

The use of *Polistes versicolor* (Olivier, 1971) in the control of *Ascia monuste orseis* (Godart, 1819) in kale cultivation

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Abstract

Social wasps have been successfully utilized as means of biological control, particularly for the larvae of Lepidoptera. *Ascia monuste orseis* causes devastating effects on the kale, inducing production losses of up to 100%, therefore, requiring stringent control measures. This work aimed testing the species *Polistes versicolor* as potential means of biological control of *A. monuste orseis*, during autumn and winter, when the kale crop shows good development. These experiments were conducted at the IFMG - Bambuí *Campus*, between May and June 2017, during which time four *P. versicolor* colonies were translocated to artificial shelters constructed in proximity to the kale crop, being registered daily the predation of the social wasp on like of *A. monuste orseis* caterpillars. The translocation of *P. versicolor* colonies onto the kale crop during the cold and drought seasons was shown to be ineffective in controlling the *A. monuste orseis* population. This was because this social wasp exhibited low foraging activity, and therefore a low degree of predation on the target pest; however, it became crucial to assess their activity during the hottest and most humid times of the year, as *P. versicolor* effectively preys upon the various species among the Lepidoptera.

Keywords: *Brassica oleracea*. Biological control. Lepidoptera. Social wasps.

Introduction

The social wasps (Hymenoptera: Vespidae) are usually included among the subfamilies Polistinae, Stenogastrinae and Vespinae, of which Polistinae alone comprises 343 species in Brazil (HERMES et al., 2017).

Significant as natural predators of pest insects, these social wasps are effective even in small populations and make substantial contributions towards controlling and reducing the peak times of infestation (PICANÇO et al., 2010). Lepidopteran larvae are among the preferred prey of social wasps (PREZOTO; MACHADO, 1999; BICHARA-FILHO et al., 2009; FREITAS et al., 2015). Some species of polistine wasps, particularly those of the genus *Polistes*, have already been employed in biological control programs in Brazil (PREZOTO; MACHADO, 1999; MARQUES, 2005; ELISEI et al., 2010).

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Kale (*Brassica oleracea* var. *acephala*), which belongs to the family Brassicaceae, is the largest among the oyster species, and it includes 14 vegetables. Besides the common cabbage (*B. oleracea* var. *capitata*), the others are cauliflower (*B. oleracea* var. *botrytis*), broccoli (*B. oleracea* var. *italica*) and mustard (*B. juncea*) (FILGUEIRA, 2000). The kale has its best development during the autumn and winter; however, it expresses a high degree of adaptability to varied climates (FILGUEIRA, 2000). Several lepidoptera also attack the kale, such as *Agrotis ipsilon* (Hufnagel, 1776) (Noctuidae), *Trichoplusia ni* (Hübner, 1803) (Noctuidae), *Ascia monuste orseis* (Godart, 1819) (Pieridae) e *Plutella xylostella* (L., 1758) (Plutellidae) (GALLO et al., 2002).

Ascia monuste orseis is one of the key pests of crops in the Neotropical region, mainly in Brazil (BITTENCOURT-RODRIGUES; ZUCOLOTO, 2009). As the caterpillars of this species devour the leaves, they cause great cultivation losses, which translate sometimes into as much as 100% production loss (VENDRAMIM; MARTINS, 1982).

Four or five days after the females of this pest oviposit the undersurface, most often, of the young leaves (BITTENCOURT-RODRIGUES; ZUCOLOTO, 2009), the caterpillars hatch out. During the first and second instars, they feed in the site where oviposition had occurred. However, the fourth and fifth instar caterpillars exhibit some degree of mobility and move to other leaves and sometimes even from one cultivar to another (BARROS-BELLANDA; ZUCOLOTO, 2003). The larval period extends for 20 to 25 days, after which the pupal stage lasts for a mean of 11 days (BITTENCOURT-RODRIGUES; ZUCOLOTO, 2009).

Ascia monuste orseis is mostly controlled by insecticide application, which can result in several problems, such as remaining as residues in food, mortality of natural enemies, poisoning to the applicators, and development of resistant pest populations. Thus, the use of agents of biological control is one method to minimizing the employment of these products. However, only one study is available, demonstrating the effectiveness of the social wasp *Polybia ignobilis* (Haliday, 1836) in the biological control of this pest (PICANÇO et al., 2010). Although there is no study of the specific relationship of the genus *Polistes* with this pest, it is recognized that wasps of this genus are excellent predators of agricultural pests, mainly Lepidoptera caterpillars (ELISEI et al., 2010).

The *Polistes versicolor* (OLIVIER, 1971) species in particular was selected as an agent of biological control for various reasons, as listed: a) availability of the predation records of this wasp on the lepidopteran caterpillars (MARQUES, 2005, ELISEI et al., 2010); b) as the dominant species in the IFMG - Bambuí *Campus* (JACQUES et al., 2015), which facilitates nest location; c) being a registered forage species on the kale culture (JACQUES et al., 2018); d) easy translocation of their nests (ELISEI et al., 2012), which enables them to accept the shelter; and e) wide distribution of this species across Brazil (BARBOSA et al., 2016), opening up opportunities to employ this methodology throughout the country.

The objective of this work, therefore, is to examine the effectiveness of the *P. versicolor* (Hymenoptera: Vespidae) found in the kale crop (*B. oleracea* var. *acephala*), on the biological control of *A. monuste orseis* (Lepidoptera: Pieridae), during the autumn and winter seasons, the time when this brassica crop develops well.

Material and methods

From May to June 2017, all the experiments were performed at the Federal Institute of Minas Gerais, Bambuí *Campus*, Bambuí, Minas Gerais, Brazil (20°02'16.1"S 46°00'28.6"W; 725.9 m), in a kale crop (*B. oleracea* var. *acephala*), and subjected to treatment with conventional cultivation practices (FILGUEIRA, 2000), without the pesticide application.

The experiment included two treatments: T1 - Kale planting with the *P. versicolor* wasp colonies and *A. monuste orseis* caterpillar infestation; T2 - Kale being planted without the wasp colonies and with *A. monuste orseis* caterpillar infestation. The second treatment was employed as a control, with which the mortality rate of the treatments with the wasp colonies and without them could be compared.

Each treatment was conducted in an area of 5.0 x 5.0 m, provided with 1.0 x 0,5 m spacing (FILGUEIRA, 2000), for a total of 5 rows containing 10 plants in each. The areas were 900 m apart, to ensure that the T1 treatment wasps did not consume the T2 treatment caterpillars. The longest return distance to the nest for the *P. versicolor* workers was established as 850 m (GOBBI, 1978).

In the T1 area, artificial wooden shelters, constructed using a 0.3 x 0.4 x 0.1 m sized board and attached to a deck of 1.8 m, were installed. In each shelter, a 0.13 x 0.17 x 0.11 m sized white plastic pot, open at the base alone, was installed, to offer protection against the rain and sun (ELISEI et al., 2012). The base of each batten, up to a height of around 0.50 m, was coated with burnt oil and grease, to protect against ant attacks (PREZOTO; MACHADO, 1999). Four such shelters were constructed at about one meter distance from the border of the crop.

Four *P. versicolor* colonies, with 32, 34, 21 and 14 wasps per nest, were identified and gathered from man-made constructions on *campus*, and, using the translocation method proposed by Elisei et al. (2012), the colonies were captured during the early hours of the night, when most of the wasps are in the nest (PREZOTO; MACHADO, 1999). After carefully bagging the colonies in a large plastic bag without destroying their peduncles, the wasps were separated from the nest. The wasps showed positive phototropism, moving immediately to the highest and brightest portion of the bag, facilitating their separation from the nest. Then, the colonies were immediately glued to the shelters by their peduncles, using cyanoacrylate ester glue or Super-Bonder® (Figure 1). The plastic bag containing the individuals was wrapped in the overnight shelter of the translocation and removed the next morning after all the wasps had flown away from it.

Figure 1 – The *Polistes versicolor* colony translocated to the artificial shelter.



Source: From de author (2018).

Once the nests were translocated, 30 numbers of the third and fourth instar larvae of *A. monuste orseis* were released at 7 o'clock in the morning, on five randomly selected kale plants, for both treatments T1 and T2, for fifteen days. In this experiment five plants corresponded to 10% of the total number of plants, demonstrating the degree of economic loss to the crop (PICANÇO et al., 2005). At 18 hours of the same day, the caterpillars were collected and the daily degree of predation was recorded for both treatments. As *P. versicolor* experiences a diurnal rhythm, the caterpillars were left undisturbed at night to minimize their death due to other factors. Daily observations were recorded between 11am and 1pm (and feeding was *ad libitum*), in order to confirm the cause of death of the *A. monuste orseis* caterpillars.

The *A. monuste orseis* were produced by first collecting the postures in the IFMG-BambuÍ garden. They were packed in 500 ml pots and brought to a B.O.D. with the temperature controlled at 25 ± 2 °C and a 12 h photoperiod. Fresh kale leaves were supplied daily to the caterpillars, until they reached the pupal stage. The pupae were transferred to a cage (2.5 x 2.5 x 2.5 m) in a greenhouse having 20 pots with kale seedlings for oviposition. The adults were fed with 10% honey and the new postures collected every day.

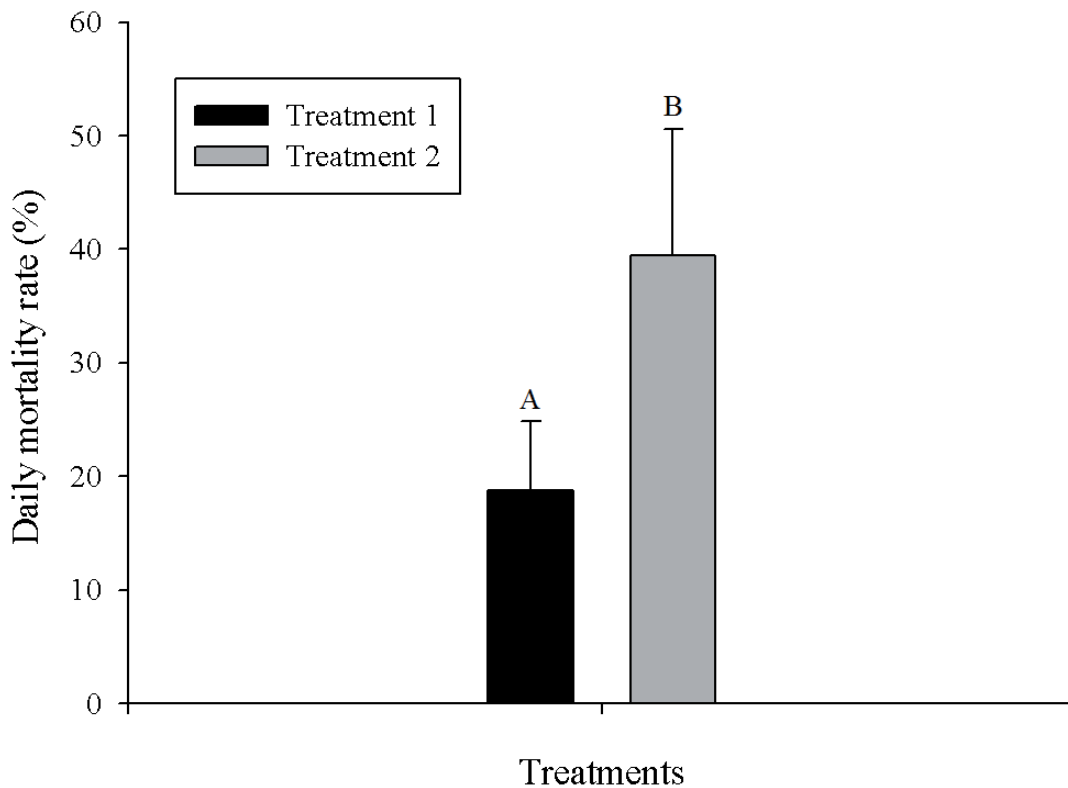
A comparison was made of the daily mortality rate between the two treatments and the means were compared using the T test at the 5% level of significance through the statistical program Past, v. 2.17c (HAMMER et al., 2005). The *P. versicolor* colonies were also closely tracked, and the number of individuals from the colonies was observed every day (PREZOTO; MACHADO, 1999). The colonies were then removed from the T1, 15 days after the experiment commenced and the predation each day was noted for another 15 days to record the effect of the treatment site on the final findings.

The findings recorded of the daily mortality rate were subjected to regression analyses, accounting for the variables of "daily temperature" and "relative air humidity", with $p < 0.05$ using the BioEstat 5.3 program (AYRES et al., 2007). Relative temperatures and humidities were determined from the Bambuí weather station, situated on the IFMG-BambuÍ Campus. Measurements were taken at nine and fifteen hours every day, and their means were utilized for the regression analyses.

Results and discussion

Treatment T1, involving the *P. versicolor* colonies, showed a value of 18.8% for the mean daily mortality rate of the *A. monuste orseis*. However, the T2 treatment, in the absence of the *P. versicolor* colonies, was statistically higher ($p = 0.001$), showing a mean value of 39.46% (FIGURE 2).

Figure 2 – Daily mortality rate (%) from day 1 to 15 of the experiment for Treatments (1), with the *P. versicolor* colonies, and (2), without the *P. versicolor* colonies.



Source: From de author (2018).

Translocations of social wasp nests can cause stress in the colony, leading to abandonment of the nest. The success of the translocation technique is considered by the presence of the individuals in the colonies at least five days after the transfer (ELISEI et al., 2012), and this occurs in about 60 to 85% of the cases (BUTGNOL, 1992; PREZOTO; MACHADO, 1999). In our study, the translocations of the colonies *P. versicolor* were completely successful and all four colonies remained unchanged throughout the experiment.

However, during the observation period, these colonies were only slightly active, with merely three predatory attacks by these wasps on *A. monuste orseis* being recorded. During the experiment, the mean temperature was 22°C and the mean relative humidity 62.2%. These values may have caused the decline in the foraging activity of *P. versicolor*, which is much greater under conditions of high light intensity and humidity and, particularly so at high air temperatures (ELISEI et al., 2010), decreasing between the months of May and September (ELISEI et al., 2013). The return of the *P. versicolor* workers to prey on the eucalyptus plantation during the cold and dry seasons is very minimal (ELISEI et al., 2010). Normally, the higher levels of temperatures, light intensity, humidity and air velocity favor the well being of the foraging of social wasps (DE CASTRO et al., 2011).

The foraging demand is likely stimulated by the climatic variables, as well as the biological needs of the colony (DETONI et al., 2015). When the experiment was concluded, the cells were empty, without eggs and larvae, indicating a probable abandonment of the colonies. Nests which

support a decreasing number of immature ones, also experience a drop in the food collection. The prey supplies protein essential for offspring growth and development; therefore, the quantity of prey captured using fodder is an indirect estimation of the number of immature wasps and, thus, the protein demand of the colony (CANEVAZZI; NOLL, 2011).

The foraging behavior pattern evident in *P. versicolor* is not directed by a queen or any other individual exerting control, but arises only based on the colony requirements (DE SOUZA; PREZOTO, 2012a). Although they lack a queen, the workers carry on the foraging activity (DE SOUZA; PREZOTO, 2012a). Aggressive behavior among the individuals induces exit foraging, reducing the number of workers as the needs of the colony decline (DE SOUZA; PREZOTO, 2012b). Besides, the return of workers which exhibit foraging is the main stimulus which initiates the activities within the colony (DE SOUZA; PREZOTO, 2012a).

Carbohydrates and proteins are amenable to storage within the cells for consumption at a later date, and form a good store of reserve for the unfavorable seasons (MICHELUTTI et al., 2017); this results in a reduction in the foraging activities. Such storage abilities have been recorded earlier for the colonies of *Polistes simillimus* Zikán, *Polybia paulista* (Von Lhering), *P. occidentalis*, *Mischocyttarus drewseni* (Saussure) and *Mischocyttarus cassununga* (Von Lhering) (MICHELUTTI et al., 2017). However, foraging activities for water are also observed to decline during the cold and dry seasons, as water is principally utilized in the colony for keeping it cool, a finding earlier reported for *P. versicolor* (ELISEI et al., 2013).

The foraging behavior of *P. versicolor* for plant fiber is also at a minimum during the cold and dry seasons, as this resource is mainly required during the demographic explosion phase within the colony, to building and expand the nest cells (ELISEI et al., 2010), although such activities are not noticeable in the translocated nests. Foraging for vegetable fibers occurs when the worker uses the jaw to shave the vegetal substrate, including stems, trunks or other such materials. This process takes place more easily when the substrate is moist, and the plant fibers are soft (ELISEI et al., 2010).

During the experiment, we observed that 90 to 100% of the mortality of *A. monuste orseis* was found as a result of predation by another social wasp, *Polybia ignobilis* (Haliday, 1836), for both treatments. This wasp, recognized as the main predator of *A. monuste orseis* (Picanço et al., 2010), was found in large number in T2 treatment, which did not have the colonies of *P. versicolor*, especially during the initial stages of the experiment.

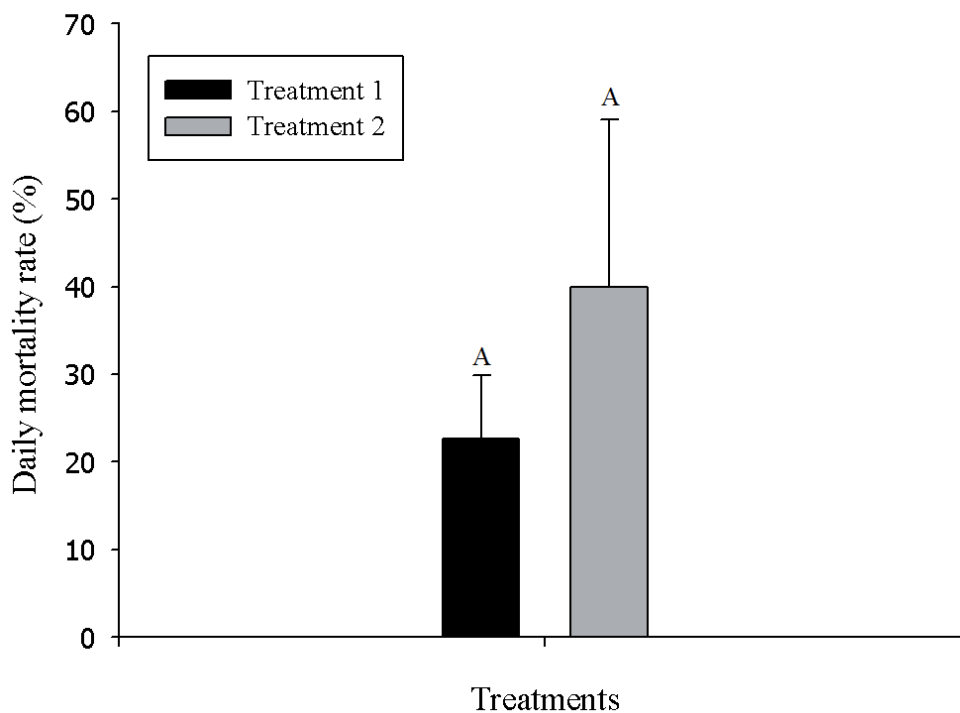
For the T1 treatment, the findings revealed a very low predation rate, particularly in the first five days (10.4%), which were statistically below ($p = 0.031$) the average recorded in the other ten days (25.0%). This was probably because of the necessity to separate the two areas (900 meters) in order to minimize the likelihood of the *P. versicolor* foraging in the T2 treatment. The sample area T2 was thus nearer to the horticulture section of the Campus, which supported a variety of cultures like cucurbitaceae, lettuce, tomato, sunflower and other brassicaceae, providing a more heterogeneous ecosystem, which positively affected the prey availability for *P. ignobilis*, with respect to the T1 sample area.

This vespid preys on a variety of insects including *Edessaru fomarginata* (De Geer, 1773), *Chlosynela lacinia saunderssi* Doubleday & Hewitson, 1849, *Diaphania hyalinata* (L., 1767), *Diaphania nitidalis* Cramer, 1782, *Diabrotica speciosa* (Germar, 1824), *Diatraea* sp., *Elasmopalpus lignosellus* (Zeller, 1848), *Heliothis zea* (Boddie, 1850), *Mocis latipes* (Guenée, 1852), *Pectinophora gossypiella* (Saunders, 1844), *Spodoptera frugiperda* (Smith, 1797) and *Utetheisa ornatrix* (L.,

1758) (SOUZA; ZANUNCIO, 2012), which might have induced it to migrate more quickly to the T2 treatment.

Comparing the two treatments in terms of the mortality rate, a similarity ($p = 0.662$) was noted between days 6 and 15 (FIGURE 3). This may have been due to decrease in the stress of translocated *P. versicolor* colonies. In addition, an increase in *P. ignobilis* activity and foraging evident in Treatment T1 was observed. Such an escalation in the *P. ignobilis* foraging activity might be linked to the more intense defoliation in the kale precipitated by *A. monuste orseis*, which most likely stimulated a higher degree of sinomonium secretion, which in turn attracted more numbers of these predatory wasps. When plants experience a herbivorous attack, they emit a wide variety of volatile substances in large quantities, induced by these herbivores (HIPVs). Their natural enemies use these secretions to find their hosts/prey. Such behavior has been recorded earlier for *P. ignobilis* which forages on *Pasiflora edulis* Sims (RAW, 1998). Other species belonging to genus *Polybia* are also drawn to plants that have experienced herbivore attacks (SARAIVA et al., 2017).

Figure 3 – Daily mortality rate (%) from day 6 to 15 of the experiment for treatments (1), with the *P. versicolor* colonies, and (2), without the *P. versicolor* colonies.



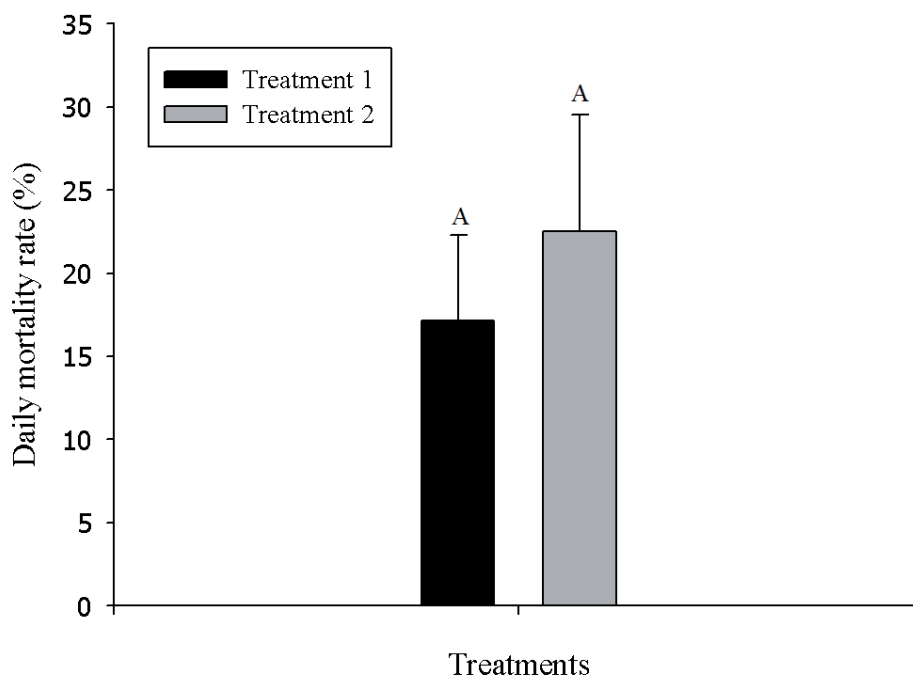
Source: From de author (2018).

After being attracted to the T1 treatment area, characterized by abundant food supply, *P. ignobilis* began to forage frequently this area, exhibiting a behavior pattern reported earlier for this species (RAW, 1998). Social wasp workers search for food alone and opportunistically (MICHELUTTI et al., 2017), returning to hunt in places of success of the previous hunt and feeding several times of the same species of prey (BICHARA-FILHO et al., 2009).

For both treatments no regression analysis model was fitted to the daily data on the predation rate, taking into consideration the variables “daily temperature” and “relative humidity”. This was most likely because of the low variations in the temperature and humidity during the 15 experimental days.

The two locations without the presence of the wasp colonies registered a similar daily predation rate (FIGURE 4), indicating that once the first few days of the experiment were over, the location of the treatment did not influence the results.

Figure 4 – Daily mortality rate (%) for Treatments (1), without the *P. versicolor* colonies, and (2), without the *P. versicolor* colonies, during fifteen days after the colonies were removed.



Source: From de autor (2018).

Conclusions

The translocation of the *P. versicolor* colonies onto the kale crop during the cold and drought periods was ineffective in controlling the *A. monuste orseis* population. This was because the forage activity of this social wasp was poor, therefore, predation on the target pest was also low.

O uso de *Polistes versicolor* (Olivier, 1971) no controle de *Ascia monuste orseis* (Godart, 1819) no cultivo da couve

Vespas sociais têm sido utilizadas com sucesso no controle biológico, principalmente para lagartas de Lepidoptera. *Ascia monuste orseis* causa efeitos devastadores na couve, induzindo perdas de produção de até 100%, exigindo, portanto, medidas rigorosas de controle. Este trabalho teve

como objetivo testar a espécie *Polistes versicolor* no controle biológico de *A. monuste orseis* durante o outono e o inverno, quando a cultura da couve apresenta bom desenvolvimento. Esses experimentos foram conduzidos no IFMG - Campus Bambuí, entre maio e junho de 2017, período em que quatro colônias de *P. versicolor* foram translocadas para abrigos artificiais construídos nas proximidades da cultura da couve, sendo registrada diariamente a predação da vespa social em lagartas de *A. monuste orseis*. A translocação de colônias de *P. versicolor* para a cultura da couve durante as estações frias e secas mostrou-se ineficaz no controle da população de *A. monuste orseis*. Isso ocorreu porque essa vespa social exibiu baixa atividade de forrageamento e, portanto, um baixo grau de predação sobre a praga alvo; no entanto, torna-se crucial avaliar sua atividade durante os períodos mais quentes e úmidos do ano, já que *P. versicolor* preda efetivamente várias espécies de Lepidoptera.

Palavras-chave: *Brassica oleracea*. Controle Biológico. Lepidoptera. Vespas sociais.

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