**Journal of Animal & Plant Sciences, 36(2): 2026, Page: 585-596**
**ISSN (print): 1018-7081; ISSN (online): 2309-8694**
https://doi.org/10.36899/JAPS.2026.2.0048

# DIVERSITY OF DROSOPHILIDAE FROM ČURUG (SERBIA) WITH NOTE ON INVASIVE SPECIES *Drosophila suzukii*

S. Pavković-Lučić[1], L. Lučić[1], J. Trajković[1*], V. Vujić[1], V. Tomić[1], T. Savić[2] and V. Kekić[1]

[1]University of Belgrade, Faculty of Biology, Studentski Trg 16, 11000 Belgrade, Serbia
[2]University of Belgrade, Institute for Biological Research "Siniša Stanković" - National Institute of the Republic of Serbia, Despota Stefana Boulevard 142, 11000 Belgrade, Serbia
[*]Corresponding author email: jelena.trajkovic@bio.bg.ac.rs

## ABSTRACT

Drosophilidae fauna is represented by over 60 species in Serbia and the surrounding countries of the Balkan Peninsula, including the highly invasive *Drosophila suzukii.* As polyphagous pest that infests a wide range of cultivated fruits, this species has a negative economic impact on both fruit and wine production. This paper presents the results of faunistic investigation of Drosophilidae conducted on Biserno ostrvo, near Čurug (Vojvodina, Serbia) in September 2023. Flies were captured in a semi-domestic habitat, during morning and evening hours, using mixed fruit traps. A total of 17 species was recorded, classified into three genera: *Drosophila* (14 species), *Scaptomyza* (2 species) and *Chymomyza* (1 species). *D. suzukii* was the most abundant species among fly samples, encompassing over 60% of more than 6000 captured individuals, followed by *D. immigrans* and *D. subobsura.* This field research confirmed that Drosophilidae fauna has changed dramatically in the last more than three decades. Namely, the results of the present study were compared with the results of faunistic studies conducted at the same locality in 1989, 2000 and 2002. First of all, invasive *D. suzukii* displaced previously dominant species, *D. melanogaster* at this locality. However, in spite of such high abundance of *D. suzukii* in recent research, the next significant change refers to more diverse Drosophilidae fauna when comparing 2023 study with previous ones, as a result of increased habitat heterogeneity. Based on the results, future research would include the seasonal dynamics of Drosophilidae species, above all *D. suzukii*, which is important in the context of controlling its abundance.

**Key words**: Drosophilidae, Serbia, field study, diversity, *Drosophila suzukii*.



Published first online January 20, 2026 Published final February 28, 2026

## INTRODUCTION

For more than 100 years, *Drosophila* has been used as a model system in various biological disciplines, from morphology, taxonomy, systematics and phylogeny, up to genetics, cell and developmental biology, physiology, neurobiology, behavior, ecology, and evolution (Hales *et al*., 2015; Finet *et al*., 2021). In recent decades, it has also become an important model system in biomedicine, due to possessing many orthologous genes associated with human diseases (Hales *et al*., 2015; Trajković *et al*., 2023). The abundance of recorded Drosophilidae species, combined with extensive laboratory facilities, a short life cycle, high reproductive rate, and a well-mapped genome, facilitates a wide range of comparative studies in the areas mentioned above (Markow and O'Grady, 2006; Mohr, 2018; Giansanti *et al*., 2025). In this sense, the study of the diversity of Drosophilidae fauna represents the basis for numerous investigations, both in basic and applied research.

Regarding the fauna diversity, family Drosophilidae consists of more than 4400 species worldwide (Finet *et al*., 2021). Recent investigation of unexplored regions contributed to the further knowledge of its richness (Keshtiban *et al*., 2025). The rainforests of the tropical zone are the richest in species: for example, 689 species have been discovered in Hawaii alone (Rampasso and O´Grady, 2022). In Europe, more than 130 species have been found so far (Bächli *et al*., 2004). In Serbia and the neighboring countries of the Balkan Peninsula, more than 60 species have been recorded, including the highly invasive *Drosophila suzukii* (Kekić *et al*., 1999 a; Toševski *et al*., 2014) and the recently introduced *Zaprionus tuberculatus* (Chireceanu *et al*., 2015a). During the years, faunistic studies were carried out in many biogeographical regions and ecologically different habitats in Serbia (Kekić, 2002). Field surveys were conducted in Vojvodina (Kekić, 1990; Kekić, 1997; Pavković-Lučić and Kekić, 1998; Kekić *et al*., 1999 b; Kekić, 2009), in Belgrade (Kekić *et al*., 1992; Kekić *et al*., 1999b), in central and western Serbia (Bächli and

Kekić, 1983a; Stanić *et al*., 2001, 2002; Pavković-Lučić *et al*., 2009, 2012), as well as in the eastern and southern parts of the country (Bächli and Kekić, 1983a; Kekić *et al*., 1998a). Also, field studies were performed in several locations along the Danube River, on its course throughout Serbia (Kekić *et al*., 1996; Kekić *et al*., 1998a; Kekić *et al*., 1999b).

In order to further study the diversity of Drosophilidae fauna, we conducted field research on Biserno ostrvo, near Čurug, Vojvodina, Serbia. In addition to the fauna diversity, we also monitored the fauna composition along the time gradient, considering that this locality was previously the subject of our faunistic research. In this respect, the aims of the present study were: i) to analyze fly samples collected in 2023 at the aforementioned locality, in a semi-domestic habitat, ii) to compare the diversity of Drosophilidae fauna determined in this study with the results obtained at the same locality, in 1989, 2000 and 2002 years, and iii) to determine the potential representation and abundance of *D. suzukii* in a large sample of collected specimens. This economically important species has become an integral part of European Drosophilidae fauna associated with anthropogenic crop ecosystems.

## MATERIALS AND METHODS

**Field survey:** Faunistic research was conducted on Biserno ostrvo, near Čurug, Vojvodina, Serbia (Fig. 1), at the same place where we performed our research in 1989, 2000 and 2002 (Kekić, 2003). Čurug is a typical Pannonian lowland village in the Autonomous Province of Vojvodina, Serbia, situated about 100 km north of Belgrade (for detailed habitat description, see Kekić, 2003). Flies were collected around cottages located on the shore of Stara Tisa Lake (semi-domestic area) in September 2023 (Fig. 2). Namely, according to the human impact in a given habitat during "*Drosophila* season", we have previously defined three types of habitats: wild (like forests located near settlements or tourist spots), domestic (house interiors, balconies, vine cellars, barrels with fermenting fruit used for homemade brandy preparation), and semi-domestic (vineyards, orchards, vegetable gardens, city parks, surroundings of river banks) (Kekić *et al*., 1999 a). Capturing of flies was performed in the morning and/or evening hours, during periods of their maximum activity, using fruit traps composed of bananas and apples, with addition of small quantity of yeast, sugar and apple cider vinegar. Fruit traps were set up on two different ways, i.e. by placing the substrate on plastic bags, which were distributed in an area of approximately 90 × 100 m, as well as by placing the substrate in plastic buckets, distributed in the same way (Figs. 3A and 3B). Flies were collected by sweeping net over fruit traps.

Fruit traps were distributed in several places, under trees (i.e. under apple trees where traps were surrounded by many fallen apples in the process of rotting) and near reeds and bushes. On the Tisa coast (Fig. 4), in addition to reeds, there were blackberries in the bushes, and the fruits that included plums, pears, and earlier, during the season, apricots and cherries. Habitat is also characterized by different mushroom species, both on the ground and on the willows.


**Figure 1. Map of Balkan Peninsular and surrounding, with marked location of Čurug village, Serbia. The map was created by modifying templates downloaded from https://commons.wikimedia.org/wiki/ File: Geographic_map_of_Balkan_Peninsula.svg (accessed on August 25th 2025)(Wikimedia Commons user: Ikonact).**

**Figure 2. Semi-domestic habitat where flies were captured. Photo: V. Kekić.**


**Figure 3. Fruit traps used for attracting flies: A) substrate placed on plastic bag, B) substrate placed in plastic bucket. Photos: V. Kekić.**

**Figure 4. Shore of Stara Tisa Lake. Photo: V. Kekić.**

**Species identification:** The collected fly samples were stored in Eppendorf tubes in 70% ethanol. Subsequently, captured specimens were identified in laboratory conditions, using keys to Drosophilidae genera and species (Bächli and Burla, 1985; Bächli *et al*., 2004; Markow and O´Grady, 2006; Hauser, 2011; https://www.taxodros.uzh.ch/ (accessed on November 20th 2024).

**Statistics**: As a measure of species diversity, the following indices were calculated: i) Shannon diversity index (H') that measures the richness and evenness of the species in the given locality (Shannon, 1948), ii) effective number of species (ENS) which represents the translated diversity index and indicates the equivalent number of equally frequent species, and, iii) evenness (E), that measures how evenly individuals are distributed among the species.

## RESULTS

During our 2023 field research in a semi-domestic habitat, a total of 17 species were recorded, classified into 3 genera, 14 of them belonging to genus *Drosophila*, 2 species to genus *Scaptomyza* and one species to genus *Chymomyza* (Tables 1, 2 and Fig. 5).

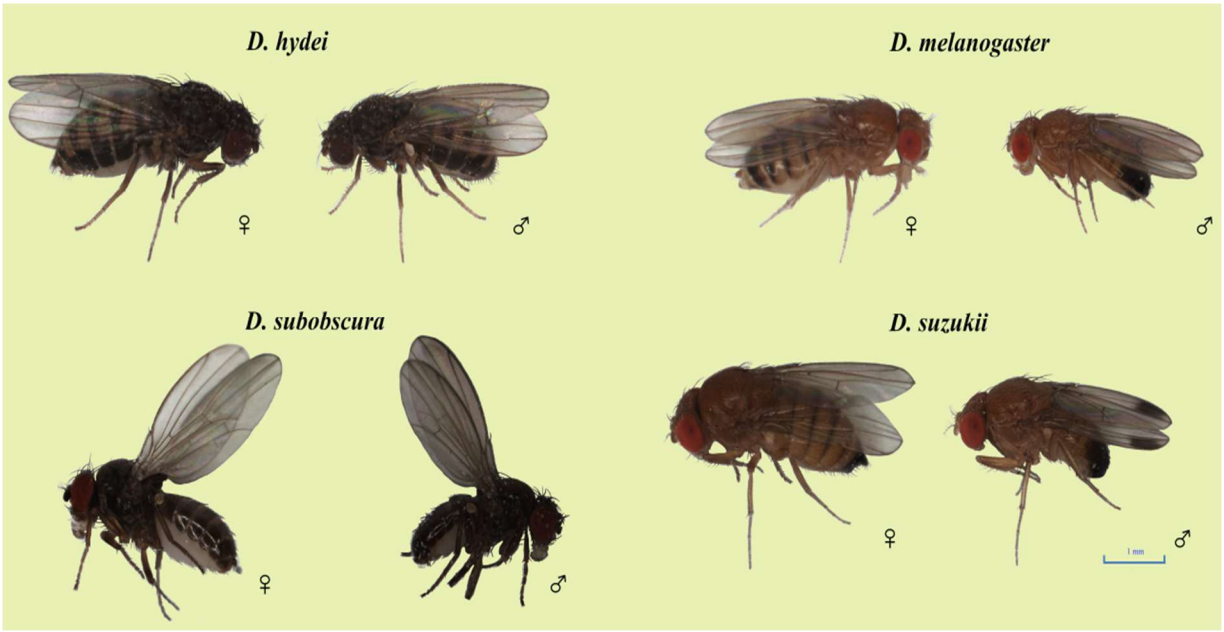


**Figure 5. Pictures of species caught in the semi-domestic habitat: *D. hydei*, *D. melanogaster*, *D. subobscura* and *D. suzukii*. Photo: V. Vujić.**

In the samples collected on fruit traps spilled on plastic bags, that numbered over 4000 individuals, *D. suzukii* was absolutely dominant, encompassing 59.93% of individuals, followed by *D. subobsura* (12.36%) and *D. immigrans* (9.56%) (Table 1). On the other side, the following seven *Drosophila* species, *D. bifasciata, D. busckii, D. funebris, D. hydei, D. kuntzei, D. transversa,* and *D. tristis* were represented by less than 10 individuals in the collection. Six *Drosophila* species, namely *D. busckii*, *D. funebris, D. hydei, D. immigrans, D. melanogaster,* and *D. simulans* recorded in a given habitat represent domestic species, i.e. those associated with humans. Two species of genus *Scaptomyza* (*S. graminum* and *S. pallida*) were represented by 10 or less than 10 individuals in the sample. Further, only one species of the genus *Chymomyza,* i.e., *C. amoena,* was present in fly samples of 59 specimens, i.e., with 1.44% (Table 1).

In the sample collected on fruit traps captured over plastic buckets, that numbered 2040 individuals, *D. suzukii* was also absolutely dominant, encompassing 72.55 % of individuals, further followed by *D. simulans* (9.51 %) and *D. immigrans* (8.28 %) (Table 2). The four *Drosophila* species, *D. busckii, D. funebris, D. hydei* and *D. kuntzei* were represented by less than 10 individuals in the sample, the first three of them being domestic. Genus *Chymomyza* was represented, as above, with only one species, *C. amoena,* which encompassed 5 individuals in this sample, while genus *Scaptomyza* encompassed only *S. pallida* with one specimen caught (Table 2). However, species composition differed depending on the method of placing the substrate: 17 species were collected on the substrate placed on plastic bags, and 13 species were captured over plastic buckets. Actually, three *Drosophila* species were not found when flies were caught above plastic buckets: *D. bifasciata, D. transversa,* and *D.*

*tristis* (Table 2). Further, *S. graminum* was not captured by net sweeping over plastic buckets, but was present in the sample collected when using substrate spilled on plastic bags (Table 2). In addition to differences in species composition, the method of substrate placement also influenced the number of individuals captured. For example, *D. immigrans* was more than twice numerous in the sample when captured on substrate spilled on plastic bags, while *D. phalerata, D. subobscura, C. amoena* and *S. pallida* were about ten times numerous when collected on the same way (Table 2). This should be taken with caution, since flies were caught over a different number of days on the given substrates, which could also affect obtained results. However, it is worth mentioning that fruit trap with the substrate placed on thin plastic bag is closer to "natural state": the bag is placed so that the soil does not immediately absorb the liquid. In that way, the substrate stays wetter and evaporates longer. Contrary to substrate spilled on plastic bags placed on the soil, the plastic bucket is a much more artificial way of collecting flies. The aforementioned is depicted in the case of *D. subobsura*, which dominates in all "wild" habitats where flies were caught (Kekić et al., 1999 a; Kekić, 2002). Namely, it was more numerous in collections when captured on plastic bags located on the ground comparing with the number of individuals collected over plastic buckets (Table 2).

When comparing fauna diversity and number of captured specimens in 2023 research in a semi-domestic habitat with those obtained in studies conducted in 1989, 2000 and 2002 (Kekić, 2003), major changes are observed (Table 3, Fig. 6). *D. suzukii* was the most abundant species in 2023, encompassing over 60% (64.11%) of 6150 captured individuals, followed by *D. immigrans* and *D. subobsura*, each represented by about 9% of individuals (9.14 % and 8.93%, respectively) (Table 3). According to the results, *D. suzukii* replaced previously the most numerous species, *D. melanogaster,* to a significant extent (Table 3): in earlier studies, *D. melanogaster* encompassed, in average, about 80% of total catch, while, in the recent study, it included only 3.84% of a total sample. The present study also determined changes in species composition in a semi-domestic habitat, i.e. the more diverse fauna, since 17 species were recorded. Among them, representatives of the genus *Scaptomyza* (*S. graminum* and *S. pallida*) were also recorded for the first time at this locality, together with two species belonging to the genus *Drosophila* (*D. kuntzei* and *D. tristis*). Throughout the years, the total number of genera and species found in a semi-domestic habitat is as follows: *Drosophila* (17 species), *Chymomyza* (one species), *Scaptomyza* (two species) and *Gitona* (one species) (Table 3; Fig. 6).

**Table 1. List of Drosophilidae fauna of Čurug, captured on fruit traps spilled on plastic bags, including the number of individuals per collecting days, as well as the total number of collected individuals.**

| **Species/Collecting days**** | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | | **Total number of individuals** |
|---|---|---|---|---|---|---|---|---|---|
| | M | E | E | M | M | E | M | E | |
| *D. bifasciata* | | | | | | | | 2 | 2 |
| ***D. busckii**** | | | | | | 2 | | 1 | 3 |
| ***D. funebris*** | | | | | | 2 | 1 | | 3 |
| ***D. hydei*** | | | 3 | 2 | 1 | 2 | 1 | | 9 |
| ***D. immigrans*** | 92 | 76 | 81 | 59 | 13 | 18 | 25 | 29 | 393 |
| *D. kuntzei* | | | 1 | 3 | | 1 | | 1 | 6 |
| ***D. melanogaster*** | 11 | 6 | 7 | 4 | 3 | 39 | 33 | 23 | 126 |
| *D. phalerata* | 53 | 15 | 13 | 38 | 1 | 14 | 5 | 5 | 144 |
| ***D. simulans*** | 34 | 37 | 39 | 34 | 4 | 35 | 56 | 26 | 265 |
| *D. subobscura* | 56 | 61 | 44 | 75 | 4 | 144 | 44 | 80 | 508 |
| *D. suzukii* | 280 | 233 | 295 | 478 | 219 | 133 | 313 | 512 | **2463** |
| *D. testacea* | 23 | 8 | 2 | 29 | | 15 | 23 | 13 | 113 |
| *D. transversa* | 1 | | | | | | | | 1 |
| *D. tristis* | | | 3 | | | | | | 3 |
| *Chymomyza amoena* | 2 | | 2 | 3 | 1 | 22 | 21 | 8 | 59 |
| *Scaptomyza graminum* | | | | | | 2 | | | 2 |
| *S. pallida* | 1 | | 1 | 1 | | 5 | 1 | 1 | 10 |
| **Total sample** | | | | | | | | | **4110** |

*bold letters indicate domestic species; **Collecting days: Day 1 – September 2nd, Day 2 – September 7th, Day 3 – September 8th, Day 4 – September 9th, Day 5 – September 14th, Day 6 – September 26th, Day 7 – September 27th. Abbreviations: M – morning collection; E – evening collection.

**Table 2. List of Drosophilidae fauna of Čurug, captured over plastic buckets, including the number of individuals per collecting days.**

| Species/Collecting days** | Day 1 | Day 2 | | Day 3 | Day 4 | | Total 1 | Total 2 | Total 1 + Total 2 |
|---|---|---|---|---|---|---|---|---|---|
| | E | M | E | E | M | E | | | |
| *D. bifasciata* | | | | | | | | 2 | 2 |
| ***D. busckii**** | | 1 | | | 1 | | 2 | 3 | 5 |
| ***D. funebris*** | | 1 | | | | | 1 | 3 | 4 |
| ***D. hydei*** | 4 | | | | 1 | 1 | 6 | 9 | 15 |
| ***D. immigrans*** | 50 | 13 | 27 | 8 | 61 | 10 | 169 | 393 | 562 |
| *D. kuntzei* | 1 | | | | | | 1 | 6 | 7 |
| ***D. melanogaster*** | 25 | 26 | 9 | 6 | 28 | 16 | 110 | 126 | 236 |
| *D. phalerata* | 2 | 2 | | 7 | | | 11 | 144 | 155 |
| ***D. simulans*** | 81 | 25 | 22 | 17 | 28 | 21 | 194 | 265 | 459 |
| *D. subobscura* | 1 | 3 | 4 | 32 | | 1 | 41 | 508 | 549 |
| *D. suzukii* | 202 | 381 | 448 | 132 | 155 | 162 | 1480 | 2463 | **3943** |
| *D. testacea* | 2 | 2 | 2 | 12 | 1 | | 19 | 113 | 132 |
| *D. transversa* | | | | | | | | 1 | 1 |
| *D. tristis* | | | | | | | | 3 | 3 |
| *Chymomyza amoena* | 2 | | | | | 3 | 5 | 59 | 64 |
| *Scaptomyza graminum* | | | | | | | | 2 | 2 |
| *S. pallida* | | | | | | 1 | 1 | 10 | 11 |
| **Total number of collected individuals** | | | | | | | **2040** | **4110** | **6150** |

*bold letters indicate domestic species; **Collecting days: Day 1 – September 22nd, Day 2 – September 23rd, Day 3 – September 25th, Day 4 – September 29th. Abbreviations: M – morning collection; E – evening collection; Total 1 – total number of flies captured in plastic buckets; Total 2 – total number of flies collected on substrate spilled on plastic bags (data from Table 1); Total 1 + Total 2 – sum of all individuals collected in two ways in a semi-domestic habitat.

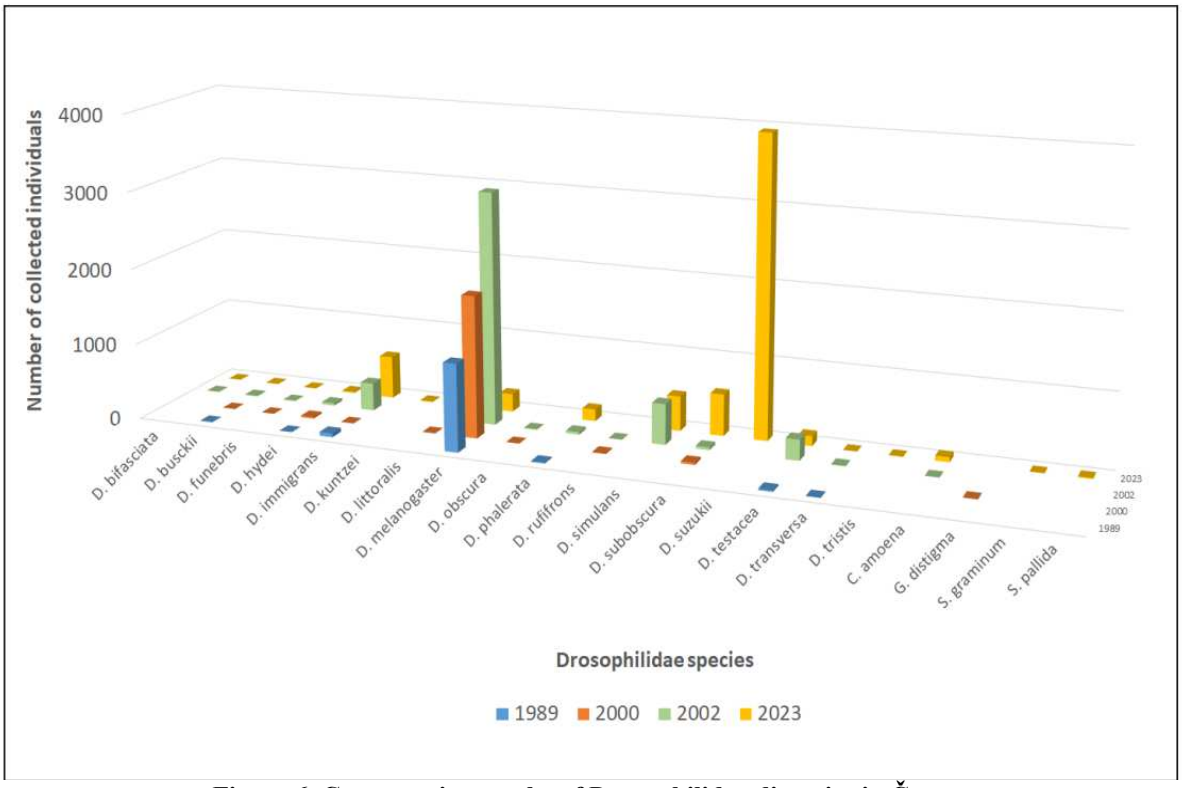


**Figure 6. Comparative results of Drosophilidae diversity in Čurug.**

**Table 3. Comparative results of Drosophilidae diversity in Čurug: number of collected individuals in this study (2023) and previous investigations (1989, 2000 and 2002 studies; Kekić, 2003), conducted at the same locality, in a semi-domestic habitat.**

| Genus and species | Year of Drosophilidae fauna investigation | | | |
|---|---|---|---|---|
| | 1989. | 2000. | 2002. | 2023. |
| ***DROSOPHILA*** | | | | |
| *D. bifasciata* | | | 1 | 2 |
| ***D. busckii**** | 1 | 1 | 8 | 5 |
| ***D. funebris*** | | 1 | 1 | 4 |
| ***D. hydei*** | | 22 | 31 | 15 |
| ***D. immigrans*** | 52 | 1 | 365 | 562 |
| *D. kuntzei* | | | | 7 |
| *D. littoralis* | | 1 | | |
| ***D. melanogaster*** | 1150 | 1860 | 3054 | 236 |
| *D. obscura* | | 1 | 3 | |
| *D. phalerata* | 13 | | 35 | 155 |
| *D. rufifrons* | | 9 | 2 | |
| ***D. simulans*** | | | 535 | 459 |
| *D. subobscura* | | 29 | 37 | 549 |
| *D. suzukii* | | | | **3943** |
| *D. testacea* | 20 | | 274 | 132 |
| *D. transversa* | 1 | | 6 | 1 |
| *D. tristis* | | | | 3 |
| ***CHYMOMYZA*** | | | | |
| *C. amoena* | | | 1 | 64 |
| ***GITONA*** | | | | |
| *G. distigma* | | 1 | | |
| ***SCAPTOMYZA*** | | | | |
| *S. graminum* | | | | 2 |
| *S. pallida* | | | | 11 |
| Total sample size | 1237 | 1926 | 4353 | **6150** |

*bold letters indicate domestic species

Values of Shannon diversity index (H') also indicated that diversity was lowest in 2000, suggesting poor richness or dominance by some species. Increase in diversity occurred from 2000 to 2002 and continued till 2023 (Table 4). The effective number of species, that provides a clearer absolute measure of diversity across multiple years, showed low species diversity in 1989 and 2000. For example, the sample in 2023 encompassed 4 abundant species (*D. suzukii*, *D. immigrans, D. subobsura*, *D. simulans*) in comparison with just one in 2000 (*D. melanogaster*). Evenness, as a measure of distribution of individuals among the species was very low in 1989 and 2000, suggested that some species dominated in the samples. The same index, estimated for 2023 suggested more numerous species in the sample (Table 4).

**Table 4. Biodiversity metrics: Diversity Index (H'), Effective number of species (ENS), and Evenness (E) across four years of investigation.**

| Year | Diversity Index (H') | Effective number of species (ENS) | Evenness (E) |
|---|---|---|---|
| **1989** | 0.32710 | 1.38694 | 0.11545 |
| **2000** | 0.19657 | 1.21722 | 0.06938 |
| **2002** | 1.03771 | 2.82276 | 0.36627 |
| **2023** | 1.31548 | 3.72652 | 0.46431 |

# DISCUSSION

The present study on the diversity of Drosophilidae conducted in 2023 in a semi-domestic habitat showed extensive fauna changes in comparison with previous field investigation conducted at the same locality. Such changes in the composition and abundance of Drosophilidae could be explained by the introduction of a new invasive species, *D. suzukii*, which completely changed the faunal picture of the area, but also with habitat changes and urbanization during the time gradient. Namely, about thirty years ago, observed locality was characterized by the existence of only a few farms, while crops were represented mostly by monocultures, such as wheat, corn, soybeans, cabbage, clover, together with planted walnuts, acacias and willows found near the Stara Tisa Lake. Nowadays, locality is distinguished by about thirty cottages, around which people plant ornamental trees (pines, plane trees, wild chestnuts, lindens), as well as different fruits (apples, pears, plums, apricots, cherry trees). Changes in species composition and abundance were also confirmed during previous field studies at the same locality (Kekić, 2003): the latest research showed that such changes were even more pronounced. Environmental conditions, which became more heterogeneous over time, due to the significant human influence in a given habitat, along with the appearance of *D. suzukii*, led to the development of new models of coexistence of different species at this locality.

As absolutely dominant species, *D. suzukii* outnumbered for several times and thus outcompeted other native Drosophilidae. In this respect, Drosophilidae has changed dramatically in the last more than three decades, given that in 1989, 2000 and 2002 research at the same locality, this species was not an integral part of the fruit fly fauna. In all aforementioned years, Drosophilidae in a semi-domestic habitat was characterized by the absolute dominance of human commensal *D. melanogaster,* which encompassed, in average, more than 80% of the caught flies (Kekić, 2003). Similarly, in neighboring Croatia, *D. suzukii* became the dominant species in Medjimurje County, when captured in vineyards, encompassing 69% of the total sample, followed by two sibling species, *D. simulans* (19%) and *D. melanogaster* (6%) (Pajač Živković *et al*., 2016). It was also eudominant species in orchards and vineyard in Zagreb County (Pajač Živković and Kapuđija, 2019).

*D. suzukii* originated from Far-East Asia (European and Mediterranean Plant Protection Organization, eppo_datasheet_DROSSU.pdf, accessed on January 15th 2025) but was spread worldwide mostly due to the infested fruit transport (Little *et al*., 2020). It can be found on both wild and cultivated fruit crops, such as raspberries, strawberries, blackberries, blueberries, cherries, grapes, and peaches (Lee *et al*., 2011). Females damage healthy fruits by using a very strong and serrated ovipositor, thus negatively affecting both fruit and wine production (Bühlmann and Gossner, 2022). In Europe, the first record of *D. suzukii* dates back to 2008, in Spain (Calabria *et al*., 2012). It also expanded to the Balkans. In Serbia, it was recorded for the first time in 2014, in the sampled fruits of raspberry, blackberry, fig and grape (Toševski *et al*., 2014). Its presence has been confirmed in neighboring countries, as well: in Croatia (Masten Milek *et al*., 2011), Hungary (Kiss *et al*., 2013), Romania (Chireceanu *et al*., 2015 b), Bulgaria (Karadjova *et al*., 2016), Montenegro (Radonjić and Hrnčić, 2015), and Bosnia and Herzegovina (Ostojić *et al*., 2014). Rapid spreading of this pest species was possible due to extremely pronounced physiological and behavioral plasticity (Little *et al*., 2020). Such plasticity, along with high reproductive rate, derived by overlap of multiple generations during the season (Asplen *et al*., 2015), contributes to difficult control of species abundance (for details, see Garcia, 2020). *D. suzukii* can cause significant economic damage in Serbia, which is one of the largest exporters of frozen raspberries in the world (Nikolić *et al*., 2023). As far as we know, there are no official data on the damage done. However, in Province of Trento (Italy), the estimated damage due to the yield loss on 400 ha of berries was about 3 million euros in 2011 (De Ros *et al*., 2013).

According to the results, invasive *D. suzukii* displaced *D. melanogaster,* to a significant extent, since this domestic and cosmopolitan species comprised significant proportion of the samples, from 92.97 % in 1989, 96.57% in 2000 and 70.16% in 2002 years. In coexistence with introduced pest species, *D. melanogaster* was represented by only 3.84% in 2023. Additionally, the relationship between sibling species, *D. melanogaster* and *D. simulans* is quite interesting. These two species often manifest subtle differences in distribution depending on the time of the year and habitat, which is usually related with the distinct use of ecological niches (Pavković-Lučić and Kekić, 2014). This work also revealed changes in their abundance over time. Namely, these two species showed a specific relationship in 2023 study, where *D. simulans* was almost twice as numerous as *D. melanogaster*. The opposite pattern was observed in 2002 study, when *D. simulans* was less numerous than *D. melanogaster* (encompassing 15% *vs*. 85% of collected sibling species individuals, respectively). It is worth mentioning that *D. simulans* was found for the first time in Čurug in samples collected in 2002. The first appearance of *D. simulans* in this habitat, in addition to urbanization, was probably influenced by climate changes and global warming. Namely, about thirty or more years ago, Stara Tisa Lake, as a rule, froze during the winter, which was not the case in previous several years. The relatively recent occurrence of this species in the Čurug samples confirmed that it is adapted to warmer

habitats. This is also illustrated by some of our previous works, in the samples collected in Kupari (Croatia) and Ohrid (North Macedonia) (Bächli and Kekić, 1983 b). Physiological and behavioral adaptations to higher temperatures affected not only the appearance of *D. simulans* at this locality, but also its greater presence in the samples compared to *D. melanogaster*.

Despite such a high abundance of *D. suzukii* in the samples, the present study also revealed the most diverse Drosophilidae in a semi-domestic habitat, since 17 species were found in 2023 study, contrary to 1989 study (6 species recorded), 2000 study (10 species recorded) and 2002 study (14 species recorded). In 2023 investigation, along with the most numerous *D. suzukii*, four species were observed for the first time at this locality, in a semi-domestic habitat. Namely, specimens of the genus *Scaptomyza* were discovered for the first time in Čurug collections, represented by two species (*S. graminum* and *S. pallida*), as well as two species belonging to the genus *Drosophila* (*D. kuntzei* and *D. tristis*). On the other side, species listed below were recorded in small numbers in previous field studies, but not in 2023 investigation: *D. littoralis* (in 2000 study), *D. obscura* (in 2000 and 2002 studies), and *D. rufifrons* (in 2000 and 2002 studies). Further, only one specimen of the genus *Gitona* (*G. distigma*) was collected in 2000 study.

When taken into account the faunistic data from all years of investigation, including this study, the Drosophilidae fauna of Čurug in a semi-domestic habitat counts 4 genera and 21 species: *Drosophila* (17 species), *Chymomyza* (one species), *Scaptomyza* (two species) and *Gitona* (one species). North-American species *C. amoena* was found in Serbia in 1983 (Kekić, 1998 b): it was another alien species recorded in significant proportion in recent research, comparing with previous field surveys. The first discovery of a genus *Scaptomyza* represented by two species further contributes to the diversity of the fauna of this area. As previously noted, just one individual of *G. distigma* was captured in Čurug collections in 2000. It represented the third specimen caught in a corpus of over 200.000 individuals collected during more than 30 years of research in the Central and Western Balkans (Kekić, 2003). In addition to those mentioned, only one more Drosophilidae species was found in previous Čurug collections (*D. repleta*), but in a habitat characterized as domestic (Kekić, 2003).

Ultimately, an increase in the values of the Shannon diversity index, richness, and evenness could be the result of habitat restoration and reforestation (planting ornamental and fruit trees), climate changes, introduction of new species (such as *D. suzukii*) or the return of some native ones. Such continued increase towards 2023 may suggests long-term favorable conditions for some species in this habitat compared to earlier years. However, the composition of Drosophilidae species in a given habitat always depends on numerous factors, seasonal (temperature, humidity, precipitation) (Gornostaev *et al*., 2024), the availability of food resources, breeding sites and places to hide. Species composition is also affected by the ability of species to adapt to seasonal changes and different types of resources, their dispersal and competitive abilities, as well as differences in their life history traits (Gornostaev *et al*., 2022). In that sense, it is important to monitor changes in Drosophilidae composition, which will be the goal of future research.

**Conclusion**: In recent decades, faunistic and ecological research on Drosophilidae has gained new importance and direction. *D. suzukii*, an invasive species that causes damage to agricultural crops has emerged as a major concern due to its economic impact in different regions. As a result, contemporary field surveys play a crucial role as the first step in monitoring its spread and formulating the strategies for managing its populations.

Looking ahead, continued research will be essential for improving early detection methods, understanding ecological dynamics of invasion, and developing control techniqes. Integrating faunistic data with modern tools could significantly enhance our ability to mitigate the impact of *D. suzikii*.

**Author contributions:** SPL and VK performed the study and wrote the original manuscript. The other authors read, reviewed, edited and made comments that improved the manuscript. All authors contributed equally to the concept of the study. Also, all authors approved the final version of the manuscript.

**Conflicts of interest:** The authors declare no conflict of interest.

**Acknowledgements:** This work was supported by the Serbian Ministry of Science, Technological Development and Innovation (Grants No. 451-03-137/2025-03/ 200178; 451-03-136/2025-03/ 200178, and 451-03-136/2025-03/ 200007). The authors are grateful to the Editor and two anonymous reviewers for their valuable comments and suggestions, which have improved the manuscript.

## REFERENCES

Asplen, M.K., G. Anfora, A. Biondi, D.S. Choi, D. Chu, K.M. Daane, P. Gibert, A.P. Gutierrez, K.A. Hoelmer, W.D. Hutchison, R. Isaacs, Z.L. Jiang, Z. Kárpáti., M.T. Kimura, M. Pascual, C.R. Philips, C. Plantamp, L. Ponti, G. Vétek, H. Vogt, V.M. Walton, Y. Yu, L. Zappalà and N. Desneux (2015). Invasion biology of spotted wing *Drosophila* (*Drosophila suzukii*): a global perspective and future priorities. J. Pest. Sci.

88(3): 469–494. https://doi.org/10.1007/s10340-015-0681-z

Bächli, G. and V. Kekić (1983a). Studies of Drosophilidae (Diptera) in Yugoslavia. II. Collections from Mt. Goč, Mt. Jastrebac and Priština. Drugi simpozijum o fauni SR Srbije. Zbornik. 107–110.

Bächli, G. and V. Kekić (1983b). Studies of Drosophilidae (Diptera) in Yugoslavia. IV. Collections from Ohrid, Kupari and Poreč. Biosistematika. 9: 109–118.

Bächli, G. and H. Burla (1985). Diptera: Drosophilidae. Insecta Helvetica. Fauna, 7. ETH-Zentrum; Zürich. 116 p. ISSN: 2813-9704

Bächli, G., C. R. Vilela, S. A. Escher and A. Saura (2004). The Drosophilidae (Diptera) of Fennoscandia and Denmark. Fauna Entomologica Scandinavica. 39. Brill; Leiden (Netherlands). 362 p. ISBN: 9004140743

Bühlmann, I. and M.M. Gossner (2022). Invasive *Drosophila suzukii* outnumbers native controphics and causes substantial damage to fruits of forest plants. NeoBiota. 77(1): 39–77. https://doi.org/10.3897/neobiota.77.87319

Calabria, G., J. Máca, G. Bächli, L. Serra and M. Pascual (2012). First records of the potential pest species *Drosophila suzukii* (Diptera: Drosophilidae) in Europe. J. Appl. Entomol. 136(1-2): 139–147. https://doi.org/10.1111/j.1439-0418.2010.01583.x

Chireceanu, C., A. Teodoru and A. Chiriloaie (2015a). The first detection of fruit fly *Zaprionus tuberculatus* Malloch (Diptera: Drosophilidae) in Eastern part of Europe (Romania). Ann. Univ. Craiova. 20(56): 377–382.

Chireceanu, C., A. Chiriloaie and A. Teodoru (2015b). First record of the spotted wing drosophila, *Drosophila suzukii* (Diptera: Drosophilidae) in Romania. Rom. J. Plant. Prot. 8: 86–95.

De Ros, G., G. Anfora, A. Grassi and C. Ioriatti (2013). The potential economic impact of *Drosophila suzukii* on small fruits production in Trentino (Italy). IOBC-WPRS Bull. 91: 317–321.

Finet, C., V.A. Kassner, A.B. Carvalho, H. Chung, J.P. Day, S. Day, E.K. Delaney, F.C. De Re, H.D. Dufour, E. Dupim, H.F. Izumitani, T.B. Gauterio, J. Justen, T. Katoh, A. Kopp, S. Koshikawa, B. Longdon, E.L. Loreto, M.D.S. Nunes, K.K.B. Raja, M. Rebeiz, M.G. Ritchie, G. Saakyan, T. Sneddon, M. Teramoto, V. Tyukmaeva, T. Vanderlinde, E.E. Wey, T. Werner, T.M. Williams, L.J. Robe, M.J. Toda and F. Marletaz (2021). DrosoPhyla: Resources for Drosophilid Phylogeny and Systematics. Genome Biol. Evol. 13(8): evab179. https://doi.org/10.1093/gbe/evab179

Garcia, F. R. M. (Ed.) (2020). *Drosophila suzukii* management. Springer; Cham, (Switzerland). 287 p. https://doi.org/10.1007/978-3-030-62692-1

Giansanti, M.G., A. Frappaolo and R. Piergentili (2025). *Drosophila melanogaster*: How and Why It Became a Model Organism. Int. J. Mol. Sci. 26(15): 7485. https://doi.org/10.3390/ijms26157485

Gornostaev, N.G., A.B. Ruchin, M.N. Essin and A.M. Kulikov (2022). Seasonal Dynamics of Fruit Flies (Diptera: Drosophilidae) in Forests of the European Russia. Insects. 13(8): 751. https://doi.org/10.3390/insects13080751

Gornostaev, N.G., Y.V. Lyupina, O.E. Lazebny and A.M. Kulikov (2024). Seasonal Dynamics of Fruit Flies (Diptera: Drosophilidae) in Natural Parks of Moscow City, Russia. Insects. 15(6): 398. https://doi.org/10.3390/insects15060398.

Hales, K.G., C.A. Korey, A.M. Larracuente and D.M. Roberts (2015). Genetics on the Fly: A Primer on the *Drosophila* Model System. Genetics. 201(3): 815–842. https://doi.org/10.1534/genetics.115.183392

Hauser, M. (2011). A historic account of the invasion of *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae) in the continental United States, with remarks on their identification. Pest. Manag. Sci. 67(11): 1352–1357. https://doi.org/10.1002/ps.2265

Karadjova, O., Z. Ilieva, E. Petrova and M. Laginova (2016). Predicted and actual distribution of the invasive species *Drosophila suzukii* (Diptera: Drosophilidae) in Bulgaria. Jubilee Scientific Conference with International Participation, Traditions and Challenges facing Agricultural education, Science and Business, 29–31 October 2015, Plovdiv, Bulgaria. Agric. Sci. 8(19): 45–52.

Keshtiban, N.T., R. Vafaei Shoushtari, F. Kazerani, E. Sanatgar and S. Goldasteh (2025). New records of the family Drosophilidae from Iran. Redia – J. Zool. 108: 65–69. https://doi.org/10.19263/REDIA-108.25.07

Kekić, V. (1990). Istraživanja Drosophilidae (Diptera) Jugoslavije. VIII. Kolekcije sa Fruške Gore. Biosistematika. 16: 81–88. (in Serbian)

Kekić, V., N. Popović and N.J. Milošević (1992). Istraživanja Drosophilidae (Diptera) Jugoslavije. VII Kolekcije iz Beograda. Glasnik Prirodnjačkog muzeja u Beogradu. B 4, 7: 175–186. (in Serbian)

Kekić, V., M. Anđelković, D. Marinković and N. Milošević (1996). Studies of Drosophilidae (Diptera) in Yugoslavia. XI. Collection from

Stari Slankamen at Danube coast. Arch. Biol. Sci. 48: 55–58.

Kekić, V. (1997). Studies of Drosophilidae (Diptera) in Yugoslavia. XV. Collections from Bačko Gradište and Palić. Acta Entomol. Serbica. 2(1/2): 27–35.

Kekić, V., D. Marinković, M. Anđelković and N. Milošević (1998a). Studies of Drosophilidae (Diptera) in Yugoslavia. X. Collection from Vinci at Danube coast. Glasnik Prirodnjačkog muzeja u Beogradu. B(48-50):191–200.

Kekić, V. (1998b). *Chymomyza amoena* Loew (Drosophilidae, Diptera): nova vrsta u fauni Jugoslavije. Zaštita bilja. 49(4): 329–334. (in Serbian)

Kekić, V., G. Bächli and S. Pavković-Lučić (1999a). Drosophilidae fauna (Diptera) of former Yugoslavia. In: Giokas, S., A. Legakis, R. Polymeni, S. Sfenthourakis, M. Thessalou-Legaki, and A. Zenetos, editors. Contributions to the Zoogeography and Ecology of the Eastern Mediterranaen region. The Hellenic Zoological Society, Greece. 1(suppl.). 9–15.

Kekić, V., S. Pavković-Lučić, J. Milošević, N. Popović and N.J. Milošević (1999b). Studies of Drosophilidae (Diptera) in Yugoslavia. XII. Collections from Belgrade and Sremska Kamenica at Danube coast. In: Giokas, S., A. Legakis, R. Polymeni, S. Sfenthourakis, M. Thessalou-Legaki, and A. Zenetos, editors. Contributions to the Zoogeography and Ecology of the Eastern Mediterranaen region. The Hellenic Zoological Society, Greece. 1(suppl.). 1–7.

Kekić, V. (2002). The Drosophilae (Drosophilidae, Diptera) of Yugoslavia. In: Ćurčić, B.P.M., and M. Anđelković, editors. Genetics, Ecology, Evolution. Monographs, Volume VI, Institute of Zoology, Faculty of Biology, University of Belgrade (Serbia). 109–120.

Kekić, V. (2003). Studies of Drosophilidae (Diptera) in Serbia. XVII. Collections from Čurug, Vojvodina. Arch. Biol. Sci. 55(1–2): 17P–18P.

Kekić, V. (2009). The Drosophilidae (Diptera) of Fruška Gora Mountain. In: Šimić, S., editor. Invertebrates (Invertebrata) of the Fruška Gora Mountain. Matica Srpska, Department of Natural Sciences (Belgrade). 63–84.

Kiss, B., G. Lengyel, Z. Nagy and Z. Karpati (2013). First record of spotted wing drosophila [*Drosophila suzukii* (Matsumura, 1931)] in Hungary. Növényvédelem. 49(3): 97–99.

Lee, J.C., D.J. Bruck, A.J. Dreves, C. Ioriatti, H. Vogt and P. Baufeld (2011). In focus: spotted wing drosophila, *Drosophila suzukii*, across perspectives. Pest. Manag. Sci. 67(11): 1349–1351. https://doi.org/10.1002/ps.2271

Little, C.M., T.W. Chapman and N.K. Hillier (2020). Plasticity is key to success of *Drosophila suzukii* (Diptera: Drosophilidae) invasion. J. Insect Sci. 20(3): 5; 1–8. https://doi.org/10.1093/jisesa/ieaa034

Markow, T.A. and P.M. O'Grady (2006). *Drosophila*: a guide to species identification and use. Oxford, Academic Press (Amsterdam). 259 p. ISBN: 978-0-12-473052-6.

Masten Milek, T.M., G. Seljak, M. Šimala and M. Bjeliš (2011). First record of *Drosophila suzukii* (Matsumura, 1931) (Diptera: Drosophilidae) in Croatia. Glasilo biljne zaštite. 11(5): 377–382.

Mohr, S. E. (2018). First in Fly. *Drosophila* Research and Biological Discovery. Harvard University Press; Cambridge, MA and London (England). 272 p. https://doi.org/10.4159/9780674984721

Nikolić, M., I. Božić and D. Božić (2023). Foreign trade and competitiveness of raspberry of the Republic of Serbia and selected countries. Ekonomika poljoprivrede. 70(3): 797–812. https://doi. org/10.59267/ekoPolj2303797N

Ostojić, I., M. Zovko and D. Petrović (2014). First record of spotted wing *Drosophila suzukii* (Matsumura, 1931) in Bosnia and Herzegovina. Works of the Faculty of Agriculture, University of Sarajevo. 59(64): 127–133.

Pajač Živković, I., B. Barić, D. Lemić, I. Blažević, M. Šubić, G. Seljak and A. Mešić (2016). The Drosophilid Fauna (Diptera, Drosophilidae) of IPM Vineyards in Croatia. Agric. Conspec. Sci. 81(4): 231–234.

Pajač Živković, I. and D. Kapuđija (2019). New finding sites of *Drosophila suzukii* (Matsumura, 1931) in perennial crops of Zagreb County. Pom. Croat. 23(1-2): 15–24.

Pavković-Lučić, S. and V. Kekić (1998). A preliminary note on the Drosophilidae (Diptera) fauna in Kamarište, Yugoslavia. Arch. Biol. Sci. 50(4): 39P-40P.

Pavković-Lučić, S., L. Lučić and D. Miličić (2009). Preliminary list of the fauna of Drosophilidae from Užice, Serbia. Dros. Inf. Serv. 92: 93–94.

Pavković-Lučić, S., T. Savić, M. Jelić, B. Kenig, M. Tanasković, M. Stamenković-Radak and M. Anđelković (2012). Note on the fauna of *Drosophila* (Diptera: Drosophilidae) and the first record of *Opomyza florum* (Diptera: Opomyzidae) from Mountain Goč, Serbia. Acta Entomol. Serbica. 17(1/2): 45–51.

Pavković-Lučić, S. and V. Kekić (2014). Seasonal and spatial distribution of two sibling species, *Drosophila melanogaster* and *Drosophila*

*simulans* (Diptera: Drosophilidae) in Belgrade, Serbia. Acta Zool. Bulg. 66(2): 173–178.

Radonjić, S. and S. Hrnčić (2015). First record of spotted wing drosophila *Drosophila suzukii* (Diptera: Drosophilidae) in Montenegro. Pestic. Phytomed. 30(1): 35–40. https://doi.org/10.2298/PIF1501035R

Rampasso, A.S. and P.M. O'Grady (2022). Standardized terminology and visual atlas of the external morphology and terminalia for the genus *Scaptomyza* (Diptera: Drosophilidae). Fly. 16(1): 37–61. https://doi.org/10.1080/19336934.2021.1969220

Shannon, C.E. (1948). A mathematical theory of communication. Bell Syst. Tech. J. 27(3): 379–423. https://doi.org/10.1002/j.1538-7305.1948.tb01338.x

Stanić, S., V. Kekić and S. Pavković-Lučić (2001). Studies of Drosophilidae (Diptera) in Serbia and Montenegro. XVIII. Collections from Kragujevac. Acta Entomol. Serbica. 6(1/2): 151–155.

Stanić, S., V. Kekić and S. Pavković-Lučić (2002). A contribution to knowledge of Drosophilidae (Diptera) fauna in Kragujevac basin. Acta Entomol. Serbica. 7(1/2): 151–154.

Toševski, I., S. Milenković, O. Krstić, A. Kosovac, M. Jakovljević, M. Mitrović, T. Cvrković and J. Jović (2014). *Drosophila suzukii* (Matsumura, 1931) (Diptera: Drosophilidae) – a new invasive pest in Serbia. Plant Prot. 65(3): 99–104. https://doi. org/10.5937/zasbilj1403099T

Trajković, J., V. Makević, M. Pešić, S. Pavković-Lučić, S. Milojević, S. Cvjetković, R. Hagerman, D. Budimirović and D. Protić (2023). *Drosophila melanogaster* as a model to study Fragile X - associated disorders. Genes. 14(1): 87. https://doi.org/10.3390/genes14010087

**Web resources:**

https://www.eppo_datasheet_DROSSU.pdf (accessed on January 15th 2025)

https://www.taxodros.uzh.ch/ (accessed on November 20th 2024)

https://commons.wikimedia.org/wiki/File:Geographic_map_of_Balkan_Peninsula.svg (accessed on August 25th 2025).