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Monitoring of spotted wing drosophila (*Drosophila suzukii* Mats.) and assessment of the new attractant SuzukiiTrap® in Tijuana, Baja California, Mexico

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Abstract

This work was performed in Tijuana, Baja California, Mexico, from October 2012 to January 2013. The work aimed to evaluate the effectiveness of two different traps and the SuzukiiTrap® attractant in the catch of *Drosophila suzukii*. The monitoring of pest confirmed the presence of spotted-wing drosophila (*Drosophila suzukii* Mats.) in the territory of Baja California, Mexico. This fly had a population peak of females in November 2012 in proportion (2:1) respect to the total of flies and a lower incidence of both sexes in January 2013. *D. suzukii* could be monitored by red traps, followed by yellow traps, with SuzukiiTrap® attractant. These yellow traps, slighly exceeded the control capture with vinegar. All traps that used the SuzukiiTrap® attractant take longer time before to be rebaiting again, while the traps with vinegar were loaded in shorter time. The relationship between the insects captured by red traps in different types of host such as citrus (*Citrus* spp.), guava (*Psidium guajava* L.), ornamentals (alternative host) and loquat (*Eribotrya japonica*) was significanly higher, followed by the artisanal traps with vinegar, that had better correlation with peach (*Prunus persica* L.), guava (*Psidium guajava* L.) and grape (*Vitis vinifera* L.), while the yellow traps were only associated with ornamentals (alternative host). The guava (*P. guajava* L.) was the plant species most dangerously infested during monitoring of this pest. However, this is not included in the register host of *D. suzuki* in Mexico. As to the weather conditions, it was observed that maximum temperature did not appear to influence negatively on populations of *D. suzukii*. It was also observed that female have adaptability to environmental changes. However, the difference between maximum and minimum temperatures over 14°C had a negative influence on the total number of insects collected and males, which occurred by the abrupt decline in temperature and frost of December.

Key words: *Drosophila suzukii* Mats, traps, SuzukiiTrap®, monitoring, attractant.

Introduction

The fruit fly spotted wing drosophila, is native to Asia [6]. The first reported detection of *D. suzukii* in Europe was in 2008 in Rasquera, Spain [3]. Until late 2011, European detection of *D. suzukii* had been limited to dry Mediterranean climates. Now, the presence of this insect was confirmed in Germany, in autumn 2011 [13, 14]. The discovery in Belgium is of great importance, since these are the first records of the species in the more temperate northwest-European regions. Ecological simulations seem to indicate that those Mediterranean conditions are not optimal for the growth of *D. suzukii* [11].

Up till now, the only report of crop damage in Europe due to *D. suzukii* was the publication of Lee *et al.* [20], who reported crop destructions of up to 80% in Trentino, Italy. However, Hauser *et al.* [11] suggested that *D. suzukii* could develop into a serious pest in the more humid northwest European areas.

D. suzukii was referred for the first time in Mexico in 2011 [4, 20]. Other infestations for *D. suzukii* were reported in cherry orchards along the central coast of California, in the Santa Clara Valley in Yolo and Stanislaus counties [3, 11, 28]. *D. suzukii* is currently spreading in many areas, such as the USA (West and East coast), Canada, Mexico and Europe (a history of the introduction in North America is reviewed by Hauser [12]) [4].

Most species of *Drosophila* are infesting ripe fruits fallen and rotting fruit. However, the females of *D. suzukii* lay eggs in ripe fruit and the larvae develop in the fruit and cause it to become soft and with no commercial value. At the time of ripening *D. suzukii* can affect health of different fruits, such as cherry, strawberry, fig, grape, plum, apricot, apple, peach, persimmon, raspberry, blueberry, blackberry, kiwi and pear [2, 9, 29, 30].

This insect prefers the low temperate such as the Pacific coast; however, it had survived and prospered in relatively cold climate as northern Japan [15]. Mitsui *et al.* [22] suggested that the fly can migrate to avoid resource-poor conditions. Based on the distribution of this fly in 2009 and supported by a climate model, anticipating dispersion expanded its presence along the Pacific Coast from northern California to central British Columbia [5].

Cycle duration depends on the environmental conditions. Adults become sexually mature and 1-2 days after the pupa emergence. They can live between 21 and 66 days and a female can lay between 1 and 3 eggs at each oviposition, with an average of 380 eggs during a lifetime.

Recent observations about life cycle of *D. suzukii* from egg to egg-laying females report duration of 12-15 days at 18.3°C (65°F). Another study found a litte more than a week with 21.1°C (70°F) [30], the cycle lasted little more than a week. Mitsui *et al.* [22] found that *D. suzukii* adults collected in autumn were reproductively immature, suggesting winter reproductive diapause.

The ability to survive and replicate in a wide range of climatic conditions is obviously an important factor to these insects. Limiting temperatures for *D. suzukii* reproduction are between 10 and 32°C for oviposition and up to 30°C for male fertility [26]. The peak of activity and development is around 20 to 25°C [15]. *D. suzukii* can be considered a species with high thermal tolerance, being observed tolerant to heat as summers in Spain, also cold tolerant in the mountainous regions of Japan or in the Alps areas.

The wide host range represents a problem for the management of this pest, not only because *D. suzukii* can cause damage to many species, but also because populations can survive almost everywhere, alternating with different hosts throughout the year, both farmed and wild. While plants grown in high population density are generated, the wild and ornamental hosts serve as shelters providing sources of re-infestation and wintering habitats [18].

In Latin America and the Caribbean, people use chemical control and McPhail traps to control and monitor the fruit flies, because they are the only accessible and cost-effective tools available. However, pesticides are not the best solution to control *D. suzukii* as they have a high environmental impact, which is unacceptable in many regions where soft fruits are grown. Moreover, direct pesticide treatments are prohibited when fruits are very close to harvest, when infestation of *D. suzukii* is expected.

Several groups of investigators have recommended the use of different types of traps for monitoring this species. Lee *et al.* [21] obtained good results with the Haviland trap, followed by red, Van Steenwyk and transparent. In five different crops, Haviland trap was the one with the highest number of catches. Traps with higher input areas and meshes appear to be more effective than those with only holes on the sides. In terms of sensitivity and selectivity, the traps that catch more flies are the same as the first individuals captured. In all the traps, *D. suzukii* represented 26-31% of the total captured *Drosophila*. These researchers recommended that traps incorporate a greater number of inlets and evaluate other baits more selective and efficient.

The trapping performance is also highly influenced by the trap's colour, shape and structure. Red and black have been shown to be the most attractive colours, hence coloured traps would be recommended [23]. However, there was no clear advantage of the red-coloured traps, although the red trap was statistically similar to the Haviland trap at nine sites. Previous greenhouse and field studies suggested that red traps were sometimes preferable over clear or white traps, when all other trap features were equal [20]. Landolt *et al.* [19] reported that the number of flies captured with wine and vinegar mixtures varied somewhat, but the vinegar rice was the best catch of flies obtained, however, the length of various age-attractant bait was 0-7 days.

Recently, new specific attractants, such as SuzukiiTrap®, developed by Bioiberica, have been evaluated for the capture of *D. suszukii* in Europe [1]. This food bait based on a protein hydrolyzed (7% protein) is a 100% organic, environmentally friendly, because it does not have in its formulation any insecticide, and produces an emission of volatile attractants and staggered in time with specificity for *D. suzukii* [1].

The present study aimed to monitor *D. suzukii* Mats. on frontier of Tijuana, Baja California, Mexico and to compare different types of traps and effectiveness of new SuzukiiTrap® attractant.

Materials and Methods

The trial was conducted in Tijuana municipal, Baja California, Mexico (Fig. 1), from October 18/ 2012 until January 18/2013. Fifteen points were distributed over the line of frontier, to east of the town to a length (-16.85801) and latitude (32.53117).

Traps: The monitoring was conducted with the use network formed by 60 traps located on fifteen observation points. Four treatments were tested during research (Fig. 2) and a system composite by traps and food attractant was the experimental unit. Treatments I: Artisanal trap with transparent plastic container (0.95 L^{-1}), two penetration hole and yellow paper glued inside. This trap was baited with 250 ml cider commercial vinegar [24]. Treatment II: White trap (*A & C Trap + SuzukiiTrap® 300 ml).

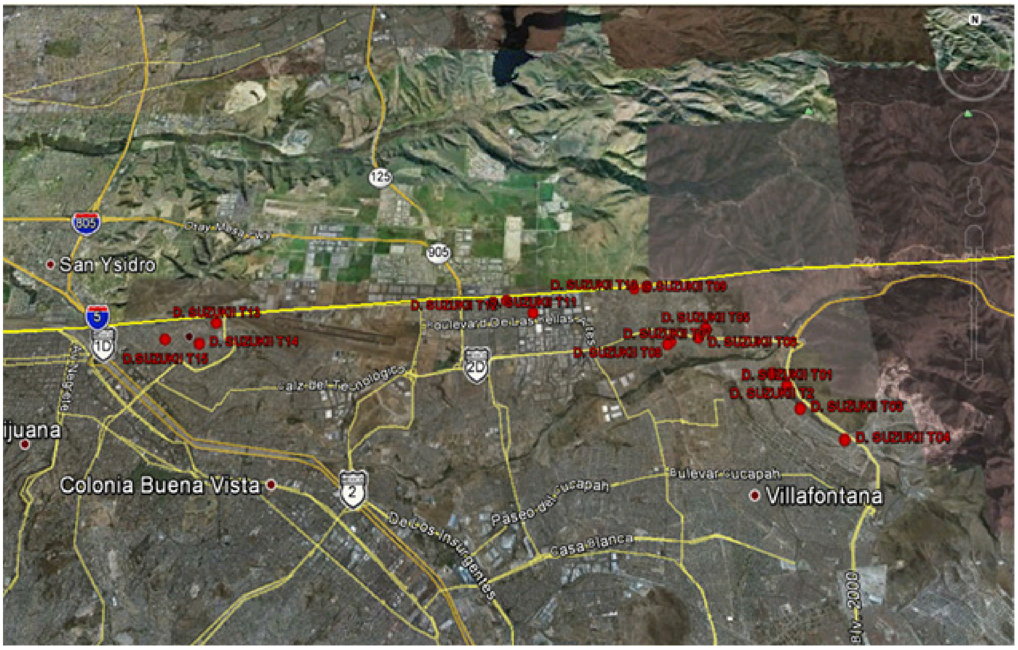

Figure 1. Location and distribution of fifteen monitoring points in Tijuana, Baja California, Mexico. The traps were located over line with red points longitude (-116.85801) and latitude (32.53734).

Figure 2. Treatments: I) Artisanal trap of transparent plastic container (0.95 L^{-1}) and two penetration holes (1). Treatments (II, III and IV) using (*A & C Traps) produced by Aerial Service Company, Biological and Forestry, Mubarqui [10], Mexico, with four holes and three different colour: 2) White trap, 3) Yellow trap and 4) Red trap, these traps were baited with 300 ml of SuzukiiTrap® attractant. produced for Bioiberica SA.

Treatment III: Yellow trap (*A & C Trap + SuzukiiTrap® 300 ml).
Treatment IV: Red trap (*A & C Trap + SuzukiiTrap® 300 ml).

Hosts: Each point had observation trap per treatment (total four), these traps were placed randomly on the plants of the area evaluated. The traps were separated to avoid interference in capturing, fifteen feet between them. As shown in Table 1, the reference of Geographic Positioning System (GPS) of the different crops appears that were used to analysis catches of *D. suzukii*: guava (*Psidium guajava* L.), loquat (*Eribotrya japonica* (Thunb.) Lindl.), citrus (*Citrus* spp.), peach (*Prunus persica* L.), grape (*Vitis vinífera* L.), fig (*Ficus carica* L.) and ornamentals (alternative host).

Table 1. Observation points and geographical position where the traps were placed over crops for catching *D. suzukii*.

Point observation	X Length	Y Latitude	Hosts
1	-116.85801	32.53117	Citrus (*Citrus* spp.) Peach (*Prunus persica* L.)
2	-116.86127	32.53374	Guava (*Psidium guajava* L.) Ornaments (Alternative host)
3	-116.85569	32.52631	Peach (*Prunus persica* L.)
4	-116.84662	32.51985	Guava (*Psidium guajava* L.) Peach (*Prunus persica* L.)
5	-116.87645	32.54359	Peach (*Prunus persica* L.)
6	-116.87843	32.54143	Fig (*Ficus carica* L.) Guava (*Psidium guajava* L.) Peach (*Prunus persica* L.)
7	-116.8854	32.5898	Peach (*Prunus persica* L.)
8	-116.88526	32.54045	Guava (*Psidium guajava* L.)
9	-116.8939	32.55232	Guava (*Psidium guajava* L.)
10	-116.89079	32.5527	Guava (*Psidium guajava* L. Loquat (*Eribotrya japonica*)
11	-116.9198	32.54606	Guava (*Psidium guajava* L.) Peach (*Prunus persica* L.)
12	-116.92658	32.548661	Grape (*Vitis vinífera* L.)
13	-116.99961	32.54202	Grape (*Vitis vinífera* L.) Loquat (*Eribotrya japonica*)
14	-117.00282	32.53734	Guava (*Psidium guajava* L.)
15	-117.00283	32.53784	Loquat (*Eribotrya japonica*) Fig (*Ficus carica* L.)

Evaluations: The observations were made during 12 weeks by personnel Fruit Flies National Campaign in the Tijuana State of Baja California, those who collected the insects in each trap, identified and shelter in vials with alcohol 70%. The flies species were corroborated by the National Reference Center Plant for the presence of *D. suzukii* Mats. in the territory. For treatments II - IV, from the eighth week the traps were checked for the level of the attractant, but remained without re-priming, all time during the test. The artisanal traps (treatment I) were changed when the attractant was not clear, was bad or when the level of bait was less than 250 ml.

The observations were made during 12 weeks by personnel of National Campaign against Fruit Flies, in Tijuana State, Baja California; those collected the insects in each trap and placed in vials with 70% alcohol for identification. The *D. suzukii* species was corroborated by specialist from the National Reference Center in Mexico.

Climate data: During the 12 weeks, climatic variables concerning to rain (mm), maximum, minimum anf average temperatures (°C), presence of cold fronts and frost were collected in Weather Station 'El Florido' No. 142 and 'Presa Rodriguez' No. 28, for the territory of Baja California. Compiled daily data were organized and assigned to each week to find correspondence with catching flies.

Statistical analysis: Statistical analysis applied during the test corresponded to a completely randomized design, considering one trap as experimental unit in the treatment. The only restriction was the number of observations that was equal for each treatment.

Data on total number of flies (*D. suzukii*) for males and females were analysed using t and Tukey test ($p \leq 0.05$). Equally correlation analyses were applied unilateral and bilateral parametric Spearman Rho coefficient and Pearson with one-factor ANOVA. This allowed correlating relationships between treatment collections, the hosts and climatic factors. The data obtained in the experiment were processed using the SPSS [27] (Statistical Package for Social Sciences) Ver. 19.0.

Results

Capture of spotted wing fruit fly (D. suzukii* Mats.*) by sex during monitoring in Baja California: A big significant difference between sexes was observed respect to total flies captured, demonstrating the predominance of females of *D. suzukii* during monitoring and the great flight activity of the pest in the territory of Baja California, Mexico, as well as the efficiency of the method used for detection of the pest dynamics (Table 2).

Table 2. Mean comparison t-test ANOVA, between female and males with total *D. suzukii* captured in traps during monitoring in Baja California, Mexico.

ANOVA		Squares sum	D.f	Quad. Mean	F.	Signif.
Females Tot. */ Flies Tot	Inter-group	629.000	9	69.889	23.296	0.042*
	Intra-group	6.000	2	3.000		
	Total	635.000	11			
Males Tot. /Flies Tot	Intra-group	212.917	9	23.657	7.886	0.118
	Intra-group	6.000	2	3.000		
	Total	218.917	11			

*Significant difference (P = 0.05) for the average of the females caught by traps to total *D. suzukii* collected during monitoring. ANOVA (F = 23.29, E = 1.221).

Comparison of capture efficiency of D. suzukii in each treatment: Table 3 shows the analysis of correlation between catches of different treatments used: control, white, yellow and red traps,

*A&C Trap was developed by Aerial Services Company, Biological and Forestry, Mubarqui [10] Ciudad Victoria Tamaulipas. Mexico.

against total capture of *D. suzukii*, total of females and total of males.

As shown in Table 3, the yellow coloured trap significantly correlated with total *D. suzuki* captured, and also was highly significant with the total females. The best result was obtained for red traps, which significantly correlated with the total females captured, and also highly significant with total males and total flies captured, while the control traps significantly correlated with total *D. suzukii* and highly significantly with the total males. These treatments in turn differ from the white traps, as did not correlate with the capture of females or males. The first females were captured in red, white and control traps.

Relation between average catch of D. suzukii with the plants species referred during monitored: Fig. 3 shows that females of *D. suzukii* were collected in adult higher average (6.25) during monitoring, while the males were approximately half of females with average catch (3.58) of adults.

Generally, all treatments coincided with high catches of spotted wing fruit flies (*D. suzukii*), when the observation points was guava (*Psidium guajava* L.), followed by loquat (*Eribotrya japonica*), peach (*Prunus persica* L.) or fig (*Ficus carica* L.). On the other plant species capture was low.

Statistical analysis of correlation between treatments and plant species present in the monitored area showed a significant correlation between catch of the red colour traps baited SuzukiiTrap® and crop such as citrus, guava, ornamental and loquat plants, followed by control trap with attractive commercial apple vinegar, which also correlated significantly with peach, guava and grape. Finally, the yellow trap had significant correlation with ornamentals; contrary to white traps which were not related to any plant species (Table 4).

Influence of climatic factors on the weekly average catch of D. suzukii in different treatments: As shown in Fig. 4, there was a peak population of females and males of *D. suzukii* in November 2012, when the average maximum temperatures coincided with 27.1°C, minimum temperature of 12.1°C and the difference between them was around 14°C.

From the fourth week (15/11/2012) until the eighth week, there was a reduction of the captured insects, which coincided with the beginning of accumulated rainfall (6.8 mm) and the decrease in average maximum temperature (21.1-15.7°C) and minimum temperature (7.1-6.1°C) with a difference between maximum and minimum temperatures of 14-9.6°C.

The smaller capture occurred during two weeks when there were two consecutive frosts between the eighth and ninth week, where temperatures had maximum (13.6-15.7°C) and minimum (6.10-0.4°C), with differences between maximum and minimum temperatures of 9.6-13.2°C.

After this depression, the insect population, especially females, had a rapid recovery in the tenth week (04/01/2013),with average high temperatures (16.6°C), minimum temperature (3.7°C), and supporting difference between maximum and minimum temperatures (12.9°C).

The negative influence of the mechanical effect produced by accumulated rainfall up to 6.9 mm, was felt on the insect population in the fourth and eleventh week, which coincided with high temperature averages (21.1-18.6°C), minimum average temperatures (7.10-6.9°C), as well as differences between the maximum and minimum temperatures (14-11°C). The correlation analysis (Table 5) shows the relationship between the total population of the insect and sex with the weekly average temperatures. There was a significant correlation between average minimum temperatures and total of *D. suzuki*, as well as the average males. It also showed significant correlation between average males and the temperature difference between maximum and minimum temperatures.

It is inferred that great adaptability mainly from females to climatic changes as the maximum temperatures and a negative factor, when sudden drop occurred in minimum temperature, induced by a cold front or a frost.

Table 3. Analysis of Spearman nonparametric correlation, which compares the collections of females and males *D. suzuki* in the four treatments: control, white, yellow and red trap.

Treatments (Rho de Spearman)				Males Tot.	Females Tot.	*suzukii* Tot.
White trap	Correlation C.			0.117	0.330	0.317
	Sig. (unilateral)			0.359	0.148	0.158
	N			12	12	12
	Bootstrap[a]	Slant		-0.003	-0.029	-0.031
		Typ. Error		0.305	0.282	0.263
		Confid. interval 95%	Inf.	-0.514	-0.324	-0.315
			Sup.	0.663	0.783	0.716
Yellow trap	Correlation C.			0.384	**0.685****	**0.575***
	Sig. (unilateral)			0.109	**0.007**	**0.025**
	N			12	12	12
	Bootstrap[a]	Slant		-0.005	-0.025	-0.014
		Typ. Error		0.289	0.168	0.232
		Confid. interval 95%	Inf.	-0.264	0.264	0.025
			Sup.	0.866	0.919	0.939
Red trap.	Correlation C.			**0.856****	**0.502***	**0.666****
	Sig. (unilateral)			**0.000**	**0.048**	**0.009**
	N			12	12	12
	Bootstrap[a]	Slant		-0.026	-0.012	-0.007
		Typ. Error		0.111	0.283	0.229
		Confid. interval 95%	Inf.	0.534	-0.211	0.109
			Sup.	0.974	0.905	0.969
Artisanal trap	Correlation C.			**0.842****	0.376	**0.616***
	Sig. (unilateral)			**0.000**	0.114	**0.017**
	N			12	12	12
	Bootstrap[a]	Slant		-0.025	-0.007	-0.017
		Typ. Error		0.163	0.306	0.233
		Confid. interval 95%	Inf.	0.391	-0.324	0.059
			Sup.	0.993	0.864	0.951

** Correlation is highly significant to P = 0.01 (unilateral). * Correlation is significant to P = 0.05 (unilateral).

Discussion

During the study, there was a great flight activity of the fruit fly in the territory of Baja, California, primarily of females of *D. suzukii* regarding (12: 5.7) males, which confirms the danger of this pest for the Mexico in several crops.

This species was reported in the country for the first time [20, 30] and phytosanitary alerts for spotted wings fly occurred in November 2011 on blackberry in the municipality of Los Reyes, Michoacán. Also many traps were confirmed infested with *D. suzukii,* in Zapotiltic, Zapotlan Great and Sayula [24], plus five positive cases, two

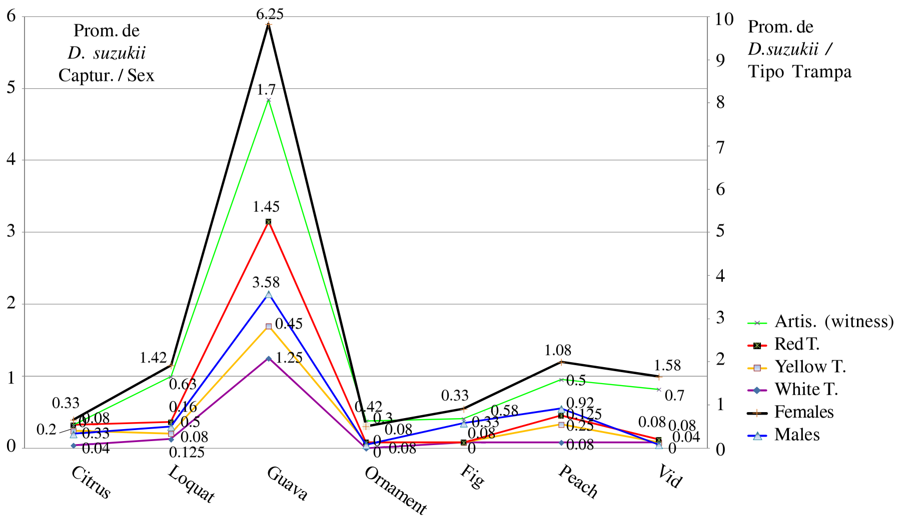

Figure 3. Average catch per treatment: control artisanal trap, white trap, yellow trap, red trap, and the catch taken during monitoring in reference to crops as observation points.

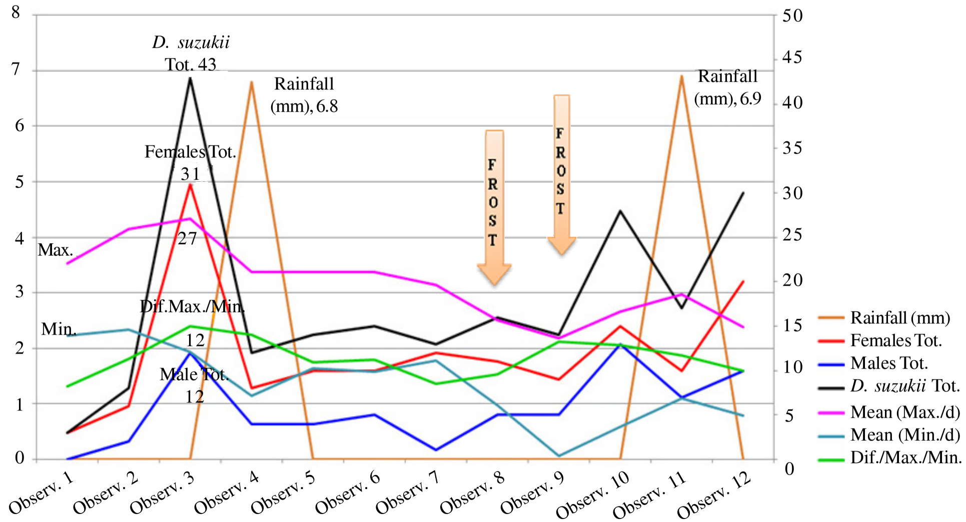

Figure 4. The average, the maximum, minimum and difference between maximum and minimum temperatures each week, the weekly cumulative rainfall (mm) and frost, coinciding with the average catch of males and females and total insects.

Table 4. Pearson correlation analysis, which compares the catch collected from *D. suzukii* in the four treatments (control, white, yellow and red trap) and plants species corresponding to monitored point of *D. suzukii* in Baja California.

Pearson Correlation		Citrus	Peach	Guava	Ornato	Fig	Loquat	Grape
White trap	Correlation	-0.104	0.000	-0.035	-0.274	0.000	0.104	-0.276
	Sig. (unilateral)	0.374	0.500	0.457	0.195	0.500	0.374	0.192
	N	12	12	12	12	12	12	12
Yellow trap	Correlation	0.420	0.061	0.162	0.555*	0.169	-0.211	-0.060
	Sig. (unilateral)	0.087	0.426	0.308	0.031	0.300	0.255	0.427
	N	12	12	12	12	12	12	12
Red trap	Correlation	0.895**	0.081	0.610*	0.597*	-0.200	0.620*	0.024
	Sig. (unilateral)	0.000	0.401	0.018	0.020	0.267	0.016	0.470
	N	12	12	12	12	12	12	12
Artisanal trap	Correlation	-0.243	0.641*	0.508*	0.038	-.084	0.020	0.939**
	Sig. (unilateral)	0.224	0.012	0.046	0.453	0.398	0.476	0.000
	N	12	12	12	12	12	12	12

** Correlation is highly significant to P=0.01 (unilateral). * Correlation is significant to P=0.05 (unilateral).

Table 5. Kendall correlation analysis that compared the collection taken from *D. suzuki* sex and total insects, in relation to average temperatures max, min and differences between maximum and minimum produced during monitoring in Baja.

Correlation Kendall		Males Tot.	Females Tot.	*D. suzukii* Total
Max temp.	Correlation	-0.288	-0.270	-0.313
	Sig. (unilateral)	0.104	0.118	0.083
	N	12	12	12
Min temp.	Correlation	-0.500*	-0.202	-0.382*
	Sig. (unilateral)	0.013	0.184	0.043
	N	12	12	12
Max/Min Dif. Temp.	Correlation	0.406*	0.016	0.260
	Sig. (unilateral)	0.036	0.472	0.121
	N	12	12	12

** Correlation is highly significant to P=0.01 (unilateral). * Correlation is significant to P=0.05 (unilateral).

in peach and grape in Aguascalientes [25].

The active ratio in favour of females corroborates the point made by Landolt *et al.* [19], where significant difference was observed with females and males (1335: 968) in traps loaded with wine/ vinegar of different ages.

The preference or attraction in *D. suzukii* with the evaluated treatments indicate that traps have a high potential for use in signaling of this species in areas under monitoring, ensuring that the capture of this species is favoured when used SuzukiiTrap® attractant in A & C traps (colour red and yellow). However, it accepts the use of commercial vinegar as directed in the protocol from Mexico [7]. Thus, it was confirmed that the colour of the trap influences the capture and improves collection efficiency when using suitable bait. In this case, the use of the attractant SuzukiiTrap® was favoured by A & C traps.

Cini *et al.* [4] said that the capture's performance is also greatly influenced by the colour, shape and structure of the trap, reiterating that the red and black colour traps have proved attractive colours, but the transparent trap was not recommended [23]. As some have recommended acceptable use of different types of traps for monitoring this species, Lee *et al.* [21] obtained variations between sites and the trap type, the catch of *D. suzukii* received by Haviland was followed by the red colour, Van Steenwyk and transparent type.

It corroborates the point made by Landolt *et al.* [19], which indicated that chemicals like vinegar, acetic acid and wine, including ethanol, are attractive to this species. They suggest that age of baits and exposure time can be influence the insect's attraction. These baits, after seven days have low volatility and lower attraction.

The SuzukiiTrap® attractant is 100% organic food, contains hydrolyzed protein, it is a formulation ready to use, unchanged without heterogeneous mixtures with volatile emission staggered over time, specific for *D. suzukii*, which avoided having to recharge the trap often, so its effectiveness is guaranteed while in liquid form it is attractive and the weather permits territory [1].

In the monitoring, when using red traps with the SuzukiiTrap® attractant, the fly had preference for fruit species, such as citrus, guava, ornamentals and loquat, while the control, loaded with commercial vinegar, is related to peach, guava and grape. Finally, the capture of yellow traps was related only with ornamentals. Interestingly, the guava in Mexico is not located within the host at risk of infestation by this fly [7], however, this crop should be considered for inclusion in the list of high risk on the inspection protocol and monitored.

D. suzukii is able to grow in a wide range of soft-skinned fruits cultivated and wild on many host plants native and invaded areas, where the berries can be preferred hosts [4].

Various researchers corroborated that females of *D. suzukii* lay eggs in the ripe fruit, which becomes soft and with no commercial value [2, 9, 29, 30]. Asserting that this species can affect various healthy fruits like cherry, strawberry, fig, grape, plum, apricot, apple, peach, persimmon, raspberry, blueberry, blackberriy, kiwi and pears, as cultivated plants generate high population density, while the wild and ornamental hosts serve as refuges and sources of reinfestation and wintering habitats [18].

During monitoring, the maximum temperatures observed did not seem to adversely affect populations of *D. suzukii*, which showed great adaptability of the females. Moreover, the sudden drop in temperatures caused by frost negatively influenced on pest, which had to rapid recovery for a week.

This shows that there are relations with minimum temperatures, which influence the total number of insects collected and on total males, but at last, are most influenced by the difference in degrees between maximum and minimum temperatures.

Cini *et al.* [4] explains tolerance in a wide range of weather conditions for this species. The ability to survive and reproduce in different conditions is obviously a relevant factor of these insects. Temperature limits established for breeding are between 10 and 32°C and up to 30°C for male fertilization [26]. The peak of activity and development is around 20-25°C [15]. *D. suzukii* can be considered a species with high thermal tolerance.

Dreves *et al.* [9] confirmed that 3 to 10 generations are expected for most production climates in California and Walsh *et al.* [30] estimated that it can have up to 10 in this state. This explains that the flies are most active at temperatures of 68°F (20°C), and its activity, longevity, and oviposition come down to higher temperatures (above 86°F (30°C)). These prefer to develop, in fresh temperatures that are presented during the early summer and fall.

Nevertheless, *D. suzukii* has been found in the summer seasons of California and Florida where it is hot, which means, they must be able to survive in high temperatures found during the summer in the Oregon. Walsh *et al.* [30] inferred that the eggs, larvae and adults of this species can die at temperatures below zero, but it does not necessarily mean that all population is eliminated at low temperatures and *D. suzukii* is set on the island of Hokkaido in Japan, where winter average temperature is -12 to -4°C.

Adults are particularly cold tolerant compared to other Drosophila [16] and females come to reproductive diapauses as a stage of hibernation [15, 22, 30].

This tolerance may be mediated by physiological or behavioural adaptation to area. Some authors suggest that *D. suzukii* survives in adverse conditions, due to its altitudinal migration [22], acclimatization [30], artificial hibernation habitats or other protected sites [17].

Conclusions

Based on the monitoring of the pest, it was possible to confirm the presence of the spotted wing fruit fly (*Drosophila suzukii* Mats.) in Baja California, Mexico.

This dangerous pest had the largest population female's peak in November 2012 in proportion of 2:1, from the total of flies caught in traps and two population peaks both sexes in January 2013.

The population of fruit flies can be efficiently monitored with red traps, followed by the yellow traps using SuzukiiTrap® attractant. However, artisanal traps with vinegar are efficient as the yellow traps, but have more preference for males, negative aspect that should be considered by the great flight dynamics and peaks population of the females.

There is a strong relationship between the catch by red traps and the plant species such as citrus, guava, ornamentals and loquat; followed by artisanal trap, which has a better catch on peach, guava and grape, while the yellow traps were only associated with ornamentals. The white traps did not show direct relation between captured insects and the plants.

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