Turkish Journal of Zoology
http://journals.tubitak.gov.tr/zoology/
Short Communication

Turk J Zool
(2020) 44: 69-79
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doi:10.3906/zoo-1909-6

First contribution on distribution, abundance, and species richness of blowfly species (Diptera) of Isparta Province with five new records for the Turkish fauna*

Ozan DEMİRÖZER[1,], Gamze PEKBEY[2], Rüstem HAYAT[3], Azime HERDOĞAN[4], Jelena AČANSKI[5], Marija MILIČIĆ[5,6], Asiye UZUN[1]**

[1]Department of Plant Protection, Faculty of Agriculture, Isparta University of Applied Sciences, Isparta, Turkey
[2]Department of Plant Protection, Faculty of Agriculture, Bozok University, Yozgat, Turkey
[3]Department of Plant Protection, Faculty of Agriculture, Akdeniz University, Antalya, Turkey
[4]İnhisar District Directorate of Agriculture and Forestry, Bilecik, Turkey
[5]BioSense Institute, University of Novi Sad, Novi Sad, Serbia
[6]LIBRe – Laboratory for Integrative Biodiversity Research, Finnish Museum of Natural History, University of Helsinki, Helsinki, Finland

Received: 11.09.2019 • **Accepted/Published Online:** 16.12.2019 • **Final Version:** 03.01.2020

Abstract: Despite the increasing importance of species richness of blowfly fauna and their environmental, medical, and agricultural importance in the world they are poorly studied in Turkey. This study was carried out in 2014 and 2015 to determine the distribution, abundance, and species richness of blowfly species in Isparta Province of Turkey. A total of 15 species (10 from Calliphoridae, 4 from Polleniidae, and 1 from Rhiniidae) were identified from 13 different localities. The adult specimens were obtained from areas of organic and decayed organic matters, waste and dumpsite, surrounding waste water deposits, and flowering plants. While all the species were new for Isparta, *Bellardia tatrica* (Enderlein, 1933), *Calliphora subalpina* (Ringdahl, 1931), *Lucilia silvarium* (Meigen, 1826), *Melinda gentilis* (Robineau-Desvoidy, 1830) and *Pollenia griseotomentosa* (Jacentkovsky, 1944) were determined as new records for the Turkish fauna. According to the study results, the highest levels of blowfly species richness will be mainly focused in the eastern part of Isparta Province. *Chrysomya albiceps* and *Lucilia sericata* were determined as the most common species in the study.

Key words: Blowflies, fauna, Isparta, biodiversity, Turkey

The families Calliphoridae, Polleniidae, and Rhiniidae, commonly known as blowflies, are synanthropic and familiar calyptrate families of the order Diptera. Although many species are characterized by their bright metallic green or blue bodies, some others could be totally or somewhat dark or black in color (Jewiss-Gaines et al., 2012; Castro et al., 2016; Williams et al., 2016; Shirokov and Chaika, 2017).

The biology of the family is mainly based on omnivore larval habitats. Mainly, the species are oviparous and gravid females are attracted to decomposing organic materials to lay eggs. They exhibit diversity of feeding habits such as necrophagy, coprophagy, saprophagy, parasitism, and myiasis (Rognes, 1991). Within the necrophagous insect community calliphorids are among the first visitors and colonizers of carrion and they have a very significant role as both decomposers and forensic indicators of postmortem interval estimations (Rivers and Dahlem, 2014; Martín-Vega et al., 2017). Thus, the identification of blowflies is not important only for basic entomology, but also for other fields of science, especially medical, forensic, and veterinary entomology (Baumgartner and Greenberg, 1984; Anton et al., 2011; Prado e Castro et al., 2012; Šuláková and Barták, 2013; Sanford et al., 2014; Keshavarzi, 2016).

The blowflies are represented by more than 150 genera and nearly 1500 species worldwide (Velásquez et al., 2017). There are more than 250 species in the Palearctic region and nearly 115 species occur in Europe (Rognes, 1991; Castro et al., 2016).

Except for a few studies, which usually represent a part of some general taxonomic and faunistic papers or individual forensic entomology or myiasis cases, there is no comprehensive work on Turkish blowflies. Thus, the exact number of species and their current status is still unknown. According to the relevant literature, a

* This study was produced from the MSc thesis prepared by the fourth author.
** Correspondence: ozandemirozer@isparta.edu.tr

total of 11 species of Calliphoridae [*Bellardia vulgaris* (Robineau-Desvoidy, 1830); *Calliphora loewi* Enderlein, 1903; *Calliphora vicina* (Robineau-Desvoidy, 1830); *Calliphora vomitoria* (Linnaeus, 1758); *Chrysomya albiceps* (Wiedemann, 1819); *Lucilia ampullacea* Villeneuve, 1922; *Lucilia caesar* (Linnaeus, 1758); *Lucilia coeruleiviridis* Macquart, 1855; *Lucilia cuprina* (Wiedemann, 1830); *Lucilia illustris* Meigen, 1826; *Lucilia sericata* (Meigen, 1826)], 9 species of Polleniidae [*Pollenia amentaria* (Scopoli, 1763); *Pollenia angustigena* Wainwright, 1940; *Pollenia dasypoda* Portschinsky, 1881; *Pollenia labialis* Robineau-Desvoidy, 1863; *Pollenia paupera* (Rondani, 1862); *Pollenia pediculata* Macquart, 1834; *Pollenia rudis* (Fabricius, 1794); *Pollenia vagabunda* (Meigen, 1826); and *Pollenia viatica* (Robineau-Desvoidy, 1830)], and 5 species of Rhiniidae [*Rhinia apicalis* (Wiedemann, 1830); *Rhyncomya cyanescens* Loew, 1844; *Rhyncomya peusi* Zumpt, 1956; *Rhyncomya speciosa* (Loew, 1844); and *Stomorhina lunata* (Fabricius, 1805)] have been listed from Turkey (Rognes, 1991, 1997, 2002; Verves, 2003; Civelek and Tezcan, 2005; Şabanoğlu and Sert, 2010; Verves and Khrokalo, 2010; Çoban and Beyarslan, 2013; Szpila et al., 2013; Pekbey et al., 2016; Dawah et al., 2019). From these, the existence of *L. coeruleiviridis* in Turkey (Çoban and Beyarslan, 2013) is doubtful because of the Nearctic and Neotropical distribution of that species (Byrd and Castner, 2001; Whitworth, 2010).

This study aims to establish the occurrence of valid species and their distributions, abundance, and species richness on a small scale and contribute new records and data to the Turkish blowflies fauna.

The material of the study is composed of adult calliphorid species both previously stored in EMIT (Entomological Museum of Isparta, Turkey) and collected from research areas.

Adult specimens of blowflies were collected with insect sweep nets from 12 different localities (Aksu, Atabey, central district, Gönen, Eğirdir, Keçiborlu, Senirkent, Sütçüler, Şarkikaraağaç, Uluborlu, Yalvaç, and Yenişarbademli) of Isparta Province of Turkey from April to October in 2014 and 2015. Each locality was visited two times a year and areas with decayed organic matters, waste and dumpsites, waste water deposits, and flowering plants were particularly chosen for collecting. For each sampling site, latitude, longitude, and elevation data were obtained in the field using a Magellan eXplorist 110 handheld GPS receiver.

The species were identified using a Leica S8APO stereomicroscope and following the identifications of Rognes (1991, 2002), Akbarzadeh et al. (2015), and Whitworth (2010). The identification of *Rhyncomya cyanescens* and *Bellardia tatrica* were confirmed by Professor Knut Rognes (Norway).

For nomenclature and classification, Rognes (1991) was followed. After the identification process, all specimens were deposited in EMIT.

To address the diversity of blowflies in Isparta province, we calculated the following ecological indices: abundance, relative abundance, species (and genus) richness, and Shannon–Wiener (H') index.

Abundance (A) is the number of specimens collected from a particular species, while the relative abundance (RA) represents the percent composition of a particular species relative to the total number of species in the area. The RA of each species is expressed as RA (%) = Number of individuals per species × 100 / Total number of individuals. Species (and genus) richness was calculated as the number of species or genera within a grid of 15 × 15 km.

The Shannon–Wiener H' index of diversity accounts for both abundance and evenness of species. Increases in species richness and a more even abundance of individual species both contribute to a higher Shannon–Wiener index.

Observed genus and species richness and the Shannon–Wiener index were mapped in DIVA-GIS (v7.5) using a 15 – 15 km grid size. Distributional maps were created in GenGIS Version 2.4.1 (Parks et al., 2013).

In order to assess both current and future species richness patterns of blowfly species, we conducted the procedure of species distribution modeling.

In order to cope with sampling bias, prior to modeling, we applied a thinning procedure within R package red (Cardoso, 2018), where the algorithm used eliminates records found closer than a given distance to any other record. Species that had less than 5 different occurrence points after thinning were dropped from further analyses.

For describing climatic conditions of the area, 19 bioclimatic layers in 30 arcmin resolution available on the Worldclim web site were used (Hijmans et al., 2005). A list of all variables can be found at https://www.worldclim.org/bioclim. Selected climatic projection describing future climate of for the period 2061–2080 was applied with the HadGEM2-ES model with RCP 8.5 (Representative Concentration Pathway), which is a trajectory of greenhouse gases that predicts the continuous rise of emissions throughout the 21st century. Processing of the climatic layers was conducted using R packages raster and rgdal. To eliminate highly correlated variables, we conducted a two-step modeling procedure for each species separately: the first run was conducted with all variables, while in the second run we retained only stronger predictors with >10% contribution from the initial model.

The modeling procedure was conducted using the maxent function within the dismo R package (https://cran.r-project.org/web/packages/dismo/index.html). Maxent represents one of the most commonly used

algorithms for inferring species distributions based on presence-only data (Phillips and Dudik, 2008; Warren and Seifert, 2011). The dataset was split into training and test data and 1000 background points were selected due to the relatively small area, while other parameters were kept at the default. TSS (True Skill Statistic) was used as an evaluation measure in order to predict the predictive performance of the models. TSS values range from –1 to +1, where higher values indicate better performance (Allouche et al., 2006).

The obtained prediction maps for each individual species were overlaid and summed for each period separately, revealing the cumulative species richness patterns. By subtracting the overall present and future richness maps, we were able to determine changes in diversity per cell between two periods. All maps were created and processed using DIVA-GIS software.

Results of the study reveal that 15 species were found in the working area, which belonged to the families Calliphoridae (10), Polleniidae (4), and Rhiniidae (1). Information on the studied materials is given below in alphabetical order within each family.

Family: Calliphoridae

Subfamily: Calliphorinae

Genus: *Bellardia* Robineau-Desvoidy, 1863

***Bellardia tatrica* (Enderlein, 1933)**

Material examined: Gönen: Senirce Highway, 37°53′02″N, 30°30′28″E, 1170 m, 20.V.2015, 3♂♂ 6♀♀.

Distribution: Gaza Strip, Greece, Israel, Russia, Syria (Rognes, 2002).

Turkish records: New record for the Turkish insect fauna.

Genus: *Calliphora* Robineau-Desvoidy, 1830

***Calliphora subalpina* (Ringdahl, 1931)**

Material examined: Yenişarbademli: Pınargözü Cave park area, 37°41′50″N, 31°18′33″E, 1560 m, 30.VI.2015, 1♂.

Distribution: Austria, Belarus, Bulgaria, Czech Republic, Denmark, Finland, Germany, Hungary, Italy, Japan, Korea, Lithuania, Mongolia, Norway, Poland, Romania, Russia, Serbia, Siberia, Slovakia, Sweden, Switzerland, Trans-Caucasus, Ukraine, United Kingdom (Rognes, 1991; Verves and Khrokalo, 2010; Pohjoismäki and Kahanpää, 2014; Szpila, 2017).

Turkish records: New record for the Turkish insect fauna.

Calliphora vicina (Robineau-Desvoidy, 1830)

Material examined: Central province: 08.VI.2000, 1♀; 29.X.2000, 1♀; 05.XI.2000, 1♀; 10.XI.2000, 1♀; 30.IX.2001, 1♀; 01.X.2001, 3♀♀; 02.X.2001, 1♀; 06.X.2001, 1♀; 02.I.2002, 1♂; 03.VI.2002, 1♀; 12.VI.2004, 2♀♀; 10.VI.2007, 1♀; 28.VII.2007, 2♀♀; 20.IX.2008, 1♀; 28.IX.2008, 1♀; 04.VII.2009, 1♀; 11.X.2009, 1♀; 10.IX.2011, 1♀; Işıkkent district, 37°45′36.2″N, 30°31′55.8″E, 1126 m, 18.IV.2015, 1♀; SDU (Süleyman Demirel University), East Campus, 37°50′16.77″N, 30°32′17.61″E, 1017 m, 05.III.2015, 1♂; 12.V.2015, 1♀; 14.V.2015, 3♀♀; 22.V.2015, 1♀; Gönen: Gönen Pond, 37°57′55.1″N, 30°31′25.4″E, 1086 m, 01.IX.2015, 1♀; Keçiborlu: Airport Junction, 37°53′58.41″N, 30°19′50.38″E, 927 m, 20.V.2015, 1♀; Gülköy road, 37°53′53.4″N, 30°10′59″E, 1522 m, 22.VI.2015, 1♀; Uluborlu: Uluborlu Highway, 38°01′209″N, 30°19′58″E, 1304 m, 2.V.2015, 1♂ 1♀.

Distribution: Australia, Central and South America, Czech Republic, East and Holarctic regions, Finland, India, Iran, Kerguelen Islands, Pacific Islands, Pakistan, Poland, Portugal, South Africa, Ukraine (Rognes, 1991; Verves and Khrokalo, 2010; Bharti, 2011; Pohjoismäki and Kahanpää, 2014; Hassan et al., 2018).

Turkish records: Ankara (Şabanoğlu, 2007), Edirne (Çoban, 2009), Elazığ (Şaki and Özer, 1999), Samsun (Karapazaroğlu, 2010), and Şanlıurfa (Sevgili et al., 2004).

Calliphora vomitoria (Linnaeus, 1758)

Material examined: Central province: SDU East Campus, 37°50′16″N, 30°32′17″E, 1017 m, 12.V.2015, 1♂ 1♀.

Distribution: Afghanistan, Arabia, Australia, Canary Islands, China, Cuba, Czech Republic, Finland, Hawaiian Islands, India, Japan, Kazakhstan, Korea, Mongolia, Morocco, Nepal, New Zealand, Philippines, Poland, Portugal, Pakistan, Taiwan, Thailand, Trans-Caucasus, Tunisia, Ukraine (Rognes, 1991; Verves and Khrokalo, 2010; Bharti, 2011; Prado e Castro et al., 2012; Pohjoismäki and Kahanpää, 2014; Hassan et al., 2018).

Turkish records: Edirne (Çoban, 2009), Elazığ (Şaki and Özer, 1996), and Şanlıurfa (Sevgili et al., 2004).

Subfamily: Chrysomyinae

Genus: *Chrysomya* Robineau-Desvoidy, 1830

***Chrysomya albiceps* (Wiedemann, 1819)**

Material examined: Central province: Davraz Mountain, 37°46′57″N, 30°45′33″E, 1672 m, 27.VIII.2015, 4♂♂ 2♀♀; Gölcük Natural Park, 37°42′58.8″N, 30°29′42.65″E, 1445 m, 18.VII.2014, 1♂; Eğirdir: Isparta Highway, 37°52′20.73″N, 30°41′42.85″E, 986 m, 24.VII.2014, 1♀; Barla road, 38°1′10.96″N, 30°48′40.51″E, 944 m, 24.VII.2014, 3♂♂ 3♀♀; Kovada Lake park area, 37°37′47.27″N, 30°52′19.21″E, 910 m, 29.V.2014, 1♀; Gelendost: Gelendost Highway, 38°8′56.65″N, 31°3′55.95″E, 941 m, 22.VII.2014, 1♂ 1♀; Gönen: Gönen pond area, 37°57′55.1″N, 30°31′25.4″E, 1086 m, 01.IX.2015, 2♂♂ 1♀; Senirkent: Büyükkabaca Highway, 38°11′53.7″N, 30°43′20.8″E, 950 m, 01.IX.2015, 2♂♂ 2♀♀; Sütçüler: Çandır road, 37°29′41.89″N, 30°56′44.86″E, 347 m, 14.VII.2014, 1♂ 1♀; Yazılı Canyon, 37°28′52.49″N, 30°56′48.59″E, 427 m, 16.VII.2014, 1♂ 1♀; Şarkikaraağaç: Beyşehir Highway, 37°59′13.78″N, 31°28′52.08″E,

19.VIII.2014, 1226 m, 4♂♂ 2♀♀; Yalvaç: 38°13′29.0″N, 31°07′03.8″E, 1022 m, 01.IX.2015, 2♂♂.

Distribution: Argentina, Bermuda, Bolivia, Brazil, Colombia, Ecuador, Costa Rica, Guatemala, India, Iran, Mexico, Pakistan, Paraguay, Peru, Poland, Portugal, Puerto Rico, Ukraine, Venezuela (Parchami-Araghi et al., 2001; Szpila et al., 2008; Verves and Khrokalo, 2010; Bharti, 2011; Hassan et al., 2018).

Turkish records: Ankara (Şabanoğlu, 2007), Edirne (Çoban, 2009), Elazığ (Şaki and Özer, 1999), Samsun (Karapazaroğlu, 2010), and Şanlıurfa (Sevgili et al., 2004).

Subfamily: Lucilliinae

Genus: *Lucilia* Robineau- Desvoidy, 1830

***Lucilia caesar* (Linnaeus, 1758)**

Material examined: Central province: Kirazlıdere area, 37°47′20.2″N, 30°30′55″E, 1310 m, 08.IX.2015, 1♂; Yenişarbademli: Pınargözü Cave pathway, 37°42′20.2″N, 31°18′51″E, 1510 m, 25.VIII.2015, 1♂.

Distribution: Afghanistan, Algeria, Canary Islands, China, Czech Republic, Egypt, Finland, Germany, Iran, Israel, Japan, Kazakhstan, Korea, Morocco, Northern Europe, Mongolia, Portugal, Russia, Syria, Turkey, Ukraine (Rognes, 1991; Verves and Khrokalo, 2010; Pohjoismäki and Kahanpää, 2014).

Turkish records: This species has been reported from Turkey without locality information by Verves and Khrokalo (2010) and Akbarzadeh et al. (2015).

***Lucilia cuprina* (Wiedemann, 1830)**

Material examined: Central province: SDU East Campus, 37°50′16″N, 30°32′17″E, 1017 m, 15.X.2001, 1♀.

Distribution: Australia, Eastern Palearctic, Iberian Peninsula, India, New Zealand, Near East, Pakistan, Spain, South and North Africa, Sri Lanka, United States (Rognes, 1994; Heath and Bishop, 2006; Whitworth, 2006; Velásquez et al., 2010; Bharti, 2011; Hassan et al., 2018; Owings and Picard, 2018).

Turkish records: Edirne (Çoban, 2009). Akbarzadeh et al. (2015) without detailed localization.

***Lucilia sericata* (Meigen, 1826)**

Material examined: Central province: Gölcük Natural Park area, 37°43′25″N, 30°29′25″E, 1422 m, 18.VII.2014, 1♀; Dere area, 37°44′57″N, 30°31′47″E, 1187 m, 8.VI.2015, 2♂♂ 1♀; 16.V.2015, 1208 m, 1♂ 1♀; Doğancı area, 37°45′18″N, 30°32′50″E, 1129 m, 13.V.2015, 1♂; Işıkkent area, 37°45′28″N, 30°31′30″E, 1126 m, 18.IV.2015, 2♂♂, Vatan area, 37°45′167″N, 30°35′28″E, 1200 m, 22.IV.2015, 1♀; Kirazlıdere area, 37°44′34″N, 30°31′23″E, 1220 m, 29.VI.2015, 1♀; 37°44′20″N, 30°30′55″E, 1300 m, 11.VII.2015, 1♂; SDU East Campus, 37°50′16″N, 30°32′17″E, 1017 m, 08.VII.2014, 1♀; 15.VII.2014, 1♂; 07.V.2015, 1♂; 12.V.2015, 1♂; 14.V.2014, 3♂♂; 10.VI.2015, 1♂; 10.VIII.2015, 1♂ 1♀; Davraz Mountain, 37°46′54″N, 30°45′30″E, 1250 m, 12.VI.2004, 1♀; 1663 m, 03.IX.2014, 1♂; 37°46′54″N, 30°45′30″E, 1672 m, 27.VIII.2015, 5♀♀; Aksu: 37°48′01″N, 31°01′29″E, 1238 m, 28.IV.2015, 1♀; Vali Fountain, 37°42′52″N, 31°17′38″E, 1822 m, 30.VI.2015, 1♀; Eğirdir: Yeşilköy road, 37°58′38″N, 30°58′00″E, 928 m, 21.IV.2015, 1♂; Gelendost: Gelendost Highway, 38°46′54″N, 30°45′30″E, 941 m, 19.VII.2014, 1♀; Keçiborlu: 37°56′23″N, 30°18′44″E, 975 m, 02.V.2014, 1♀; Airport Junction, 37°53′58″N, 30°19′50″E, 945 m, 16.V.2014, 8♂♂ 2♀♀; Kaplanlı road, 37°55′51″N, 30°11′39″E, 1463 m, 19.VI.2014, 1♀; Gönen: Gönen pond, 37°57′55″N, 30°31′25″E, 1086 m, 01.IX.2015, 1♂; Senirce road, 37°54′08″N, 30°30′43″E, 950 m, 20.V.2015, 3♀♀; Sütçüler: Ayvalıpınar village, 37°40′38″N, 31°1′73″E, 1173 m, 10.VI.2014, 1♀; Şarkikaraağaç: Şarkikaraağaç Highway, 38°10′39″N, 31°15′18″E, 1226 m, 19.VIII.2014, 2♂♂ 2♀♀; 38°8′53″N, 31°17′29″E, 1132 m, 22.VII.2014, 2♂♂; Yalvaç: 38°16′20″N, 31°9′35″E, 1022 m, 01.IX.2015, 2♂1♀; Yenişarbademli: Melikler Plateau, 37°41′47″N, 31°17′38″E, 1635 m, 04.IX.2014, 1♀; Pınargözü Cave park area, 37°42’29″N, 31°17′45″E, 1747 m, 22.VII.2014, 2♂♂; 37°42′4.62″N, 31°17′43″E, 1725 m, 22.VII.2014, 1♂; Pınargözü Cave park area, 37°41′46″N, 31°18′31″E, 1542 m, 22.VII.2014, 1♀; 37°42′20″N, 31°18’51″E, 1510 m, 25.VII.2015, 5♂♂, 2♀♀.

Distribution: Australia, Austria, Azerbaijan, Belgium, Bulgaria, Brazil, Algeria, Canada, Chile, China, Colombia, Croatia, Czech Republic, Denmark, Egypt, France, Finland, Greece, Hungary, India, Iran, Ireland, Italy, Japan, Kenya, Macedonia, Namibia, Netherlands, New Zealand, Paraguay, Peru, Pakistan, Poland, Portugal, Romania, Russia, Serbia, Spain, Sweden, Switzerland, Turkey (city information is not available), Ukraine, United Kingdom, United States, Uruguay, Venezuela (French et al., 1995; Sherman, 2000; Bharti, 2011; Prado e Castro et al., 2012; Pohjoismäki and Kahanpää, 2014; Hassan et al., 2018).

Turkish records: Afyonkarahisar, Ankara, Elazığ, and Şanlıurfa (Şaki and Özer, 1999; Sevgili et al., 2004; Şabanoğlu, 2007; Yücel et al., 2008), Eskişehir (Aksoy, 2009), and Samsun (Karapazaroğlu, 2010).

***Lucilia silvarum* (Meigen, 1826)**

Material examined: Central province: Gölcük Natural Park area, 37°44′7″N, 30°29′48″E, 1400 m, 25.VI.2015, 1♀; Kirazlıdere area, 37°47′20″N, 30°30′55″E, 1310 m, 08.IX.2015, 1♂; SDU East Campus, 37°50′16″N, 30°32′17″E, 1017 m, 08.VII.2014, 1♀; Yalvaç: 38°13′29″N, 31°07′03″E, 1022 m, 01.IX.2015, 1♀.

Distribution: Canada, China, Czech Republic, Finland, Israel, Japan, Mongolia, Northern Europe, Russia, Trans-Caucasus, Ukraine, Unites States (Verves and Khrokalo, 2010; Pohjoismäki and Kahanpää, 2014; Akbarzadeh et al., 2015).

Turkish records: New record for the Turkish insect fauna.

Subfamily: Melanomyinae

Genus: *Melinda* Robineau-Desvoidy, 1830

***Melinda gentilis* (Robineau-Desvoidy, 1830)**

Material examined: Central province: Gölcük Natural Park area, 37°44′7″N, 30°29′48″E, 1400 m, 25.VI.2015, 3♀♀; SDU East Campus, 37°50′16.77″N, 30°32′17″E, 1017 m, 01.IV.2015, 2♀♀; 16.IV.2015, 2♀♀.

Distribution: Albania, Austria, Belgium, Czech Republic, Denmark, Eastern Europe, Eastern Palearctic, Finland, Germany, Hungary, Italy, Macedonia, Near East, Netherlands, North Africa, Pakistan, Poland, Romania, Slovakia, Spain, Sweden, Switzerland, United Kingdom (Rognes 1991; Pohjoismäki and Kahanpää, 2014).

Turkish records: New record for the Turkish insect fauna.

Family: Polleniidae

Genus: *Pollenia* Robineau- Desvoidy, 1830

***Pollenia amentaria* (Scopoli, 1763)**

Material examined: Central province: Davraz Mountain, 37°46′57″N, 30°45′33″E, 1670 m, 16.VI.2015, 1♀.

Distribution: Afghanistan, Europe, Finland, Iran, North Africa, Poland, Trans-Caucasus, Turkey (city information is not available), Ukraine (Rognes, 1991; Szpila and Draber-Mońko, 2008; Verves and Khrokalo, 2010; Parchami-Araghi et al., 2014; Pohjoismäki and Kahanpää, 2014).

Turkish records: This species has been reported without locality information by Verves and Khrokalo (2010) in Turkey.

***Pollenia griseotomentosa* (Jacentkovsky, 1944)**

Material examined: Aksu: Aksu-Yenişarbademli Highway, 37°44′47″N, 31°14′21.75″E, 1400 m, 10.VI.2014, 2♀♀.

Distribution: Andorra, Belarus, Canada, Czech Republic, Estonia, Finland, Georgia, Germany, Ireland, Italy, Lithuania, Netherlands, Norway, Poland, Russia, Slovakia, Spain, Switzerland, Ukraine, United Kingdom, United States (Rognes, 1991; Verves and Khrokalo, 2010; Jewiss-Gaines et al., 2012; Pohjoismäki and Kahanpää, 2014).

Turkish records: New record for the Turkish insect fauna.

***Pollenia pediculata* (Macquart, 1834)**

Material examined: Central province: Davraz Mountain, 37°46′54″N, 30°45′30″E, 27.VIII.2015, 1672 m, 1♂; SDU East Campus, 37°50′16″N, 30°32′17″E, 1017 m, 12.V.2015, 1♂ 2♀♀; Atabey: Atabey-Gönen Highway, 37°56′28″N, 30°34′44″E, 1000 m, 19.VI.2014, 1♂ 2♀♀; 37°54′20″N, 30°38′19″E, 996 m, 19.VI.2014, 1♂ 1♀; Gönen: Gönen pond area, 37°57′55″N, 30°31′25″E, 1086 m, 01.IX.2015, 1♂; Keçiborlu: Gülköy, 37°54′30″N, 30°10′33″E, 1452 m, 20.V.2015, 1♀.

Distribution: Andorra, Austria, Bosnia and Herzegovina, China, Croatia, Cyprus, Czech Republic, Denmark, Egypt, Finland, France, Germany, Greece, Hungary, India, Iran, Israel, Italy, Kazakhstan, Lebanon, Macedonia, Montenegro, Netherlands, New Zealand, North America, Norway, Pakistan, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Spain, Sweden, Switzerland, Syria, Turkey (city information is not available), Turkmenistan, Ukraine, United Kingdom, Yemen (Verves and Khrokalo, 2010; Pohjoismäki and Kahanpää, 2014; Hassan et al., 2018).

Turkish records: This species has been reported without locality information by Verves and Khrokalo (2010) in Turkey.

***Pollenia rudis* (Fabricius, 1794)**

Material examined: Central province: Davraz Mountain, 37°46′54″N, 30°45′34″E, 1735 m, 18.VII.2015, 1♀; SDU East Campus, 37°50′16″N, 30°32′17″E, 1017 m, 12.V.2015, 1♂; Aksu, 37°47′17″N, 30°59′6″E, 1190 m, 10.VI.2014, 1♂; Gönen: Senirce road, 37°54′08″N, 30°30′43″E, 950 m, 20.V.2015, 3♂♂ 1♀; Şarkikaraağaç, 37°45′22″N, 31°24′53″E, 1132 m, 22.VII.2014, 3♀♀.

Distribution: Afghanistan, Algeria, Arabia, Armenia, Azerbaijan, Canary Islands, China, Egypt, Europe, Finland, Gaza, Georgia, India, Iraq, Iran, Israel, Japan, Jordan, Kazakhstan, Korea, Kyrgyzstan, Lebanon, Mongolia, Morocco, Pakistan, Syria, Tajikistan, Tibet, Turkey (city information is not available), Turkmenistan, Uzbekistan (Verves and Khrokalo, 2010; Bharti, 2011; Pohjoismäki and Kahanpää, 2014; Hassan et al., 2018).

Turkish records: Eskişehir (Sert et al., 2014).

Family: Rhiniidae

Genus: ***Rhyncomya*** Robineau-Desvoidy, 1830

***Rhyncomya cyanescens* (Loew, 1844)**

Material examined: Central province: Davraz Mountain, 37°46′57.7″N, 30°45′33″E, 1672 m, 27.VIII.2015, 1♂; Gölcük Natural Park area, 37°42′58″N, 30°29′42″E, 1445 m, 18.VII.2014, 2♂♂; Gölcük Natural Park, 37°43′43″N, 30°29′09″E, 1414 m, 05.VIII.2015, 1♂ 2♀♀; Kirazlıdere area, 37°47′20″N, 30°30′55″E, 1310 m, 08.IX.2015, 3♀♀; Sütçüler: Çandır, 37°29′41″N, 30°56′44″E, 347 m, 16.VI.2014, 1♂; Yenişarbademli: Melikler Plateau, 37°41′47″N 31°17′38″E, 1635 m, 04.IX.2014, 1♀.

Distribution: Albania, Algeria, Azerbaijan, Bulgaria, Croatia, Cyprus, Greece, Iran, Macedonia, Morocco, Romania, Syria, Tajikistan, Ukraine (Parchami-Araghi et al., 2001; Rognes, 2002).

Turkish records: This species has been reported without locality information by Rognes (2002) in Turkey.

As a result of our study, totally 15 species were determined with 201 specimens from the following species: *Bellardia tatrica*, *Calliphora subalpina*, *C. vicina*,

C. vomitoria, *Chrysomya albiceps*, *Lucilia caesar*, *L. cuprina*, *L. sericata*, *L. silvarum*, *Melinda gentilis*, *Pollenia amentaria*, *P. griseomentosa*, *P. pediculata*, *P. rudis*, and *Rhyncomya cyanescens*.

The former subfamily Rhiniinae was raised to the family level (Castro et al., 2016). In that study, this family was represented by only *R. cyanescens*. Likewise, the subfamily Polleniinae was recently reconstituted as new dipteran family of Oestroidea and 4 species of it were identified in the results of the current study.

Five species were recorded for the first time for the Turkish insect fauna as well as for Isparta Province: *Bellardia tatrica*, *C. subalpina*, *L. silvarum*, *M. gentilis*, and *Pollenia griseotomentosa*.

The most common blowfly species in Isparta Province were *C. albiceps* and *L. sericata*, and they together with *R. cyanescens* inhabit the widest altitudinal range (Figures 1A and 1B). *Bellardia tatrica*, *C. subalpina*, *C. vomitoria*, *L. cuprina*, *P. amentaria*, and *P. griseomentosa* were found mostly above 1000 m a.s.l. (Figures 1A, 1C, and 1D).

The overall abundance of the species ranged from 1 individual per species to 71 individuals per species (Figure 2). As shown, *L. sericata* was the most abundant species in Isparta Province with 71 registered specimens, followed by *C. albiceps* and *C. vicina*. *C. subalpina*, *C. vomitoria*, *L. cuprina*, *L. caesar*, *P. amentaria*, and *P. griseomentosa* were the least abundant species (Figure 2).

The seasonal relative abundance of each species is represented in Figure 3. Common species like *C. vicina*, *L. sericata*, and *C. albiceps* were observed during the entire season, with a peak in summer and autumn. According to our observations, *C. subalpina*, *C. vomitoria*, *P. amentaria*, *P. griseomentosa*, and *B. tatrica* occur during May and June, while *L. silvarum* and *R. cyanescens* had continuous activity from June to September. Additionally, *L. caesar* and *L. cuprina* were recorded in autumn. Considering the altitudinal gradient of the study area, the highest species richness and abundance were found between 1000 and 1200 m a.s.l. (Figures 4A and 4B).

A detailed view of the observed specimens and species richness in Isparta Province is presented in Figure 5. The highest number of individuals was recorded in the western part of the province (Isparta central district) (Figure 5A), while the highest species richness was recorded in Isparta

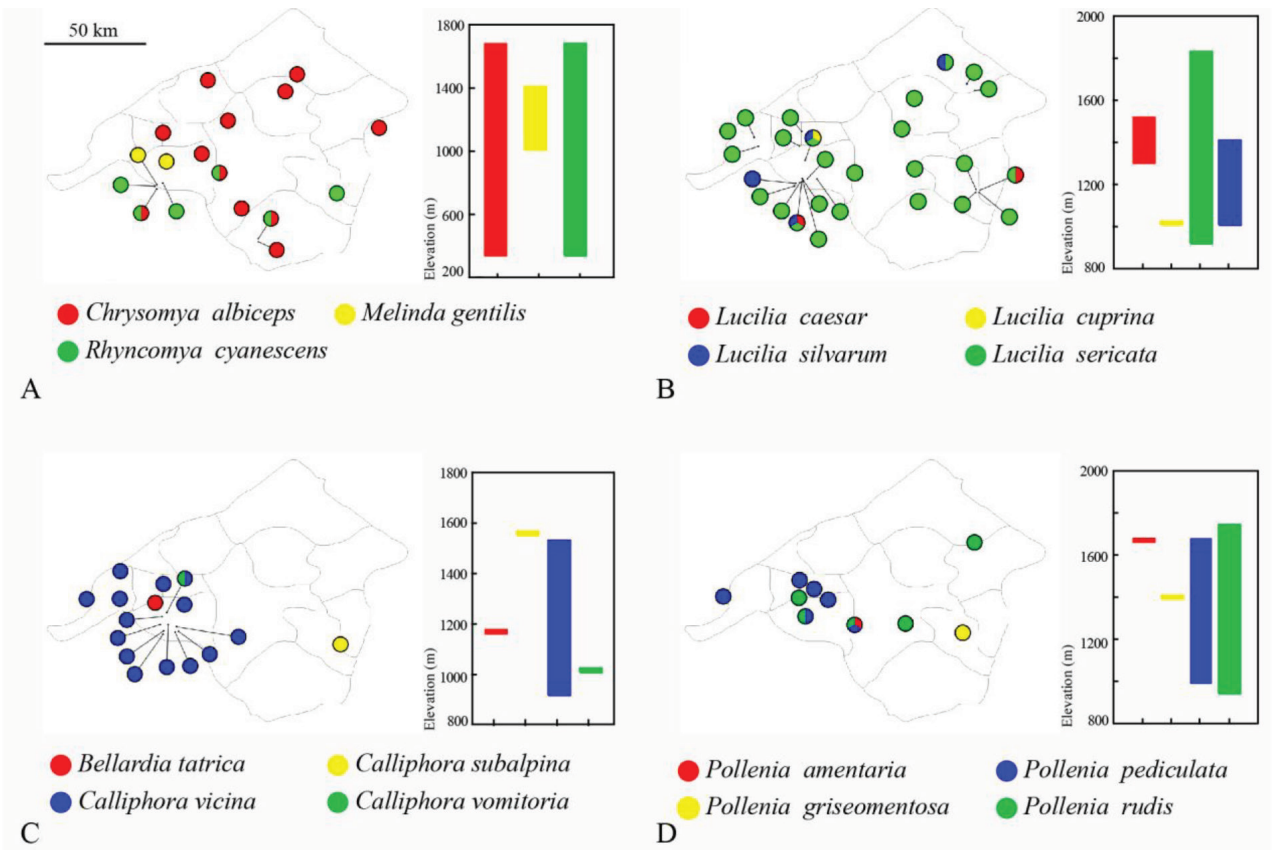

Figure 1. Map of Isparta Province showing distribution of species from family Calliphoridae with variability plot of species elevation gradient. A) *Chrysomia albiceps*, *Melinda gentilis*, *Rhyncomya cyanescens*; B) *Lucilia caesar*, *L. cuprina*, *L. silvarum*, *L. sericata*; C) *Bellardia tatrica*, *Calliphora subalpina*, *C. vicina*, *C. vomitoria*; D) *Pollenia amentaria*, *P. pediculata*, *P. griseomentosa*, *P. rudis*.

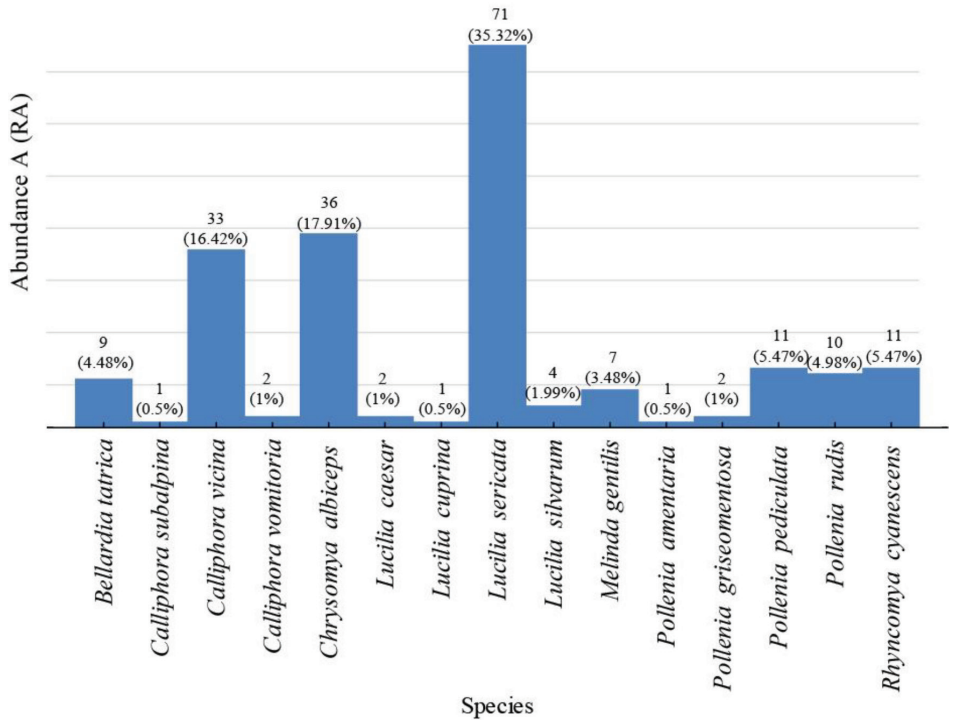

Figure 2. Observed abundance per species.

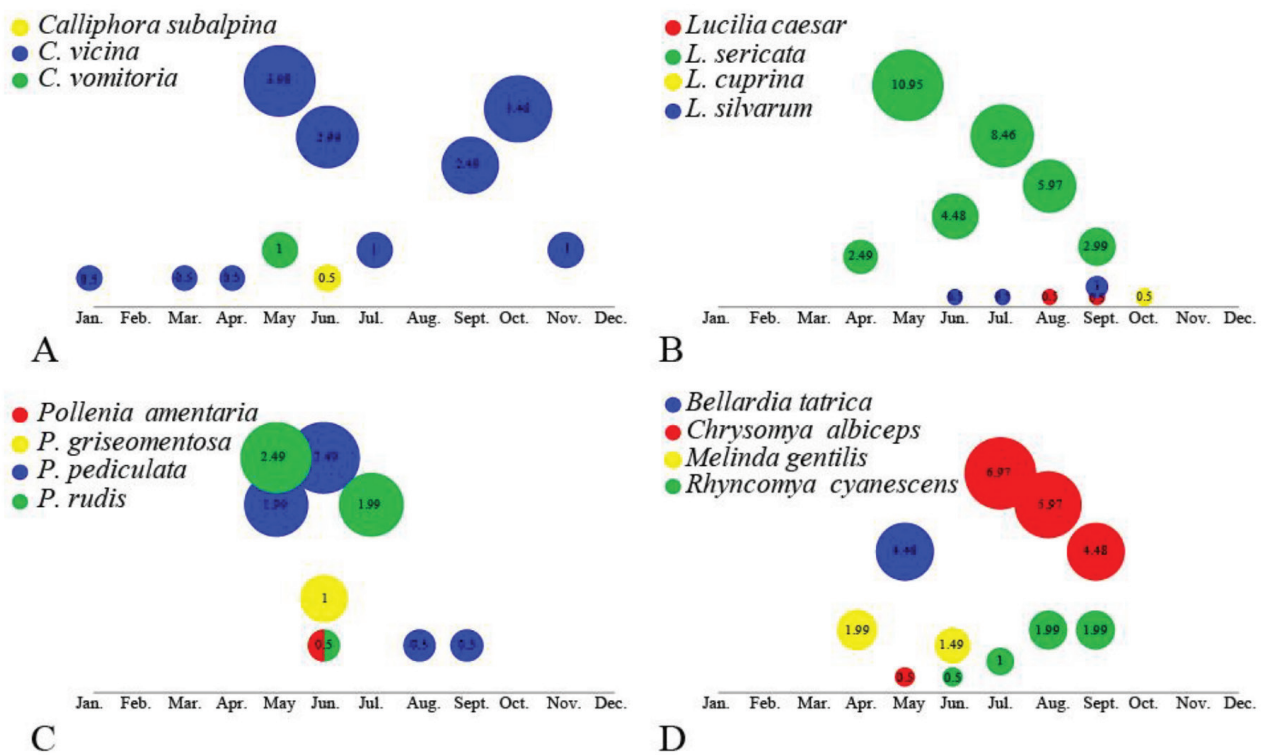

Figure 3. Relative abundance of different Calliphoridae species across the seasons (all years pooled). Point size is proportional to the total number of specimens contained in the respective sample. A) *Calliphora subalpina*, *C. vicina*, *C. vomitoria*; B) *Lucilia caesar*, *L. cuprina*, *L. silvarum*, *L. sericata*; C) *Pollenia amentaria*, *P. pediculata*, *P. griseomentosa*, *P. rudis*; D) *Bellardia tatrica*, *Chrysomia albiceps*, *Melinda gentilis*, *Rhyncomya cyanescens*.

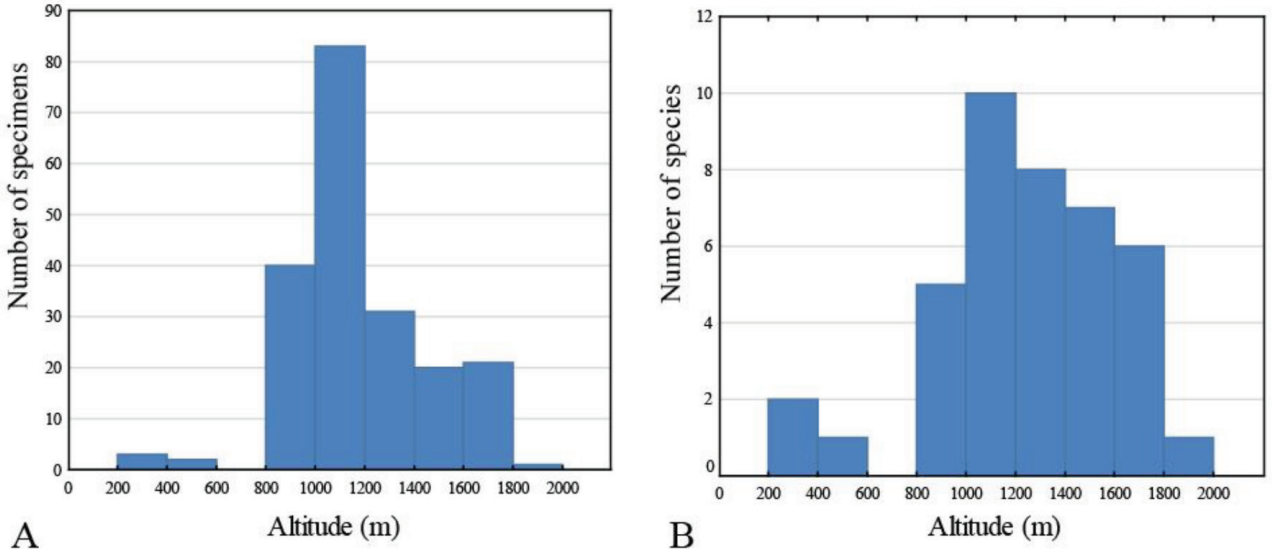

Figure 4. Altitudinal gradient of the study area. A) Number of specimens; B) number of species.

center, Gönen, Aksu, and Yenişarbademli (Figure 5B). The highest Shannon diversity index range (1.017–2) was recorded in the western part of Isparta Province, while an index range of 0.678 to 1.017 was recorded in Yalvaç, Eğirdir, Aksu, and Yenişarbademli (Figure 5C).

In total, the modeling procedure was conducted for six species. TSS values ranged from 0.4 and 0.8, representing a good fit of the models. The most important bioclimatic variable, contributing in three out of six models, was mean diurnal range (bio 2).

Our results show that the highest levels of blowfly species richness will be mainly focused in the eastern part of Isparta Province. At present, the most species-rich district is predicted to be the center district (Figure 6A), while for 2070, besides the center district, Gönen and Keçiborlu will also experience higher levels of species richness (Figure 6B). Out of 6 analyzed species, 3–5 are predicted to have suitable climatic conditions for their survival in these areas.

By comparing species richness patterns between the present and future, a potential increase in species richness is predicted for the southeastern part of the province, in southeast Eğirdir and on the western end of the Keçiborlu district, which are predicted to gain between 1 and 3 species (Figure 6C). Contrastingly, certain areas in the western part of Isparta (mainly in Yalvaç and the eastern part of Eğirdir) are predicted to lose species across time (Figure 6C).

In our study, the obtained species belong to the families Calliphoridae (Calliphorinae, Chrysomyinae, Lucilliinae, and Melanomyinae), Polleniidae, and Rhiniidae, as previously mentioned. Importantly, five species were recorded for the first time for the Turkish fauna, as well as for Isparta Province: *Bellardia tatrica*, *Calliphora subalpina*, *Lucilia silvarum*, *Melinda gentilis*, and *Pollenia griseotomentosa*.

Lucilia sericata, known as a cosmopolitan species, was the most common species with 71 out of 201 specimens in the present study. This species is also found in several other locations in Turkey: Afyonkarahisar, Ankara, Elazığ, Şanlıurfa (Şaki and Özer, 1999; Sevgili et al., 2004; Şabanoğlu, 2007; Yücel et al., 2008), and Eskişehir (Aksoy, 2009). The second most common species, *C. albiceps*, was collected between 347 and 1672 m a.s.l. in the study areas. The species was reported from different locations from Turkey, such as Ankara (Şabanoğlu, 2007), Edirne (Çoban, 2009), Elazığ (Şaki and Özer, 1999), and Şanlıurfa (Sevgili et al., 2004). In previous studies, *Calliphora vicina* was found in the provinces of Ankara (Şabanoğlu, 2007), Edirne (Çoban, 2009), Elazığ (Şaki and Özer, 1999), and Şanlıurfa (Sevgili et al., 2004). Here, this common species was collected between 927 and 1522 m a.s.l, mostly in the center district of Isparta. *Lucilia sericata*, *C. albiceps*, and *C. vicina* were observed during the entire season, with a peak in summer and autumn.

The species *C. subalpina*, *C. vomitoria*, *L. cuprina*, *P. amentaria*, and *P. griseotomentosa* were considered as rare species due to the fact that there was only one specimen per species in separate locations. These species, except *L. cuprina*, were found above 1000 m a.s.l. in early summer (May and June). *Lucilia cuprina* and *L. caesar* were recorded as autumn species.

In this study, 13 of 15 species were recorded from Isparta's central district. Based on field observations, we thought that human activities such as livestock and the presence of open dumpsites could have an effect on the

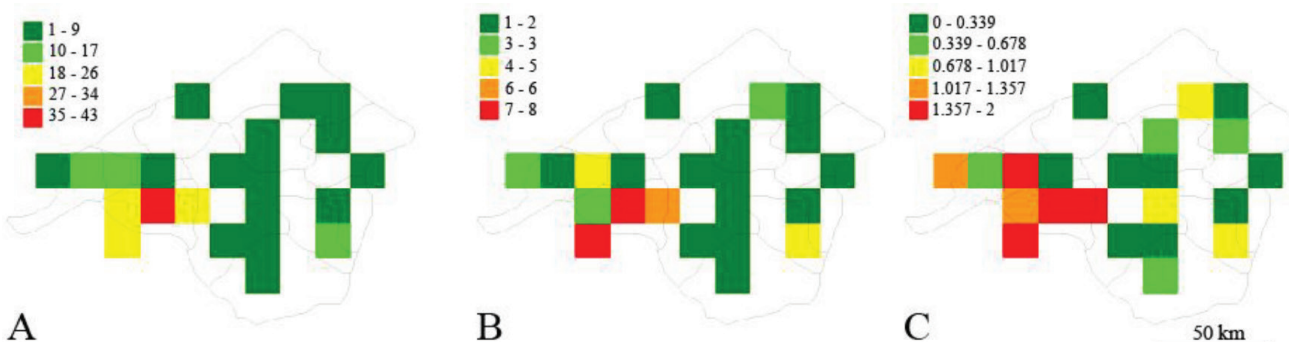

Figure 5. Map of Isparta Province showing different types of richness on a 15 × 15 km grid. A) Number of observations; B) species richness; C) Shannon–Wiener (H') index.

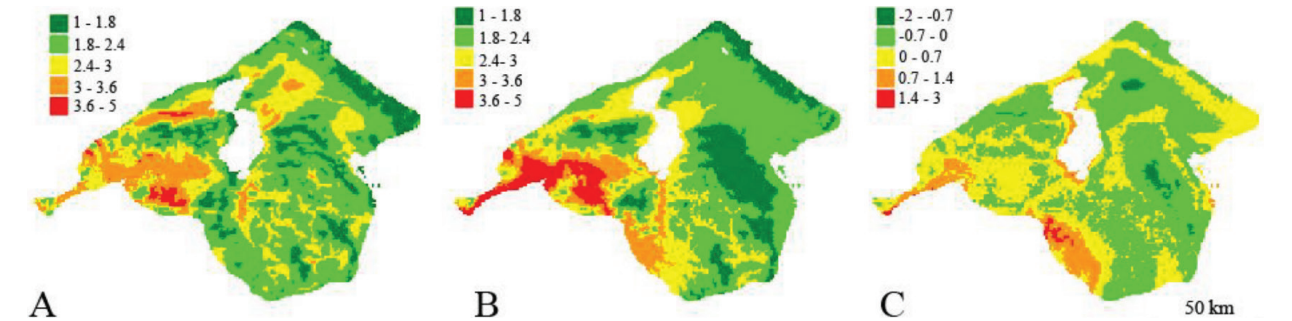

Figure 6. Projected potential species richness of blowflies in Isparta Province for A) present and B) future, with C) difference between 2070 and present. Each cell represents the total number of species in defined grid cells.

abundant species numbers in the central district of the province.

Along altitudinal gradients, both species richness and abundance were high between 800 and 1800 m a.s.l., with a peak between 1000 and 1200 m a.s.l. Considering the richness across Isparta Province, the highest abundance and species richness were seen in the western part of the province. The highest species richness was recorded in the central district with 7 to 8 species in a 15 × 15 km grid. This district together with Gönen had the highest values of the Shannon diversity index. Other districts, such as Yalvaç, Eğirdir, Aksu, and Yenişarbademli, had moderate species diversity.

Based on our results, it seems that the analyzed blowfly species will not be severely affected by climate change in the future. While some areas in western Isparta will lose a part of the species in the future, more areas are predicted to have stable species richness patterns, or even to increase the number of species. This is probably due to the fact that the development of these species is not directly conditioned with factors affected by rising temperatures. Larvae of these species are mainly scavengers, meaning that food sources do not represent a limiting factor for their development. The sensitivity of these species to climate change may come from the connection of adult flies with the plants that they use as food sources, as well as the effect of the temperature on the rate at which they grow and develop (Verves, 2003).

Until now, without any particular checklist, a total of 26 species (including *L. coeruleiviridis* and Rhiniidae) have been listed from Turkey (Rognes, 1991, 2002; Verves, 2003; Civelek and Tezcan, 2005; Şabanoğlu and Sert, 2010; Verves and Khrokalo, 2010; Çoban and Beyarslan, 2013; Szpila et al., 2013; Akbarzadeh et al., 2015). With our study's results, the number of species has risen to 31 in Turkey.

Acknowledgments and disclaimers

The authors thank Prof. Dr. Knut Rognes (University of Stavanger, Norway), Prof. Dr. Terry Whitworth (Washington State University, USA), and Olga Sivell (University College London) for kind help in the identification of some species and reference support for the study. This study was a part of Ms thesis entitled "First contribution on distribution, abundance, and species richness of blowfly species (Diptera) of Isparta province with five new records for the Turkish fauna.

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