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Determination of distribution and population change of Drosophilidae (Diptera) species in cherry and peach orchards in Tokat province (Türkiye)

Hüseyin Bilal TAŞLIOĞLU[1], Turgut ATAY[2]*

[1] Middle Black Sea Transitional Zone Agricultural Research Institute, Tokat-Türkiye
[2] Tokat Gaziosmanpaşa University, Faculty of Agriculture, Department of Plant Protection, Tokat-Türkiye

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***CONTACT**

turgut.atay@gop.edu.tr

A B S T R A C T

In this study, the presence and prevalence of Drosophilidae species were studied in cherry and peach plantations of Tokat province in 2021-2022. In addition, the population of the species belonging to the family was monitored for two years in one peach and cherry plantations in central district of Tokat. According to the results, a total of 10 species were recorded. These species are *Drosophila hydei* Sturtevant, 1921, *D. immigrans* Sturtevant, 1921, *D. melanogaster* Meigen, 1830, *D. phalerata* Meigen, 1830, *D. simulans* Sturtevant, 1919, *D. subobscura* Collin, 1936, *D. suzukii* (Matsumura, 1931), *Gitona distigma* Meigen, 1830, *Scaptomyza pallida* (Zetterstedt, 1847), *D. transversa* Fallen, 1823. Of these, 10 species were determined in the central district of Tokat, 9 species in Erbaa, 8 species in Turhal and 6 species in Pazar. *D. subobscura* Collin, 1936 was the most common species in cherry and peach fields in central district of Tokat in 2021 and 2022. In Erbaa, *D. subobscura* was the most common species in cherry fields in 2021 and *D. hydeii* Sturtevant, 1921 and *S. pallida* (Zetterstedt, 1847) took the first place in terms of prevalence in peach fields. In 2022, the most common species in cherry and peach fields was *D. subobscura* in Erbaa. While *D. hydei* was the most common species in cherry and peach plantations in Turhal in 2021, *D. immigrans* Sturtevant, 1921 in cherry fields, and *D. subobscura* in peach fields were common in 2022. In the cherry fields in Pazar, the common species was *D. immigrans* in 2021 and *D. subobscura* in 2022. *D. suzukii* (Matsumura, 1931), one of the important species in the family, was recorded in cherry and peach plantations in central district of Tokat and Erbaa, and in peach plantations in Turhal. *D. suzukii* was seen for the first time on 25 Aug. (2 specimens) in the cherry fields of Tokat Centre in 2021, while it could not be detected in the peach fields. In 2022, the first adult detection in cherry areas was made on 29 Aug. (7 specimes) and in peach areas on 08 Aug. (1 specimen). This study is the first detailed study on Drosophilidae family in Tokat (Türkiye) province.

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ORCID> 0000-0002-8109-6301 (HBT), ORCID> 0000-0002-9074-0816 (TA)

1. Introduction

Drosophilidae is a family of Diptera with a rich species diversity with 4700 species belonging to 77 genera worldwide (Bächli, 2023). Only 36 species are known in our country (Koçak and Kemal, 2013). Most drosophilid species are saprophagous and it is known that they consume decomposing plant materials (Schmitz et al., 2007). Some species of the family have caused significant quality and quantity losses in fruit areas, especially in recent years (Živković et al., 2019). In Türkiye, there are suitable habitats for the species of Drosophilidae family due to the fact that there are many different climatic conditions, geographical conditions are very variable regionally and host plant diversity is high. Some of the species of Drosophilidae family may pose a threat to agricultural production because they feed on cultivated plants, have a rapid spread and reproduction potential, easily adapt to climatic conditions, have a high number of generations and are polyphagous. Although many species of the family feed on rotten fruits on the ground, species such as *Drosophila suzukii* (Matsumura, 1931) and *Zaprionus indianus* Gupta, 1970 attack ripe and healthy fruits (Lee et al., 2011; Walsh et al., 2011; Özbek-Çatal et al., 2019). Especially in recent years, the prevalence of *D. suzukii* and *Z. indianus* species, which are invasive pests of the family, throughout the country and causing significant damages (Orhan et al., 2016; Özbek-Çatal et al., 2019) has increased the interest in the family in our country (Kaçar and Koca, 2017; Efil, 2018; Kasap and Özdamar, 2019; Zengin, 2020; Özbek-Çatal et al., 2021).

Drosophila suzukii, which is an invasive quarantine pest and has spread rapidly both in the world and in our country in recent years, is one of the important factors preventing fruit production. This species is a polyphagous pest that damages many fruits, especially of fruits (Bieńkowski and Orlova-Bienkowskaja, 2020; Çatal et al., 2021). *D. suzukii*, whose native land is Asia, was first detected in strawberry fields in Italy in Europe, then invaded western countries and America, infected many parts of these countries in a short time and threatened fruit production (Lee at al., 2011). In our country, it was first detected in strawberry orchards in Erzurum province in 2014, and its presence was observed in grape, nectarine, apple, pear, plum and cherry areas in Çanakkale, Adana, Karaman and Uşak provinces (Orhan et al., 2016; Efil, 2018; Öğür et al., 2018; Kasap and Özdamar, 2019; Zengin and Karaca, 2019). *Zaprionus indianus*, another invasive species belonging to the family, originates from tropical Africa and is known to be widespread throughout Central and South America in recent years. It has also been detected in some European countries (Soto et al., 2006; Yassin et al., 2008; Kremmer et al., 2017). It was determined for the first time in Türkiye in Adana, Hatay, Mersin and Osmaniye in 2019 (Özbek-Çatal et al., 2019). It is known that *Z. indianus* is a primary pest in about 80 fruit species such as figs, apples and strawberries and causes serious damage to fruits (Yassin and David, 2010). In our country, it has been determined that it damages figs, persimmon, blackberry, cherry, peach and plum (Özbek-Çatal et al., 2019). The presence of Z. tuberculatus, another species belonging to the genus *Zaprionus*, in our country was revealed in 2012 (Patlar et al., 2012) and is known as a secondary pest.

Studies on the family Drosophilidae in Türkiye are quite limited. Especially after the detection of the invasive species *D. suzukii*, *Z. indianus* and *Z. tuberculatus* in our country, studies on the detection and prevalence of these species and other species belonging to the family in our country have increased (Kaçar and Koca, 2017; Efil, 2018; Özbek-Çatal et al., 2019; Kasap and Özdamar, 2019). In the province of Tokat, which is an important fruit producer and in the transitional zone in terms of climate, no study has been carried out to determine the species belonging to the Drosophilidae family. In this study, it was aimed to determine the presence, distribution, first adult times and population fluctuations of the species belonging to the Drosophilidae family in the cherry and peach fields of Tokat province.

2. Material and methods

2.1. Determination of the distribution of species of the Drosophilidae

The surveys were carried out for two years in 4 districts (cherry and peach orchards in Centre, Erbaa and Turhal districts and only cherry orchard in Pazar district) where fruit is intensively cultivated in Tokat province. In the surveyed orchards, 2% of the districts with 50-100 da production, 1% of the districts with 101-1000 da production and 0.1% of the districts with 1001-10000 da production were sampled (Bora and Karaca, 1970) (Table 1, 2).

Table 1. Pest survey area in fruit orchards (Anonymous, 2020)

Districts	Total Area (decare)		Estimated Investigated Area (decare)	
	Peach	Cherry	Peach	Cherry
Erbaa	250	150	2.5	1.5
Pazar	-	350	-	3.5
Turhal	460	345	4.5	3.5
Centre	7.750	4.550	7.7	4.5

Table 2. Information on the gardens where traps were hung

Districts/Villages	Orchard	Coordinates	Altitude
Tokat/Centre/Kömeç	Peach	40.35876°N, 36,45025°E	621m
Tokat/Centre/Kemalpaşa	Cherry	40.36301°N, 36,50897°E	611m
Tokat/Turhal/Çarıksız	Peach	40.32504°N, 36,26169°E	608m
Tokat/Turhal/Çarıksız	Cherry	40.33115°N, 36,26230°E	651m
Tokat/Erbaa/Karayaka	Cherry	40.72877°N, 36.60200°E	272m
Tokat/Erbaa/Salkımören	Peach	40.72527°N, 36.61157°E	275m
Tokat/Pazar/Seyitali	Cherry	40,26889°N, 36,28472°E	629m

Particular attention was paid to the selection of untended and unsprayed orchards for the surveys. In order to determine the distribution of the species, traps were hung in the selected orchards one month before harvest. 100 mL of apple cider vinegar was placed in 500 mL plastic bottles with about 10 holes with a diameter of 3 mm. The traps prepared in this way were hung on the outer parts of the trees with 3 traps per garden (Figure 1). The traps were hung in the southeast direction of the trees at a height of 1.5 m from the ground (Grassi et al., 2011; Öğür et al., 2018; Zengin, 2020). For monitoring purposes, apple cider vinegar traps were checked weekly until harvest.

Figure 1. Vinegar traps hung in cherry and peach orchards

2.2. Determination of the first adult emergence time and population monitoring

In the centre of Tokat, studies were also carried out to determine the first adult emergence and population monitoring. For this purpose, population monitoring studies were carried out for two years in peach orchards with 100 trees in Kömeç and cherry orchards with 100 trees in Kemalpaşa, villages of Tokat-Centre. The traps prepared as mentioned above were hung in 4 pieces in each orchard at least 1 month before the mole fall period, when the fruits start to sweeten depending on the phenology of the fruit variety. The traps were checked weekly until one month after the fruit was harvested. The obtained data were correlated with the climatic data (daily average temperature and daily average relative humidity) obtained from Tokat Meterology Directorate. Temperature and humidity values are given as weekly average temperature and weekly average relative humidity. Graphs were created for the first 5 species with high population density. Specimens caught in the traps were preserved in 70% alcohol.

Identifications of the determined species were made according to Markow and O'Grady (2006), Miller et al. (2017) and Yuzuki and Tidon (2020). The identification of the species that could not be identified and the confirmation of the identifications were carried out by Dr. Burcu ÖZBEK ÇATAL (Çukurova University Pozantı Vocational School-Pozantı/Adana) and Assoc. Prof. Dr. Asime Filiz ÇALIŞKAN KEÇE (Çukurova University, Faculty of Agriculture, Department of Plant Protection-Adana).

3. Results

3.1. Determination of the distribution of species of the Drosophilidae

According to the results obtained, a total of 10 species were identified in Tokat province (Table 3). When the determined species are analyzed according to districts, years and fruit types 8 species were found in the cherry orchard in Tokat Centre in both 2021 and 2022, 8 species in 2021 and 9 species in 2022 in the peach orchard. In Turhal district, 4 species were found in 2021 and 6 species in 2022 in the cherry orchard, 5 species in 2021 and 7 species in 2022 in the peach orchard. In Erbaa district, 5 species were found in the cherry orchard in both 2021 and 2022, and 6 species were found in the peach orchard in both 2021 and 2022. In Pazar district, 3 species were found in 2021 and 6 species were found in 2022 in the cherry orchard (Table 3).

Table 3. Drosophilidae species detected in cherry and peach orchards by districts in 2021-2022

Species	Year	Cherry				Peach		
		Centre	Turhal	Erbaa	Pazar	Central	Turhal	Erbaa
Drosophila hydei Sturtevant, 1921	2021	+	+	+	+	+	+	+
	2022	+	+	+	+	+	+	+
D. immigrans Sturtevant, 1921	2021	+	+	+	+	+	+	+
	2022	+	+	+	+	+	+	+
D. melanogaster Meigen, 1830	2021	+	-	-	-	+	-	+
	2022	+	+	-	-	+	+	+
D. phalerata Meigen, 1830	2021	+	-	-	-	+	-	-
	2022	+	+	+	+	+	-	-
D. simulans Sturtevant, 1919	2021	+	-	-	-	+	-	-
	2022	+	-	+	-	+	+	+
D. subobscura Collin, 1936	2021	+	+	+	+	+	+	+
	2022	-	+	+	+	+	+	+
D. suzukii (Matsumura, 1931)	2021	+	-	+	-	+	+	-
	2022	+	-	-	-	+	+	+
Gitona distigma Meigen, 1830	2021	-	+	+	-	-	+	+
	2022	+	+	-	-	+	+	-
Scaptomyza pallida (Zetterstedt, 1847)	2021	+	-	-	-	+	-	+
	2022	-	-	-	+	-	-	-
D. transversa Fallen, 1823	2021	-	-	-	-	-	-	-
	2022	+	-	-	+	+	-	-

Turhal district in 2021, *D. hydei* (76 adults in cherry and 49 adults in peach) was the most frequently detected species in both cherry and peach orchards, followed by *D. immigrans* (13 adults in cherry and 12 adults in peach). In the 3rd place was *D. subobscura* (5 adults in cherry, 5 in peach). It was observed that *D. hydei* had a high population in June in both cherry and peach orchards in 2021 (Table 4). In 2022, *D. immigrans* (327 adults) had the highest population in cherry fields, followed by *D. subobscura* (137 adults) and *D. hydeii* (15 adults). In the cherry orchard, *D. immigrans* and *D. subobscura* were caught in traps in very high numbers in late May and early June. In peach orchards, the highest number of specimens was obtained from *D. subobscura* (49 adults), followed by *D. hydeii* (27 adults) and *D. immigrans* (21 adults). The highest number of *D. subobscura* and *D. immigrans* were caught in the traps at the end of May, while *D. hydei* was caught in the traps in mid-July and early August (Table 5).

Table 4. Drosophilidae species caught in traps in cherry and peach orchards in Turhal district in 2021

Species	Orchard	24 May.	31 May.	07 Jun.	14 Jun.	21 Jun.	28 Jun.	05 Jul.	12 Jul.	19 Jul.	26 Jul.	02 Aug.	09 Aug.
Drosophila hydeii	Cherry	1	0	32	10	8	25	-	-	-	-	-	-
D.hydeii	Peach	0	2	10	13	7	0	1	0	0	11	5	0
D.immigrans	Cherry	4	0	6	2	0	1	-	-	-	-	-	-
D. immigrans	Peach	1	0	2	3	1	0	0	0	0	0	1	4
D.subobscura	Cherry	2	0	0	2	1	0	-	-	-	-	-	-
D. subobscura	Peach	0	0	0	1	0	1	0	0	0	2	1	0
D. suzukii	Cherry	0	0	0	0	0	0	-	-	-	-	-	-
D.suzukii	Peach	0	0	0	0	0	0	0	3	0	0	0	1
Gitona distigma	Cherry	1	0	0	0	0	0	-	-	-	-	-	-
G.distigma	Peach	0	0	0	0	1	0	0	0	0	0	1	2

Table 5. Drosophilidae species caught in traps in cherry and peach orchards in Turhal district in 2022

Species	Orchard	23 May.	30 May.	06 Jun.	13 Jun.	20 Jun.	27 Jun.	04 Jun.	11 Jun.	18 Jun.	25 Jun.	01 Aug.	08 Aug.	15Aug.	22Aug.	29Aug.
Drosophila hydeii	Cherry	0	2	4	3	2	1	3	-	-	-	-	-	-	-	-
D. hydeii	Peach	1	2	0	3	5	0	0	0	5	0	3	5	2	1	0
D. immigrans	Cherry	250	26	51	0	0	0	0	-	-	-	-	-	-	-	-
D. immigrans	Peach	5	1	3	0	1	0	0	0	3	2	3	1	0	2	0
D. melonogaster	Cherry	0	0	0	0	0	0	0	-	-	-	-	-	-	-	-
D. melonogaster	Peach	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
D. phalerata	Cherry	2	0	0	0	0	0	0	-	-	-	-	-	-	-	-
D. phalerata	Peach	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D. simulans	Cherry	0	0	0	0	0	0	0	-	-	-	-	-	-	-	-
D. simulans	Peach	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1
D. subobscura	Cherry	71	14	33	3	5	9	2	-	-	-	-	-	-	-	-
D. subobscura	Peach	18	5	1	1	1	0	0	0	3	0	4	0	9	7	0
D. suzukii	Cherry	0	0	0	0	0	0	0	-	-	-	-	-	-	-	-
D. suzukii	Peach	0	0	0	0	0	0	0	0	0	0	1	0	0	1	3
Gitona distigma	Cherry	0	0	0	0	2	1	1	-	-	-	-	-	-	-	-
G. distigma	Peach	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0

In Erbaa district, *D. subobscura* (11 adults) was the most frequently detected species in the traps in the cherry orchard in 2021, followed by *D. hydei* (9 adults). In 3rd place was *D. immigrans* (5 adults). *D. subobscura* was most abundant in the traps in mid-May, while *D. hydei* and *D. immigrans* were seen in early June. In the peach orchard, *D. hydei* and *Scamptomyza pallida* (9 adults) shared the first place, followed by *D. immigrans* (5 adults). *D. hydei* and *D. immigrans* were detected in high numbers in the traps in mid-May and *S. pallida* in early June (Table 6). In 2022, the population density in the cherry orchard was determined as *D. subobscura* (63 adults), *D. immigrans* (10 adults) and *D. hydei* (5 adults), respectively. When we look at the months of the year, it is understood that *D. subobscura* was most abundant in early June, *D. immigrans* in early May and *D. hydei* in mid-June. In the peach orchard, the order of density was *D. subobscura* (36 adults), *D. suzukii* (16 adults) and *D. immigrans* (3 adults) and the months of occurrence were determined as early June for *D. subobscura*, August for *D. suzukii* and late August for *D. immigrans* (Table 7).

Table 6. Drosophilidae species caught in traps in cherry and peach orchards in Erbaa district in 2021

Species	Orchard	17 May.	24 May.	31 May.	07 Jun.	14 Jun.	21 Jun.	28 Jun.	05 Jul.	12 Jul.	19 Jul.	26 Jul.	02Aug.	09 Aug.
Drosophila subobscura	Cherry	5	1	1	1	2	1	0	-	-	-	-	-	-
D. subobscura	Peach	1	0	0	1	0	1	0	0	0	0	0	0	0
Gitona distigma	Cherry	1	0	0	0	0	0	1	-	-	-	-	-	-
G. distigma	Peach	1	0	0	0	0	0	0	0	0	0	0	0	0
D. immigrans	Cherry	1	0	0	2	0	1	1	-	-	-	-	-	-
D. immigrans	Peach	4	0	1	0	0	0	0	0	0	0	0	0	0
D. hydeii	Cherry	0	0	2	4	2	0	1	-	-	-	-	-	-
D. hydeii	Peach	3	2	2	1	0	0	0	0	0	0	0	1	0
Scamptomyza pallida	Cherry	0	0	0	0	0	0	0	-	-	-	-	-	-
S. pallida	Peach	0	0	0	5	0	4	0	0	0	0	0	0	0
D. suzukii	Cherry	0	0	0	0	0	1	0	-	-	-	-	-	-
D. suzukii	Peach	0	0	0	0	0	0	0	0	0	0	0	0	0
D. melonogaster	Cherry	0	0	0	0	0	0	0	-	-	-	-	-	-
D. melonogaster	Peach	0	0	0	0	0	0	0	0	0	0	0	1	0

Table 7. Drosophilidae species caught in traps in cherry and peach orchards in Erbaa district in 2022

Species	Orchard	23 May.	30 May.	06 Jun.	13 Jun.	20 Jun.	27 Jun.	04 Jul.	11 Jul.	18 Jul.	25 Jul.	01Aug.	08Aug.	15 Aug.	22 Aug.	29 Aug.
D.subobscura	Cherry	9	0	19	7	23	5	0	-	-	-	-	-	-	-	-
D.subobscura	Peach	8	3	10	0	0	0	0	3	5	0	1	0	1	1	4
D.immigrans	Cherry	4	0	3	1	2	0	0	-	-	-	-	-	-	-	-
D.immigrans	Peach	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0
D.hydeii	Cherry	0	0	1	2	1	0	1	-	-	-	-	-	-	-	-
D.hydeii	Peach	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0
D.simulans	Cherry	0	0	1	0	0	0	0	-	-	-	-	-	-	-	-
D.simulans	Peach	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
D.phalerata	Cherry	0	0	1	0	0	0	0	-	-	-	-	-	-	-	-
D.phalerata	Peach	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D.suzukii	Cherry	0	0	0	0	0	0	0	-	-	-	-	-	-	-	-
D.suzukii	Peach	0	0	0	0	0	0	0	0	2	2	-	2	4	2	4
D.melonogaster	Cherry	0	0	0	0	0	0	0	-	-	-	-	-	-	-	-
D.melonogaster	Peach	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0

In Pazar district, the highest population density was observed in *D. immigrans* (49 adults) in the cherry orchard where traps were hung in 2021. This was followed by *D. hydei* (15 adults) and *D. subobscura* (8 adults). When it was analysed in terms of the time of peak densities, it was found that D. immigrans and *D. hydei* were detected during June and *D. subobscura* was detected at the end of June (Table 8). In 2022, *D. subobscura* (290 adults), *D. hydei* (29 adults) and *D. immigrans* (23 adults) constituted the first three ranks according to population density, and when their densities according to months were examined, it was determined that *D. subobscura* and *D. immigrans* were seen intensively in the traps in May-June and *D. hydei* in late May-early June (Table 9).

Table 8. Drosophilidae species caught in traps in cherry orchard in Pazar district in 2021

Species	Orchard	17 May.	24 May.	31 May.	07 Jun.	14 Jun.	21 Jun.	28 Jun.	05 Jul.
Drosophila immigrans	Cherry	8	0	0	17	3	12	9	0
D. subobscura	Cherry	1	0	1	0	0	0	6	0
D. hydeii	Cherry	0	0	1	1	4	4	5	0

Table 9. Drosophilidae species caught in traps in cherry orchard in Pazar district in 2022

Species	Orchard	23 May.	30 May.	06 Jun.	13 Jun.	20 Jun.	27 Jun.	04 Jul.
Drosophila immigrans	Cherry	6	5	3	5	1	3	0
D. subobscura	Cherry	65	32	32	63	66	28	4
D. hydeii	Cherry	3	9	11	4	1	0	1
D. phalerata	Cherry	0	3	3	0	3	4	0
D. transversa	Cherry	0	0	1	0	1	1	0
Scamptomyza pallida	Cherry	0	0	0	0	1	0	0

3.2. Determination of the first adult emergence time and population monitoring

The first adult of *Drosophila subobscura* in Tokat-Centre-Kemalpaşa village cherry orchard in 2021 was seen in the traps on 21.04.2021 (14.7°C, 61.4% RH), the number of insects caught reached the highest number with 120 individuals on 19.05.2021 (18.8°C, 60.8% RH) and the maximum number of insects caught by the end of June was 2 on a weekly basis (Figure 2a). In 2022, the first adult was detected in the traps on 09.05.2022 (14.6°C, 56.9% RH), reached the highest number with 263 individuals on 16.05.2022 (15.3°C, 58.3% RH) and the number of insects caught by the end of July did not exceed 5 (Figure 2b). The first adult emergence of *D. subobscura* in Tokat-Centre-Kömeç village peach orchard in 2021 was on 28.04.2021 (18.6°C, 54.3% RH), the number of insects caught in traps reached the highest level with 31 individuals on 19.05.2021 (18.8°C, 60.8% RH) and the number of adults caught in the following counting intervals did not exceed 2 (Figure 2c). In 2022, the first adult emergence was detected on 25.04.222 (18.3°C, 53% RH), reached the highest number with 68 individuals on 16.05.2022 (15.3°C, 58.3% RH) and the number of adults captured from the end of May did not exceed 6 (Figure 2d).

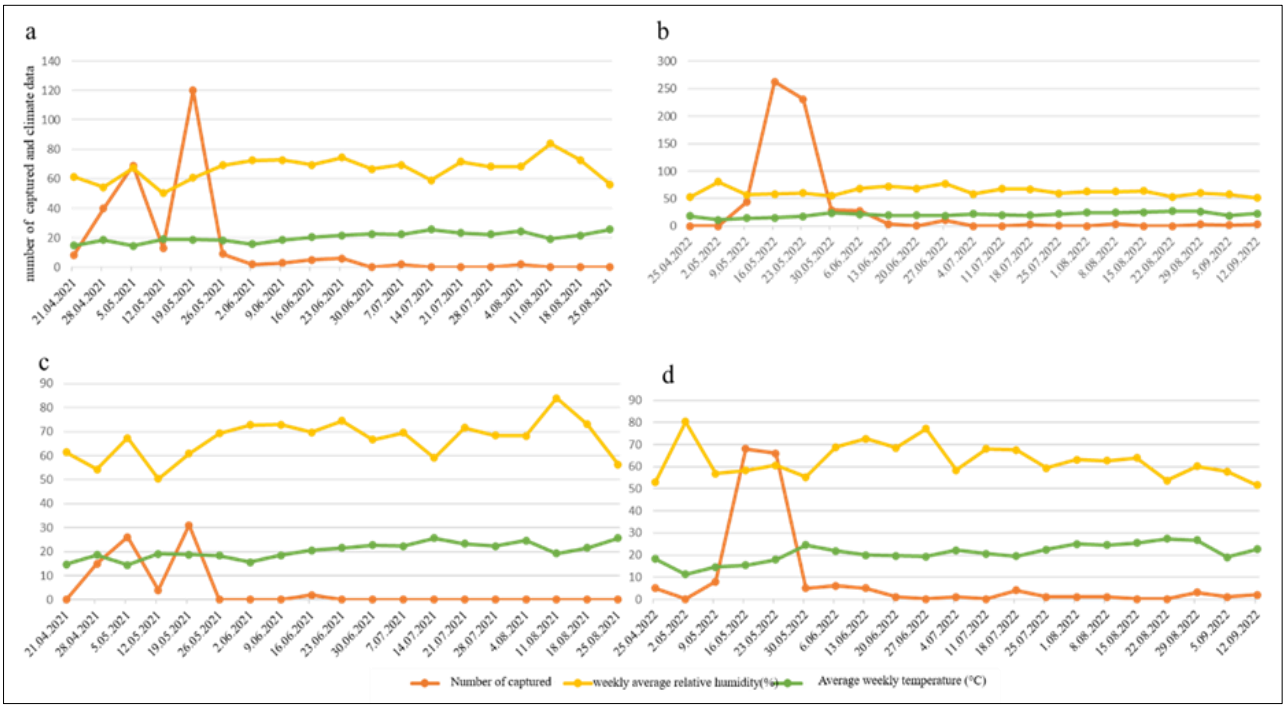

Figure 2. Population density of *Drosophila subobscura* in cherry and peach orchards in Tokat-Centre in 2021-2022 (a-2021 cherry, b-2022 cherry, c-2021 peach, d-2022 peach)

Drosophila immigrans appeared in the cherry orchard of Tokat-Centre-Kemalpaşa village in 2021 on 28.04.2021 (18.6°C, 54.3% RH) and in 2022 on 09.05.2022 (14.6°C, 56.9% RH) and the number of adults caught in traps during the vegetation did not exceed 4 individuals in both years (Figure 3a, b). The first adult of *D. immigrans* in the peach orchard of Tokat-Centre-Kömeç village in 2021 was detected on 28.04.2021 (18.6°C, 54.3% RH) and in 2022 on 13.06.2022 (20°C, 72.7% RH), and the number of adults caught in traps during the vegetation did not exceed 5 individuals in both years (Figure 3d, c).

The first adult of *Drosophila hydei* in Tokat-Centre-Kemalpaşa village cherry orchard in 2021 was detected on 28.04.2021 (18.6°C, 54.3% RH) and the highest population density was recorded on 19.05.2021 (18.8°C, 60.8% RH) with 16 individuals (Figure 4a). In 2022, the first adult was seen on 16.05.2022 (15.3°C, 58.3% RH) and the number of adults caught in other counts made in traps during the season in both years did not exceed 4 (Figure 4b). In the peach orchard of Tokat-Centre-Kömeç village, *D. hydei* was first seen in traps on 19.05.2021 (18.8°C, 60.8% RH) in 2021 and on 16.05.2022 (15.3°C, 58.3% RH) in 2022, and the number of adults caught in traps did not exceed 2 in both years during the vegetation (Figure 4c, d).

Figure 3. Population density of *Drosophila immigrans* in cherry and peach orchards in Tokat-Centre in 2021-2022 (a-2021 cherry, b-2022 cherry, c-2021 peach, d-2022 peach)

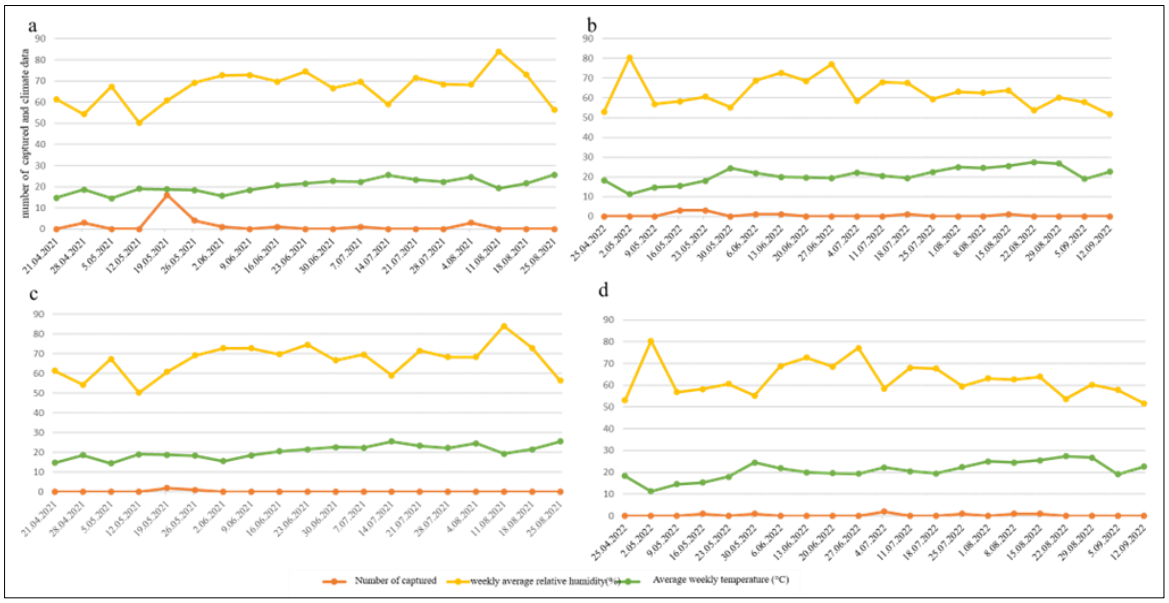

Figure 4. Population density of *Drosophila hydei* in cherry and peach orchards in Tokat-Centre in 2021-2022 (a-2021 cherry, b-2022 cherry, c-2021 peach, d-2022 peach)

Drosophila melanogaster was first detected in the cherry orchard of Tokat-Centre-Kemalpaşa village in 2021 on 28.04.2021 (18.6°C, 54.3% RH) and the highest number of adults in the traps was found on 19.05.2021 (18.81°C, 60.8% RH) with 9 individuals. Afterwards, the number of individuals caught was quite low and reached 7 at most (Figure 5a). In 2022, the first detection was made on 27.06.2022 (19.4°C, 77.1% RH), and the number of individuals caught did not exceed 3 (Figure 5b). *D. melanogaster* was first caught in traps on 05.05.2021 (14.5°C, 67.3% RH) in the peach orchard of Tokat-Centre-Kömeç village in 2021, and the number of adults caught weekly did not exceed 4 (Figure 5c). In 2022, the first detection was made on 15.08.2022 (25.5°C, 63.4% RH) and the highest population density was determined on 05.09.2022 (19°C, 57.8% RH) with 10 individuals. In the other 2 counting intervals, the number of insects in the traps did not exceed 7 (Figure 5d).

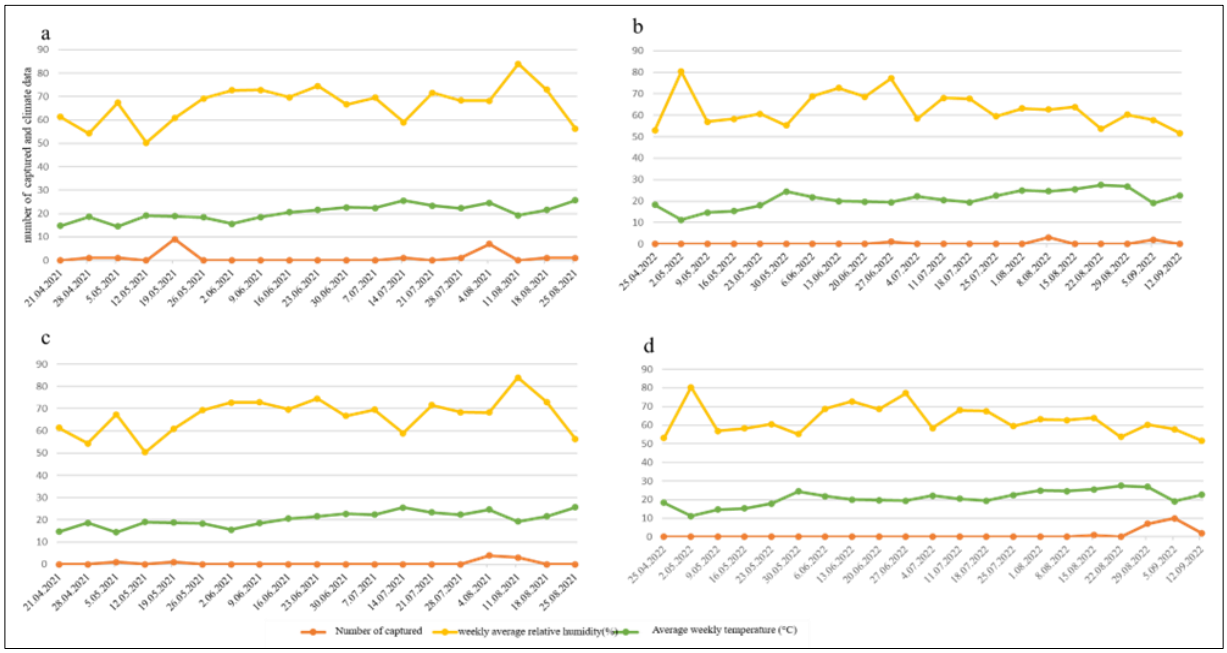

Figure 5. Population density of *Drosophila melonigaster* in cherry and peach orchards in Tokat-Centre in 2021-2022 (a-2021 cherry, b-2022 cherry, c-2021 peach, d-2022 peach)

Drosophila suzukii was detected only on 25.08.2021 (25.6°C, 56.3% RH) in the cherry orchard of Tokat-Centre-Kemalpaşa village in 2021 (Figure 6a). In 2022, it was first detected on 29.08.2022 (26.8°C, 60.2% RH) and the highest population density was determined on 05.09.2022 (19.04°C, 57.8% RH) with 16 individuals. In the next single counting interval, 1 individual was detected (Figure 6b). *D. suzukii* was not detected in the peach orchard of Tokat-Centre-Kömeç village in 2021. In 2022, the first adult was detected on 08.08.2022 (24.5°C, 62.6% RH) and the highest population density was observed on 12.09.2022 (22.6°C, 51.7% RH) with 6 individuals (Figure 6c).

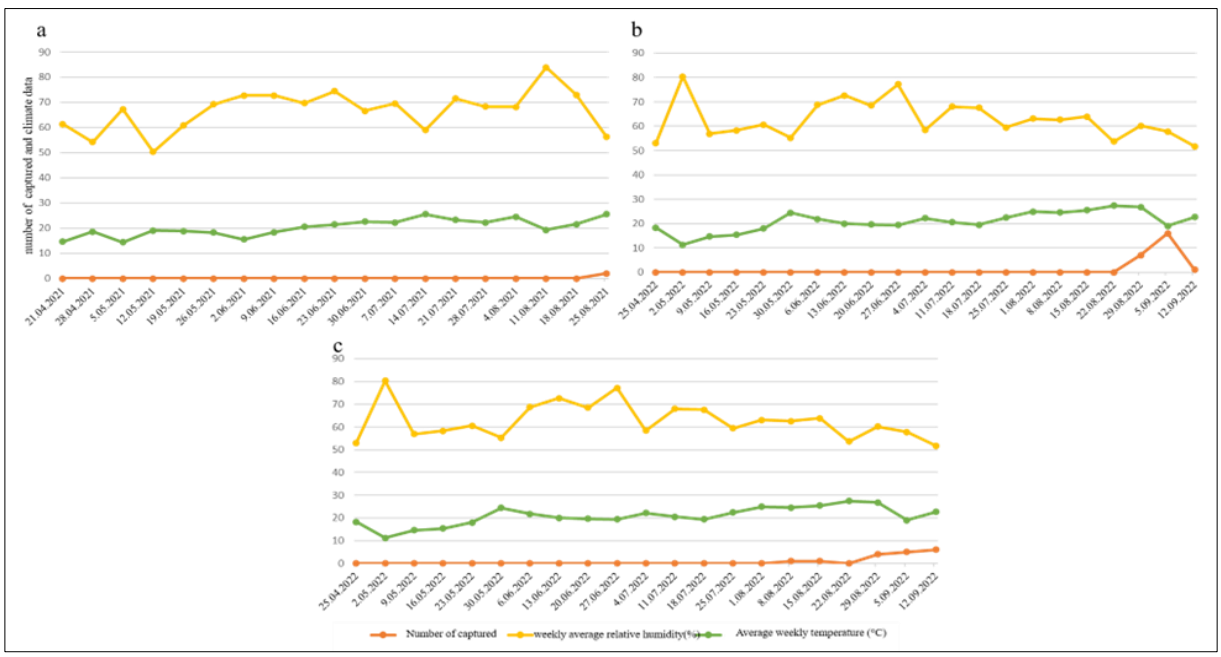

Figure 6. Population density of *Drosophila suzukii* in cherry and peach orchards in Tokat-Centre in 2021-2022 (a-2021 cherry, b-2022 cherry, c-2022 peach)

Drosophila simulans was not detected in the cherry orchard of Tokat-Centre-Kemalpaşa village in 2021. In 2022, the first adult detection was made on 23.05.2022 and the highest population was obtained on the same date (18°C, 60.6% RH) with 8 individuals. In other counting intervals, the number of adults in the traps did not exceed one. *D. simulans* was caught in the traps for the first time on 19.05.2021 (18.8°C, 60.8% RH) in 2021 and on 16.05.2022 (15.3°C, 58.3% RH) in 2022 in the peach orchard of Tokat-Centre-Kömeç village and the number of adults detected at other counting intervals did not exceed 1 in both years.

Drosophila phalerata was detected for the first time on 05.05.2021 (14.5°C, 67.3% RH) in the cherry orchard of Tokat-Centre-Kemalpaşa village in 2021, and at most 1 individual was seen at other counting intervals. In 2022, the first adult was detected on 16.05.2022 (15.3°C, 58.3% RH) and reached the highest number with 11 individuals caught on 23.05.2022 (18°C, 60.6% RH). No adults were detected at other counting intervals. In both 2021 and 2022, no adult of *D. phalerata* was detected in the peach orchard of Tokat-Centre-Kömeç village.

Drosophila transversa was not detected in the cherry orchard of Tokat-Centre-Kemalpaşa village and peach orchard of Tokat-Centre-Kömeç village in 2021. In 2022, it was detected for the first time in Tokat-Centre-Kemalpaşa village cherry orchard on 16.05.2022 (15.3°C, 58.3% RH) and in Tokat-Centre-Kömeç village peach orchard on 23.05.2022 (18°C, 60.6% RH). The number of detections in the traps did not exceed 1 at other time intervals.

Gitona distigma was not detected in the cherry orchard of Tokat-Centre-Kemalpaşa village and in the peach orchard of Tokat-Centre-Kömeç village in 2021. In 2022, only one was detected in the cherry orchard of Tokat-Centre-Kemalpaşa village on 16.05.2022 (15.3°C, 58.3% RH) and in the peach orchard of Tokat-Centre-Kömeç village on 25.07.2022 (22.4°C, 59.4% RH).

Scamptomyza pallida was detected as 1 specimen on 19.05.2021 (18.8°C, 60.8% RH) in the cherry orchard of Tokat-Centre-Kemalpaşa village in 2021 and was not seen in 2022. In both 2021 and 2022, it was not found in the traps in the peach orchard in Tokat-Centre-Kömeç village.

4. Discussion

In this study, the presence and prevalence of the species belonging to the family Drosophilidae in the cherry and peach fields of Tokat province were tried to be determined. In addition, population monitoring of the species belonging to the family was carried out for two years in one peach and cherry orchard determined in Tokat-Centre. As a result of the study, 10 species belonging to the family were identified in Tokat province. Considering the number of species obtained on the basis of districts, 10 species were identified in Tokat centre, 9 species in Erbaa, 8 species in Turhal and 6 species in Pazar.

It was observed that *D. subobscura*, *D. immigrans*, *D. hydei* and *D. melonogaster* were prominent in terms of prevalence and density, respectively. Özbek-Çatal et al. (2021), in their study conducted in the orchards of the Eastern Mediterranean Region, determined a total of 11 species belonging to the family and reported that *D. immigrans*, *D. melanogaster* and *D. subobscura* were common in the region. Similarly, Zengin (2020), detected a total of 13 species belonging to the family in the fruit fields of Uşak province and stated that *D. subobscura* was the most common species. In addition, Başpınar et al. (2022), detected totally 11 species of Drosophilidae in the orchards of Aydın province and reported that *D. subobscura* was the most abundant species, followed by *D. immigrans* and *D. melanogaster*.

Drosophila suzukii, one of the important species in the family, was found in cherry and peach fields in Tokat-Centre and Erbaa districts, and in peach fields in Turhal district. It was observed that the population of *D. suzukii* increased from the end of August to mid-September 2022 in the cherry and peach areas of Tokat Centre and from mid to late August 2022 in the peach areas of Erbaa district. Arıdıcı-Kara and Ulusoy (2020), detected D. suzukii in cherry and peach orchards in the Eastern Mediterranean Region and stated that the species caused significant damage especially in cherries. Öğür et al. (2018), reported that the pest was detected in cherry orchards in Karaman province. Kasap and Özdamar (2019), reported that D. suzukii was observed in Çanakkale vineyards in September-February every year and its population peaked in December. Again, Zengin and Karaca (2019), in their study conducted in Uşak province in 2017-2018, reported that D. suzukii density started to increase from the end of September in both years and started to decrease from the end of November.

Tokat province is an important agricultural city located in the transition zone of the Central Black Sea Region and has a variable climate due to its location in the transition zone. This variability has caused the variability of product pattern and varieties in the province and has brought Tokat to an important position in fruit production. The fact that the climatic conditions of the province are suitable for agricultural production has a positive effect on the diversity and intensity of the species that cause damage in these products. As a matter of fact, the number of species obtained as a result of this study carried out in Tokat-Centre and 3 districts with two different fruit species is not a small number compared to the studies covering larger areas and more fruit species in the literature. The study revealed that Drosophilidae family species are widespread in Tokat province. It is important to carry out similar studies in other cultivated plants which are intensively cultivated in the province, and which may be possible hosts of the species belonging to the family.

Compliance with Ethical Standards

Conflict of interest

The authors declare that they have no conflict of interest.

Authors' contributions

Hüseyin Bilal TAŞLIOĞLU: Methodology, Investigation, Field studies, Writing - original draft. **Turgut ATAY**: Methodology, Investigation, Writing - original draft.

Ethical approval

Not applicable.

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Data availability

Not applicable.

Consent for publication

Not applicable.

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