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Occurrence of invasive species and seasonal dynamics of fruit flies (Diptera: Drosophilidae) species in Uşak province, Turkey

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Ocurrencia de especies invasoras y dinámica estacional de especies de moscas de la fruta (Diptera: Drosophilidae) en la provincia de Uşak, Turquía

RESUMEN. En Turquía, el estudio de las especies de Drosophilidae, las cuales no son consideradas perjudiciales para la agricultura, no ha sido profundizado en cuanto a presencia, diversidad y cambios estacionales en sus poblaciones, hasta que *Drosophila suzukii* comenzó a extenderse por todo el mundo. Como resultado de esto, en los últimos años, las investigaciones sobre la fauna de Drosophilidae y sus relaciones entre sí se han acelerado. En este trabajo fueron monitoreadas especies de Drosophilidae y sus cambios estacionales en un huerto de frutas y un viñedo durante 2017-2018. Se examinaron un total de 304 trampas y se identificaron 21.688 individuos pertenecientes a 7 géneros y 13 especies. *Drosophila subobscura* fue la especie más abundante en trampas en ambos años. Además, en el presente estudio, la especie invasora *Zaprionus tuberculatus* se ha identificado por primera vez en el oeste de Turquía.

PALABRAS CLAVE. Diversidad de especies. Drosofílido. *Drosophila suzukii*. *Zaprionus tuberculatus*.

ABSTRACT. In Turkey, studies on Drosophilidae species, which are not considered agriculturally harmful, have not been deepened about their presence, diversity and seasonal population changes, until *Drosophila suzukii* began to spread worldwide. As a result of this, in recent years researches on the fauna of Drosophilidae and their relationships with each other have been accelerated. In the current study, Drosophilidae species and their seasonal changes in a fruit orchard and a vineyard were monitored in 2017-2018. A total of 304 traps were examined and 21,688 individuals belonging to 7 genera and 13 species were identified. *Drosophila subobscura* was the most abundant species in traps in both years. Furthermore, in the present study, invasive *Zaprionus tuberculatus* has been identified for the first time in western Turkey.

KEYWORDS. *Drosophila suzukii*. Drosophilid. Species diversity. *Zaprionus tuberculatus*.

INTRODUCTION

Generally known as vinegar or fruit flies, family Drosophilidae consists of approximately 4,000 species into 78 genera (Yassin, 2013; Miller et al., 2017). Since these species generally feed on the bacteria and yeasts arising from the fermentation of foods that are rich in carbohydrates (Silva et al., 2005), they were not considered to be a threat for the agriculture in Turkey until recent years. However, after detecting the invasive species such as *Drosophila suzukii* (Matsumura) and *Zaprionus indianus* Gupta, which caused significant economic losses in fruit production in our country, the interest in this family has increased. It has been determined that *D. suzukii* has solely caused an annual economic loss of USD 500 million in the USA and *Z.*

indianus has caused a 50% decrease in fig production in Brazil (Rego et al., 2017).

Besides the economic losses caused by the invasive species, the damage they had on the biodiversity and ecosystem of the region is also important (Lee, 2002). As a result of the advancements in transportation opportunities, the propagation of the insect species between the countries and even between the continents has significantly accelerated (Westphal et al., 2008). Since some species couldn't adapt to the ecological conditions of the new regions, they couldn't gain an intense population. However, the propagation of the invasive species that are capable of adapting to the new conditions has occurred very rapidly because of various reasons such as the absence or low population of the rival species in the region and the absence of natural enemies. The increase in the population had a very negative effect on the other local species. It has been reported that 49% of the endangered species are under risk due to such invasive species (Wilcove et al., 1998).

Koçak & Kemal (2013) stated that Turkey has 26 species belonging to eight genera in family Drosophilidae. In the following years, this number increased to 29 with findings of non previously registered species namely *D. suzukii*, *Zaprionus tuberculatus* Malloch and *Chymomyza procnemoides* Wheeler.

The current study reports the diversity of the drosophilid species in Uşak, the status of the invasive species, and the seasonal dynamics of fly populations.

MATERIAL AND METHODS

Surveys were carried out in an approximately 5 ha fruit orchard composed of apple, cherry and plum trees (38°44'47" N, 29°46'45" E; 920 masl) and 1 ha vineyard (38°44'48" N, 29°48'34" E; 957 masl) located in the Banaz district of the Uşak province between 2017 and 2018, using apple cider vinegar traps. The study sites situated in the eastern part of the Banaz have a continental climate and are surrounded by wheat and barley fields. The traps were hung between the beginning of April and the end of December on annual basis in order to detect Drosophilidae species and follow their populations. Each trap was made of a 500 ml plastic bottle containing 100 ml of apple cider vinegar. To overcome the surface resistance, 1-2 drops of dishwashing liquid were also added. Eight to ten holes of 2-3 mm diameter were drilled on top of the plastic bottle to allow entry of insects. The traps were hung on the branches at 1.5 m height and replaced weekly. In both years, three traps were placed with 10 m distance in the mixed fruit orchard and one trap in the vineyard. The trap content was examined under binocular microscope after filtering with fine muslin. A total of 304 traps (228 in the fruit orchard and 76 traps in vineyard) were examined between 2017 and 2018. All collected drosophilids were identified based on the keys performed by Miller et al. (2017) and Markow & O'Grady (2006) and were preserved in 70% ethanol.

SPSS 16.0 was used in all the statistical analyses. The groups were composed of the total number of drosophilid individuals caught in the fruit orchard in Bağkonak village and in the vineyard in Hasanköy village in both years. The difference between the groups was examined using one-way (ANOVA) variance analysis and independent samples t-test. The comparison between the groups, in which a difference was found, was performed using the Tukey test at the significance level of 0.05. In order to ensure the homogeneity in comparisons between the numbers of drosophilid individuals captured in the traps, $lg_{10}(x+1)$ formula was utilized. Moreover, since there were three traps in fruit orchard and one trap in vineyard, the mean number of the catches was used for the fruit orchard.

The Shannon diversity index (H) and the Simpson index (D) were calculated for each weekly sampling. The Shannon index increases as both of the dominance and diversity of the species increase. Since this causes problems in comparing the environments or regions, where the diversity of species is very high, the results are thus presented together with the Simpson index (Fig. 1).

RESULTS AND DISCUSSION

As a result of the study, 7,489 individuals from six genera and 12 species were detected in 2017, while 14,199 individuals from seven genera and 12 species were found in 2018. Out of the 7,489 individuals counted in 2017, 6,306 were captured in the fruit orchard whereas 1,183 were caught in traps placed in the vineyard. In 2018, 11,420 were caught in the fruit orchard and 2,779 in the vineyard (Table I, Table II). In both years, it was determined that there was no statistically significant difference between the total number of drosophilid individuals caught in the fruit

$$H = -\sum_i^s pi \ln(pi)$$

$$D = \frac{1}{\sum_i^s pi^2}$$

Fig. 1 Shannon diversity index (H) and Simpson index (D) (Shannon, 1948; Daly et al., 2018). "s" refers to the number of species, and "pi" refers to the proportion of species "i" to the total number of species. The indices were calculated separately in relation to each sampling date.

Species	n (2017)	n (2018)
Chymomyza procnemoides	2	1
Drosophila busckii	448	561
Drosophila immigrans	829	1011
Drosophila melanogaster	2198	4184
Drosophila phalerata	114	187
Drosophila subobscura	3549	5070
Drosophila suzukii	255	2123
Drosophila transversa	7	19
Gitona distigma	61	118
Hirtodrosophila cameraria	12	104
Leucophenga maculata	3	5
Phortica variegata	11	17
Zaprionus tuberculatus	0	799

Table I. Drosophilid species detected in traps hung in Bağkonak and Hasanköy (Banaz/Uşak) villages in 2017-2018

orchard in Bağkonak village and the total number of individuals caught in the vineyard in Hasanköy village (2017, t_{74} = 1.434; p = 0.156; 2018, t_{74} = 1.526; p = 0.131). Among the species detected in 2017, the most frequently observed species was *Drosophila subobscura* Collin constituting 47.4% of the total, followed by *Drosophila melanogaster* Meigen (29.3%) and *Drosophila immigrans* Sturtevant (11.1%). Similarly, in 2018, the most frequently observed species was *D. subobscura* (35.7%), followed by *D. melanogaster* (29.5%) and *D. suzukii* (14.9%). These results are different from those reported by Gleason et al. (2019) in Kansas, USA, who found that the most frequently observed species was *Drosophila simulans* Sturtevant (57.1%), *D. melanogaster* (19.9%), and *D. suzukii* (11.1%), which are tropical species. Since the resistance of tropical drosophilid species to the winter cold is weaker than that of the other drosophilid species, these species prefer the sheltered locations, which are close to the residential areas, in order to survive the winter (Hoffmann et al., 2003; Langille et al., 2016). Since the survey area was very close to the residential area in the study carried out by Gleason et al. (2019), these species were found to be the dominant species in the traps. In the present study, however, the dominant species was determined to be *D. subobscura* since the forest is at 1 km distance from the study fields and there was a more rural habitat.

In another study carried out in vineyards from Croatia by Zivkovic et al. (2016), the authors reported eight drosophilid species belonging to two genera, with *D. suzukii* as dominant species (69%). In the current study, however, *D. suzukii* accounted for 2.9% of total abundance in 2017 and 14.9% in 2018. In contrast with the other *Drosophila* species, the fact that *D. suzukii* can infest the healthy fruits, which have not been damaged by any factor, causes significant economic losses in agriculture. Regarding this insect, the first record in Croatia was reported in 2010, and *D. suzukii* constituted 69% of all the drosophilid species caught in traps in 2016. In Turkey, this insect was detected firstly in Erzurum in 2014 (Orhan et al., 2016).

In the present study, when compared to the other drosophilid species, the increase in population intensity of *D. suzukii* by 12% from 2017 to 2018 was found to be very important since it is an invasive species. It is thought that the temperature in the winter season of 2017, which was higher than in other years, contributed to this increase. Since September 2017, a constant increase in the number of adult *D. suzukii* in the traps was determined and the female individuals were found first in the traps. In 2018, *D. suzukii* individuals were intermittently found in the traps between April and August. However, since August 2018, the *D. suzukii* individuals were constantly caught in the traps. Similarly, the female individuals were identified first in the traps (April 13th). Briem et al. (2018) reported that *D. suzukii* adult population was low during the summer period due to the high temperature exceeding 30 °C. This study also showed low number of catches in the summer and as of September, when the temperature began to decrease, fly density in the traps increased. In 2017, the highest number of catch in a single day was found on October 27th (80 individuals, mean temperature of 6 °C, and relative humidity of 55%), whereas the highest number of catch in 2018 was 605 on November 17th (mean temperature of 10 °C and relative humidity of 79%) (Fig. 2). Similarly, the highest numbers of catches were reported to be in November in the studies carried out in Switzerland and Spain (Arno et al., 2016; Dorsaz et al., 2017). Wang et al. (2019) observed population dynamics of *D. suzukii* at different elevations in California, USA, and determined that the fly populations have two peaks, namely spring and fall, at lowest elevation (106 masl). Whereas only one peak (fall) was found at 525 masl, which is the closest altitude in the current study. The fact that the number of captured *D. suzukii* reached its peak in autumn and remained low in other months was similar to this study.

Moreover, the numbers of *D. suzukii* individuals caught in traps placed in Bağkonak and Hasanköy villages in 2018 were statistically compared, and it was determined that the number of *D. suzukii* individuals caught in fruit orchard in Bağkonak village was statistically significantly higher than the number of *D. suzukii* individuals caught in vineyard in Hasanköy (t_{46} = 0.969; p = 0.338). The reason of more *D. suzukii* being collected in the fruit orchard was that the number of traps there were higher than in the vineyard.

Average temperature of October and November with highest number of catch was 5 to 10 °C. whereas in

Species	*Chymomyza procnemoides*		*Drosophila busckii*		*Drosophila immigrans*		*Drosophila melanogaster*		*Drosophila phalerata*		*Drosophila subobscura*		*Drosophila suzukii*	
Collecting dates	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
7-Apr	0	0	0	2	0	0	0	0	0	0	109	208	0	0
14-Apr	0	0	0	3	0	4	0	0	0	0	349	723	0	1
21-Apr	0	0	0	0	0	3	0	1	0	0	312	365	0	0
28-Apr	0	0	0	0	0	2	0	0	0	0	413	447	0	0
5-May	0	0	0	0	0	5	0	0	0	0	648	769	0	1
12-May	0	0	0	0	0	0	0	0	0	0	187	239	0	0
19-May	0	0	0	5	0	3	0	1	0	0	145	179	0	0
26-May	0	0	0	3	0	7	1	3	0	0	100	105	0	0
2-Jun	0	0	2	0	0	3	0	2	0	0	45	64	0	0
9-Jun	0	0	0	2	0	18	0	1	0	2	67	96	0	1
16-Jun	0	0	1	9	0	8	1	2	0	0	58	83	0	0
23-Jun	0	0	2	5	0	1	3	1	0	3	11	16	0	0
30-Jun	0	0	3	6	0	3	1	0	0	5	35	50	0	0
7-Jul	0	0	6	4	0	3	0	1	0	0	14	20	0	0
14-Jul	0	0	1	0	0	4	1	4	1	0	5	7	0	0
21-Jul	0	0	1	1	0	1	2	6	1	2	22	31	0	2
28-Jul	0	0	3	0	0	2	15	23	0	0	9	13	0	0
4-Aug	0	0	2	0	1	0	9	21	0	3	8	11	0	7
11-Aug	0	0	0	0	0	0	38	34	2	1	6	9	0	29
18-Aug	0	0	3	2	0	1	183	354	1	3	14	20	0	69
25-Aug	0	0	3	6	2	1	263	575	0	3	5	7	0	81
1-Sep	0	0	5	4	0	8	96	183	0	3	17	24	0	23
8-Sep	0	0	4	12	0	26	186	338	2	5	71	101	2	41
15-Sep	0	0	13	4	5	11	144	209	5	12	77	110	1	22
22-Sep	1	0	11	7	8	14	102	155	9	16	125	179	3	38
29-Sep	0	0	9	12	11	32	88	148	12	25	74	106	15	57
6-Oct	0	0	11	21	78	139	116	259	11	14	113	162	20	51
13-Oct	0	1	16	15	65	20	72	110	7	11	88	126	19	121
20-Oct	0	0	11	25	87	111	78	149	10	8	113	179	43	149
27-Oct	0	0	37	70	148	256	287	538	13	9	79	113	80	98
3-Nov	0	0	96	126	174	161	264	555	11	15	67	110	15	184
10-Nov	1	0	72	75	91	38	87	202	11	16	68	97	23	473
17-Nov	0	0	68	110	68	110	102	272	9	15	71	229	21	605
24-Nov	0	0	36	6	74	7	44	7	6	10	6	9	11	23
1-Dec	0	0	21	6	12	1	3	6	3	5	1	2	1	6
8-Dec	0	0	9	13	5	8	9	18	0	1	5	45	1	28
15-Dec	0	0	2	7	0	0	1	6	0	0	9	13	0	10
22-Dec	0	0	0	0	0	0	1	0	0	0	2	3	0	3
Total	**2**	**1**	**448**	**561**	**829**	**1011**	**2198**	**4184**	**114**	**187**	**3549**	**5070**	**255**	**2123**

Table II. Detail of individuals collected during the survey.

Species	*Drosophila transversa*		*Gitona distigma*		*Hirtodrosophila cameraria*		*Leucophenga maculata*		*Phortica variegata*		*Zapriomus tuberculatus*		Number of individuals	
Collecting dates	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	**2017**	**2018**
7-Apr	0	0	4	6	0	0	0	0	0	0	0	0	**113**	**216**
14-Apr	0	0	2	6	0	0	0	0	0	0	0	0	**351**	**737**
21-Apr	0	0	5	0	0	0	0	0	0	0	0	0	**317**	**369**
28-Apr	0	0	0	0	0	0	0	0	0	0	0	0	**413**	**449**
5-May	0	0	0	2	0	0	0	0	1	0	0	0	**649**	**777**
12-May	0	0	0	0	0	0	0	0	0	0	0	0	**187**	**239**
19-May	0	0	0	0	0	0	0	0	1	1	0	0	**146**	**189**
26-May	0	0	1	0	0	0	0	0	0	2	0	0	**102**	**120**
2-Jun	0	0	0	0	0	0	0	0	0	2	0	0	**47**	**71**
9-Jun	0	1	0	1	0	0	0	0	3	1	0	0	**70**	**123**
16-Jun	0	0	0	0	0	0	0	0	0	0	0	0	**60**	**102**
23-Jun	0	3	0	0	0	0	0	0	0	0	0	0	**16**	**29**
30-Jun	0	0	2	1	0	0	0	0	0	0	0	0	**41**	**65**
7-Jul	1	0	0	1	0	0	0	0	0	0	0	0	**21**	**29**
14-Jul	0	0	0	0	0	0	0	0	0	1	0	0	**8**	**16**
21-Jul	0	1	0	1	0	0	0	0	0	0	0	0	**26**	**45**
28-Jul	0	0	0	0	0	0	0	0	0	0	0	0	**27**	**38**
4-Aug	2	1	1	1	0	0	0	0	0	0	0	0	**22**	**44**
11-Aug	0	0	3	4	0	0	0	0	0	1	0	0	**49**	**78**
18-Aug	0	2	8	11	0	0	0	0	0	1	0	1	**209**	**464**
25-Aug	0	0	12	33	0	0	0	0	0	0	0	16	**285**	**722**
1-Sep	0	0	6	11	0	0	0	1	0	0	0	16	**124**	**273**
8-Sep	0	2	8	20	0	0	0	0	0	0	0	22	**273**	**567**
15-Sep	0	1	3	8	0	0	1	0	2	0	0	19	**251**	**396**
22-Sep	1	0	3	6	0	0	0	0	1	0	0	20	**264**	**435**
29-Sep	0	0	0	0	2	0	0	0	0	0	0	112	**211**	**492**
6-Oct	0	1	1	2	1	0	0	0	0	0	0	98	**351**	**747**
13-Oct	0	0	1	1	2	21	2	0	0	1	0	17	**273**	**444**
20-Oct	2	0	0	2	2	46	0	1	0	0	0	30	**346**	**700**
27-Oct	1	2	0	1	1	8	0	0	0	1	0	124	**646**	**1220**
3-Nov	0	1	1	0	3	17	0	0	0	0	0	170	**631**	**1339**
10-Nov	0	0	0	0	0	3	0	1	0	1	0	59	**353**	**965**
17-Nov	0	2	0	0	0	9	0	0	1	0	0	89	**340**	**1441**
24-Nov	0	1	1	0	0	0	0	1	1	2	0	1	**179**	**67**
1-Dec	0	1	0	0	0	0	0	1	1	2	0	2	**43**	**32**
8-Dec	0	0	0	0	0	0	0	0	0	1	0	1	**29**	**115**
15-Dec	0	0	0	0	0	0	0	0	0	0	0	2	**12**	**38**
22-Dec	0	0	0	0	0	0	0	0	0	0	0	0	**3**	**6**
Total	**7**	**19**	**61**	**118**	**12**	**104**	**3**	**5**	**11**	**17**	**0**	**799**	**7489**	**14199**

Table II (cont.). Detail of individuals collected during the survey.

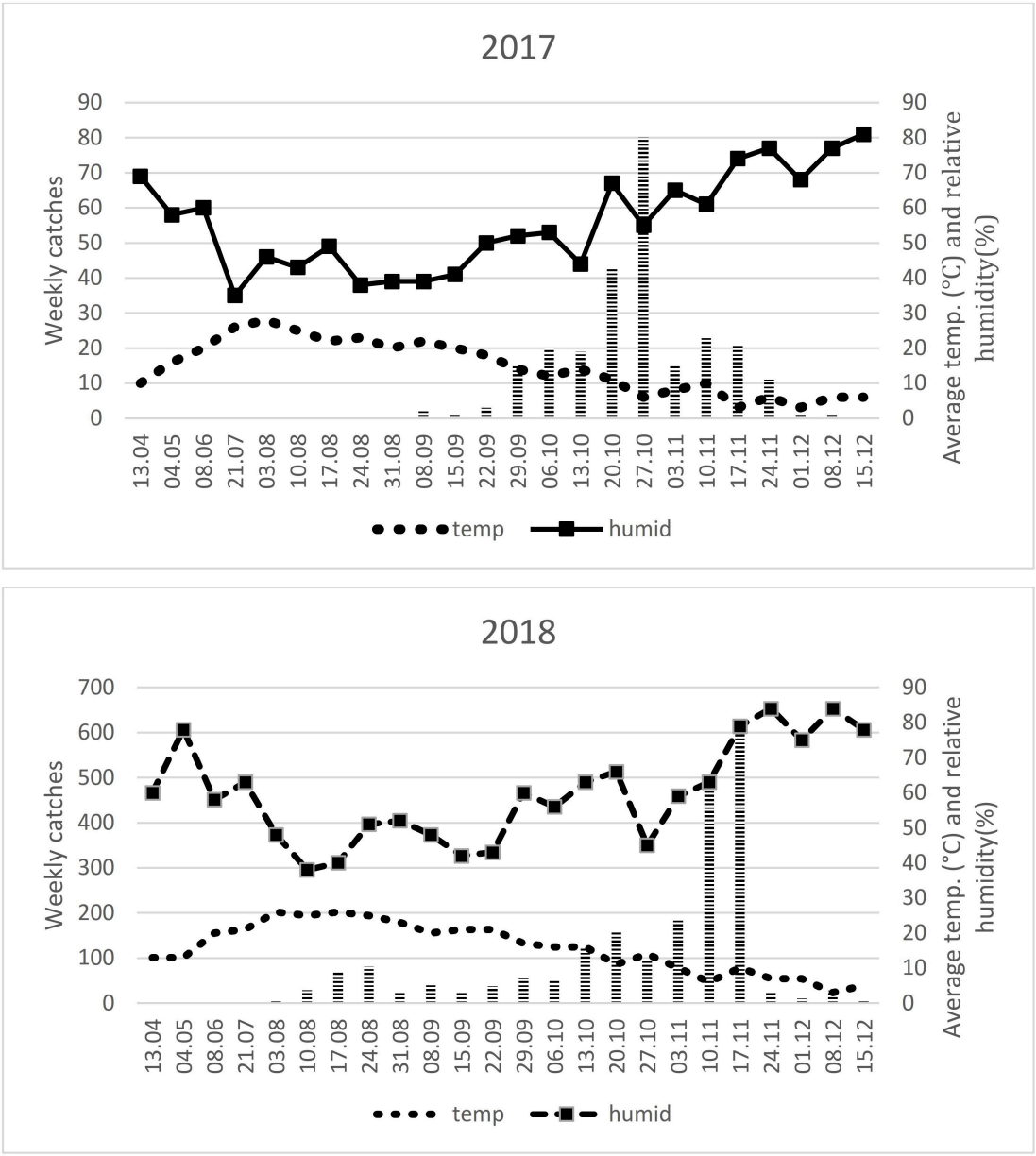

Fig. 2. Weekly catches of *Drosophila suzukii* in 2017-2018, average temperature and relative humidity in Banaz district.

September, when the temperature was more favorable for the fly, numbers of catch were less. Even if there is a negative correlation in which the number of *D. suzukii* increases as average temperature decreases ($r = -0.37$; $p < 0.05$), it is considered that the increase is due to lack of fresh fruit sources as stated by Briem et al. (2018). The cherry trees, on which the traps were hung, were harvested in July, whereas the plum, apple, and grapes were harvested in October. *Drosophila suzukii* cannot live all life stages on the fermenting materials as in other drosophilid and the female individuals need intact fruits for laying their eggs (Cini et al., 2012). For this reason, it is thought that *D. suzukii* having difficulties in finding food tended towards the traps containing apple vinegar and the maximum numbers of catch were reached in October and November.

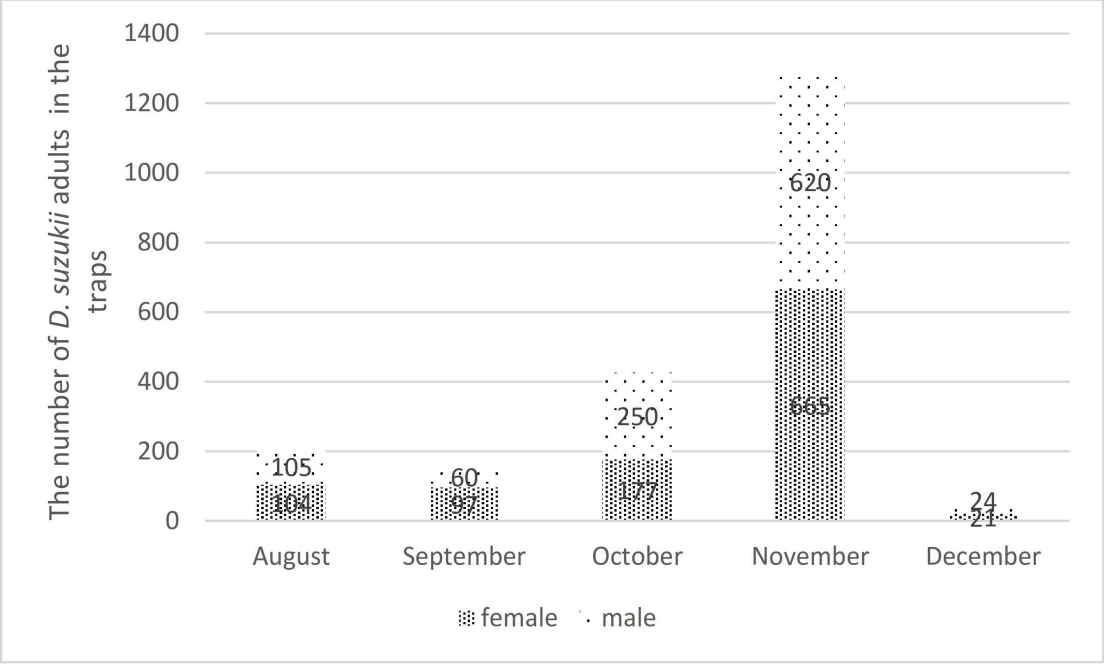

Fig. 3. *Drosophila suzukii* individuals monthly caught in Bağkonak and Hasanköy villages, Banaz district, in 2018.

On the monthly basis, no statistically significant difference was found between August, November, and December in terms of the proportions of female *D. suzukii* individuals caught in the traps, whereas the highest proportion was found in September (61.8%) and the lowest in October (41.5%) ($F_{4, 20} = 4.5019$; $p = 0.014$) (Fig. 3). Since the total number of *D. suzukii* caught in 2017 was significantly lower than the number of *D. suzukii* individuals caught in 2018, this analysis was performed only for 2018.

Another invasive species detected in the present study and taken into the alert list by the European and Mediterranean Plant Protection Organization (EPPO) in 2016 (Balmes & Mouttet, 2019) is *Z. tuberculatus*. This species, which is native to the Afro-tropical region, has been detected in Turkey for the first time in Adana province in 2011 (Patlar et al., 2012) and since then no other record has been reported in Turkey. This species arrived in the continental Europe, in Italy, in 2013 (Raspi et al., 2014). While *Z. tuberculatus* was not detected in any of the traps in 2017, it was constantly seen in the traps launched after August 10th, 2018. In their study, Patlar et al. (2012) reported similar results regarding the detection of *Z. tuberculatus* in August. However, since no sampling has been performed in the months before and after August, the status of *Z. tuberculatus* in these months was unknown. However, Constantina et al. (2015) have detected this species in Romania for the first time in 2014 and they have reported that *Z. tuberculatus* has been found in the traps from late September to late October. In this study, 799 individuals were identified in total and 242 of them were collected from the vineyard and 557 individuals were from the fruit orchard (Fig. 4). There was no significant difference between the number of *Z. tuberculatus* individuals caught in the fruit orchard and that of those caught in vineyard ($t_{34} = 0.278$; $p = 0.783$). DNA barcoding analyses of detected fly larvae from the imported goods at the ports of entry in France between 2010 and 2016 showed 3 of 17 specimens were *Z. tuberculatus* (Balmes & Mouttet, 2019). It is thought that the propagation of the invasive drosophilid species to the new regions via the imported fruits has occurred very rapidly since the knowledge on morphological identification of drosophilid larvae was very limited and insufficient and the identification using DNA-barcoding method takes a long time. Although this species has not been identified as harmful agriculturally so far, it has been considered to be potentially harmful since it is a relative to *Z. indianus*, which is harmful to fig fruit (Patlar et al., 2012).

Chymomyza procnemoides, which is native form northern America and feeds on trees damaged from both natural and man-made causes, has been found in Europe for the first time in Hungary in 1990 (Band, 1995). This study is reporting its first detection in Turkey between September 23rd and October 7th, 2017. In 2018, one female individual was also detected on October 13th in the trap hung in vineyard in Hasanköy village. The detection of this species in Turkey is in parallel with the study of Papp (1992) reporting that the propagation of

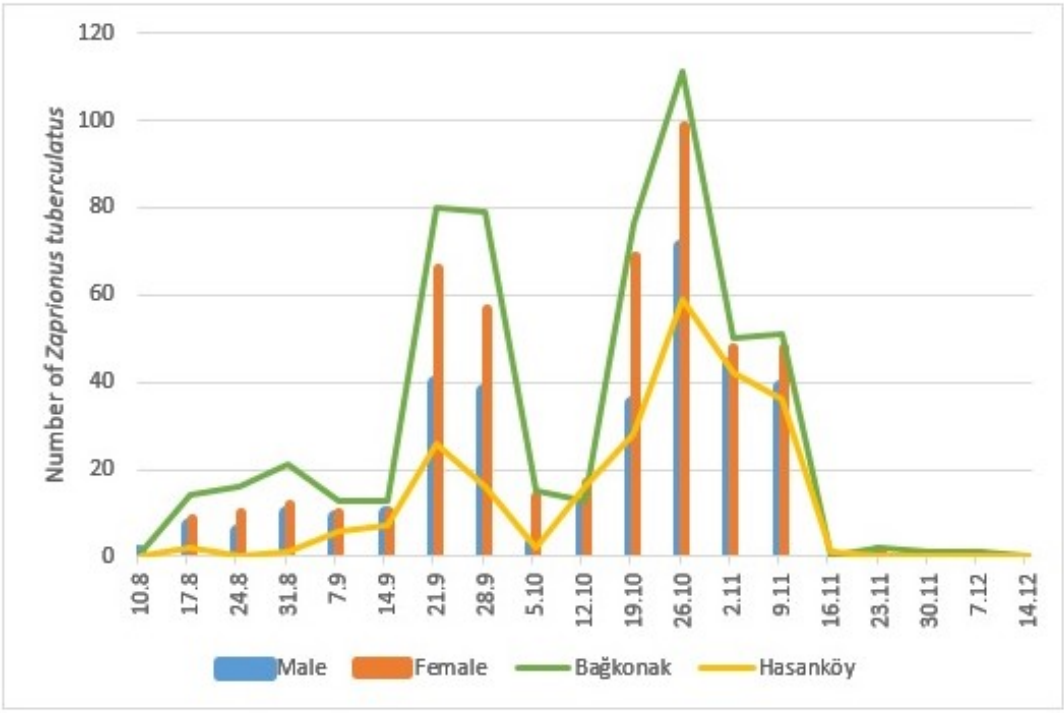

Fig. 4. *Zaprionus tuberculatus* individuals weekly caught in Bağkonak and Hasanköy villages, Banaz district, in 2018.

C. procnemoides in the Palearctic region is not limited to Hungary but the necessary efforts have not been performed in neighbor countries.

In both years, *D. subobscura* was observed in the traps since early April and it remained the most frequently detected species. As a result of the studies performed, it was reported that a vast majority of *Drosophila* species spent the winter as adult, but some others might overwinter in the larvae, pupa, or reproductive diapause (Stephens et al., 2015). In contrast, since *D. subobscura* overwinters without entering the diapause (Goto & Yoshida, 1999), it was more abundant during the early seasons than the other species. Moreover, the lack of natural food sources in April and May directed this species to the vinegar traps. Then, the population intensity significantly decreased in June. As seen in Figure 5, when the mean temperature reached at the level suitable for the other drosophilid species to break the diapause and become active, these species didn't prefer the vinegar traps when the natural food sources were available. Thus, the number of individuals caught between June and October was limited. Since the harvesting of the fruit orchard and the vineyard was completed in October, they tended towards the traps and the number of caught individuals increased.

Moreover, given the biodiversity indices of the traps, the values found in October (for both Shannon and Simpson indices) were found to be higher than in other months. Also, these results show that the diversity of species identified in traps and the number of individuals caught were higher in October (Fig. 6).

The studied months were divided into two groups as of the end of August, and then the Shannon and Simspon indices values of the groups were compared with independent samples t test. As a result, the values of the second group (September-December) were significantly higher than those of the first group (April-August) (Shannon $t_{36} = -7.96$, $p < 0.001$; Simpson $t_{36} = -7.706$, $p < 0.001$). These results proved that diversity and density of drosophilid species caught in traps increased as of September. However, in a study conducted in northeast Brazil by Coutinho-Silva et al. (2017), they didn't ascertain any difference in species richness between seasons (January-March and June-August). The fact that the region has a tropical climate with temperatures ranging from 20 to 30 degrees throughout the year led to this difference.

In this study, a significant increase in the population of *D. suzukii* which represents a serious agricultural pest was determined. Moreover, *Z. tuberculatus*, which was not detected in any trap in 2017 but found in 2018, was considered important since it constitutes 5.6% of the drosophilid species. Further studies are needed to determine the damage caused by *D. suzukii* in this region. Research on the role of other drosophilid species in the increase of this damage is also necessary. This is the first study carried out on this subject in Turkey.

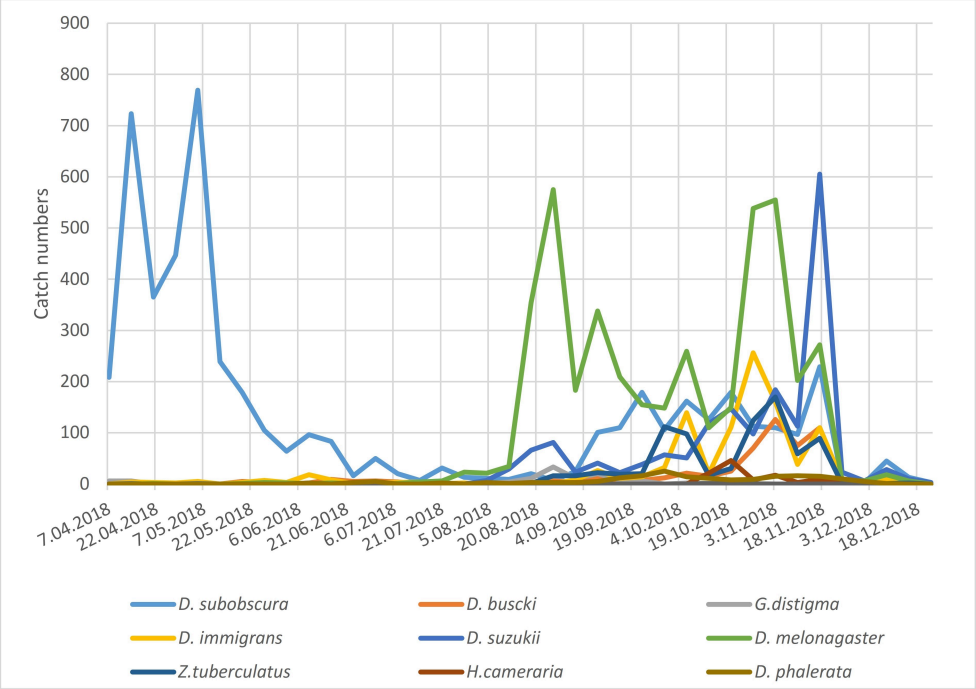

Fig. 5. Number of individuals caught in traps in 2018. Species for which the catch numbers was below 100 were not included.

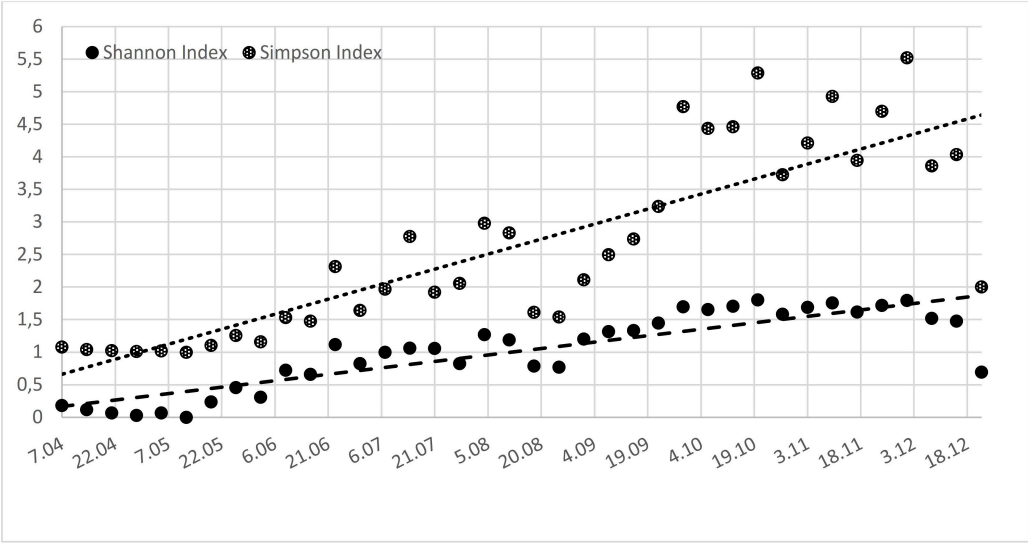

Fig. 6. Shannon and Simpson diversity indices calculated in traps on weekly basis.

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