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THE SPOTTED WING DROSOPHILA *DROSOPHILA SUZUKII* (MATSUMURA, 1931) – MONITORING AND FIRST RECORDS IN POLAND

Barbara H. ŁABANOWSKA, Wojciech PIOTROWSKI*
Research Institute of Horticulture, Konstytucji 3 Maja 1/3, 96-100 Skierniewice, Poland

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ABSTRACT

The spotted wing drosophila (*Drosophila suzukii*) (SWD) monitoring was carried out between 2012-2014 in eight locations. In order to determine the presence of *Drosophila suzukii*, several types of traps and baits were used. In 2014, Polish (prototype of Drosinal) and Spanish (Cera Trap) traps and baits were used in our study. In each year, traps were placed on the plantations of blueberry, strawberry, raspberry and at a wholesale market at the beginning of July, and monitored once or twice a week until mid-December. During 2012 and 2013 there were no flies of the spotted wing drosophila in traps. First flies of this species were captured in 2014 in two locations: Września (3rd week of October) and Brzezna (1st week of December) – western and southern Poland respectively, in both types of the traps. However, Polish traps were more effective in trapping *D. suzukii*. In addition, the Polish product has small holes and therefore captures less no target and beneficial insects than Spanish traps. Despite detection of SWD in Poland, damaged fruits were not found.

Key words: occurrence, spotted wing drosophila, *Drosophila suzukii*, SWD, Cera Trap, ICB Pharma trap

INTRODUCTION

The spotted wing drosophila (SWD) (*Drosophila suzukii* Matsumura, 1931) (Diptera: Drosophilidae), also known as the cherry fruit fly or cherry vinegar fly, is a polyphagous, invasive species originating from South-Eastern Asia (Kanzawa 1935; Walsh et al. 2011). This is unique species in comparison to other drosophilids, including the common fruit fly, *Drosophila melanogaster*, which lays eggs into previously damaged fruit (EPPO 2013).

Due to the global fresh fruit trade, *D. suzukii* coupled with the cryptic nature of the larvae to hide inside the fruit undetected until after transportation, entered to Hawaii Islands in 1980 (Hauser 2011), and then in 2008 to California (Burrack et al. 2012) and to Europe (first in Spain and in the late autumn to Italy and France) (Grassi et al. 2009; Calabria et al. 2010; Cini et al. 2012). Since 2008 it has spread rapidly throughout the temperate regions of North (Burrack et al. 2012) and South (Hauser 2011; Deprá et al. 2014) America and Europe (Mandrin et al. 2010; Lethmayer 2011; Milek et al. 2011; Baroffio & Fisher 2011; Mortelmans et al. 2012; Vogt et al. 2012; Kiss et al. 2013; Helsen et al. 2013; Ostojic et al. 2014; Tosevski et al. 2014 and Radonjić & Hrncić 2015). In the short period of time, *D. suzukii* became one of the most damaging pests in the temperate regions (Saguez et al. 2013).

D. suzukii overwinter as adults (Dalton et al. 2011). Flies emerge in spring, but some adults may be active even during warm winter days (Kanzawa 1935; Kiss et al. 2013). The SWD adults are approximately 2-3 mm in length (females are slightly larger than males), with red eyes, pale brown thorax and pale brown abdomen with black transverse stripes (Tochen et al. 2014). Males are distinguishable by the presence of a dark spot near the wing tips and by two short sex combs on the 1st and 2nd segment (respectively) of fore tarsi (Kanzawa 1939). Females have a highly sclerotized and serrated ovipositor, which allows oviposition in ripening pre-harvest fruits as well as in ripe, overripe, and fallen or damaged fruits (Lee et al. 2011). The number of eggs per fruit, ranges from one to several; they are scattered over the fruit (Burrack et al.

*Corresponding author:
e-mail: Wojciech.Piotrowski@inhort.pl

2013). Oviposition lasts between 10-65 days, with up to 21 eggs per day. Average fertility of each female is at least 195-400 eggs during lifetime (Kanzawa 1939; Tochen et al. 2014). Eggs develop within 1-3 days, larvae matures in 3-13 days and most of them pupate in the fruit, but some drop and creep into the soil (Kanzawa 1939). Pupae period lasts from 4 to 43 days. The minimum, optimal and maximum temperature for developing was estimated at 13.4, 21.0 and 29.4 °C by Tochen et al. (2014). The larvae of *D. suzukii* destroys the fruit flesh by feeding (Grassi et al. 2009), and other insects, fungi and bacteria may cause further fruit damage (Walsh et al. 2011). The damage caused by *Drosophila suzukii* larvae make the fruit unsuitable for sale (Kanzawa 1939). This pest infests a wide range of fruit crops (especially small and stone fruits with soft skin), including grape, as well as a number of fruits from non-cultivated plants (Walsh et al. 2011; Cini et al. 2012). *D. suzukii* can develop 3-9 generations per year (West United States, Canada and northern Italy), which may contribute towards rapid spread (approximately 1400 km a year), given availability of suitable hosts (Calabria et al. 2010). *D. suzukii* is listed on the EPPO alert list.

The aim of this study was to check the occurrence of the spotted wing drosophila in Poland.

MATERIALS AND METHODS

Field tests

Between 2012-2014 monitoring of the spotted wing drosophila was carried out in eight locations in Poland. In 2012, studies were only carried out in Dąbrowice and Skierniewice in central Poland. In 2013, research was continued in the above locations, but also extended to monitor the plantations in other regions of the country: Grójec and Piskórka (central Poland) and Września and Ochla (western part of the country). Observations were also carried out at the wholesale market in Bronisze near Warsaw, where imported and domestic fruits are stored and traded as well as maintained prior to shipment to other countries. In 2014, research was continued at the same places as in 2013 and extended to Brzezna (southern part of Poland).

In order to verify the presence of *Drosophila suzukii*, several types of traps and liquid attractants (baits) were used and tested in our study. In 2012, traps and baits made at the Research Institute of Horticulture (RIH), following the study carried out in the Research and Innovation Centre, Fondazione Edmund Mach, Italy (personal communication with Dr. Andrea Tandardini) were used. The traps consisted of PCV bottles with 6-7 holes of 5 mm diameter and a capacity of 1.0-1.5 L, filled with 250 ml of liquid attractant. The attractant consisted of 200 ml of apple vinegar and 50 ml of red wine. In 2013, the same traps and baits were used, in addition to traps and liquid attractant that were supplied by Polish company (ICB Pharma). In 2014, the traps and baits were used from Polish – prototype of Drosinal (ICB Pharma) (Fig. 5) and Spanish – Cera Trap (Bioiberica) (Fig. 6) companies. The traps were filled with 300 ml of liquid baits. The composition of baits is the companies secret. Every 4 weeks, baits in traps were replaced with new ones. In Września, Ochla, Bronisze and Brzezna, one Polish and one Spanish trap were placed. The traps were spaced approximately 10 m apart, in each of the other locations (Skierniewice, Dąbrowice, Grójec, Piskórka) only Polish traps were used.

In the tree orchards, traps were hung at a height of 1.0-1.5 m in a shaded area, while at bushes plantations traps were hung at the height of fruiting shoots. At the tunnel cultivation of strawberry, traps were placed in row, about 10 cm above the plants. In the fresh fruit market, traps were placed on a fence in the shade. Every year, during the three years period, traps were placed in the plantations and the wholesale market at the beginning of July. These were monitored once or twice a week until a mid-December. The captured flies were removed from each trap and transported to the RIH, where they were identified.

Laboratory tests

Morphological identification was carried out using a stereomicroscope according to the key by Okada (1956), the description by Bock and Wheeler (1972) that provides pictures of the sex combs and genitalia of males, and following the EPPO (2013) diagnostic protocol for *D. suzukii*. The first putative adult specimens were confirmed by Dr. Andrew G.S. Cuthbertson from Fera Science Ltd. in the UK on the base of stereomicroscopic images (Fig. 1-4).

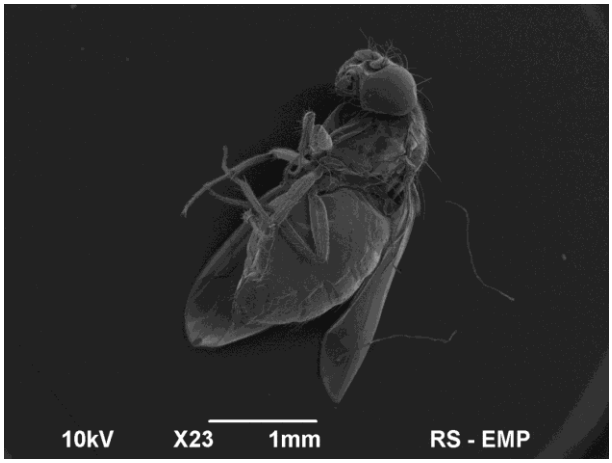

Fig. 1. *D. suzukii* female (photo by B. Dyki)

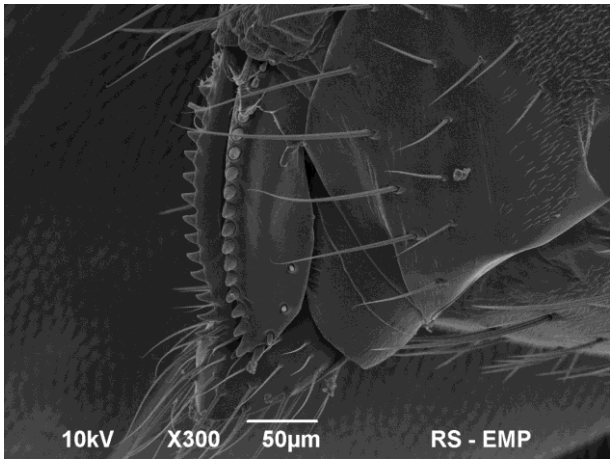

Fig. 2. Strongly serrated ovipositor of *D. suzukii* female (photo by B. Dyki)

Fig. 3. *D. suzukii* male (photo by A. Murgrabia)

Fig. 4. Sex combs on forelegs tarsomere of *D. suzukii* male (photo by A. Murgrabia)

Fig. 5. Polish trap (prototype of Drosinal) at plastic tunnel (2014) (photo by W. Piotrowski)

Fig. 6. Spanish trap (Cera Trap) at plastic tunnel (2014) (photo by W. Piotrowski)

RESULTS

The monitoring of *D. suzukii* in 2012 and 2013, did not lead to the capture any flies of this species. From early July to the first week of October in 2014, there were also no flies of SWD in the traps (Łabanowska & Piotrowski 2015; Łabanowska et al. 2015), but in the third week of October – 4 females and 5 males of *D. suzukii* were collected in Września (Fig. 7). *Drosophila suzukii* flies were also caught in the last week of October at this location. A total of 21 SWD (11 females and 10 males) were caught in this month. More flies were also caught within November, when 23 females and 19 males were found, and ended in early December with 3 female specimens that were found in Brzezna (Fig. 7). In total, throughout 2014, 37 females and 29 males of SWD were found (Table 1). All flies captured in October and December come from Polish traps. While in November, 18 females and 13 males were captured using Polish traps, and 5 females and 5 males by Spanish traps. The total number captured flies by Polish traps was 55, and 11 by Spanish traps (Table 2).

Polish and Spanish traps also captured other flies as *D. melanogaster* and *Drosophila immigrans*. However, their number was not dependent on the type of trap used. Furthermore, Spanish traps caught other flies, that were bigger than SWD because they were provided with larger holes (10 mm), whereas in Polish traps, holes were 5 mm. The most common insects found in Spanish traps were wasps (*Vespula vulgaris* L.), earwigs (*Forficula auricularia* L.), houseflies (*Musca domestica* L.). Sometimes, the number of other insects in Spanish traps was very high, which increased time needed for identification of *D. suzukii*.

Fig. 7. Map showing where *Drosophila suzukii* was detected on the territory of Poland in 2014 (W. Piotrowski)

Although this pest has been detected in Poland, the damage to the fruits was not observed. In 2015, monitoring of SWD is still ongoing at the Research Institute of Horticulture, the Agricultural Advisory Centre, the Main Inspectorate of Plant Health and Seed Inspection, and Growers in about 200 locations.

Table 1. Results from the monitoring of *D. suzukii* adults on the territory of Poland during 2014

Month	Collection date								Total number	
	1st week		2nd week		3rd week		4th week			
	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂
July	-	-	0	0	-	-	0	0	0	0
August	-	-	0	0	-	-	0	0	0	0
September	0	0	-	-	0	0	-	-	0	0
October	0	0	-	-	4	5	7	5	11	10
November	3	6	6	4	11	8	3	1	23	19
December	3	0	0	0	-	-	-	-	3	0

Table 2. Results from the monitoring of *D. suzukii* adults using Polish and Spanish traps in 2014

Location (GPS coordinates)	Crop	Traps	Females (♀)	Males (♂)	Total number
Skierniewice (51°57'45.2"N 20°10'11.2"E)	Blueberry (around are raspberry, currant, grape)	P	0	0	0
		S	-	-	-
Dąbrowice (51°54'47.4"N 20°06'54.1"E)	Sweet cherry, blueberry, hardy kiwifruit, small forest	P	0	0	0
		S	-	-	-
Grójec (51°50'58.6"N 20°40'33.0"E)	Blueberry surrounded by forest	P	0	0	0
		S	-	-	-
Piskórka (51°59'25.6"N 21°00'16.9"E)	Blueberry surrounded by forest	P	0	0	0
		S	-	-	-
Września (52°09'50.6"N 17°40'26.6"E)	Blueberry, apricot, blackberry, wild fruiting species	P	22	30	52
		S	5	6	11
Ochla (51°52'49.3"N 15°27'28.9"E)	Strawberry (tunnel cultivation)	P	0	0	0
		S	0	0	0
Bronisze (52°13'17.9"N 20°50'21.4"E)	Fresh fruit market	P	0	0	0
		S	0	0	0
Brzezna (49°36'01.3"N 20°36'46.2"E)	Raspberry (around are sweet cherry and forest)	P	3	0	3
		S	0	0	0

P – Polish traps; S – Spanish traps

DISCUSSION

Morphologically, specimens of *D. suzukii* caught in Poland did not differ from the specimens of this species recorded in other parts of Europe (Grassi et al. 2009; Calabria et al. 2010; Vogt et al. 2012).

Records of this invasive organism in Poland are not surprising, in connection with information about the rapid spread of this insect across Europe (Cini et al. 2012). In our study, the first record of *D. suzukii* in Poland took place in the third week of October 2014. A similar situation had happened in Spain (Calabria et al. 2010), Italy (Grassi et al. 2009, 2012), France (Cini et al. 2012), Switzerland (Baroffio et al. 2013), and Germany (Vogt et al. 2012), where insect activity was recorded between mid-September and late October in the first year of capture. However, most of first findings were not associated with fruit damage, except in northern Italy (Grassi et al. 2009). In the above countries, the number of *D. suzukii* captures was the highest in late fruiting crops such as raspberries, blackberries and blueberries and in the surrounding vineyards. Generally, three years after the first catch, damage to fruits of economic value were noted in the above western European countries.

According to Bolda et al. (2010) and Walsh et al. (2011), preliminary studies in the USA (California, Oregon and Washington) indicated that annual damage caused by *D. suzukii* on five crops (strawberries, blueberries, raspberries, blackberries and cherries) was about 20%, which meant a loss of more than 510 million dollars. De Ros et al. (2013) reported damage of more than 3.3 million EUR annually to Italian fruits from the same crops in Italy (Trentino region).

To catch SWD, a number of prototypes and commercial traps and attractants were developed. A variety of trap prototypes made by researchers from several countries, and commercial traps are available to monitor adult *D. suzukii*. Commercial traps include Droso-Trap (Biobest, Belgium), Moskizan Trap (Koppert, UK), Pherocon SWD (Trece, USA), Cera Trap (Bioiberica, Spain), Hemitrap (Probodelt, Spain), Riga trap (Andermat, Switzerland), Maxi-trap (SEDQ, Spain), and others.

Some of these traps are adaptations of existing designs and were not designed originally for *D. suzukii* detection. Comparisons among different trap designs (size, color, volatilization area, entry area) have been performed across different regions and crops (Lee et al. 2012, 2013). Generally, traps with narrow entry points were considered better than those with wide holes because the narrow ones slowed evaporation of the bait and prevented entry of insects larger than *D. suzukii* (Kanzawa 1939).

Lee et al. 2013 stated, that yellow and red traps caught more *D. suzukii* than clear traps, however black traps captured less than yellow traps overall, but more than clear traps. For this reason both of our tested traps (Polish and Spanish) were yellow. Basoalto et al. (2013) reported that the preference to red and black color was evident in several cage tests. More *D. suzukii* were caught in clear traps with red or black caps than with white caps on traps of different colors. Such differences could be the result of differences among hues. A preference for yellow color may be based on attraction to foliage-like hues (Prokopy & Owens 1983).

Lee et al. 2013 found that attractiveness of different colors may also be connected with crop type. In the case of *D. suzukii*, which has a wide host range, attraction to colors may not be fully explained by host association. A combination of volatile cues or physical contrast with the environment may also affects their attraction to colors. The attractiveness of colors might vary with the time of the year, depending on crop maturity and senescence. Lee et al. (2013) caught more *D. suzukii* in sweet cherry, grape, and raspberry crops when the entry points were on the side traps rather than on the top. Such results were not confirmed in our recent study, because traps with top entries caught more *D. suzukii* flies than those with side entry. In addition, traps used by Lee et al. (2013) were not stable, because they were made with a plastic cup covered by a bowl on the top, and both were joined by wire. The space between cup and bowl was too big, and rain could enter inside. On the other hand, efficacy of this trap with top-entry should be checked and confirmed in other experiments.

Bait is needed to attract the flies to the trap. Apple cider vinegar was one of the first baits used because it is readily available, inexpensive, and transparent to see captured bodies, but it is not the most attractive bait (EPPO, 2013; Lee et al. 2013). This lure has recently been improved by adding wine (Landolt et al. 2011) and wine and sugar (Grassi & Maistri 2013). The combination of wine and apple cider vinegar caught more *D. suzukii* in the field compared to apple cider vinegar alone (Landolt et al. 2012). The fly response to the combination of vinegar and wine was greater than the response to acetic acid or the combination of acetic acid and ethanol, which are the principal volatile chemical components of vinegar and wine respectively (Landolt et al. 2011). This finding indicates that other volatile chemicals are emitted by vinegar and wine, in addition to acetic acid and ethanol that may also be attractive to male and female *D. suzukii*. A sugar-yeast bait has been used successfully and out-performed apple cider vinegar (Knight et al. 2013). A small drop of dish soap added to the liquid bait as a surfactant, or the placement of a sticky card within the trap, results in more fly captures. Many other different baits are already present in the market, including Riga (Andermat, Switzerland; Fruits Fly (Koppert, UK); Pherocon SWD (Trece, USA); Suzukii Trap (Bioiberica, Spain); Dros'Attack (Biobest, Belgium), Pherobank (Netherlands), Droskidrink (Italy) and other. Many commercialized baits are also being evaluated, and it is a key step toward making trapping more effective. However, there are no baits on the market, which could be more effective to attract *D. suzukii* than ripe fruits. Traps used recently, cannot be replaced for chemical protection, because even 150-200 traps per hectare did not prevent damage of fruits (personal communication with Dr. Kirsten Köppler, Center for Agricultural Technology, LTZ, Germany).

Spanish traps (Cera Trap) and lure (Suzukii trap) were tested in France and Spain. According to Claire Weydert, (Centre technique interprofessionnel des fruits et legumes – Ctifl, France), Droso-Trap was more effective than Cera Trap in capture of SWD flies. On the other hand, Riga traps were as effective as Cera Trap, if they were filled with the same attractant. She also mentioned that e.g. Riga, Dros'attract and Pherocon lures were more effective to attract SWD than Spanish lure – Suzukii

trap. In Spanish research, Droskidrink based on apple cider vinegar, vine and sugar, and even used as control diluted cider vinegar and molasses were more effective in captures *D. suzukii* flies than Spanish (Suzukii trap) (personal communication with Dr. Adriana Escudero, Research & Technology, Food & Agriculture, IRTA, Spain).

An ideal trap or bait should be selective and does not attract other flies, especially beneficial organisms. However, the published study revealed no differences in species selectivity by traps and baits. A good idea is to develop a trap based on mechanical selectivity (nets in all holes, with size of mesh about 3-5 mm) or few small holes in the traps walls. The holes of the commercial traps have at least 1 cm and consequently captured a large number of Lepidopterans, and Hymenopterans (Baroffio et al. 2013). The number of *D. suzukii* captured increases consistently in traps with greater entry areas, but the proportion of non-target drosophilids captured remained the same (Lee et al. 2013).

Poland is the main producer of several fruit species (strawberry, raspberry, blueberry, cherry, currant, as well as others) in EU. The first detection of *D. suzukii* in western and southern parts of Poland may pose a serious threat in the future for soft skinned fruits. We expect further spread of SWD in Poland. We also expect that the new invasive *Drosophila* species might substantially change the fruit production strategy. The presence of SWD also implies that insecticide treatments must be adapted to address this new entomological challenge, especially because *D. suzukii* attacks fruit just before and during harvest. In 2015, the Polish Ministry of Agriculture and Rural Development promptly registered spinosad, thiacloprid and deltamethrin against *D. suzukii*, for application before oviposition in fruits. Spreading of the SWD may results in cost increases due to potential yield losses. Future research should include traps with improved physical characteristics, with an emphasis on lure improvement for early detection of flies. This will enable growers to predict crop risk and optimize timely management decisions.

CONCLUSION

1. The monitoring of *D. suzukii* adults in 2012-2014 showed the detection of this pest in Poland in 2014.
2. Both the Polish and Spanish traps and baits can be used for detection and monitoring of *D. suzukii*.
3. Identification of *D. suzukii* captured by Polish traps is easier due to the fact that smaller holes only caught small flies.

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