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OCCURRENCE OF *Drosophila suzukii* (Matsumura, 1931) (DIPTERA, DROSOPHILIDAE) IN VINEYARD CULTIVARS IN THE SERRA GAÚCHA REGION, BRAZIL

Fabiane Foppa[1], Regina da Silva Borba[1*]

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ABSTRACT - In Rio Grande do Sul State, viticulture is an activity of great importance. *Drosophila suzukii* (Matsumura, 1931) (Diptera, Drosophilidae) is a polyphagous pest with a small body size that lays its eggs in healthy, intact fruits. This study monitors *D. suzukii* in different grapevine cultivars and in the grape receiving area of a winery, verifying berries infestation, as well as the pest's body size. The monitoring of *D. suzukii* adults was carried out by installing a fly trap containing apple cider vinegar as a food attractant in each area of the vineyard and in the winery. The insects collected were identified based on their external morphology and genitalia analysis. Four hundred berries were randomly collected in each area and placed in jars until all adults emerged, after which they were identified and sexed. Females were measured using a digital caliper. The Moscato Bailey cultivar had the highest number of emerged *D. suzukii* adults. Females from the Moscato Bailey and Malvasia cultivars had larger body sizes. During the monitoring period, the presence of adults *D. suzukii* was observed in grapevines of the Malvasia, Merlot, Tannat, Moscato Bailey, and Riesling cultivars in the municipality of Farroupilha, as well as in the grape receiving area.
Keywords: spotted wing *Drosophila*, monitoring, viticulture.

OCORRÊNCIA DE Drosophila suzukii (Matsumura, 1931) (DIPTERA, DROSOPHILIDAE) EM CULTIVARES DE VIDEIRA, NA REGIÃO DA SERRA GAÚCHA, BRASIL

RESUMO - No Rio Grande do Sul a viticultura é uma atividade de grande importância. *Drosophila suzukii* (Matsumura, 1931) (Diptera, Drosophilidae) é uma praga polífaga, de reduzido tamanho corporal, e que coloca seus ovos em frutos sadios e intactos. O objetivo do trabalho foi realizar o monitoramento de *D. suzukii* em diferentes cultivares de videira, e na área de recebimento de uvas em uma vinícola, verificar a infestação em bagas e o tamanho corporal da praga. O monitoramento dos adultos de *D. suzukii* foi realizado através da instalação de uma armadilha "caça-mosca", contendo vinagre de maçã como atrativo alimentar, em cada área do vinhedo e na vinícola. Os insetos coletados foram identificados com base na morfologia externa e análise da genitália. Foi estipulada a flutuação populacional e a razão sexual de *D. suzukii*. Foram coletados aleatoriamente, 400 bagas em cada área, sendo acondicionadas em potes até que todos os adultos emergissem, sendo identificados e sexados. As fêmeas foram medidas utilizando um paquímetro digital. A cultivar Moscato Bailey apresentou maior número de adultos de *D. suzukii* emergidos. As fêmeas oriundas das cultivares Moscato Bailey e Malvasia apresentaram maior tamanho corporal. Durante o período de monitoramento foi constatada a presença de adultos de *D. suzukii*, na cultura da videira nas cultivares Malvasia, Merlot, Tannat, Moscato Bailey e Riesling, no município de Farroupilha e na área de recebimento de uva.
Palavras-chave: drosófila-da-asa-manchada, monitoramento, viticultura.

INTRODUCTION

Brazilian viticulture has been expanding significantly, both in traditional growing regions and in new regions, presenting great diversity, and becoming an activity of great importance for the state of Rio Grande do Sul (RS). According to data from IBGE (2021), it is the largest producing state with a total area of 46.295 ha, developed for grape cultivation and responsible for approximately 54% of the national production, of 951.254 tons. The municipality of Farroupilha has 3.680 ha cultivated, with a production of 67.200 tons of grapes (IBGE, 2021). Originally from Japan, *D. suzukii* is a polyphagous quarantine pest, with a small body size (2-3 mm in length) and high dispersal capacity, that lays its eggs inside healthy and intact fruits (SANTOS, 2014a).

D. suzukii can infest a wide variety of fruits, especially, small ones. There are records of significant damage to strawberries, blueberries, blackberries, raspberries, cherries, plums, peaches, and apricots. Damage to grapevine cultivars (*Vitis sp.*) was recently registered in pink-skinned berries in the regions of Quebec, Canada, and Michigan, in the United States (ANDREAZZA *et al.*, 2016).

In Brazil, the pest species *D. suzukii* was recently recorded in Rio Grande do Sul when specimens were collected in a forest garden in the municipality of Capão do Leão and in three biological reserves in the state of Santa

[1]Instituto Federal de Educação, Ciência e Tecnologia do Rio Grande do Sul, *Campus* Bento Gonçalves (IFRS-BG), Bento Gonçalves, RS, Brasil. E-mail: regina.borba@bento.ifrs.edu.br. *Corresponding author.

Catarina. Despite this, there were still no records of the pest attacking fruit species. However, in January 2014, a producer reported a loss of 30% of strawberry production due to damage by *D. suzukii* in the city of Vacaria, RS. Such pest infests a wide variety of fruits, especially those with thin skin (SANTOS, 2014a; 2014b). According to Schlesener *et al.* (2017), the pest prefers to lay eggs in fruits with fragile skin, but is not restricted to this because of its opportunistic and versatile behavior.

The species *D. suzukii* is a dipteran belonging to the Drosophilidae family, known abroad as Spotted Wing Drosophila (SWD), with a high dispersal capacity, spreading rapidly through countries in Europe and North America (SANTOS, 2014a). It has a yellow to pale brown thorax with longitudinal black stripes along the abdomen. Males are easily identifiable, measuring an average of 2.3 to 3.0 mm in length and presenting a black spot on their wings, as well as two sexual combs on the first pair of legs. In the case of females, they have an average size of 2.5 to 4.0 mm in length. Identification is more difficult and can be confirmed by the characteristic shape of the ovipositor, which is long, narrow and doubly serrated, and capable of depositing eggs inside fruits attached to the plant (SANTOS, 2014a).

The eggs of *D. suzukii* are semi-transparent, milky, and shiny, with two respiratory filaments (usually the only visible part of the egg), measuring on average 0.62 x 0.18 mm. The larvae have three larval instars, are milky white in color, and vary in size from 0.67 x 0.17 mm to 3.94 x 0.88 mm. They remain inside the fruit until pupation, which can occur inside or on the surface of the fruit or in the soil.

Such flies are active at temperatures above 10ºC and, under ideal conditions, can have up to 15 generations per year (SCHLESENER *et al.*, 2017). *D. suzukii* insects have a life cycle lasting approximately 10 days at a temperature of 25°C, 12 days at a temperature of 16°C and 21 to 25 days at a temperature of 15°C (SCHELESENER *et al.*, 2017). According to Santos (2014a), the primary damage made by *D. suzukii* is caused by the females when they pierce the surface of the fruit to lay their eggs and, later, by the larvae, that feeds on the fruit pulp. Secondary damage appears later and is caused by microorganisms such as fungi and bacteria, which develop from the oviposition holes.

Females actively seek out ripening fruits to lay their eggs. Generally, one to three eggs are laid per fruit. During her lifetime, a female can lay 300-400 eggs. Oviposition occurs preferably on ripe fruits, but it may also lay eggs on unripe fruits (SCHLESENER *et al.*, 2017). The insect pest is dispersed through the flight of adults *D. suzukii* or the movement of fruits containing larvae and/or pupae over short distances (inside the property area) or long distances (fruit consumer markets) (SANTOS, 2014b).

Monitoring of the pest should begin one to two months before the fruits ripen. To this end, two to three "fly traps" made from PET bottles must be placed per hectare, containing between five and seven 5 mm holes positioned equidistantly (following the perimeter of the bottle) in its lower third (SANTOS, 2014a).

Research on food attractants has been intensified to identify the best attractant, since their attraction should override the fruits' (MATEUS *et al.*, 2016). As a trap food attractant, a mixture of very ripe fruits, composed of at least 50% banana and, the remainder, of seasonal fruit, is recommended as bait. However, according to Santos (2014a), until more efficient attractants are obtained, the use of pure apple cider vinegar is suggested. As it is a quarantine pest and its presence has only recently been detected in the country, there is still no level of economic damage for *D. suzukii* in Brazil, emphasizes Santos (2014a).

In Rio Grande do Sul, the occurrence of such quarantine pest appears as a warning to fruit growers, winegrowers, and researchers, since there is little information about this pest and the conditions of Serra Gaúcha region. According to Andreazza *et al.* (2016), *D. suzukii* infestation may be favored in the southern region of Brazil, since grapevine is grown on small properties where there is a diversity of host fruits for such pest. Its occurrence in vineyards in Serra Gaúcha was recorded by Bucco *et al.* (2016), who, when monitoring vineyards in the municipality of Bento Gonçalves, observed the occurrence of the pest in the Merlot, Moscato, and Malvasia cultivars.

This study aims to monitor *D. suzukii* adults in grapevines of the Malvasia, Merlot, Moscato Bailey, Riesling, and Tannat cultivars, as well as the grape receiving area for winemaking on the premises of a wine cooperative, in the municipality of Farroupilha, in Serra Gaúcha region, to verify the infestation level and body size of the pest in berries of such cultivars.

MATERIAL AND METHODS

Drosophila suzukii monitoring in grapevine

The study was carried out on a rural property and at Cooperativa Vinícola São João Ltda., both located in the city of Farroupilha, in Serra Gaúcha, in the 2017/2018 agricultural year. Monitoring process was carried out in areas of commercial cultivation of grapevines of the cultivars Malvasia (0.5 ha), Merlot (0.29 ha), Moscato Bailey (0.33 ha), Riesling (0.45 ha), and Tannat (0.45 ha), as shown in Figure 1, and in the grape receiving area at Cooperativa Vinícola São João Ltda., where the amount of white and red grapes received in such period are shown in Figure 2.

The monitoring process of adults *D. suzukii* was performed by placing a fly trap in each area of the vineyard and in the winery. As recommended by Santos (2014a), the traps were made from small PET bottles (250 mL) with five to seven 5 mm holes positioned equidistantly (along the perimeter of the bottle) in the lower third, as shown in Figure 3. Pure apple cider vinegar was used as a food attractant throughout the experiment, as recommended by Gerdeman *et al.* (2011). Monitoring was carried out from the end of berry formation until one week after harvest, which was between December 17, 2017, and March 4, 2018, and from January 7 to March 11, 2018, at the winery. Traps were inspected once a week, when specimens were collected and the food attractant was replaced by a fresh one, as recommended by Mateus *et al.* (2016).

The insects collected were placed in vials containing 70% alcohol and taken to the Entomology Laboratory of Instituto Federal de Educação, Ciência e Tecnologia, Bento Gonçalves *Campus* (IFRS-BG), where they were identified based on external morphology and analysis of the adults' genitalia. In other words, males were identified by observation of the dark spot on their wings, and females were identified by observing the doubly serrated ovipositor. A stereoscopic binocular magnifying glass with 5x magnification was used for such purpose.

FIGURE 1 - Arrangement of traps in an area with vines, where *D. suzukii* was monitored. Source: Google Earth, 2018.

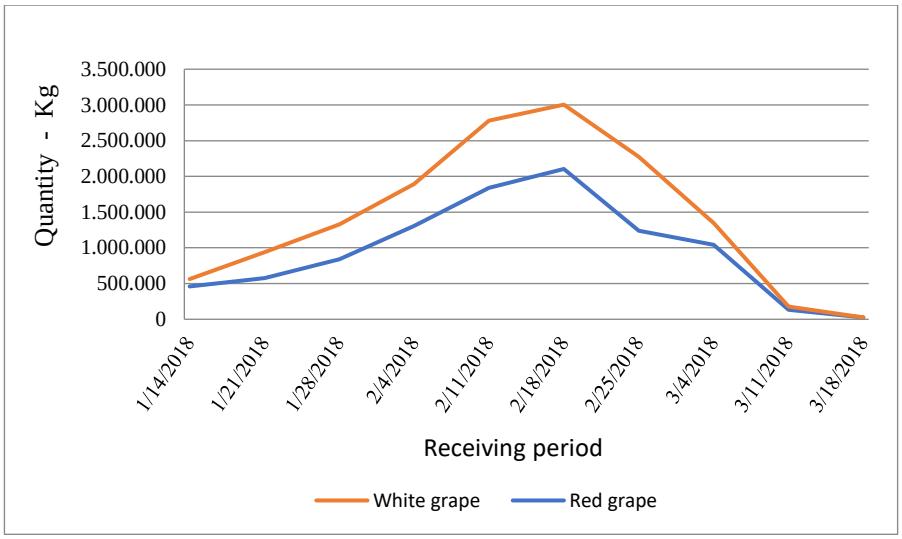

FIGURE 2 - Number of grapes received at Cooperativa Vinícola São João Ltda., where *D. suzukii* monitoring was carried out.

FIGURE 3 - Fly trap for monitoring *Drosophila suzukii* in the grape receiving area, at Cooperativa Vinícola São João Ltda. (left) and in a vineyard (right), both located in the city of Farroupilha, RS.

The collected insects were analyzed individually. The adults identified as *D. suzukii* were separated from the other *Drosophila* species and sexed. The sex ratio was calculated by dividing the number of females by the total number of individuals (males + females), according to the methodology of Silveira-Neto *et al.* (1976). With the obtained data, graphs were created showing the population fluctuation of *D. suzukii* in the areas.

During the research, conventional phytosanitary treatments were carried out on the property. During this period, insecticide applications were carried out between the months of September and January (Table 1). The applications were made to control *Eurhizococcus brasiliensis* (ground pearl), *Eumorpha vitis* (vine sphinx), *Cryptoblabes gnidiella* (honeydew moth), and *Maecolaspis trivialis* (defoliating beetles).

At the time of harvesting each cultivar, berries were collected to verify the occurrence of *D. suzukii*. These berries were collected in the areas of Malvasia, Merlot, Moscato Bailey, Riesling, and Tannat cultivars, located in the municipality of Farroupilha. The samples comprised 400 berries of each cultivar, randomly collected and divided into two treatments: healthy berries (T1) and damaged berries (T2), with 10 replicates per treatment, and each replicate consisting of 20 berries. The berries were taken to the Entomology Laboratory of IFRS-BG, where they were individually packaged in transparent plastic pots with 500 mL capacity, according to the methodology adapted from Souza Filho (2009).

TABLE 1 - Insecticides applied to different grapevine cultivars in the 2017/2018 harvest.

Vine cultivars	Commercial brand	Active Ingredient (Chemical Group)	Date of application (month/day)
Malvasia	Karate®	Lambda-cyhalothrin (pyrethroid)	01/19
	Karate®	Lambda-cyhalothrin (pyrethroid)	01/27
Merlot	Mustang®	Zeta-cypermethrin (pyrethroid)	01/04
	Mustang®	Zeta-cypermethrin (pyrethroid)	01/12
	Karate®	Lambda-cyhalothrin (pyrethroid)	01/27
Moscato Bailey	Karate®	Lambda-cyhalothrin (pyrethroid)	01/27
Riesling	Karate®	Lambda-cyhalothrin (pyrethroid)	10/07
	Rumo®	Indoxacarbe (oxadiazina)	10/19
	Karate®	Lambda-cyhalothrin (pyrethroid)	01/03
	Karate®	Lambda-cyhalothrin (pyrethroid)	01/12
Tannat	Actara®	Tiametoxan (neonicotinóide)	09/19
	Rumo®	Indoxacarb (oxadiazine)	10/19
	Mustang®	Zeta-cypermethrin (pyrethroid)	01/05
	Karate®	Lambda-cyhalothrin (pyrethroid)	01/13

***Drosophila suzukii* infestation in grape berries**

A thin layer of vermiculite (Figure 4) was placed at the base of the pots to retain moisture and promote insect pupation, according to the methodology of Santos (2014a). Each pot was covered with voile fabric and secured with latex elastic bands to prevent the emerging adults from escaping. Each pot containing the berries was placed on a bench, and the distribution occurred randomly. The temperature and relative humidity were monitored using a thermohydrometer, with the minimum temperature recorded at 19.4°C and the maximum at 31.9°C, and the minimum relative humidity recorded at 36% and the maximum at 75%.

FIGURE 4 - Detail of the experiment with grape berries stored in a disposable plastic pot with a capacity of 500 mL, with a layer of vermiculite at the bottom and covered with voile fabric held together by latex elastic bands.

The berries were kept under such conditions for 22 days, so that the adults could emerge, after which the insects were removed and analyzed to prevent their decomposition. The pots containing live adults were placed in the freezer for 10 minutes. After this period, the insects were removed from the pots and placed in glass jars individually containing alcohol 70%, to be later identified, counted, and sexed.

The experimental design was completely randomized, with two treatments and 20 replicates for each cultivar. The data obtained were subjected to analysis of variance and the means compared by the Tukey test at 5% probability of error, using the Winstat statistical program (MACHADO; CONCEIÇÃO, 2002).

Body size of *Drosophila suzukii* adults on grape berries

The females of *D. suzukii* collected from the grapevine cultivars Malvasia, Merlot, Moscato Bailey, Riesling, and Tannat were individually placed in glass bottles containing alcohol 70%, to analyze the size developed in each variety.

Females were measured at the IFRS-BG Entomology Laboratory using a digital caliper. Only females were used due to the low number of males collected during the study.

The data obtained were subjected to analysis of variance (ANOVA) and the means compared by the Tukey test at 5% probability of error, using the statistical program R, version 3.6.0 (R DEVELOPMENT CORE TEAM, 2019).

RESULTS AND DISCUSSION

Drosophila suzukii monitoring in grapevine

During the entire monitoring period, the presence of *D. suzukii* was observed in the Malvasia, Merlot, Moscato Bailey, Riesling, and Tannat grapevine cultivars, in a commercial vineyard and in the winery's receiving area, both located in Farroupilha. The same was reported by Bucco *et al.* (2016), while monitoring the species in Bento Gonçalves, where they captured *D. suzukii* in areas where the Moscato, Malvasia, and Merlot cultivars were cultivated, using fly traps with apple cider vinegar as food attractant.

Since the first week of monitoring (December 17 to 24, 2017), *D. suzukii* was captured in the vineyard areas, as shown in Figure 5, with an increasing number of captured specimens, increasing the number of insects collected according to the development and ripening of the berries, corroborating Lee *et al.* (2011), who, by providing cherries at the beginning of ripening, half-way, and completely ripe, observed that the preference for oviposition was 11%, 34% and 55%, respectively.

According to Bruno (2014), puncture in small fruits occurs preferentially in ripe ones, but it can occur to a lesser extent in immature fruits or in the maturation phase, because the insect's ovipositor is doubly serrated, allowing it to pierce more resistant epidermises. According to Schlesener *et al.* (2015), females prefer fruits in a more advanced stage of ripening, compared to immature ones. This behavior can be explained by the difficulty that *D. suzukii* larvae have in completing their cycle in acidic fruits (MALGUASHCA *et al.*, 2010).

In the present study, it was possible to verify that the capture peak differed among the grapevine cultivars, since they have different cycles and maturation. In Riesling, the capture peak occurred on January 28, 2018, considering that the harvest occurred in the same month and year, but on the 25th. In the Tannat cultivar, the capture peak occurred in the week of February 18 to 25, with an average of 106 adults, with the harvest on February 20th. Females actively search for ripening fruits to lay their eggs, generally laying 1 to 3 eggs per fruit and, during their lifetime, an average of 300 to 400 eggs.

In the Merlot cultivar, the capture peak occurred from February 11 to 18, with 40 adults per trap, with harvesting occurring on February 15, while in the Malvasia cultivar, the capture peak occurred after harvest (February 25 to March 4), with 96 adults. And in the Moscato Bailey cultivar, the capture peak occurred between February 18 and 25, with 78 adults, with harvesting occurring on February 27. Bucco *et al.* (2016), when monitoring *D. suzukii* in areas where Moscato, Malvasia, and Merlot grapes were cultivated, found the presence of adults in all three cultivars, with increased capture over time.

The Moscato Bailey cultivar had the highest number of individuals captured in the trap (341), followed by the Malvasia cultivar (283), and the Riesling, an early cultivar, had the lowest number of adults collected (51). Bucco *et al.* (2016) observed a higher number of individuals captured in white cultivars (Moscato and Malvasia) than in the red Merlot. According to Ioriatti *et al.* (2017), many observations indicate that white cultivars are generally less colonized than red ones and that cultivars with compact bunches are more infested than those with loose bunches, with the risk of attack increasing, inversely proportional to the thickness of the berry skin.

Moscato Bailey is considered a high-yield cultivar, with large and very loose bunches (GIOVANINNI, 2008). However, the high number of *D. suzukii* captured may be related to the location of the vineyard, which is close to native vegetation (Figure 5). The Malvasia cultivar is a white one, but with compact bunches, which may be the responsible factor for the presence of a large number of insects, while Riesling, with compact and white bunches, was the one that presented the lowest capture of *D. suzukii*, a fact possibly related to the precocity of the cultivar.

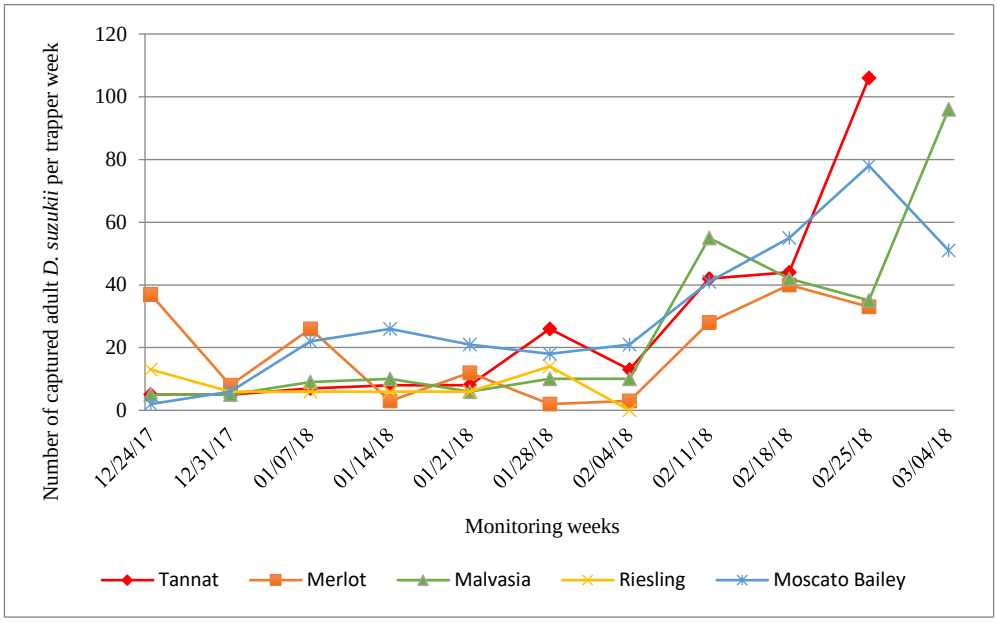

FIGURE 5 - Population fluctuation of adults *D. suzukii* in grapevines of the Malvasia, Merlot, Moscato Bailey, Riesling, and Tannat cultivars, in the municipality of Farroupilha, RS.

In the Tannat cultivar, capture increased after February 4, possibly related to the insecticide applications carried out on January 5 and 13 in the vineyard (Table 1), increasing the mortality of adults *D. suzukii* in the area. The same happened in the Merlot cultivar, which showed a decrease in capture from February 7, with insecticide application on January 4, and in the Malvasia cultivar, where capture increased after February 4, with insecticide application on January 27. In the Riesling cultivar, capture remained constant between December 31 and January 21, with two insecticide applications carried out during such interval. In the Moscato Bailey, no decrease in adults *D. suzukii* was observed, related to the insecticide application. According to Schlesener *et al.* (2015), chemical control is the most widely used control method in places where this insect occurs, with good results in the control of pyrethroids by contact and residual power over the pest, in cherry, raspberry, blueberry, strawberry, and grapevine crops. In Brazil, there is only one product registered for pest control, spinetoram (spinosyn) (AGROFIT/MAPA, 2022).

Schlesener *et al.* (2017), when evaluating adult mortality and the ovicidal effect of some insecticides, found that deltamethrin, timetoate, spinosad, fenitrothion, fosmed, malathion, methidathion, and zeta-cypermethrin resulted in total mortality of adult individuals three days after their application and concluded that fenitrothion, malathion, and methidathion rendered 100% of the eggs unviable and diflubenzuron caused a significant reduction in larval hatching, two days after treatment.

Throughout the monitoring period, adults of *Drosophila* sp. were captured in the vineyard in all cultivars (Figure 6), with increasing capture rates as the grapes developed and matured. Roumbaut *et al.* (2017) stated that the combined occurrence of *D. suzukii* and *D. melanogaster* can increase acid rot problems in vineyards, since *melanogaster* cannot trigger rot symptoms in healthy berries. However, the injury caused by the oviposition of *suzukii* induces the appearance of rot, thus allowing infestation by other *Drosophila* species.

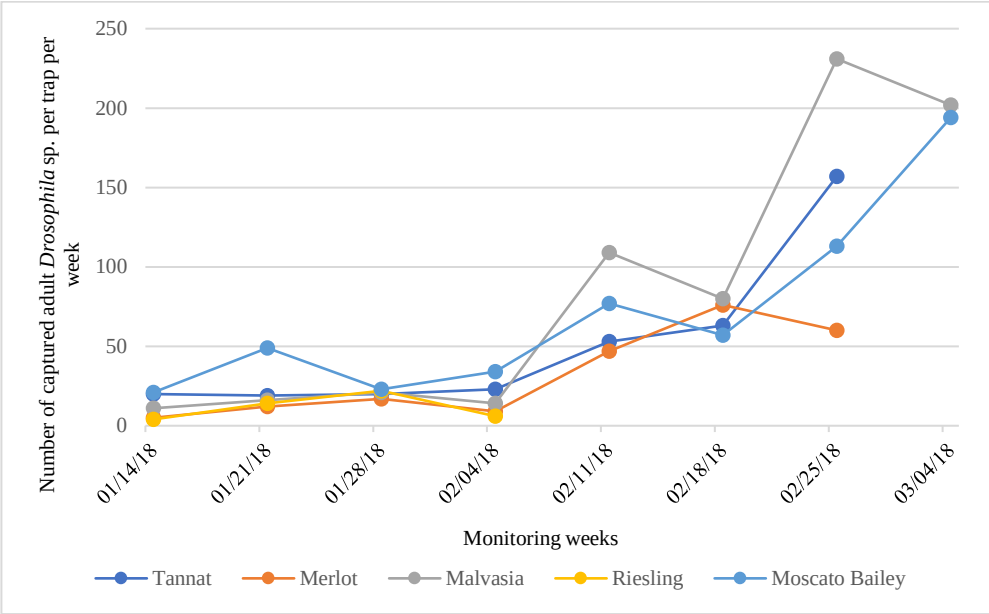

FIGURE 6 - Population fluctuation of *Drosophila* sp. adults in grapevines of the Malvasia, Merlot, Moscato Bailey, Riesling, and Tannat cultivars, in the municipality of Farroupilha, RS.

According to Kehrli and Linder (2018), in Swiss vineyards, the presence of *D. suzukii* was abundant and sour rot was high, since the climatic conditions associated with the pest contributed to the spread of the disease. The risk of infestation may also increase with grape ripening and the number of berries physically injured or infected by diseases (IORIATTI *et al.*, 2017).

During the monitoring of *D. suzukii* adults in the grape receiving area at Cooperativa Vinícola São João Ltda., the presence of the insect was verified throughout the period. The number of adults captured increased with the number of grapes received by the winery during the harvest, reaching a peak of capture of 126 adults in the week (February 11, 2018) concomitant with the peak of grape receipt, exceeding 3 million kilos. After this date, the capture decreased, with, in the last week of monitoring (March 18, 2018), 22 adults captured, along with the receipt of 25 thousand kilos of grapes. Figure 7 shows that the monitoring of insects in the winery presented the same capture pattern.

These data demonstrate that the species is found in grape receiving areas and, therefore, information should be spread on the potential for dispersion and damage of the pest in grapevine crops. In Australia, Lam and Howell (2015), when monitoring drosophilids in vineyards and wineries during harvest, found that different species of *Drosophila* were associated with the yeasts studied, compromising the flavor of the berries and, consequently, the quality of the wine. Turner and Ray (2009) highlighted that drosophila are common in wine environments, as they are attracted to the carbon dioxide emitted by ripe fruit and fermenting yeasts.

Santos *et al.* (2017), after evaluating the occurrence of *D. suzukii* adults near fruit sales points in Vacaria (RS), found that 64.3% of the establishments had the presence of the insect, thus concluding that the pest was widely distributed, including in urban areas. In the present study, in relationship to the sex ratio, during the entire monitoring period of adults, a higher proportion of females was observed (Table 2).

Bucco *et al.* (2016), when monitoring *D. suzukii* in Bento Gonçalves (RS), in an orchard of Moscato, Malvasia, and Merlot cultivars, found a greater number of females than males. Santos (2014b), analyzing strawberry fruits attacked by the same insect in orchards in the municipality of Vacaria (RS), found the same number as the authors cited above. Bortoncello *et al.* (2015), evaluating the occurrence of the pest in a commercial peach orchard in the municipality of Cotiporã (RS), found a greater number of males than females, as did Lee *et al.* (2011), in a peach orchard in Canada.

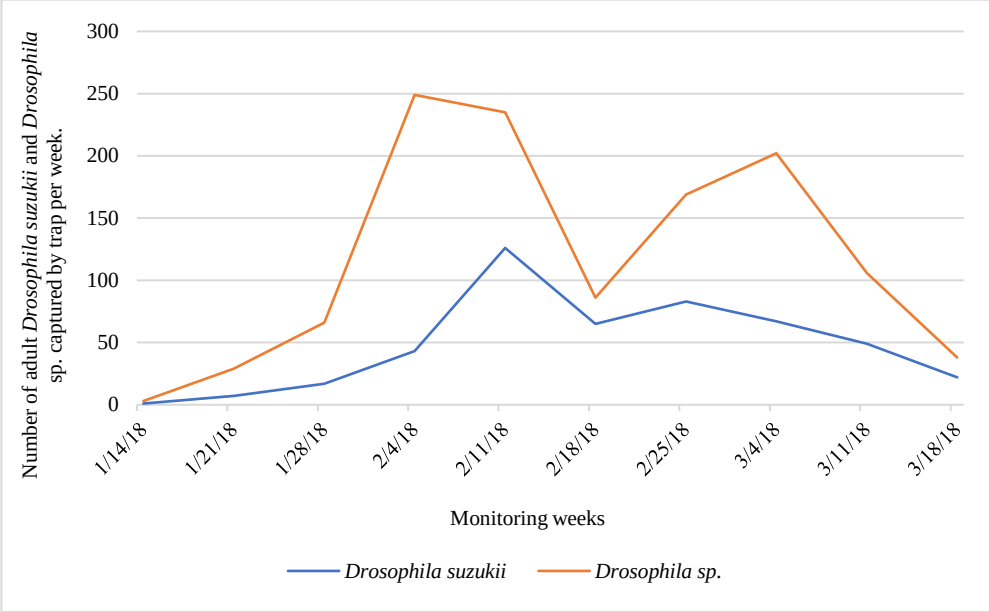

FIGURE 7 - Population fluctuation of adults of *Drosophila suzukii* and *Drosophila* sp., in the grape receiving area of the Cooperativa Vinícola São João Ltda., in the municipality of Farroupilha, RS.

TABLE 2 - Males, females, and sex ratio of *Drosophila suzukii* adults captured in an orchard of grapevine cultivars and in the grape receiving area of Cooperativa Vinícola São João Ltda., Farroupilha, RS.

	*Drosophila suzukii**		
Vine cultivars	Males	Females	Sex ratio
Malvasia	8	275	0.97
Merlot	55	137	0.71
Moscato Bailey	60	281	0.82
Riesling	6	45	0.88
Tannat	38	226	0.86
Winery	30	450	0.94

*Data related to total adults captured during the monitoring period.

The food attractant used in the traps can influence the attractiveness of the insect, as well as the sex ratio. Nunes *et al.* (2013) found differences in the sex ratio of *Anastrepha fraterculus* in an apple orchard, depending on the type of food attractant used in the traps. Likewise, Bortoncello *et al.* (2018) tested different food attractants on the attractiveness of *D. suzukii* in peach crops.

Occurrence of *Drosophila suzukii* in grape berries

Regarding the berries that were collected in the orchard and kept in the laboratory for a period of 22 days, the treatment with damaged berries was the one that presented emergence of adults of *D. suzukii* and *Drosophila* sp., in the cultivars Malvasia, Merlot, Moscato Bailey, Riesling, and Tannat. In the intact berries, there was no emergence of adult insects (Table 3).

TABLE 3 - Means (minimum and maximum) of adults of *D. suzukii* and *Drosophila* sp. emerged from damaged and intact berries in an orchard of grapevine cultivars.

	Drosophila suzukii		*Drosophila* sp.	
Vine cultivars	Damaged berries	Intact berries	Damaged berries	Intact berries
Malvasia	22.95 (0-42) a*	0 (0-0) b	36.55 (6-65) a	0 (0-0) b
Moscato Bailey	19.15 (0-69) a	0.05 (0-1) b	47.20 (14-87) a	0 (0-0) b
Riesling	3.60 (0-13) a	0 (0-0) b	12.10 (3-29) a	0 (0-0) b
Merlot	1.70 (0-7) a	0 (0-0) b	4.15 (0-12) a	0.25 (0-5) b
Tannat	0.55 (0-5) a	0 (0-0) b	1.80 (0-19) a	0 (0-0) a

*Means followed by the same letter in the line do not differ from each other, according to the Tukey test, at a 5% error probability.

Lee *et al.* (2011), in a study evaluating the attack susceptibility by *D. suzukii* in an orchard of grapevine cultivars, observed oviposition on intact grape berries only of the Flame cultivar, while on damaged berries, there was oviposition on the Flame, Early Campbell, Merlot, and Riesling cultivars. Santos *et al.* (2016), evaluating the occurrence of the same insect in an apple orchard in Vacaria (RS), reported that, in the fruits collected in the field, it was

only possible to evidence eggs of the pest in fruits with damage to the epidermis, originating from other insect pests or cracks. Stewart *et al.* (2014), when working with peaches, observed that fruits without external damage did not have the insect eggs. However, in fruits that had some external damage they verified the presence of eggs.

The cultivar that presented the highest number of adult *D. suzukii* was Malvasia, followed by Moscato Bailey, but with no statistical difference. Riesling, Merlot, and Tannat presented the lowest number of emerged adults, also with no statistical difference (Table 4). Lee *et al.* (2011), when evaluating the susceptibility of wine cultivars to the insect attack, did not observe any difference in the number of eggs and development among Chardonnay, Merlot, Pinot Gris, and Pinot Noir.

TABLE 4 - Means (minimum and maximum) of adults of *D. suzukii* and *Drosophila* sp. emerged from damaged berries of different grape cultivars.

Vine cultivars	*Drosophila suzukii*	*Drosophila* sp.
Malvasia	22.95 (0-42) a*	36.55 (6-65) b
Moscato Bailey	19.15 (0-69) a	47.20 (14-87) a
Riesling	3.60 (0-13) b	12.10 (3-29) c
Merlot	1.70 (0-7) b	4.15 (0-12) cd
Tannat	0.55 (0-5) b	1.80 (0-19) d

*Means followed by the same letter in the column do not differ from each other, according to the Tukey test, at a 5% error probability.

The average number of *D. suzukii* adults emerging from damaged berries in the Malvasia cultivar was 22.95, while in the Moscato Bailey cultivar was 19.15. When evaluating the susceptibility of grapevine cultivars in Italy and Oregon (USA), Ioriatti *et al.* (2015) found values lower than two *D. suzukii* eggs laid per berry in the Chardonnay, Yellow Moscat, Traminer, Pinot Noir, Teroldego, and Schiava cultivars. Andreazza *et al.* (2016), when evaluating the susceptibility of berries of grapevine genotypes, concluded that no oviposition was found in *Vitis labrusca*. In the present study, for the Riesling, Merlot, and Tannat cultivars, the average was 3.6, 1.70, and 0.55 insects respectively, with no statistical difference among them. The greater number of adults emerging from the Moscato Bailey cultivar may be related to the orchard's proximity to native vegetation.

Burrack *et al.* (2013), when evaluating host selection of *D. suzukii* in the field and in a laboratory in the southeastern United States, concluded that infestation rates differ among species and cultivars within the genus *Rubus*. They also reported that host attractiveness probably depends on additional factors, such as soluble sugar content. Ioriatti *et al.* (2015), when evaluating the potential attack of *D. suzukii* in wine grapes, reported that oviposition increased along with sugar content and decrease in acidity levels in the berries.

Regarding *Drosophila* sp., there was a higher emergence of adults in the Moscato Bailey cultivar, followed by Malvasia, and a lower number in Riesling, Merlot, and Tannat, following the same emergence pattern as *D. suzukii*. The low number of adults emerged from both insects in Tannat may be related to the large number of tannins present in such cultivar. Tannins are known to jeopardize growth and survival rates of insects in the orchards (SCHALLER, 2008). The effect of tannins on insects occurs because such compounds form complexes with the digestive enzymes present in the intestine of herbivores and, therefore, leads to a reduction in the efficiency of protein digestion, thus impairing growth (SCHOONHOVEN *et al.*, 2005).

The pest's sex ratio was between 0.94 and 1.00, indicating that a much greater number of females emerged from the damaged berries of the Malvasia, Moscato Bailey, Riesling, Merlot, and Tannat cultivars (Table 5), according to the results obtained during the monitoring period at the orchard.

Body size of adults *Drosophila suzukii* on grape berries

During the body size analysis of *D. suzukii* females emerging from damaged berries of grapevine cultivars, a larger body size was observed for females originating from Moscato Bailey, with an average size of 2.58 mm, and Malvasia, with an average size of 2.48 mm, with no statistical difference between them (Table 6). However, female insects originating from Merlot, Tannat, and Riesling presented smaller body size and differed statistically from Moscato Bailey and Malvasia.

TABLE 5 - Adults *Drosophila suzukii* sex ratio emerged from damaged berries of different grape cultivars.

	*Drosophila suzukii**		
Vine cultivars	Males	Females	Sex ratio
Malvasia	0	459	1,00
Moscato Bailey	1	382	0.99
Riesling	0	72	1.00
Merlot	2	32	0.94
Tannat	0	11	1.00

*Data are related to total adults emerged during the experiment.

TABLE 6 - Female *Drosophila suzukii* body size from grapevine cultivar berries.

Vine cultivars	Females body size of *Drosophila suzukii* (mm)
Moscato Bailey	2.58 a*
Malvasia	2.48 a
Merlot	2.16 b
Tannat	2.00 b
Riesling	1.97 b
CV (%)	22.70

*Means followed by the same letter, in the column, do not differ from each other, according to the Tukey test, at a 5% error probability.

Bellamy *et al.* (2013) state that the body size of insects can be an indicator of diet quality. Thus, the different sizes of adults *D. suzukii* observed in Moscato Bailey, Malvasia, Merlot, Tannat, and Riesling grapes may be related to the nutritional quality such cultivars. The same authors demonstrated that females developed on a grape diet had lower weight when compared to those developed on a raspberry diet. According to Dias *et al.* (2016), quantitative nutrition studies are carried out through the determination and analysis of nutritional indexes, verifying how insects respond to different foods and how the food influences their growth.

The *D. suzukii* species was present in the five studied grape cultivars. However, its development was impaired in Merlot, Tannat, and Riesling. According to Bellamy *et al.* (2013), females newly emerged from raspberry and cherry fruits had larger body sizes when compared to those emerged from other fruits, such as grapes, which means that these berries do not represent an ideal host for such species. Winemakers should be aware of the presence of such pest in vineyards as it can spread microorganisms that cause rot in the bunches.

CONCLUSIONS

During the monitoring period, the presence of adults *D. suzukii* was observed at grapevine cultures of the Malvasia, Merlot, Tannat, Moscato Bailey, and Riesling cultivars, in the municipality of Farroupilha, and in the grape receiving area of Cooperativa Vinícola São João Ltda.

The species completes its cycle in grapevine cultivation. However, its development is different depending on the cultivar and requires some injury to the berry to perform oviposition. Nevertheless, the occurrence of *D. suzukii* associated with the presence of other *Drosophila* species can disseminate microorganisms responsible for causing rot in bunches, especially acid rot.

The fact that such pest was detected at the winery demonstrates the presence of the species in urban areas and in areas where grapes are received for winemaking, spreading to other yeasts and harming the wine quality.

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