids (de Conti *et al*., 2010). According to this environmental factor, the success of biological control is directly related to the tolerance of natural enemies to temperature. It is possible that, for the control of a particular pest species, several species of parasitoids or individuals of the same species are needed; however, they can be adapted to different climatic conditions (Messenger and van den Bosch, 1971). Adaptability to climatic conditions is among the key factors influencing the success of parasitoids in biological control programs (Nascimento, 2011).

Thus, the objective of this work was to survey the occurrence of the parasitoids of *M. persicae* associated with the tobacco crop in Rio Grande do Sul, Brazil, as well as to evaluate the influence of temperature on the occurrence of parasitoid species.

MATERIALS AND METHODS

The survey of the parasitoids of *M. persicae* in Virginia tobacco was carried out during 2010, 2011, 2012, and 2013, where seasons lasted from October to December of each year. The main tobacco producing regions in Rio Grande do Sul were visited, totaling 42 cities (Table 1). The visited crops were managed conventionally using synthetic products such as fertilizers, herbicides, fungicides and insecticides throughout the growing process.

The methodology outlined by Kavallieratos *et al*. (2005) was adapted to this study. There was not set an experimental design, and tobacco leaves attacked by *M. persicae*, with different levels of infestation, were collected randomly.

Table 1. Cities of Rio Grande do Sul where tobacco leaf collections with infestations of *M. persicae* were carried out in each season to verify the occurrence of its parasitoids.

Crop	Cities
2010	Agudo; Cerro Branco; Paraiso do Sul; Vera Cruz
2011	Agudo; Anta Gorda; Arroio do Tigre; Arvorezinha; Candelária; Casca; David Canabarro; Dr. Ricardo; Estrela Velha; Gramado Xavier; Muçum; Paraíso do Sul; Relvado; Segredo; Sinimbu; Sobradinho; Venâncio Aires; Vera Cruz; Vespasiano Corrêa
2012	Amaral Ferrador; Barão do Triunfo; Camaquã; Canguçu; Cerro Grande do Sul; Chuvisca; Dom Feliciano; Forquetinha; Herval; Herveiras; Novo Cabrais; Passo do Sobrado; Pelotas; Piratini; Santa Cruz do Sul; Santa Tereza; São Jeronimo; São Lourenço do Sul; Sério; Sertão Santana; Sinimbu; Vale do Sol; Venâncio Aires; Vera Cruz
2013	Arroio do Tigre; Herveiras; Sinimbu; Vale do Sol; Venâncio Aires; Vera Cruz

The leaves were then stored in plastic bags and sent to the Laboratory of Entomology of the University of Santa Cruz do Sul (UNISC), where they were cut into squares (3×3 cm), without accounting for the density of aphids in them. The material was conditioned in plastic containers (9.5 cm long × 7 cm wide × 5 cm deep), acclimatized at 26±2 °C for 10 d for further screening and verification of parasitoids emergence.

The emerged parasitoids were identified at a species level according to Wharton *et al*. (1997) and Kavallieratos *et al*. (2001). Dr. Marcus Vinicius Sampaio, professor of the Federal University of Uberlândia, confirmed the identification of the specimens. Subsequently, the material was collected and stored in alcohol (70%) at the Entomological Collection of Santa Cruz do Sul (SESC).

In addition to the survey of the parasitoid occurrence, a correlation was made between the parasitoid species found and the temperature (°C) of the cities. For this purpose, the average temperature of spring was considered according to data obtained from Climate-Data.Org (2017). This temperature was used because it is the period of planting, flowering, and the emergence of tobacco in the South region of Brazil, and consequently it represents a higher incidence of aphids.

For the correlation analysis between the occurrence of parasitoids and the temperature, the data of the cities only were used when ten or more parasitoids emerged from the collected aphids during all the crop seasons. As the sample number was different in each city and season, the total proportion of individuals in each site was considered.

The distribution map of the cities visited was plotted using the CorelDRAW® X7. The regression models were constructed using SigmaPlot 11.0 software (SigmaPlot, 2008).

RESULTS AND DISCUSSION

During the four crop seasons studied, 2963 parasitoids emerged from *M. persicae*, of which 2305 (78%) were *Aphidius colemani* Viereck (Hymenoptera: Braconidae) and 659 (22%) corresponded to *Praon volucre* (Haliday) (Hymenoptera: Braconidae). Among the 42 cities visited, there was the occurrence of parasitoids in 25 of them (Figure 1). Summing up the data of the four seasons, *P. volucre* was the most abundant species in 13 cities and *A. colemani* in 12 (Table 2). The low occurrence of parasitoids or their absence in some cities can be justified by the small sample in some of them, either by not locating crops infested with aphids or due to the excessive use of chemical agents on the crops.

Silva *et al.* (2012) had already reported the occurrence of these parasitoid species in tobacco in Rio Grande do Sul. According to a bibliographical survey, *A. colemani* came from the Mediterranean and Central Asian regions. Since 1992, it has been marketed in several countries for the control of aphids in protected crops (van Lenteren, 1997). In the past, it was successfully used in southern Brazil to control wheat aphids (Gassen and Tambasco, 1983), adapting to the climatic conditions. *Aphidius colemani* is considered a dominant species among those found in aphids in South America and presents a high potential as a biological control agent (Sampaio *et al*., 2007), corroborating the results of this study.

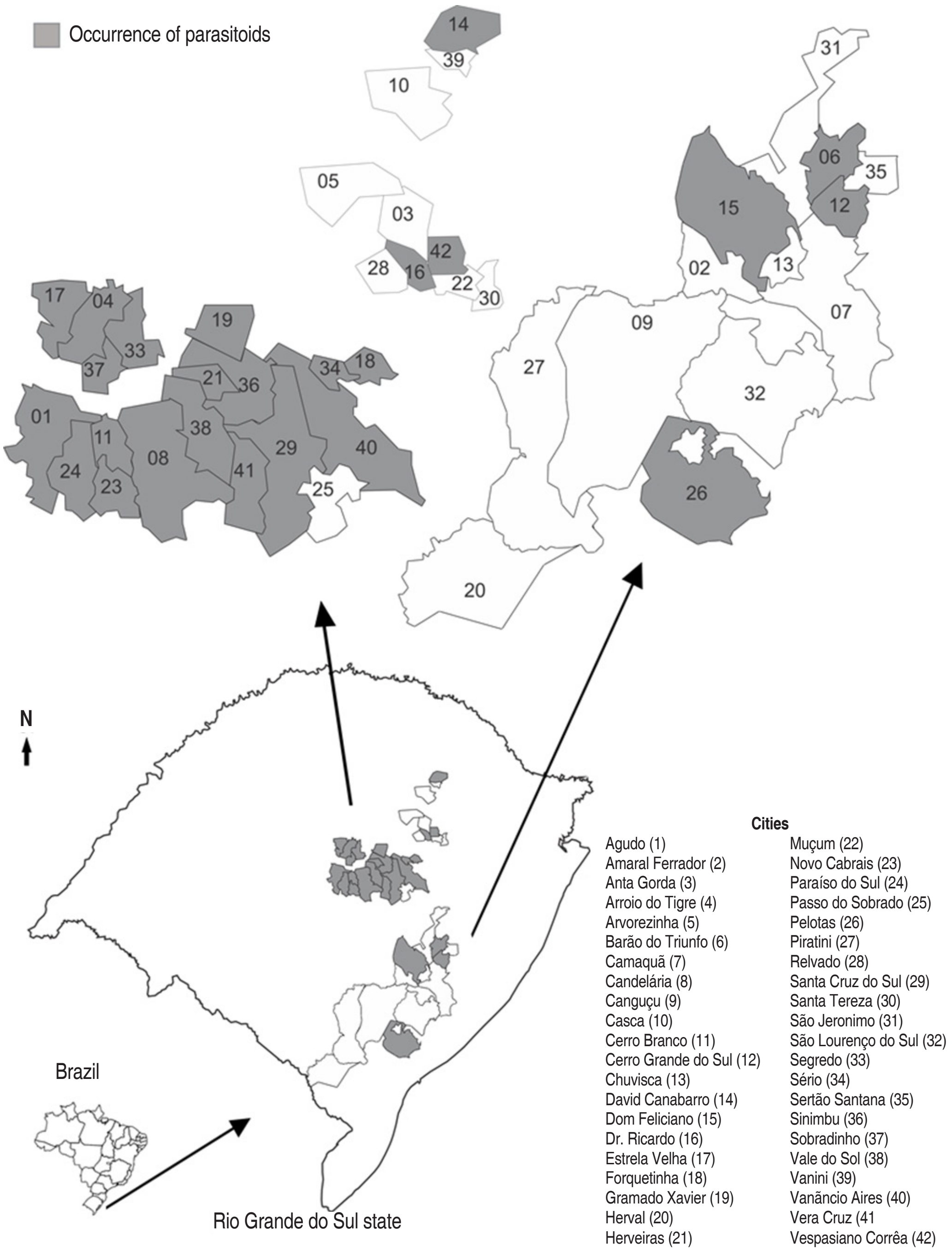

Figure 1. Cities in Rio Grande do Sul state where the surveys were carried out, highlighting the sites where there were occurrences of the parasitoids of *M. persicae* in tobacco crops.

Table 2. Number of parasitoids sampled in the cities of Rio Grande do Sul during four tobacco crop seasons.

Temp. (°C)	Cities	Crop				Total	
		2010	2011	2012	2013	*A. colemani*	*P. volucre*
18.5	David Canabarro	-	12	-	-	4	8
18.8	Sério	-	-	5	-	0	5
18.9	Vespasiano Corrêa	-	3	-	-	3	0
19.1	Dr. Ricardo	-	1	-	-	1	0
19.4	São Lourenço do Sul	-	-	10	-	0	10
19.5	Herveiras	-	-	184	137	120	201
19.7	Dom Feliciano	-	-	2	-	2	0
20.0	Gramado Xavier	-	5	-	-	5	0
20.4	Estrela Velha	-	116	-	-	0	116
20.5	Barão do Triunfo	-	-	3	-	1	2
20.6	Segredo	-	1	-	-	0	1
20.6	Sobradinho	-	17	-	-	0	17
20.7	Arroio do Tigre	-	10	-	4	2	12
20.7	Cerro Grande do Sul	-	-	5	-	0	5
21.9	Sinimbu	-	0	171	16	26	161
21.9	Vale do Sol	-	-	24	26	13	37
22.0	Agudo	2	0	-	-	0	2
22.0	Cerro Branco	25	-	-	-	9	16
22.0	Forquetinha	-	-	3	-	0	3
22.1	Santa Cruz do Sul	-	-	478	-	478	0
22.2	Candelária	-	84	-	-	82	2
22.2	Novo Cabrais	-	-	34	-	34	0
22.2	Paraíso do Sul	94	0	-	-	93	1
22.2	Venâncio Aires	-	0	525	9	522	12
22.2	Vera Cruz	0	0	838	119	907	50

- No collected tobacco leaves attacked by *M. persicae* in this year.

On the other hand, endoparasitoid *P. volucre*, of Palearctic origin, was also introduced in Brazil for the control of wheat aphids, establishing itself and becoming part of the group of parasitoids with potential use as control agents of different aphid species in different crops (de Conti *et al*., 2008). Nowadays, *Praon volucre* is a cosmopolitan species of great importance for several crops, both in field conditions and in protected environments in Brazil (Silva *et al*., 2008). It may be related to the adaptation of the species to the different climatic conditions of each region.

In Greece, Kavallieratos *et al.* (2005) support that *A. colemani* and *Diaeretiella rapae* (M'Intosh) (Hymenoptera: Braconidae) are the principal parasitoid species of *M. persicae* in tobacco. In contrast, Kavallieratos *et al.* (2004) found that *P. volucre* was the dominant parasitoid species of *M. persicae* in a different tobacco growing area of Greece, whereas *D. rapae* was not recorded in that area. According to Starý (1970), interspecific relations are influenced by the geographical distribution of parasitoids which also affects their occurrence.

With respect to the proportion of individuals in each municipality and the average temperature in spring, a correlation for temperature with respect to the proportion of *P. volucre* was verified (r^2=0.92), that is, with the increase in temperature, there was a proportional decrease in the number of individuals of this species (Figure 2). For the occurrence of *A. colemani*, there was a correlation in which the proportional incidence of individuals of this species increased at higher temperatures (r^2=0.84)(Figure 3).

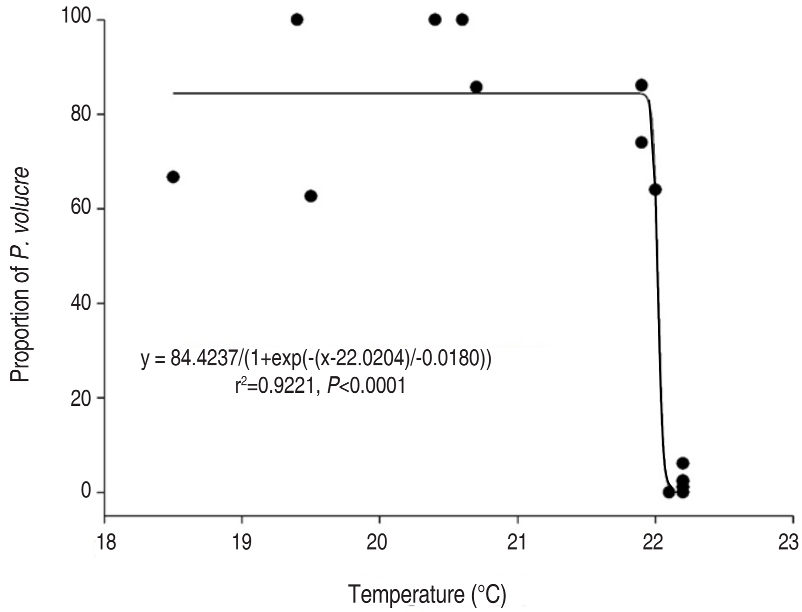

Figure 2. Correlation between the proportion of *P. volucre* emerged from *M. persicae* according to the different spring average temperatures of each city.

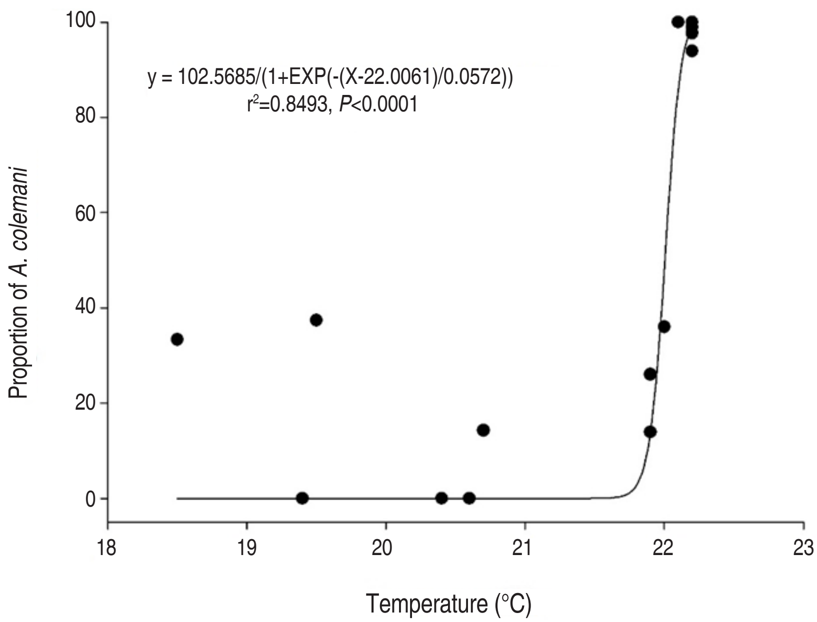

Figure 3. Correlation between the proportion of *A. colemani* emerged from *M. persicae* according to the different spring average temperatures of each city.

The results demonstrate that *P. volucre* presents a greater predominance in cities with average temperatures in spring equal to or lower than 22 °C (Figure 2). These results were also observed in the evaluation of the potential of *P. volucre* as an agent for the control of the aphids *Uroleucon ambrosiae* (Thomas) and *Macrosiphum euphorbiae* (Thomas) (Hemiptera: Aphididae) (de Conti *et al*., 2008; de Conti *et al*., 2010). High parasitism rates were observed at temperatures between 18 °C and 22 °C considering these climatic conditions favored mummification, emergence of parasitoids, and increasing in the longevity.

The parasitoid *A. colemani* presented predominance in cities with temperatures above 22 °C (Figure 3). This had also been observed by Zanini *et al*. (2006) in their study on aphids of the species *Sitobion avenae* (Fabricius) (Hemiptera: Aphididae), and by Sampaio *et al*. (2007) and Sampaio *et al*. (2005) in their work on the development of *A. colemani* at different temperatures and different climatic regions. The species presented a high emergence of individuals at temperatures above 22 °C, being possible to report emergence at even higher temperatures in some warmer regions.

The fact that *A. colemani* has a higher tolerance at high temperatures may explain its predominance in agricultural environments in the southern region of Brazil. Based on the literature, *A. colemani* is formed by a species group, which are important biological control agents: *A. colemani*, *Aphidius transcaspicus* Telenga, and *Aphidius platensis* Brethes. This diversity can have an impact on the plasticity of the species in different environmental conditions (Tomanovic´ *et al*., 2014). This type of study is important to know the thermal limits of each species of parasitoids in order to infer the species most adapted to each climatic situation that in the future could be more effective as a tool in integrated pest management.

CONCLUSIONS

Two species of parasitoids *A. colemani* and *P. volucre* were surveyed on tobacco farms in Rio Grande do Sul, Brazil parasitizing *M. persicae*, being possible to infer that there is a variation in the occurrence of these natural enemies according to temperature.

Under the conditions of this study, temperature exerted a direct influence on the populations of parasitoids of *M. persicae.* Individuals of *P. volucre* occurred preferably at temperatures below 22 °C, unlike to *A. colemani*, which had a clear preference for higher temperatures, above 22 °C, showing a different thermal tolerance between both parasitoid species.

Therefore, the results demonstrate that there is a possibility of using the natural enemies found for the control of *M. persicae* in tobacco growing in Rio Grande do Sul state.

ACKNOWLEDGEMENTS

The authors are grateful to the University of Santa Cruz Sul (UNISC) for the financial support, and the company Premium Tabacos do Brasil Ltda., for the technical support, field visits and financial support.

REFERENCES

Backer L, Wackers FL, Francis F and Verheggen FJ. 2015. Predation of the peach aphid *Myzus persicae* by the mired predator *Macrolophus pygmaeus* on sweet peppers: Effect of prey and predator density. Insects 6(2): 514-523. doi: 10.3390/insects6020514

Burrack H. 2015. Tobacco Insect Management. pp. 145-160. In: Fisher LR. (ed.). Flue-Cured Tobacco Guide. North Carolina Cooperative Extension Service, Raleigh. 199 p.

Carvalho NL and Barcellos AL. 2012. Adoção do manejo integrado de pragas baseado na percepção e educação ambiental. Revista Eletrônica em Gestão, Educação e Tecnologia Ambiental 5(5): 749-766. doi: 10.5902/223611704204

Climate-Data.Org. 2017. Climate data for world cities. In http://pt.climate-data.org/; accessed: December 2017.

Cruz I. 2007. Controle biológico de pragas na cultura de milho para produção de conservas (Minimilho), por meio de parasitoides e predadores. Circular Técnica 91. Embrapa Milho e Sorgo, Sete Lagoas, Brazil. 16 p.

da Silva AB and de Brito JM. 2015. Controle biológico de insetos-pragas e suas perspectivas para o futuro. Revista Agropecuaria Técnica 36(1): 248-258. doi: 10.25066/agrotec.v36i1.26306

Davis DL and Nielsen MT. 1999. Tobacco: Production, Chemistry and Technology. First edition. Blackwell Publishing, Oxford. 480 p.

de Carvalho C, Kist BB, dos Santos CE, Reetz ER and Drum M. 2014. Anuário do Tabaco. Editora Gazeta, Santa Cruz do Sul. 128 p.

de Conti BF, Bueno VHP and Sampaio MV. 2008. The parasitoid *Praon volucre* (Hymenoptera: Braconidae, Aphidiinae) as a potential biological control agent of the aphid *Uroleucon ambrosiae* (Hemiptera: Aphididae) on lettuce in Brazil. European Journal of Entomology 105(3): 485-487. doi: 10.14411/eje.2008.062

de Conti BF, Bueno VHP, Sampaio MV and Sidney LA. 2010. Reproduction and fertility table life of three aphids species (Macrosiphini) at different temperatures. Revista Brasileira de Entomologia 54(4): 654-660. doi: 10.1590/S0085-56262010000400018

dos Santos CE, Kist BB, Filter CF, de Carvalho C and Treichel M. 2017. Anuário brasileiro do Tabaco. Editora Gazeta, Santa Cruz do Sul. 128 p.

Gassen DN and Tambasco FJ. 1983. Controle biológico dos pulgões do trigo no Brasil. Informe Agropecuário 9(104): 49-51.

González HD and Burgos FAL. 1997. Gêneros de Braconidae (Hymenoptera) em Yucatan: algunos elementos para el plateamiento de patrones de riqueza. Acta Zoologica Mexicana 70: 65-77.

Kavallieratos NG, Lykouressis DP, Sarlis GP, Stathas GJ, Sanchis Segovia A and Athanassiou CG. 2001. The Aphidiinae (Hymenoptera: Ichneumonoidea: Braconidae) of Greece. Phytoparasitica 29(4): 306-340. doi: 10.1007/BF02981847

Kavallieratos NG, Athanassiou CG, Tomanović Ž, Papadopoulos GD and Vayias BJ. 2004. Seasonal abundance and effect of predators (Coleoptera: Coccinellidae) and parasitoids (Hymenoptera: Braconidae: Aphidiinae) on *Myzus persicae* (Hemiptera: Aphidoidea) densities on tobacco: a two-year study from Central Greece. Biologia 59(5): 613-619.

Kavallieratos NG, Athanassiou CG, Tomanović Ž, Sciarretta A, Trematerra P and Žikić V. 2005. Seasonal occurrence, distribution and sampling indices for *Myzus persicae* (Hemiptera: Aphidoidea) and its parasitoids (Hymenoptera: Braconidae: Aphidiinae) on tobacco. European Journal of Entomology 102(3): 459-468. doi: 10.14411/eje.2005.066

Kanavaki OM, Margaritopoulos JT, Katis NI, Skouras P and Tsitsipis JA. 2006. Transmission of *Potato virus Y* in tobacco plants by *Myzus persicae nicotianae* and *M. persicae* s.str. Plant Disease 90(6): 777-782. doi: 10.1094/PD-90-0777

Kist BB, dos Santos CE, de Carvalho C, Reetz ER, Müller I, Drum M and Beling RR. 2014. Pró-tabaco: Esse negócio não pode parar. Editora Gazeta, Santa Cruz do Sul. 52 p.

Messenger PS and van den Bosch R. 1971. The adaptability of introduced biological control agents. pp. 68-92. In: Huffaker CB. (ed.). Biological control. Springer, Boston. 511 p.

Nascimento JB. 2011. Fatores que afetam a liberação e a eficiência de parasitoides no controle biológico de insetos-praga. Enciclopédia Biosfera, Centro Científico Conhecer 7(13): 550-570.

Sampaio MV, Bueno VHP, Rodrigues SMM and Soglia MCM. 2005. Resposta à temperatura de *Aphidius colemani* Viereck (Hymenoptera, Braconidae, Aphidiinae) originário de três regiões climáticas de Minas Gerais, Brasil. Revista Brasileira de Entomologia 49(1): 141-147. doi: 10.1590/S0085-56262005000100016

Sampaio MV, Bueno VHP, Rodrigues SMM, Soglia MCM and Conti BF. 2007. Desenvolvimento de *Aphidius colemani* Viereck (Hymenoptera: Braconidae, Aphidiinae) e alterações causadas pelo parasitismo no hospedeiro *Aphis gossypii* Glover (Hemiptera: Aphididae) em diferentes temperaturas. Neotropical Entomology 36(3): 436-444. doi: 10.1590/S1519-566X2007000300012

SigmaPlot. 2008. Systat Software Inc. v. 11.0. Point Richmond, California.

Silva BD, Bueno VHP, Lins Junior JC and Sidney LA. 2008. Influência da temperatura na biologia de *Praon volucre* (Hymenoptera: Braconidae) em *Aulacorthum solani* (Hemiptera: Aphiididae). p. 410. In: Anais do XXII Congresso Brasileiro de Entomologia, Uberlândia.

Silva DC, Pezzini C and Kohler A. 2012. Levantamento de himenópteros parasitoides associados a afídeos (Hemiptera, Stenorrhyncha) no plantio de tabaco (*Nicotiana tabacum* L.) no Rio Grande do Sul, Brasil. In: Anais do XXIV Congresso Brasileiro de Entomologia, Curitiba.

Starý P. 1970. Biology of aphid parasites (Hymenoptera: Aphidiidae) with respect to integrated control. Series entomologica, 6. The Hague, Dr. W. Junk N.V., The Netherlands. 643 p.

Tomanovic´ Ž, Petrovic´ A, Mitrovic´ M, Kavallieratos NG, Starý P, Rakhshani E, Rakhshanipour M, Popovic´ A, Shukshuk AH and Ivanovic´ A. 2014. Molecular and morphological variability within the *Aphidius colemani* group with a redescription of *Aphidius platensis* Brethes (Hymenoptera: Braconidae: Aphidiinae). Bulletin of Entomological Research 104(5): 552-565. doi: 10.1017/S0007485314000327

van Lenteren JC. 1997. Biological control. pp. 77-103. In: van Lenteren JC. (ed.). Integrated pest management in protected cultivation. Agricultural University Wageningen, Wageningen. 339 p.

Wharton RA, Marsh PM and Sharkey MJ. 1997. Manual of the new world genera of the family Braconidae (Hymenoptera). The International Society of Hymenopterists, Washington. 439 p.

Zanini A, Alves LFA, Menezes Junior AdeO and Prestes TMV. 2006. Aspectos ecológicos de *Aphidius colemani* Viereck (Hymenoptera: Aphidiidae) sobre a população de *Sitobion avenae* (Fabricius) (Hemiptera: Aphididae) na cultura de trigo em Medianeira, PR. Semina: Ciências Agrárias 27(2): 185-198. doi: 10.5433/1679-0359.2006v27n2p185