



Distribution and host plants of Drosophilidae (Diptera) species detected in fruit orchards of the Eastern Mediterranean Region of Turkey

Türkiye'nin Doğu Akdeniz Bölgesi'nde meyve bahçelerinde tespit edilen Drosophilidae (Diptera) türlerinin dağılımı ve konukçuları

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Ö Z E T / A B S T R A C T

Aims: Purpose of the study was to check the existence of the Drosophilidae species in fruit orchards of the Eastern Mediterranean Region, Turkey.

Methods and Results: Surveys were carried out in various fruit orchards of the Eastern Mediterranean Region (Adana, Hatay, Kahramanmaraş, Mersin, Osmaniye) of Turkey between 2016 and 2019. In total, 11 species belonging to 4 genera of the family Drosophilidae were identified as the result of the study and some of these are immensely invasive and threaten remarkably fruit cultures. In the results, *Drosophila immigrans* (Sturtevant), *D. melanogaster* (Meig.), *D. subobscura* (Collin), *D. suzukii* (Matsumura), *Zaprionus indianus* (Gupta) and *Z. tuberculatus* (Gupta) were found to be common.

Conclusions: Most drosophilids obtained in this study are thought to be widely dispersed natural populations in Turkey biomes and two Drosophilidae species recently recorded from Turkey.

Significance and Impact of the Study: This results emphasizes the importance of regional biodiversity studies with scientific collections.

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INTRODUCTION

The Drosophilidae is a large cosmopolitan family of alypbrate flies. Most of the species are saprophagous and feed on microorganisms in spoiled fruits, slime fluxes, fungi or other decaying organic matter. Some occur in flowing tree sap or in flowers. There are more than 4500 Drosophilidae species in the world (Bächli, 2020). The Palaearctic Region is an important area for studying the geographic distribution of drosophilid flies (Bächli and Rocha Pité, 1984). The Palaearctic fauna currently comprises 482 species of 27 genera (Brake and Bächli, 2008). The Drosophilid fauna of the Middle East, excluding Turkey, Israel and Lebanon (Máca, 1987; Bächli et al., 2002), is poorly known. The genus *Drosophila*

contains nearly half of the 4,000 species in the family Drosophilidae. This genus has adapted and dispersed in various niches (Markow and O'Grady, 2008), and presently separated into nine subgenera (O'Grady and DeSalle, 2018). The largest subgenus is *Drosophila* Fällén.

Turkey with its varied climatic and diverse physiographic conditions ensure large number of natural environment for colonisation by Drosophilidae. In Turkey, 36 species belonging to six genera of Drosophilidae have been reported (Koçak and Kemal, 2013). 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 (Orhan et al., 2016; Catal et al., 2019).

Purpose of the study was to check the existence of the Drosophilidae in fruit orchards of the Eastern Mediterranean Region, Turkey.

MATERIALS and METHODS

Surveys were carried out various fruit orchards in the Eastern Mediterranean Region (Adana, Hatay, Kahramanmaraş, Mersin, Osmaniye) of Turkey between 2016 and 2019 (Figure 1). The presence of a drosophilid species was determined at diverse locations. Traps baited with 50% apple cider vinegar and 8-10 holes no

larger than 3 mm were placed to fruit trees and also samples were taken from the apple cider vinegar traps hung by the producers in the orchards. In addition, infected fruits were collected and placed in the plastic boxes to obtain adult flies. All drosophilid specimens were placed in 70% ethanol for further identification. All samples were studied and deposited in the Nedim Uygun Biological Control Laboratory of Department of Plant Protection, Faculty of Agriculture, Cukurova University, Adana, Turkey. Identification of the species was made by us and confirmed by Dr. Amir YASSIN (CNRS researcher, Institut de Systématique, Evolution, Biodiversité / France).

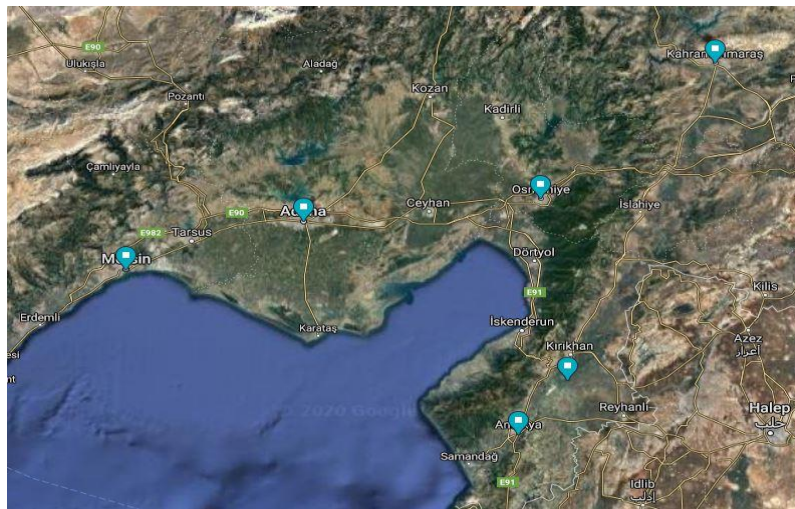


Figure 1. Locations sampled for Drosophilidae species (satellite image from Anonymous, 2020).

RESULTS and DISCUSSION

Turkey has varied climatic and diverse physiographic conditions and hence is very important for studying a large number of natural environments for colonisation by Drosophilidae. Drosophilids has drawn the attention of researchers for over five decades (Dobzhansky, 1965; Lewontin, 1965; David and Tsacas, 1981; Parsons, 1983), and it is well known that they can be used as models in works of biological invasions (Gibert et al., 2016). As a result of the study, in the material examined list, 11 species in 4 genera were identified. Two genera belong to the subfamily Drosophilinae (*Drosophila* Fallén, 1823 and *Zaprionus* Coquillett, 1901) and two belong to Steganinae (*Leucophenga* Mik, 1886 and *Gitona* Meigen, 1830). In the results, *Drosophila immigrans* (Sturtevant), *D. melanogaster* (Meig.), *D. subobscura* (Collin), *D. suzukii* (Matsumura), *Zaprionus indianus* (Gupta) and *Z. tuberculatus* (Gupta) were found to be common. Virtually all species recorded here are extensively dispersed not only in Turkey but also in other regions of

the world (Bächli, 2020).

The distribution and hosts of all the identified species are given in the examined material (Figure 2). The species were listed in alphabetical order.

Family: Drosophilidae

Subfamily: Drosophilinae

Genus: *Drosophila* Fallén, 1823

***Drosophila busckii* Coquillett, 1901**

Material examined: **Adana**, Pozantı, Alpu, *Prunus avium* L. (Rosaceae), 04.V.2018, 1♀, 1♂; Pozantı, Belededik, *P. avium*, 17.V.2019, 2♀♀; Pozantı, Hamidiye, *P. avium*, 13.VI.2018, 2♀♀, 1♂; Pozantı, Karakışlakçı, *Fragaria x ananassa* Duch. (Rosaceae), 09.V.2019, 1♀; Pozantı, Karakışlakçı, *P. armeniaca* L., 09.V.2019, 1♂; Pozantı, Belededik, *P. persica* (L.) Batsch, 28.XII.2019, 1♂; **Mersin**, *P. domestica* L., 28.VI.2018, 2♀♀, 1♂; Mersin, *P. persica*, 28.VI.2018, 1♂; Mersin, *Vitis vinifera* L. (Vitaceae), 13.VII.2018, 1♀; Çayır yurt, *P. persica*, 13.VII.2018, 1♀, 1♂; Kızıllağ, *P. persica*, 13.VII.2018, 1♀.

Host: *Aphelandra micans* Moritz ex Vatke (Acanthaceae), *Malus domestica* Borkh. (Rosaceae), *Musa* sp., *P. armeniaca*, *P. avium*, *Pyrus communis* L. (Rosaceae), *V. vinifera* (Watabe et al., 1993; Zengin and Karaca, 2019; Zengin, 2020).

Distribution: Caucasus, Cosmopolitan, China, European part, Far East., Russia: Siberia (Toda, 1986; Watabe et al. 1993; Ivannikov and Zakharov, 1994; Ivannikov et al., 1998).

Distribution in Turkey; Mersin, Şanlıurfa, Uşak (Koçak and Kemal, 2013; Zengin and Karaca, 2019).

***Drosophila hydei* Sturtevant, 1921**

Material examined: **Adana**, Yüreğir, Kadıköy mah., *Citrus sinensis* L. (Rutaceae), 30.V.2017, 2♀♀, 1♂; Yüreğir, Kadıköy mah., *C. reticulata* L., 30.V.2017, 1♀, 3♂♂; Yüreğir, Kadıköy mah., *C. paradisi* L., 30.V.2017, 1♀; Pozantı, Alpu, *P. avium*, 01.VI.2017, 1♀, 1♂; Karşıyaka, *P. persica*, 30.VI.2017, 2♂♂; Merkez, *Fragaria x ananassa*, 24.IV.2018, 1♀; Pozantı, Belededik, *P. avium*, 17.V.2019, 2♀♀, 1♂; Pozantı, Karakışlakçı, *P. avium*, 05.XII.2019, 2♂♂; Pozantı, Belededik, *P. persica*, 28.XII.2019, 2♀♀; **Mersin**, *P. persica* var. *nucipersica* (L.) C.K. Schneid., 15.VI.2018, 2♂♂; Mersin, *P. domestica*, 21.VI.2018, 2♀♀, 1♂; Mersin, *P. persica*, 21.VI.2018, 1♀, 2♂♂; Çayır yurt, *P. persica*, 13.VII.2018, 4♀♀, 2♂♂; Huzurkent, *P. domestica*, 13.VII.2018, 1♀, 3♂♂; Huzurkent, *V. vinifera*, 13.VII.2018, 3♀♀; Mersin, *P. cerasus*, 16.VII.2018, 2♀♀; Mersin, *V. vinifera*, 16.VII.2018, 1♂; Mersin, *Rubus fruticosus* L. (Rosaceae), 16.VII.2018, 2♀♀, 1♂.

Host: *Caltha arctica* R.Br. (Ranunculaceae), citrus garden, *Ficus carica* L. (Moraceae), *Musa* sp., *Puccinellia phryganoidea* (Trin.) Scribn. & Merr. (Poaceae) (Watabe et al., 1993; Ebejer, 2001; Gençer et al., 2005; Nartshuk, 2014).

Distribution: Caucasus, Cosmopolitan, European part, Far East., Russia, West Siberia (Ivannikov and Zakharov, 1994; Ivannikov et al., 1998; Nartshuk, 2014).

Distribution in Turkey. Bursa (Gençer et al., 2005).

***Drosophila immigrans* Sturtevant, 1921**

Material examined: **Adana**, Balcalı, *P. persica* var. *nucipersica*, 10.V.2017, 5♀♀, 4♂♂; Pozantı, Alpu, *P. avium*, 25.V.2017, 3♀♀, 1♂; Yüreğir, Kadıköy mah., *C. sinensis*, 30.V.2017, 4♀♀, 2♂♂; Yüreğir, Kadıköy mah., *C. paradisi*, 30.V.2017, 4♀♀, 5♂♂; Yüreğir, Kadıköy mah., *C. reticulata*, 30.V.2017, 5♀♀, 6♂♂; Tufanbeyli, Merkez, *P. avium*, 17.VII.2017, 4♀♀, 1♂; Merkez, *Fragaria x ananassa*, 24.IV.2018, 1♀, 4♂♂; Balcalı, *C. paradisi*,

30.IV.2018, 6♀♀, 8♂♂; Aladağ, *P. avium*, 07.VI.2018, 3♀♀, 2♂♂; Saimbeyli, *R. fruticosus*, 24.VII.2018, 1♀, 2♂♂; Pozantı, Belededik, *P. avium*, 28.V.2019, 2♀♀; Pozantı, Hamidiye, *P. avium*, 13.VI.2019, 2♀♀, 1♂; Pozantı, Belededik, *P. persica*, 28.XII.2019, 4♀♀, 2♂♂; **Kahramanmaraş**, Andırın, Çiğsar, *P. avium*, 19.VII.2018, 2♀♀, 1♂; **Mersin**, *P. persica* var. *nucipersica*, 15.VI.2018, 3♂♂; Kıpırlı, *P. domestica*, 13.VII.2018, 2♀♀, 3♂♂; Çayır yurt, *P. persica*, 13.VII.2018, 2♀♀, 2♂♂; Çayır yurt, *V. vinifera*, 13.VII.2018, 3♂♂; Kızıllağ, *P. persica*, 13.VII.2018, 1♀, 2♂♂; Huzurkent, *V. vinifera*, 13.VII.2018, 1♀, 1♂; Mersin, *P. cerasus*, 16.VII.2018, 2♀♀, 1♂; Mersin, *P. domestica*, 16.VII.2018, 4♀♀, 3♂♂; Mersin, *R. fruticosus*, 16.VII.2018, 5♀♀, 2♂♂.

Host: Citrus garden, *F. carica*, *Musa* sp., *P. communis*, *V. vinifera* (Watabe et al., 1993; Ebejer, 2001; Gençer et al., 2005; Zengin and Karaca, 2019).

Distribution: Azerbaijan, Caucasus, China, Cosmopolitan, European part, Far East., Georgia, Russia: West Siberia, East Siberia (Sturtevant, 1942; Watabe et al., 1993; Ivannikov and Zakharov, 1994; Ivannikov et al., 1998; Oboňa et al., 2019).

Distribution in Turkey. Bursa, Mersin, Trabzon, Uşak (Gençer et al., 2005; Koçak and Kemal, 2013; Zengin and Karaca, 2019).

Drosophila immigrans, a cosmopolitan species within the subgenus of *Drosophila* is abundant in the Nearctic and Palearctic Regions (David and Tsacas, 1981) and have been wide in our region. It has been observed that *D. immigrans* continues to be seen in nature at high altitudes with the cooling of the weather in our region. It has also been reported by researchers that the plenty of *D. immigrans* appears low in warmer regions, but increases in colder southern regions (Sene et al., 1980; Hochmüller et al., 2010).

***Drosophila melanogaster* Meigen, 1830**

Material examined: **Adana**, Balcalı, *Morus alba* L. (Moraceae), 17.VI.2016, 6♀♀, 7♂♂; Balcalı, *M. nigra* L., 17.VI.2016, 19♀♀, 13♂♂; Pozantı, Alpu, 20.VII.2016, *P. domestica*, 9♀♀, 11♂♂; Pozantı, Alpu, *M. nigra*, 20.VII.2016, 12♀♀, 8♂♂; Yüreğir, Kadıköy mah., *C. sinensis*, 30.V.2017, 4♀♀, 2♂♂; Yüreğir, Kadıköy mah., *C. paradisi*, 30.V.2017, 3♀♀; Yüreğir, Kadıköy mah., *C. reticulata*, 30.V.2017, 1♀, 6♂♂; Pozantı, Alpu, *P. avium*, 01.VI.2017, 8♀♀, 9♂♂; Tufanbeyli, Merkez, *P. avium*, 17.VII.2017, 4♀♀, 2♂♂; Merkez, *Fragaria x ananassa*, 24.IV.2018, 5♀♀, 16♂♂; Balcalı, *P. avium*, 04.V.2018, 13♀♀, 17♂♂; Balcalı, *Eriobotrya japonica* Lindl.

(Rosaceae), 20.V.2018, 4♀♀, 5♂♂; Balcalı, *C. paradisi*, 20.V.2018, 7♀♀, 6♂♂; Karaisalı, Etekli, *P. avium*, 01.VI.2018, 2♀♀, 1♂; Karaisalı, Başpınar, *M. alba*, 01.VI.2018, 3♀♀, 3♂♂; Aladağ, Değirmencik, *P. avium*, 07.VI.2018, 3♀♀, 2♂♂; Saimbeyli, Merkez, *P. avium*, 29.VI.2018, 7♀♀, 9♂♂; Saimbeyli, Merkez, *M. alba*, 29.VI.2018, 5♀♀, 3♂♂; Saimbeyli, Merkez, *P. domestica*, 29.VI.2018, 4♀♀, 1♂; Saimbeyli, Gürleşen, *P. avium*, 29.VI.2018, 2♀♀, 1♂; Saimbeyli, Obruk, *P. avium*, 29.VI.2018, 5♀♀; Saimbeyli, Merkez, *R. fruticosus*, 24.VII.2018, 3♀♀, 4♂♂; Saimbeyli, Kalesekisi, *M. alba*, 24.VII.2018, 5♀♀, 2♂♂; Saimbeyli, Kalesekisi, *P. avium*, 24.VII.2018, 8♀♀, 9♂♂; Ceyhan, Merkez, *Diospyros kaki* L. (Ebenaceae), 01.VIII.2018, 3♀♀, 1♂; Pozantı, Belemelik, *P. avium*, 17.V.2019, 4♀♀, 9♂♂; Pozantı, Aşçibekirli, *P. avium*, 26.VI.2019, 3♀♀; Pozantı, Hamidiye, *P. avium*, 09.VII.2019, 3♀♀, 2♂♂; Pozantı, Hamidiye, *M. domestica*, 09.VII.2019, 8♂♂; Pozantı, Karakışlakçı, *P. avium*, 17.VII.2019, 8♀♀, 11♂♂; Pozantı, Karakışlakçı, *M. domestica*, 17.VII.2019, 5♀♀, 6♂♂; Pozantı, Karakışlakçı, *Fragaria x ananassa*, 17.VII.2019, 11♀♀, 6♂♂; Pozantı, Aşçibekirli, *M. domestica*, 17.VII.2019, 3♀♀, 2♂♂; **Hatay**, Antakya, Merkez, *F. carica*, 22.VII.2018, 10♀♀, 12♂♂; Antakya, *P. persica*, 22.VII.2018, 5♀♀, 9♂♂; Defne, *F. carica*, 22.VII.2018, 5♀♀, 10♂♂; **Kahramanmaraş**, Geben, *P. cerasus*, 19.VII.2018, 4♀♀, 5♂♂; Andırın, Çiğsar, *P. avium*, 19.VII.2018, 6♀♀, 7♂♂; Andırın, Çökak, *P. avium*, 19.VII.2018, 3♀♀, 8♂♂; **Mersin**, Merkez, *P. persica* var. *nucipersica*, 15.VI.2018, 2♀♀, 6♂♂; Merkez, *P. domestica*, 21.VI.2018, 4♂♂; Merkez, *P. persica*, 28.VI.2018, 7♀♀, 9♂♂; Merkez, *R. fruticosus*, 16.VII.2018, 2♀♀, 5♂♂; Merkez, *P. cerasus*, 16.VII.2018, 3♀♀, 2♂♂; Kepirli, *P. domestica*, 13.VII.2018, 5♀♀, 4♂♂; Kepirli, *M. nigra*, 13.VII.2018, 7♀♀, 11♂♂; Değnek, *P. avium*, 13.VII.2018, 5♀♀, 3♂♂; Değnek, *M. nigra*, 13.VII.2018, 5♀♀, 7♂♂; Kızılbağ, *P. persica*, 13.VII.2018, 4♀♀, 2♂♂; Huzurkent, *V. vinifera*, 13.VII.2018, 1♀, 1♂; Değirmençay, *P. persica*, 13.VII.2018, 3♀♀, 4♂♂; Çayır yurt, *V. vinifera*, 13.VII.2018, 4♀♀; Çayır yurt, *P. communis*, 13.VII.2018, 1♀, 3♂♂; Çayır yurt, *P. persica*, 13.VII.2018, 1♀, 4♂♂; Gözne, 13.VII.2018, 2♂♂; **Osmaniye**, Merkez, *F. carica*, 01.VIII.2018, 7♀♀, 9♂♂; Merkez, *V. vinifera*, 01.VIII.2018, 3♀♀; Merkez, *R. fruticosus*, 01.VIII.2018, 5♀♀, 3♂♂.

Host: Citrus garden, *F. carica*, *Musa* sp., *Myrica rubra* (Lour.) Siebold and Zucc. (Myricaceae), *P. avium*, *P. communis*, *V. vinifera* (Watabe et al., 1993; Ebejer, 2001;

Gençer et al., 2005; Guo, 2007; Li et al., 2011; Zengin and Karaca, 2019).

Distribution: Cosmopolitan, China, Russia: West Siberia, European part, Caucasus, East Siberia, Far East (Sturtevant, 1942; Okada, 1954; Watabe et al., 1993; Ivannikov and Zakharov, 1994; Ivannikov et al., 1998).

Distribution in Turkey. Adana, Bursa, İstanbul, Mersin, Uşak (Gençer et al., 2005; Koçak and Kemal, 2013; Catal et al., 2018; Zengin and Karaca, 2019).

Drosophila melanogaster is one of the dominant species in the survey area. Since the survey area was very close to the residential area and agricultural area in the study carried out by Gleason et al. (2019), this species were found to be the dominant species in the traps. Also, *D. melanogaster* and *D. suzukii* 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). The African species *D. melanogaster* is one of the most studied drosophilid species (Capy and Gibert, 2004).

***Drosophila subobscura* Collin, 1936**

Material examined: **Adana**, Pozantı, Alpu, *P. avium*, 25.V.2017, 4♀♀, 2♂♂; Yüreğir, Kadıköy mah., *C. reticulata*, 30.V.2017, 5♀♀, 3♂♂; Tufanbeyli, Merkez, *P. avium*, 17.VII.2017, 1♀, 2♂♂; Merkez, *Fragaria x ananassa*, 24.IV.2018, 1♀, 4♂♂; Pozantı, Hamidiye, *P. avium*, 13.VI.2018, 2♀♀, 1♂; Saimbeyli, Merkez, *P. avium*, 29.VI.2018, 2♂♂; Saimbeyli, Obruk, *P. avium*, 29.VI.2018, 1♀, 1♂; Pozantı, Belemelik, *P. avium*, 02.I.2019, 5♀♀; Pozantı, Aşçibekirli, *M. domestica*, 05.XII.2019, 1♀; Pozantı, Karakışlakçı, *M. domestica*, 05.XII.2019, 1♂; Pozantı, Belemelik, *P. persica*, 28.XII.2019, 3♀♀, 2♂♂; **Kahramanmaraş**, Andırın, Çiğsar, *P. avium*, 19.VII.2018, 3♀♀, 1♂; **Mersin**, Kızılbağ, *P. persica* var. *nucipersica*, 15.VI.2018, 2♂♂; Değnek, *P. avium*, 13.VII.2018, 4♀♀, 3♂♂; Kızılbağ, *P. persica*, 13.VII.2018, 3♀♀, 2♂♂; Huzurkent, *P. communis*, 13.VII.2018, 1♀, 1♂.

Host: Citrus garden, *P. communis*, *V. vinifera* (Ebejer, 2001; Zengin and Karaca, 2019).

Distribution: Africa, Azores, Europe, Chile, China, Madeira (Bächli and Burla, 1985; Watabe et al., 1993). Distribution in Turkey. Adana, Antalya, Bolu, Mersin, Samsun, Trabzon, Uşak, Zonguldak (Koçak and Kemal, 2013; Catal et al., 2018; Zengin and Karaca, 2019).

Drosophila subobscura was observed in the traps since

from January to December and 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* winters without diapause (Goto et al., 1999), it is thought to be seen in the early seasons compared to other species.

***Drosophila suzukii* Matsumura, 1931**

Material examined: **Adana**, Balcalı, *M. alba*, 17.VI.2016, 2♀♀, 4♂♂; Balcalı, *M. nigra*, 17.VI.2016, 3♀♀, 4♂♂; Balcalı, *C. paradisi*, 17.VI.2016, 5♀♀, 9♂♂; Balcalı, *P. avium*, 04.V.2018, 6♀♀, 7♂♂; Ceyhan, *P. avium*, 14.V.2018, 3♀♀, 2♂♂; Balcalı, *E. japonica*, 20.V.2018, 4♂♂; Pozantı, Alpu, *P. avium*, 27.V.2018, 2♀♀, 5♂♂; Pozantı, Alpu, *Fragaria x ananassa*, 27.V.2018, 6♀♀, 5♂♂; Karaisalı, Merkez, *M. alba*, 01.VI.2018, 1♂; Karaisalı, Başpınar, *M. alba*, 01.VI.2018, 1♂; Aladağ, Merkez, *P. avium*, 07.VI.2018, 2♀♀; Aladağ, Değirmencik, *P. avium*, 07.VI.2018, 1♀, 1♂; Pozantı, Hamidiye, *P. avium*, 13.VI.2018, 4♀♀, 7♂♂; Saimbeyli, Merkez, *P. avium*, 29.VI.2018, 2♀♀; Saimbeyli, Obruk, *P. avium*, 29.VI.2018, 3♀♀; Saimbeyli, Gürleşen, *P. avium*, 29.VI.2018, 2♀♀, 1♂; Tufanbeyli, Merkez, *M. alba*, 29.VI.2018, 2♀♀; Tufanbeyli, Merkez, *P. avium*, 29.VI.2018, 3♀♀; Saimbeyli, Kalesekisi, *M. alba*, 24.VII.2018, 1♀, 1♂; Saimbeyli, Kalesekisi, *P. avium*, 24.VII.2018, 3♀♀, 1♂; Yüreğir, Kadıköy mah., *C. sinensis*, 07.VII.2018, 4♀♀, 2♂♂; Ceyhan, *D. kaki*, 01.VIII.2018, 2♀♀, 1♂; Pozantı, Belededik, *P. avium*, 22.V.2019, 3♀♀, 2♂♂; Pozantı, Karakışlakçı, *Fragaria x ananassa*, 17.VII.2019, 6♀♀, 5♂♂; Pozantı, Karakışlakçı, *P. armeniaca*, 17.VII.2019, 2♀♀, 3♂♂; Pozantı, Karakışlakçı, *P. avium*, 17.VII.2019, 2♀♀, 2♂♂; Pozantı, Aşçıbekirli, *M. domestica*, 17.VII.2019, 6♂♂; Pozantı, Belededik, *P. persica*, 07.VIII.2019, 3♀♀, 3♂♂; Pozantı, Karakışlakçı, *M. domestica*, 05.XI.2019, 62♀♀, 11♂♂; Pozantı, Aşçıbekirli, *P. avium*, 05.XII.2019, 11♀♀, 3♂♂; **Hatay**, Antakya, Merkez, *P. persica*, 22.VII.2018, 1♀; Defne, *F. carica*, 22.VII.2018, 3♀♀; Defne, *R. fruticosus*, 22.VII.2018, 2♀♀; **Kahramanmaraş**, Andırın, Çiğsar, *P. avium*, 19.VII.2018, 3♀♀, 1♂; Mersin, Çayiryurt, *P. persica* var. *nucipersica*, 13.VII.2018, 2♀♀, 1♂; Çayiryurt, *P. persica*, 13.VII.2018, 2♀♀; Çayiryurt, *V. vinifera*, 13.VII.2018, 1♀; Değnek, *M. alba*, 13.VII.2018, 1♂; Değnek, *P. cerasus*, 13.VII.2018, 1♀, 1♂; Kızılbag, *P. persica*, 13.VII.2018, 3♀♀, 2♂♂;

Huzurkent, *V. vinifera*, 13.VII.2018, 2♀♀; Kepirli, *P. domestica*, 13.VII.2018, 4♀♀; **Osmaniye**, Merkez, *R. fruticosus*, 01.VIII.2018, 3♀♀; Merkez, *F. carica*, 01.VIII.2018, 1♀.

Host: *Actinidia chinensis* Planch. (Actinidiaceae), *A. deliciosa* A. Chev., *Berberis aquifolium* Pursh. (Berberidaceae), *C. sinensis*, *Cornus* sp., *Cotoneaster lacteus* W.W. Sm. (Rosaceae), *D. kaki*, *Elaeagnus umbellata* Thunb. (Elaeagnaceae), *E. japonica*, *F. carica*, *Fragaria x ananassa*, *Lonicera caerulea* L. (Caprifoliaceae), *Lindera benzoin* L. (Lauraceae), *Malpighia emarginata* DC. (Malpighiaceae), *M. domestica*, *Morus* sp., *P. armeniaca*, *P. avium*, *P. domestica*, *P. laurocerasus* L. (Rosaceae), *P. lusitanica* L. (Rosaceae), *P. persica*, *Pyrus pyrifolia* (Burm.) Nak. (Rosaceae), *Rubus* spp., *R. spectabilis* Pursh (Rosaceae), *Sambucus nigra* L. (Adoxaceae), *Solanum dulcamara* L. (Solanaceae), *S. lycopersicum* L. (Solanaceae), *S. villosum* Mill. (Solanaceae), *Vaccinium corymbosum* L. (Ericaceae), *Vaccinium* sp., *V. vinifera*. (EPPO, 2020a).

Distribution: America, Africa, Asia, Azerbaijan, Europe, Georgia, Oceania (Parshad and Paika, 1964; Hauser, 2011; Paula et al., 2014; Oboňa et al., 2019; Quantar et al., 2020; EPPO, 2020b).

Distribution in Turkey. Adana, Erzurum, Mersin, Uşak (Orhan et al., 2016; Catal et al., 2018; Zengin, 2020).

Drosophila suzukii, known as the spotted wing drosophila, which presently deserves the cosmopolitan status. The European and Mediterranean Plant Protection Organization (EPPO) has listed *D. suzukii* on its A2 List. Likely originate of East Asia, this pest has spread to western regions: it was first detected in Hawaii in the early 1980s and following years in Europe and North America (Asplen et al., 2015). Unlike 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. In Turkey, this species was first detected on strawberry crops from eastern Turkey in 2014 (Orhan et al., 2016). In the present study, *D. suzukii* individuals were found at higher altitudes until December on commercial plantations. Zengin (2020) reported that average temperature of October and November with highest number of catch was 5 to 10 °C. The cherry trees, on which the traps were hung, were harvested in June, whereas the apple 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 until December.

***Drosophila phalerata* Meigen, 1830**

Material examined: **Adana**, Pozantı, Alpu, *P. avium*, 22.VI.2017, 1♀; Saimbeyli, Kalesekisi, *P. avium*, 24.VII.2018, 2♀♀, 1♂; **Mersin**, Çayıryurt, *P. persica*, 13.VII.2018, 1♂; Huzurkent, *V. vinifera*, 13.VII.2018, 1♀; Kızılbağ, *P. persica*, 13.VII.2018, 2♀♀, 1♂.

Host: *Ageratina adenophora* (Spreng.) King & H. Rob. (Asteraceae), *Castanea sativa* Mill. (Fagaceae), *Clethra arborea* Aiton (Clethraceae), *Eucalyptus globulus* Labill. (Myrtaceae), *Juglans regia* L. (Juglandaceae), *Laurus novocanariensis* Rivas Mart., Lousâ, Fern. Prieto, E. Díaz, J.C. Costa & C. Aguiar (Lauraceae), *M. domestica*, *Musa* sp., mushrooms, *Ocotea foetens* (Aiton) Baill. (Lauraceae), *Persea indica* (L.) Spreng. (Lauraceae), *Pinus pinaster* Aiton (Pinaceae), *P. armeniaca*, *P. avium*, *V. vinifera* (Watabe et al., 1993; Rego et al., 2014; Zengin, 2020).

Distribution: Africa, Azores, Caucasus, China, Europe, Iran, Lebanon, Morocco, Russia: East Siberia, West Siberia, Tunisia (Burla, 1951; Watabe et al., 1993; Ivannikov, 1995; Ivannikov et al., 1998).

Distribution in Turkey. Adana, Bursa, Mersin, Samsun, Trabzon, Uşak, Zonguldak (Koçak and Kemal, 2013; Catal et al., 2018; Zengin, 2020).

Genus: *Zaprionus* Coquillett, 1901

***Zaprionus indianus* Gupta, 1970**

Material examined: **Adana**, Merkez, *D. kaki*, 10.IX.2017, 7♀♀, 6♂♂; Saimbeyli, *M. nigra*, 24.VII.2018, 11♀♀, 9♂♂; Pozantı, Hamidiye, *P. avium*, 05.IX.2018, 2♀♀, 1♂; Pozantı, Belemelik, *P. avium*, 12.IX.2018, 6♀♀, 2♂♂; Pozantı, Alpu, *P. avium*, 23.IX.2018, 5♀♀, 4♂♂; Pozantı, Belemelik, *P. persica*, 17.X.2018, 3♀♀, 7♂♂; Pozantı, Aşçibekirli, *M. domestica*, 31.X.2018, 2♀♀; Pozantı, Karakışlakçı, *M. domestica*, 31.X.2018, 2♀♀; Pozantı, Karakışlakçı, *Fragaria x ananassa*, 14.XI.2018, 3♀♀, 1♂; **Hatay**, Defne, *R. fruticosus*, 22.VII.2018, 16♀♀, 8♂♂; Defne, *F. carica*, 22.VII.2018, 21♀♀, 22♂♂; Antakya, Merkez, *F. carica*, 27.VII.2018, 18♀♀, 15♂♂; **Mersin**, Değnek, *P. avium*, 13.VII.2018, 4♀♀, 3♂♂; Kızılbağ, *P. persica*, 13.VII.2018, 7♀♀, 5♂♂; **Osmaniye**, Merkez, *R. fruticosus*, 01.VIII.2018, 25♀♀, 21♂♂; Merkez, *P. domestica*, 01.VIII.2018, 19♀♀, 21♂♂.

Host: *Carica papaya* L. (Caricaceae), *Diospyros* sp., *F. carica*, *M. domestica*, *Mangifera indica* L. (Anacardiaceae), *Opuntia cordobensis* Speg (Cactaceae), *O. ficus indica* Miller (Cactaceae), *O. quimilo* K. Schum (Cactaceae), *P. avium*, *P. persica*, *Psidium guajava* L.

(Myrtaceae), *P. communis*, *Rubus idaeus* L. (Rosaceae), *Rubus* sp., *V. vinifera* (Lavagnino et al., 2008; Joshi et al., 2014).

Distribution: Africa, Argentina, Brazil, Central and North America, France, India, Saudi Arabia, South America, Spain, Uruguay (Vilela, 1999; De Toni et al., 2001; van der Linde et al., 2006; Carles-Tolrá, 2009; Kremmer et al., 2017).

Distribution in Turkey. Adana, Hatay, Mersin, Osmaniye (Catal et al., 2019).

Another invasive species, *Z. indianus*, detected in the present study and taken into the alert list by the European and Mediterranean Plant Protection Organization (EPPO) in 2016 (Balmes and Mouttet, 2019) is *Zaprionus tuberculatus* Malloch and *Z. indianus* (EPPO, 2016). Both species, in 2020, the Working Party on Phytosanitary Regulations agreed that it could be deleted, considering that sufficient alert has been given (EPPO, 2020c, d).

One of the most successful colonizing species of the genus *Zaprionus* is *Z. indianus* (Chassagnard and Tsacas, 1993), likely due to its broad niche features: it uses various food resources and shows tolerance to environmental conditions. The first record of *Z. indianus* in Turkey was in the Eastern Mediterranean region (Catal et al., 2019). In our study, we detected *Z. indianus* in apple, cherry, peach, blackberry, fig and plum orchards. In another study, it was reported that *Z. indianus* lays eggs on developing fruits such as figs, peaches and oranges (van der Linde et al., 2006).

***Zaprionus tuberculatus* Malloch, 1932**

Material examined: **Adana**, Balcalı, *M. alba*, 17.VI.2016, 10♀♀, 5♂♂; Balcalı, *M. nigra*, 17.VI.2016, 9♀♀, 3♂♂; Balcalı, *P. avium*, 04.V.2018, 3♀♀, 1♂; Pozantı, Hamidiye, *P. avium*, 05.IX.2018, 3♀♀, 1♂; Balcalı, *E. japonica*, 20.V.2018, 5♀♀, 2♂♂; Merkez, *Fragaria x ananassa*, 24.V.2018, 3♀♀; Saimbeyli, Merkez, *P. avium*, 29.VI.2018, 5♀♀, 4♂♂; Saimbeyli, Obruk, *P. avium*, 29.VI.2018, 6♀♀; Tufanbeyli, *P. avium*, 29.VI.2018, 5♀♀, 1♂; Saimbeyli, Merkez, *R. fruticosus*, 24.VII.2018, 3♀♀, 2♂♂; Saimbeyli, Kalesekisi, *M. alba*, 24.VII.2018, 2♀♀, 2♂♂; Saimbeyli, Kalesekisi, *P. avium*, 24.VII.2018, 5♀♀, 3♂♂; Pozantı, Belemelik, *P. avium*, 12.IX.2018, 20♀♀, 3♂♂; Pozantı, Alpu, *P. avium*, 23.IX.2018, 4♀♀, 5♂♂; Pozantı, Belemelik, *P. persica*, 24.X.2018, 5♀♀, 1♂; Pozantı, Aşçibekirli, *M. domestica*, 31.X.2018, 3♀♀; Pozantı, Karakışlakçı, *M. domestica*, 31.X.2018, 2♂♂; Pozantı, Karakışlakçı, *Fragaria x ananassa*, 14.XI.2018, 1♀, 1♂; Balcalı, *P. domestica*, 02.VII.2019, 11♀♀, 6♂♂;

Pozantı, Karakışlakçı, *P. avium*, 10.X.2019, 1♀; **Hatay**, Defne, *R. fruticosus*, 22.VII.2018, 6♀♀, 7♂♂; Defne, *F. carica*, 22.VII.2018, 10♀♀, 15♂♂; Defne, *P. domestica*, 22.VII.2018, 5♀♀, 4♂♂; **Kahramanmaraş**, Geben, *P. cerasus*, 19.VII.2018, 3♀♀, 1♂; Andırın, Çiğsar, *P. avium*, 19.VII.2018, 4♀♀; Andırın, Çokak, *P. avium*, 19.VII.2018, 4♀♀, 5♂♂; **Mersin**, Merkez, *P. persica* var. *nucipersica*, 15.VI.2018, 4♀♀, 2♂♂; Merkez, *P. domestica*, 21.VI.2018, 6♀♀, 2♂♂; Merkez, *P. persica*, 28.VI.2018, 8♀♀, 5♂♂; Kepirli, *P. domestica*, 13.VII.2018, 7♀♀, 4♂♂; Kepirli, *M. alba*, 13.VII.2018, 5♀♀; Değnek, *P. avium*, 13.VII.2018, 10♀♀, 5♂♂; Değnek, *P. cerasus*, 13.VII.2018, 8♀♀, 2♂♂; Huzurkent, *P. domestica*, 13.VII.2018, 7♀♀, 12♂♂; Huzurkent, *V. vinifera*, 13.VII.2018, 6♀♀, 5♂♂; Çayıryurt, *V. vinifera*, 13.VII.2018, 4♀♀; Çayıryurt, *P. communis*, 13.VII.2018, 1♀♀, 3♂♂; Çayıryurt, *P. persica*, 13.VII.2018, 4♀♀, 6♂♂; Kızılbağ, *P. persica*, 13.VII.2018, 5♂♂; Değirmençay, *P. persica*, 13.VII.2018, 1♀, 4♂♂; Gözne, *M. domestica*, 13.VII.2018, 3♀♀; Merkez, *R. fruticosus*, 16.VII.2018, 5♀♀; Merkez, *P. domestica*, 16.VII.2018, 3♀♀, 1♂; **Osmaniye**, Merkez, *V. vinifera*, 01.VIII.2018, 3♀♀, 5♂♂; Merkez, *F. carica*, 01.VIII.2018, 7♀♀, 9♂♂.

Host: *Artocarpus* sp. (Moraceae), citrus garden, *Dacryodes* sp. (Burseraceae), *Detarium senegalense* J.F.Gmel. (Fabaceae), *Ficus lutea* Vahl (Moraceae), *F. mucoso* Welw. ex Ficalho, *F. natalensis* Hochst., *F. saussureana* DC., *F. sur* Forssk., *Gambeya taiensis* Aubrév. & Pellegr. (Sapotaceae), *Guarea cedrata* (A. Chev.) Pellegrin (Meliaceae), *Hirtella* sp. (Chrysobalanaceae), *Opuntia* fruit, *Parinari excelsa* Sabine (Chrysobalanaceae), *Santiria trimera* (Oliv.) Aubrév. (Burseraceae), *Spondias mombin* L. (Anacardiaceae), *Tieghemella heckelii* (A.Chev) Pierre ex Dubard (Sapotaceae), *Uncaria* sp. (Rubiaceae) (Ebejer, 2001; EPPO, 2020c).

Distribution: Africa: Cameroon, Cape Verde, Central African Republic, Chad, Congo, Congo (Democratic republic), Cote d'Ivoire, Egypt, Gabon, Kenya, Madagascar, Malawi, Mauritius, Mayotte, Mozambique, Niger, Nigeria, Réunion, Saint Helena, Seychelles, South Africa, Tanzania, Uganda, Zambia, Zimbabwe, EPPO region: Azerbaijan, Cyprus, Egypt, Georgia, Greece (Crete), Israel, Italy, Malta, Spain (Islas Canarias only), Romania (Oboňa et al., 2019; EPPO, 2020c).

Distribution in Turkey. Adana, Uşak (Patlar et al., 2012; Zengin, 2020).

Zaprionus tuberculatus, 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). Patlar et al. (2012) and Zengin (2020) reported 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. This species has been seen in fruit and traps from May to November in our study. Constantina et al. (2015) detected this species in Romania for the first time in 2014 and they reported that *Z. tuberculatus* has been found in the traps from late September to late October. EPPO (2020c) reported that it is difficult to assess the pest potential of *Z. tuberculatus* against healthy fruit varieties because little is known about its biology and ecology. However, it has been said that, along with other primary pests (such as *D. suzukii* observed in Romania), these pests can contribute to enhancing the negative effects on fruit crops.

Subfamily: Steganinae

Genus: Leucophenga Mik, 1886

Leucophenga maculata Dufour, 1839

Material examined: **Adana**, Pozantı, Hamidiye, *P. avium*, 09.V.2019, 1♀, 2♂♂; Pozantı, Belemelik, *P. avium*, 17.V.2019, 3♀♀, 1♂; **Mersin**, *P. cerasus*, 16.VII.2018, 1♀, 1♂.

Host: *M. domestica*, *Musa* sp., mushrooms, *P. armeniaca*, *P. avium*, *V. vinifera*, (Watabe et al., 1993; Zengin, 2020).

Distribution: Azerbaijan, China, Europe, Georgia, Japan, Korea, Sri Lanka, Turkmenistan (Okada, 1956; Watabe et al., 1993; Gornostae, 1997; Oboňa et al., 2019).

Distribution in Turkey. Mersin, Samsun, Şırnak, Uşak (Koçak and Kemal, 2013; Zengin, 2020).

Genus: Gitona Meigen, 1830

Gitona distigma Meigen, 1830

Material examined: **Adana**, Pozantı, Belemelik, *P. avium*, 15.V.2019, 1♀; Pozantı, Alpu, *P. avium*, 11.VII.2019, 2♀♀.

Host: *P. communis*, *V. vinifera* (Zengin and Karaca, 2019).

Distribution: Caucasus, China, Europe, Kazakhstan, Mongolia, Russia: Siberia (Duda, 1934; Okada, 1973; Watabe et al., 1993; Ivannikov et al., 1998).

Distribution in Turkey. Hakkari, Şırnak, Uşak (Koçak and Kemal, 2013; Zengin and Karaca, 2019).



Figure 2. General view. *Drosophila busckii* (a), *Drosophila hydei* (b), *Drosophila immigrans* (c), *Drosophila melanogaster* (d), *Drosophila sukikii* female (e), and male (f), *Drosophila subobscura* (g), *Drosophila phalerata* (h), *Zaprionus indianus* (i), *Zaprionus tuberculatus* (j), *Leucophenga maculata* (k), *Gitona distigma* (l)

In conclusion, most of the drosophilids obtained in this study are thought to be widely dispersed natural populations in Turkey biomes, and two Drosophilidae species recently recorded Turkey: *D. sukikii*, first noted in 2014 (Orhan et al., 2016) and *Zaprionus indianus*, in 2019 (Catal et al., 2019). Although *Zaprionus* is a different genus, the genus *Drosophila* is paraphyletic

with *Zaprionus* (van der Linde et al., 2010). These species are particularly interest because, in contrast to most drosophilids, they are agricultural pests.

These results emphasizes the importance of scientific collections as a source of data on regional biodiversity. Most of the records are material collected with fruit and traps. It is possible that the list conferred here can be

developed not only by collecting in places that have not been sampled, but also by using other sources, such as decomposing material, fungi, flowers and other attractants.

ÖZET

Amaç: Bu çalışmanın amacı, Türkiye'nin Doğu Akdeniz Bölgesi'ndeki meyve bahçelerinde Drosophilidae familyası türlerinin varlığını belirlemektir.

Yöntem ve Bulgular: Sörveyler, 2016-2019 yılları arasında Türkiye'nin Doğu Akdeniz Bölgesi'nde (Adana, Hatay, Kahramanmaraş, Mersin, Osmaniye) çeşitli meyve bahçelerinde yürütülmüştür. Drosophilid türleri farklı meyvelerden toplanmış ve teşhis edilmiştir. Çalışma sonucunda, 4 cinse bağlı 11 tür tanımlanmış olup, bunların çoğu, oldukça istilacı ve özellikle meyve kültürlerini tehdit eden türlerdir. Sonuç olarak, *Drosophila immigrans* (Sturtevant), *D. melanogaster* (Meig.), *D. subobscura* (Collin), *D. suzukii* (Matsumura), *Zaprionus indianus* (Gupta) ve *Z. tuberculatus* (Gupta) türleri Doğu Akdeniz Bölgesi'nde yaygın olarak bulunmuştur.

Genel Yorum: Bu çalışmada elde edilen çoğu Drosophilid türünün, Türkiye biyomlarında yaygın olarak dağılmış doğal popülasyonlar olduğu düşünülmektedir ve bunların arasında Türkiye'de yakın zamanda kaydedilen iki *Drosophila* türü bulunmaktadır.

Çalışmanın Önemi ve Etkisi: Bu sonuçlarla bilimsel koleksiyonlar ile bölgesel biyoçeşitlilik çalışmalarının önemi vurgulanmaktadır.

Anahtar Kelimeler: Drosophilidae, *Drosophila*, *Zaprionus*, Türkiye.

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CONFLICT OF INTEREST

The authors declare no conflict of interest for this study.

AUTHOR'S CONTRIBUTIONS

The contribution of the authors is equal.

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