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CURRENT STATE OF INVASION OF *DROSOPHILA SUZUKII* (MATSUMURA, 1931) IN UKRAINE

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Abstract.
Ukraine is on the invasion front of spotted-wing Drosophila suzukii *(Matsumura, 1931) spreading in Europe. Despite this globally important pest was confirmed only on the southernmost tip of its territory, recently published species distribution models expect its occurrence also in other Ukrainian regions. Therefore, we conducted two-year monitoring (2018-2019) during the whole fruit ripening season; samples were collected on the whole Ukrainian territory; standard bait traps and active capture by an insect net were employed. Individuals of the species were recorded only at the end of the vegetation season (August–October) and only in the westernmost part of Ukraine (Transcarpathian region); in the region predicted by recent ecological niche modeling. The late occurrence of* D. suzukii *probably reflects the presence of suitable food/fruit for the larvae at the end of the growing season. Our results confirm the importance of monitoring of this pest, together with the investigation of factors that may affect its invasion.*

Key words: establishing population, invasion front, seasonal variation, spotted-wing *Drosophila*

Introduction

Drosophila suzukii (Matsumura, 1931) or the "spotted-wing *Drosophila"* (Diptera: Drosophilidae), is a highly invasive species, which causes significant damage to a number of cultivated berry and stone fruit crops (Calabria et al. 2012, Asplen et al. 2015). This dipteran originating from Asia (Kanzawa 1939) has emerged as a major insect pest of small and stone fruits in both Americas and Europe since 2008 (Asplen et al. 2015). Now it appears to be a subcosmopolitan species, with distribution range between 50° S and 70° N (e.g. Hauser 2011, Lee et al. 2011, Calabria et al. 2012, Cini et al. 2012, Kiss et al. 2013, Březíková et al. 2014, Deprá et al. 2014, Kinjo et al. 2014, Asplen et al. 2015, Lengye et al. 2015, Łabanowska & Piotrowski 2015, Lavrinienko et al. 2017, Oboňa et al. 2017, Japoshvili et al. 2018, Ørsted & Ørsted 2019, Zengin & Karaca 2019).

Invasive populations established in Europe have most probably different ecological demands compared with those in the Americas, as suggested by Ørsted & Ørsted (2019). Using species distribution models (SDMs), they predicted the occurrence of the species not only on the southernmost tip of Ukraine, where it was already recorded in 2014 (Lavrinienko et al. 2017) but also in country´s western part, adjacent to countries where *D. suzukii* was already reported: Poland, Hungary, Slovakia, Romania (e.g. Kiss et al. 2013, Chireceanu et al. 2015, Łabanowska & Piotrowski 2015, Oboňa et al. 2017, etc.). Despite this, this pest still receives almost no scientific attention in Ukraine. Therefore, our survey aims to bring new systematically collected information about the occurrence and seasonal activity of the species in Ukraine.

Material and Methods

In an effort to identify a spatio-temporal pattern of *D. suzukii* occurrence in Ukraine, which is on the westernmost invasion front of this pest (see also Ørsted & Ørsted 2019); our sampling sites covered most of the territory of the country (altogether 13 sampling sites; see Table 1, Fig. 1). Several methods were used for collection, especially standard bait traps (exposed for 14 days, see Manko et al. 2019) and active capture by an insect net. A beer with the

Table 1. List of collecting sites (see also Fig. 1)

Locality number	Site name	Site description	Collection method	Geographic coordinates	Altitude (m a.s.l.)	Sampling period	Collector
site 1.	Uzhhorod	garden with apple trees	Bait (beer)	48°39’22.0”N 22°19’50.3”E	200	two-week period in 05.2018 08.2018 05.2019 07.2019 09.2019	R. Mariychuk
site 2.	Sanatorium Karpaty	garden near a forest with apple trees	Bait (beer)	48°31’16.8”N 22°52’14.7”E	166	two-week period in 05.2018 08.2018 05.2019 07.2019 09.2019	R. Mariychuk
site 3.	Odesa	Mixed orchard nearby human residence	Bait (apples, beer)	46°29’13.91”N 30°43’51.59”E	54	two-week period in 06.2018 08.2018 09.2018 06. 2019 09.2019	D. Radionov
site 4.	Kyiv	Mixed orchard nearby human residence	Bait (apples, pears, beer)	50°21’9.06”N 30°28’57.70”E	179	two-week period in 07.2018 09.2018 08.2019	I. Kozeretska
site 5.	Varva	Local fruit factory	Active capture by an !entomo-logical net	50°29’33.30”N 32°42’50.93”E	125	09.2018 09. 2019	O. Protsenko
site 6.	Pyriatyn	Mixed orchard nearby human residence	Bait (apples, beer)	50°19’35.40”N 32°29’35.62”E	114	two-week period in 08.2018 08.2019 09. 2019	O. Protsenko
site 7.	Chornobyl	garden with apple trees	Bait (apples, beer)	51°16’21.5”N 30°13’16.9”E	121	two-week period in 09. 2019	P. Kovalenko

Table 1. (continued)

Locality number	Site name	Site description	Collection method	Geographic coordinates	Altitude (m a.s.l.)	Sampling period	Collector
site 8.	Kopachi (Chornobyl region)	Apple trees in the forest	Bait (apples, pears, beer)	51°35'11.79"N, 30°12'77.46"E	123	two-week period in 09. 2019	P. Kovalenko
site 9.	Kharkiv	Mixed orchard nearby human residence	Bait (apples, beer)	49°59'24.30"N 36°13'50.44"E	141	two-week period in 09.2018 08.2019	S. Serga
site 10.	Uman	Local fruit factory	Active capture by an insect net plus bait (apples, beer)	48°45'45.26"N 30°14'38.97"E	214	two-week period in 08.2018 09.2018 06.2019 10.2019	P. Kovalenko
site 11.	Uman K	Mixed orchard nearby human residence	Bait (apples, beer)	48°46'08.5"N 30°10'23.6"E	214	two-week period in 07.2018 08.2018 10.2018 06.2019 08.2019	P. Kovalenko
site 12.	Hlevakha	Raspberry undergrowth in forest	Bait (apples, beer)	50°17'05.9"N 30°19'55.1"E	197	two-week period in 09.2018 07.2019 08.2019	S. Serga
site 13.	Korzhove	Mixed orchard nearby human residence	Bait (apples, beer)	49°22'26.7"N 38°22'20.5"E	182	two-week period in 09.2019	Ye. Kharkivska

addition of local fruit was preferred as a bait, as this sampling method proved to be the most successful in the adjacent recently invaded countries (e.g. Oboňa et al. 2017). The sampling season reflected the ripening season of the possible host plants on the site (months from May to October depending on the ripening of the dominant fruit in the monitored area). *D. suzukii* in sampled material was identified according to Bächli et al. (2004) and Calabria et al. (2012).

Results and Discussion

Research of invasions is recently a hot topic due to the potentially deteriorating influence of invasive species on native species, communities, and/or ecosystems; and it is important to study them from their very beginning (e.g. Elton 1958, Wallace et al. 2020). One of the globally important invasive species is spotted-wing *Drosophila suzukii* (e.g. Asplen et al. 2015). Although many authors pay attention to this

Figure 1. *Drosophila suzukii* (Matsumura, 1931) positive and negative sampling sites in Ukraine based on the results of this study.

dipteran, they are focused mainly on experiments (e.g. Richardson and Pyšek 2007); occurrence data from newly invaded areas are still rather scarce (e.g. Ørsted & Ørsted 2019). *D. suzukii* is known to be present in Ukraine from one record in its southernmost tip from 2014 (Lavrinienko et al. 2017); however, considerable damage has not yet been recorded. Nevertheless, it is very important to pay attention to it and monitor its occurrence and abundance in the territory of Ukraine, especially as a large portion of the country´s farmland is planted with economically important fruit orchards (although often abandoned now, e.g. Baumann et al. 2011).

Our results seem to confirm that in Ukraine, the invasion appears to be in its early stages.

We recorded *D. suzukii* on only two sites in the Transcarpathian region (the westernmost part of Ukraine) of the 13 monitored sites (Fig. 1). Previous occurrences of *D. suzukii* were detected in the Crimean Penisula (Lavrinienko et al. 2017).

Drosophila suzukii was rare in our samples. Only 7 specimens (5 males and 2 females) were caught in 2018, and 15 specimens (4 males and 11 females in 2019). Interestingly, all individuals were recorded only in autumn. The flying activity of *D. suzukii* is reported throughout the year in their natural, but also invasive range, where it has been present for a longer time (see Asplen et al. 2015, Arnó et al. 2016, Rossi-Stacconi et al. 2016, Leach et al. 2019). In North-eastern Slovakia, directly adjacent to the region where our new *D. suzukii* occurrences were confirmed, the species was also caught only in autumn (Oboňa et al. 2017).

The lifespan of *D. suzukii* varies greatly among generations; from a few weeks to ten months (e.g., Hauser 2011, Lee et al. 2011, Calabria et al. 2012, Cini et al. 2012, Deprá et al. 2014, Kinjo et al. 2014, Asplen et al. 2015). Most studies were focused predominantly on agriculturally important areas. Generations hatched throughout the warm season have shorter lifespans than generations hatched after September. Only adults (the winter morph) overwinter successfully as was found out by Lee et al. (2011), Asplen et al. (2015), Leach et al. (2019), etc. In Ukraine, similarly to Slovakia (Oboňa et al. 2017), captured specimens represented only summer forms, the winter morph (see Leach et al. 2019) was absent. According to Harris et al. (2014), in California (USA), this pest has two distinct periods of trap capture: in spring (which has not been confirmed in Ukraine) despite the sampling, and through mid-summer. From late December through mid-Jan-

uary, high trap captures were associated with the citrus and house sites (Harris et al. 2014), which was apparently conditioned by more suitable climate for wintering, and also by the presence of a fruit store near the houses. Grassi et al. (2018) suggest that environmental conditions in Trentino, Italy, during the dormant period induce reproductive diapause but this pest has great potential for oviposition early in the season, posing a risk to early-season maturing crop hosts. However, it is possible that the species is not yet able to fully overwinter in Ukraine or it is present only in numbers that are difficult to detect (or they winter in human dwellings).

Williamson (2006), after comparing the numerous previous studies (e.g., Williamson & Brown 1986, Williamson 1996, 1999, 2000, Richardson et al. 2000, Heger & Trepl 2003, Ruiz & Carlton 2003, Colautti & MacIsaac 2004, Lockwood et al. 2005) concluded that an invasion can go through a series of stages, and can get stuck at any of them.

We assume that the *D. suzukii* invasion is only on its early stage (**"**establishing a population" according to Williamson 2006) in the studied area, similarly to Hungary (first report in 2012 – Kiss et al. 2013), Czech Republic (2014 – Březíková et al. 2014), Slovakia (2015 – Asplen et al. 2015, Oboňa et al. 2017), and Poland (2014 – Asplen et al. 2015, Łabanowska & Piotrowski 2015). The occurrence at the end of the season and absence at the beginning of the season may indicate that the pest probably just adapts to new environmental conditions, which corresponds with the conception of Samways et al. (1999), Samways (2003), Sutherst (2003). Among other factors, this new pest presumably has to deal with uneven ripening season of suitable fruits, competition with native species as well as the presence of local predators and pathogens.

Our results are fully in agreement with the recent study of Ørsted & Ørsted (2019), who predict the occurrence of *D. suzukii* in the western and southern regions of Ukraine, but not in its interior. Interestingly, this is true only when authors used European invasive populations as a predictor in their species distribution models; using American occurrences yields rather different results, with whole Ukrainian territory as potentially suitable for the invasion. According to the authors, these differences are caused by different ecological demands of *D. suzukii* populations established in Americas and the Europe (Ørsted & Ørsted 2019). According to all models, relatively low levels of precipitation and low temperatures were key limiting factors for the distribution of *D. suzukii*, which suggests that this species requires a humid environment with mild winters in order to establish a permanent population in its invasive range (Ørsted & Ørsted 2019). We also stress the importance of proper monitoring in other countries adjacent to Ukraine, where, according to their study, it is possible to expect a potential for invasion of *D. suzukii*: Ponto-Caspian region of Russia, Transcaucasia, etc.

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