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Contribution to mosquito (Diptera: Culicidae) fauna of Sakarya province and the first record of the invasive vector *Aedes albopictus* (Skuse, 1894) for Kocaeli province

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Abstract

Mosquitoes are temporary external parasites that suck blood and which can be disease carriers for humans and many animals in nature. In this study, the material obtained as a result of field studies carried out in Adapazarı and Söğütlü districts of Sakarya province and İzmit district of Kocaeli province between February 2018 and August 2018 were evaluated. 9 mosquito species were identified from Sakarya province. Five of these species [Anopheles plumbeus Stephens, 1828, Aedes geniculatus (Olivier, 1791), Ae. rusticus (Rossi, 1790), Ae. vexans (Meigen, 1830), Culiseta longiareolata (Macquart, 1838)] are new species for mosquito fauna in Sakarya province. The invasive species Ae. albopictus (Skuse, 1894) has been recorded for the first time from Kocaeli province and this record is the first record for Culicidae family in Kocaeli.

Keywords: *Mosquito, fauna, Sakarya, Kocaeli, Aedes albopictus.*

Sakarya ili sivrisinek (Diptera: Culicidae) faunasına katkılar ve invazif vektör *Aedes albopictus* (Skuse, 1894)'un Kocaeli ili için ilk kaydı

Öz

Sivrisinekler, insan ve doğadaki birçok hayvan için hastalık taşıyıcısı olabilen, kan emen, geçici dış parazitlerdir. Bu çalışmada, Sakarya ili Adapazarı ve Söğütlü ilçeleri ile Kocaeli ili İzmit ilçesinde, Şubat 2018-Ağustos 2018 tarihleri arasında

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gerçekleştirilen arazi çalışmaları sonucu elde edilen materyal değerlendirilmiştir. Sakarya ilinden 9 sivrisinek türü saptanmıştır. Bu türlerden beş tanesi [Anopheles plumbeus Stephens, 1828, Aedes geniculatus (Olivier, 1791), Ae. rusticus (Rossi, 1790), Ae. vexans (Meigen, 1830), Culiseta longiareolata (Macquart, 1838)] Sakarya sivrisinek faunası için yeni türlerdir. Kocaeli'den ise invazif sivrisinek Ae. albopictus (Skuse, 1894), ilk kez kayıt edilmiş olup, bu kayıt Kocaeli Culicidae familyası için ilk kayıt niteliğindedir.

Anahtar kelimeler: *Sivrisinek, fauna, Sakarya, Kocaeli, Aedes albopictus*.

1. Introduction

Mosquitoes placed in the Culicidae family constitute the most important medical arthropod group and more than 3500 species have been identified so far [1]. Mosquitoes are common throughout the world, but species diversity and/or density varies from region to region, and moist tropical/subtropical regions contain ¾ of all species [2]. In addition, tropical species are known to expand their distributional ranges day by day. Among these species, *Aedes albopictus* (Skuse, 1894), *Ae. aegypti* (Linnaeus, 1762), *Ae. japonicus japonicus* (Theobald, 1901) and *Ae. koreicus* (Edwards, 1917) have recently been identified as important invasive species in Europe [3]. One of these species, *Ae. albopictus*, although originated from Southeast Asia, spread to America in the 17th century and almost all over the world especially in the last 30-40 years [3,4]. *Ae. albopictus* is known to be the most dangerous of invasive mosquito species because it has the potential to transmit at least 32 disease agents, including dengue virus and chikungunya virus [3-5]. In Europe, special measures are being taken to fight against such vector species which are rather important for human health.

The number of mosquito species recorded in Turkey is 61 [6-8], but it was pointed out in the faunal studies that different species are likely to be present and/or settled in Turkey as well. This conclusion shows us that Culicidae fauna of Turkey is not fully known and that the number of Culicidae species in the country will most probably increase with further detailed faunal studies.

Marmara region, which is a geographical bridge between Europe and Asia, contains ¼ of Turkey's population and the majority of the trade dynamics in Turkey takes place in this area. These features make the region privileged for invasive mosquito species to invade and spread. Culicidae fauna is already represented by 29 species belonging to 6 genera [8-20]. Our knowledge about the fauna of Culicidae in Sakarya and Kocaeli provinces, which are important pillars of trade after İstanbul and also the transmission line between Asia and Europe, is quite insufficient. The only available data for Culicidae in Sakarya comes from a recent dissertation thesis which reported 9 species for the province [8]. On the other hand, no studies have been conducted so far on Kocaeli Culicidae fauna.

In this study, it was aimed to contribute to the local and Turkey's mosquito fauna by collecting samples belonging to the family Culicidae, which are quite important for the public health, at different times from Sakarya and Kocaeli provinces.

2. Material and methods

2.1. The study area and the sampling method

Larval, pupal and adult stages of the mosquitos were sampled in various habitats in two localities in Adapazarı and Söğütlü districts of Sakarya province and in a local area in İzmit district of Kocaeli province. The sampling area in İzmit, which was neighboring to the Sakarya province sampling areas, was included in the study considering the mosquito complaints of local residents. The sampling in Sakarya province was performed from February to August 2018 whereas sampling in Kocaeli province was only in August 2018 during the complaints (Figure 1). Details of the sampled habitats are given in results section for each identified taxon.

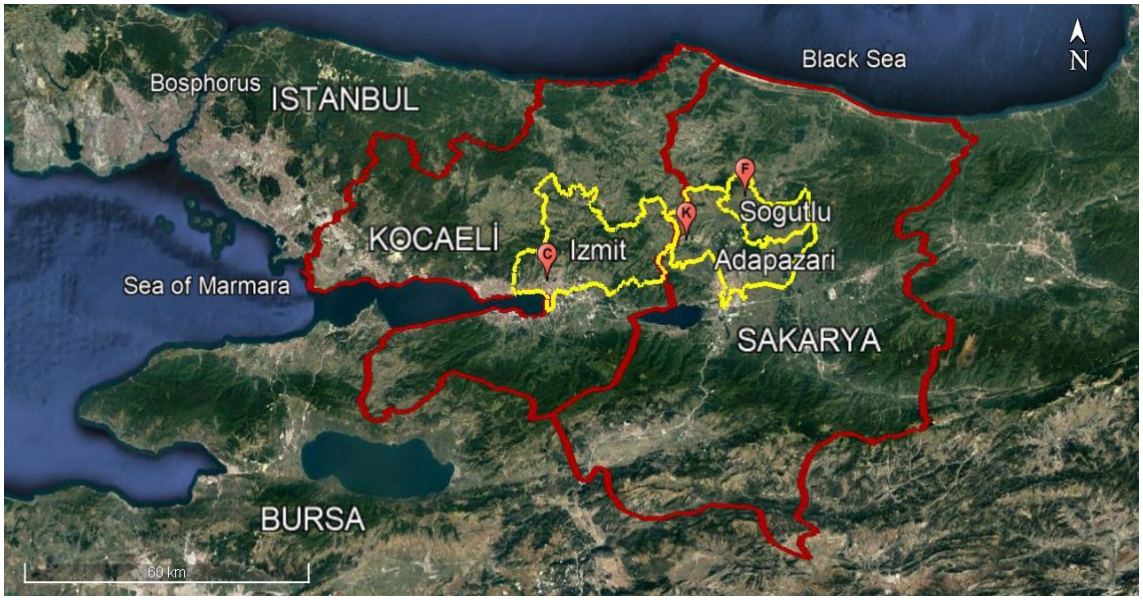

Figure 1. The localities (shown as pink placemarks) where mosquito samples were collected. The red line corresponds to provincial borders of Kocaeli and Sakarya provinces and the yellow line corresponds to district borders (F: Fındıklı village, K: Korucuk neighborhood, C: Cedit neighborhood) (modified from http://www.multimap.com/maps).

The adults of diurnal and crepuscular mosquito species were collected from the exposed limbs and other parts of voluntary people's bodies by human-landing catches (HLC) method using a manual aspirator. During sampling by HLC method, the open parts of the body were covered with net covers in order to protect against possible bites [2, 21, 22]. The captured adults were transferred to 500 mL plastic bottles inorder to bring them to the laboratory. The bottles were stored at -20°C until species identifications.

Larval and pupal stages were sampled from aquatic potential mosquito bearing habitats with a pastor pipette. The larvae were brought to the laboratory in 1200 mL plastic containers with a certain amount of the original habitat water and placed in plastic larvae breeding containers (floor dimensions: 18×25 cm; height: 15 cm; ceiling dimensions: 20×29 cm). Habitat water was added in each container until the water levels in the containers were 7 cm. The ceiling of the containers was covered with a tulle and an incision was made in the middle part of the tulle which was closed with a cotton plug. The larvae were given enough time to complete their metamorphosis in

laboratory containers and the emerging adults were collected from the containers by a manual aspirator and transferred to 500 mL plastic bottles. The bottles were stored at -20°C until species identifications.

2.2. Identifications of the mosquitoes

Identifications of collected material were made under a stereo microscope (Olympus SZ51) based on the body morphologies of both females and males by using the related references on species identification [2, 23].

3. Results

A total of 477 individuals (443♀, 34♂) were sampled during the study. A total of 10 species [*Anopheles claviger* (Meigen, 1804), *An. maculipennis* s.l. (except *An. sacharovi*) Meigen, 1818, *An. plumbeus* Stephens, 1828, *Ae. albopictus* (Skuse, 1894), *Ae. caspius* (Pallas, 1771), *Ae. geniculatus* (Olivier, 1791), *Ae. rusticus* (Rossi, 1790), *Ae. vexans* (Meigen, 1830), *Culex pipiens* s.l. Linnaeus, 1758, *Culiseta longiareolata* (Macquart, 1838)] within 4 genera belonging to 2 subfamilies were determined.

TAXONOMY
Family: CULICIDAE Stephens, 1829
Subfamily: ANOPHELINAE Lutz, 1904
Genus: *Anopheles* Meigen, 1818
Species: *Anopheles claviger* (Meigen, 1804)
Material: Sakarya-Adapazarı-Korucuk: N40°50'56.49", E30°17'33.35", (60 m asl.), 02.06.2018, 7♀, 2♂, leg: Z. ŞAKACI, det: Z. ŞAKACI.
Distribution in Turkey: Adana [8,18,24-26], Ankara [27], Antalya [28], Şanlıurfa [29-31], İstanbul [10], Kırklareli [12], Ankara, Artvin, Aydın, Bursa, Edirne, Erzincan, Iğdır, Kars, Kayseri, Kırklareli, Malatya, Sakarya, Samsun, Sinop [8], Tekirdağ [15], Muğla, Osmaniye, Edirne, Kırklareli, Tekirdağ [18], Zonguldak [33].
Geographical distribution: West, East and South of Western Palaearctic [33].
Sampling habitat: The species was sampled as larval and pupal stages in an artificial water container.
Vectorial importance: Malaria [9], Tularemia [34], Tahyna virus [35], *Setaria labiatopapillosa* [36].

Species: *Anopheles maculipennis* s.l. (except *An. sacharovi*) Meigen, 1818
Material: Sakarya-Söğütlü-Fındıklı: N40°56'16.13", E30°25'46.73", (60 m asl.), 12.08.2018, 21♀, leg: Z. ŞAKACI, det: Z. ŞAKACI.
Distribution in Turkey: İstanbul [10], Adana, Burdur, Çankırı, Edirne, Iğdır, Kırklareli, Konya, Mersin, Muğla, Samsun [11], Ankara, Artvin, Aydın, Bursa, Çankırı, Edirne, Erzincan, Eskişehir, Iğdır, Kars, Kayseri, Kırklareli, Manisa, Mardin Sakarya, Samsun, Sinop, Sivas, Tokat, Yozgat [8], Van [37], Tekirdağ [8, 15, 18], Adana, Edirne, Hatay, Kırklareli, Muğla, Osmaniye [18], Edirne [19], Bartın, Bolu, Düzce, Kastamonu, Zonguldak [32].
Geographical distribution: West, East and South of Western Palaearctic [33].
Sampling habitat: The species was sampled as adult stage in a cow barn.
Vectorial importance: Malaria [22].

Species: *Anopheles plumbeus* Stephens, 1828

Material: Sakarya-Adapazarı-Korucuk: N40°51'37.73", E30°17'43.15", (164 m asl.), 15.04.2018, 32♀: N40°51'34.22", E30°17'45.72", (151 m asl.), 22.06.2018, 45♀: N40°50'54.41", E30°17'30.57", (61 m asl.), 22.08.2018, 4♀: N40°51'46.36"K, E30°17'27.19", (196 m asl.), 22.08.2018, 42♀, leg: Z. ŞAKACI, det: Z. ŞAKACI.
Distribution in Turkey: Antalya, Balıkesir, Muğla, Siirt [9], Artvin, Samsun, Sinop [8], Bolu [18,32], Edirne, Kırklareli, Bolu [18].
Geographical distribution: West, East and South of Western Palaearctic [33].
Sampling habitats: The species was sampled as adult stage in a *Carpinus* sp. forest and a picnic area.
Vectorial importance: Malaria [38-40].

Subfamily: CULICINAE Lutz, 1904
Genus: *Aedes* Meigen, 1818
Species: *Aedes albopictus* (Skuse, 1985)
Material: Kocaeli-İzmit-Cedit: N40°46'43.45", E29°56'23.05", (182 m asl.), 22.08.2018, 12♀, leg: Z. ŞAKACI, det: Z. ŞAKACI.
Distribution in Turkey: The Black Sea coast of Thrace Region [41], Kırklareli [17], Artvin, Giresun, Rize, Trabzon [42], Artvin, Kırklareli, Rize, Trabzon [43].
Geographical distribution: West, East and South of Western Palaearctic [33].
Sampling habitat: The species was sampled as adult stage in a housing estate garden.
Vectorial importance: Dengue virus and numerous arboviruses [44-46].
Details: Adult females have been sampled when sucking blood from people in the garden within the housing estate (Figure 2). Residents declared that there was a mass attack and they could not sit on the balconies of their houses.

Figure 2. *Ae. albopictus* sucking blood from human (Kocaeli: Cedit housing estate)

Species: *Aedes caspius* (Pallas, 1771)
Material: Sakarya-Söğütlü-Fındıklı: N40°56'12.88", E30°25'55.55", (44 m asl.), 12.08.2018, 53♀; Sakarya-Adapazarı-Korucuk: N40°51'46.36", E30°17'27.19", (196 m asl.), 22.08.2018, 82♀, leg: Z. ŞAKACI, det: Z. ŞAKACI.
Distribution in Turkey: İstanbul [10], Artvin, Aydın, Çankırı, Edirne, Erzincan, Eskişehir, Iğdır, Kars, Kırklareli, Muğla, Sakarya, Samsun, Sinop, Tekirdağ, Tokat [8], Van [37], Adana, Çanakkale, Çankırı, Edirne, Hatay, İzmir, Kırklareli, Muğla, Tekirdağ, Osmaniye [18].
Geographical distribution: West, East and South of Western Palaearctic [33].

Sampling habitats: The species was sampled as adult stage in a *Carpinus* sp. forest, a picnic area (in Korucuk), and a house garden (in Fındıklı).
Vectorial importance: West Nile virus, *Francisella tularensis*, Tahyna virus [47].

Species: *Aedes geniculatus* (Olivier, 1791)
Material: Sakarya-Adapazarı-Korucuk: N40°50'54.41", E30°17'30.57", (61 m asl.), 02.06.2018, 26♀, leg: Z. ŞAKACI, det: Z. ŞAKACI.
Distribution in Turkey: Antalya [28], Bursa, Edirne, Rize, Samsun [8], Kırklareli [8,18].
Geographical distribution: West, East and South of Western Palaearctic [33].
Sampling habitat: The species was sampled as adult stage in a *Carpinus* sp. forest.
Vectorial importance: -

Species: *Aedes rusticus* (Rossi, 1790)
Material: Sakarya-Adapazarı-Korucuk: N40°51'37.73"K, E30°17'43.15"D, (165 m asl.), 22.04.2018, 2♀, leg: Z. ŞAKACI, det: Z. ŞAKACI.
Distribution in Turkey: Kırklareli, Tekirdağ [8], Edirne, Kırklareli [18], Edirne [19].
Geographical distribution: West, East and South of Western Palaearctic [33].
Sampling habitat: The species was sampled as adult stage in a *Carpinus* sp. forest.
Vectorial importance: -.

Species: *Aedes vexans* (Meigen, 1830)
Material: Sakarya-Adapazarı-Korucuk, N40°50'54.41", E30°17'30.57", (61 m asl.), 02.06.2018, 33♀, leg: Z. ŞAKACI, det: Z. ŞAKACI.
Distribution in Turkey: İstanbul [10], Edirne, Kırklareli [18], Edirne [19], Bartın, Bolu, Düzce, Kastamonu, Zonguldak [32].
Geographical distribution: West, East and South of Western Palaearctic [33].
Sampling habitat: The species was sampled as adult stage in a *Carpinus* sp. forest.
Vectorial importance: Tahyna virus [48].

Genus: *Culex* Linnaeus, 1758
Species *Culex pipiens* s.l. Linnaeus, 1758
Material: Sakarya-Adapazarı-Korucuk: N40°51'46.98", E30°17'31.63", (200 m asl.), 14.05.2018, 83♀, 32♂; Sakarya-Söğütlü-Fındıklı: N40°56'16.13", E30°25'46.73", (60 m asl.), 12.08.2018, 7♀, leg: Z. ŞAKACI, det: Z. ŞAKACI.
Distribution in Turkey: Adana [49-51], Mersin [51], Ankara [25,26], İstanbul [10], Antalya [28, 52, 53], Manisa [54], Mersin [55,56], Muğla [57], Şanlıurfa [29], Adana, Ankara, Artvin, Aydın, Bursa, Çanakkale, Çankırı, Edirne, Erzincan, Eskişehir, Hatay, Iğdır, İstanbul, Kars, Kayseri, Kırklareli, Malatya, Manisa, Mardin, Mersin, Muğla, Rize, Sakarya, Samsun, Sivas, Tekirdağ, Tokat, Şanlıurfa [8], Van [37], Adana, Aydın, Balıkesir, Çanakkale, Edirne, Hatay, İzmir, Kahramanmaraş, Kırklareli, Muğla, Osmaniye, Tekirdağ [18], Bartın, Bolu, Düzce, Karabük, Kastamonu, Zonguldak [32], Edirne [19], Aydın, Balıkesir, Çanakkale, Denizli, İzmir, Muğla [20].
Geographical distribution: West, East and South of Western Palaearctic [33].
Sampling habitat: The species was sampled as adult stage in a chicken coop (in Fındıklı) and as larval and pupal stages in a pond (in Korucuk).
Vectorial importance: *Wuchereria bancrofti*, *Brugia malayi*, *Drofilaria immitis*, Avian malaria, Western equine encephalitis virus, St. Louis encephalitis virus [23], Ockelbo virus [48], West Nile virus [58].

Genus *Culiseta* Felt, 1904
Species *Culiseta longiareolata (*Macquart, 1838)
Material: Sakarya-Adapazarı-Korucuk: N40°51'30.77", E30°17'32.27", (165 m asl.), 24.02.2018, 1♀, leg: Z. ŞAKACI, det: Z. ŞAKACI.
Distribution in Turkey: Adana [49-51], Antalya [28, 55], Şanlıurfa [29], Ankara [26], İstanbul [10], Manisa [54], Adana, Artvin, Aydın, Bursa, Çanakkale, Erzincan, Eskişehir, Iğdır, Kars, Kayseri, Manisa, Mardin, Mersin, Muğla, Sivas [8], Van [37], Tekirdağ [15], Aydın, Çanakkale, Hatay, İzmir, Kırklareli, Muğla, Tekirdağ [18], Bolu, Düzce, Kastamonu, Zonguldak [32], Edirne [19].
Geographical distribution: West, East and South of Western Palaearctic [33].
Sampling habitat: The species was sampled as adult stage in a indoor environment.
Vectorial importance: -.

4. Discussion

The results of the present field studies showed that 5 of 9 species [*An. plumbeus*, *Ae. geniculatus*, *Ae. rusticus*, *Ae. vexans*, *Cs. longiareolata*] determined in Adapazarı and Süğütlü are the first records for Sakarya province Culicidae fauna.

Sakarya Culicidae family is represented by 14 species with the addition of the 5 new species. In addition, the record of *Ae. albopictus* in Kocaeli is also the first for Kocaeli Culicidae fauna.

In addition to the faunal contribution of the present results, another striking result is that *Ae. albopictus* was identified for the first time in western Anatolia and in Kocaeli province. The modeling study carried out according to climatic parameters, all coastline of Black Sea in Turkey was shown as an ideal residential area for *Ae. albopictus* [59]. The available distribution range of *Ae. albopictus* in Turkey covers Black Sea coastline in Thrace region, Kırklareli, Giresun, Trabzon, Rize and Artvin provinces [42]. The present record of *Ae. albopictus* in İzmit is thus of paramount importance since it filled, at least in part, the large gap between the Thrace region and the Anatolian region distributions. The determination of *Ae. albopictus* in Kocaeli is also compatible with the model that has indicated that this species can be seen along the Black Sea coastline [59]. Furthermore, the species can be expected to be recorded along the Black Sea coast in the northern part of Turkey in future studies. Although studies on mosquitos have been conducted in recent years in the southern regions of Turkey, the absence of *Ae. albopictus* here is an interesting result for the species originating from Southeast Asia.

Aedes rusticus is a species known only from Edirne, Kırklareli and Tekirdağ provinces in Turkey. The present record of the species in Sakarya is also the first record in Anatolia and extended the distribution of the species to the east.

Anopheles plumbeus has been reported so far from Edirne, Kırklareli, Bolu, Sinop, Samsun, Artvin [8, 18, 32] and *Ae. geniculatus* has been reported from Edirne, Kırklareli, Bursa, Samsun and Rize [8, 18], showing scattered distribution patterns for both species. The present records of these species from Sakarya are important records in terms of filling a gap in this scattered distribution of the species.

Among the species identified in the study, *Ae. albopictus* is much more important than the other species on the vectorial scale, because it has been reported that *Ae. albopictus* has the potential to transmit at least 32 viruses. However, its role in nature has not been fully elucidated. DENV (Dengue virus), CHIKV (Chikungunya virus), WNV (West Nile virus), ZIKV (Zika virus), YFV (Yellow Fever virus), JEV (Japanese encephalitis virus), EEEV (Eastern equine encephalitis virus), VEEV (Venezuelan equine encephalitis virus), WEEV (Western equine encephalitis virus), SLEV (St. Louis encephalitis virus), Ross River virus, SINV (Sindbis virus), Mayaro virus, Getah virus, Potosi virus, Cache Valley virus, Tensaw virus, Keystone virus, San Angelo virus, LACV (La Crosse encephalitis virus), Trivittatus virus, Oropouche virus, RVFV (Rift Valley fever virus), Orungo virus ve Nodamura virus are the most important disease agents that can be transferred by this species [44-46]. *Ae. albopictus* is also able to vector the helminthic parasites of *Dirofilaria immitis* (Leidy, 1856), Railliet & Henry, 1911 and *Setaria labiatopapillosa* (Alessandrini, 1838) in humans and dogs [60]. The distribution of *Ae. albopictus*, which acts as vectors for such various disease factors also in Turkey, should be clearly revealed as soon as possible and control measures for this mosquito should be urgently taken in terms of public health.

The fact that Turkey has been under intense pressure in terms of illegal immigrants in recent years and the possibility that these illegal immigrants will carry many different disease factors to the country requires urgent listing of the country's Culicidae fauna. In addition, this situation increases the importance and urgency of the struggle against the species which act as vectors for many diseases.

References

[1] Lehane, M.J., **The biology of blood-sucking in insects**, 336, Second Edition, Cambridge University Press, New York, (2005).

[2] Becker, N., Petric, D., Zgomba, M., Boase, C., Madon, M., Dahl, C. and Kaiser, A., **Mosquitoes and their control**, 577, Second Edition. Springer, Heidelberg, New York, (2010).

[3] Medlock, J.M., Hansford, K.M., Versteirt, V., Cull, B., Kampen, H., Fontenille, D., Hendrickx, G., Zeller, H., Van Bortel, W. and Schaffner, F., An entomological review of invasive mosquitoes in Europe, **Bulletin of Entomological Research**, 105(6), 637-663, (2015).

[4] Zhong, D., Lo, E., Hu, R., Metzger, M.E., Cummings, R., Bonizzoni, M., Fujioka, K.K., Sorvillo, T.E., Kluh, S., Healy, S.P., Fredregill, C., Kramer, V.L., Chen, X. and Yan, G., Genetic analysis of invasive *Aedes albopictus* populations in Los Angeles County, California and its potential public health impact. **PLOS ONE**, 8(7), e68586, (2013).

[5] Melaun, C., Werblow, A., Cunze, S., Zotzmann, S., Koch, L.K., Mehlhorn, H., Dörge, D.D., Huber, K., Tackenberg, O. and Klimpel, S., Modeling of the putative distribution of the arbovirus vector *Ochlerotatus japonicus japonicus* (Diptera: Culicidae) in Germany, **Parasitology Research**, 114, 1051-1061, (2015).

[6] Parrish, DW., The mosquitoes of Turkey. **Mosquito News**, 19, 264-266, (1959).

[7] Ramsdale, C.D., Alten, B., Çaglar, S.S., Özer, N., A revised, annotated checklist of the mosquitoes (Diptera, Culicidae) of Turkey, **European Mosquito Bulletin**, 9, 18-27, (2001).

[8] Günay, F., Türkiye sivrisinek faunası Üzerine DNA barkodlama yöntemiyle moleküler analizler, Doktora Tezi, Hacettepe Üniversitesi, Fen Bilimleri Enstitüsü, Ankara, (2015).

[9] Postiglione, M., Tabanli, B. and Ramsdale, C.D., The *Anopheles* of Turkey, **Rivista di Parassitologia**, 34, 127-159, (1973).

[10] Öter, K., İstanbul'da görülen sivrisinek türlerinin tespiti, Doktora Tezi, İstanbul Üniversitesi, Sağlık Bilimleri Enstitüsü, İstanbul, (2007).

[11] Sevgili, E., Türkiye'de *Anopheles maculipennis* Kompleksi'nin (Diptera: Culicidae) moleküler karakterizasyonu, Yüksek Lisans Tezi, Adnan Menderes Üniversitesi, Fen Bilimleri Enstitüsü, Aydın, (2009).

[12] Koçak, A.Ö. and Kemal, M., **Diptera of Turkey**, Priamus, (Suppl.) 28: ii+ 1-411, 186 figs. 166 maps, 3 Tables, (2013).

[13] Oter, K., Gunay, F., Tuzer, E., Linton, YM., Bellini, R. and Alten, B., First record of *Stegomyia albopicta* in Turkey determined by active ovitrap surveillance and DNA barcoding, **Vector-Borne and Zoonotic Diseases**, 13(10), 753-761, (2013).

[14] Akbay, Y., Tekirdağ'da *Culex* spp.'nin aylık üreme karakteristliğinin belirlenmesi, Yüksek Lisans Tezi, Namık Kemal Üniversitesi, Fen Bilimleri Enstitüsü, Tekirdağ, (2016).

[15] İpek, E., Tekirdağ'da *Culiseta* spp.'nin aylık üreme karakteristliğinin belirlenmesi, Yüksek Lisans Tezi, Namık Kemal, Üniversitesi Fen Bilimleri Enstitüsü, Tekirdağ, (2016).

[16] Yavasaoglu, S.I., Bursalı, F., Köşlüoğlu, Ç., Şimsek F.M., Distribution pattern and genetic structure of *Aedes zammitii* (Diptera: Culicidae) along the Mediterranean and Aegean coasts of Turkey, **Journal of Vector Ecology**, 41(1), 151-9, (2016).

[17] Öncü, C., Brinkmann, A., Günay, F., Kar, S., Öter, K., Sarıkaya, Y., Nitsche, A., Linton, YM., Alten, B. and Ergünay, K., West Nile virus, *Anopheles flavivirus*, a novel flavivirus as well as Merida-like rhabdovirus Turkey in field-collected mosquitoes from Thrace and Anatolia, **Infection, Genetics and Evolution**, 57, 36-45, (2018).

[18] Sarıkaya, Y., Türkiye-Suriye sınırında yer alan mülteci kampları çevresinde ve mülteci göç yolları üzerindeki sivrisinek (Diptera: Culicidae) türlerinin tespit edilmesi, Yüksek Lisans Tezi, Hacettepe Üniversitesi, Fen Bilimleri Enstitüsü, Ankara, (2017).

[19] Şakacı, Z., Edirne merkez ilçesinde vektöriyel öneme sahip sivrisinek (Diptera: Culicidae) türlerinin araştırılması, Yüksek lisans tezi, Trakya Üniversitesi, Fen Bilimleri Enstitüsü, Edirne, (2018).

[20] Kılıç, S., Taşkın, V., Doğaroğlu, T., Doğaç, E. and Taşkın, B.G., Genetic characterization of field populations of *Culex pipiens* Linnaeus, 1758 (Diptera: Culicidae) sampled from the Aegean region of Turkey, **Türkiye Zooloji Dergisi**, 43, 1-11, (2019).

[21] Darsie, R.E. and Samanidou-Voyadjoglou, A., Keys for the identification of the mosquitoes of Greece, **Journal of the American Mosquito Control Association**, 13, 247-254, (1997).

[22] Schaffner, E., Angel, G., Geoffroy, B., Hervy, J.P. Rhaiem, A. and Brunhes, J., **The Mosquitoes of Europe (CD-Rom)**, Montpellier, France: Instut de Resherche Pour le Developpement, (2001).

[23] Gutsevich, A.V., Monchadskii, A.S. and Shtakel`berg, A.A., **Fauna of the U.S.S.R. Insecta, Diptera, Vol. 3(4): Mosquitoes of the Family Culicidae**,

384, Leningrad Akad. Nauk SSSR Zool. Inst. N S No. 100, English translation: Israel Program for Scientific Translations, Jerusalem. (Original in Russian printed in 1971), (1974).

[24] Doğan, F., Çukurova bölgesi sivrisinek faunasının araştırılması, **Ege Üniversitesi Tıp Fakültesi Dergisi**, 26(2), 617-623, (1987).

[25] Eren, H., Yağcı, Ş. and Tanyüksel, M., Ankara yöresinde bulunan sivrisinek (Diptera: Culicidae) türleri, **Türk Hijyen ve Deneysel Biyoloji Dergisi**, 53, 25-29, (1996).

[26] Aldemir, A. and Boşgelmez, A., Population dynamics of adults and immature stages of mosquitoes (Diptera: Culicidae) in Gölbaşı district, Ankara, **Türkiye Zooloji Dergisi**, 30, 9-17, (2006).

[27] Kasap, H. and Kasap, M., Türkiye *Anophelinae* türleri, **Türk Hijyen ve Deneysel Biyoloji Dergisi**, 40(1), 39-52, (1983).

[28] Şahin, İ., Antalya ve çevresindeki sivrisinekler (Diptera: Culicidae) ve filariose vektörü olarak önemleri üzerinde araştırmalar II. Sivrisinek faunasını belirlemek amacıyla yapılan çalışmalar, **Doğa Bilim Dergisi**, 8(3), 385-396, (1984).

[29] Şimşek, F.M., Şanlıurfa ili sınırları içerisinde bulunan sivrisinek türleri (Diptera: Culicidae) ve sıtma vektörlerinin biyo-ekolojisi üzerine araştırmalar, Doktora tezi, Hacettepe Üniversitesi, Fen Bilimleri Enstitüsü, Ankara, (2004).

[30] Şimşek, F.M., Şanlıurfa (Siverek)'da sıtma vektörü Anopheles (Anopheles) claviger (Diptera: Culicidae)'in ekolojik özellikleri üzerine araştırmalar, **Türkiye Parazitoloji Dergisi**, 30(2), 115-120, (2006).

[31] Şimşek, F.M., Seasonal frequency and relative density of larval populations of mosquito species (Diptera: Culicidae) in Şanlıurfa province, Turkey, **Türkiye Zooloji Dergisi**, 30, 383-392, (2006).

[32] Kuçlu, Ö. and Dik, B., Türkiye'nin Batı Karadeniz Bölgesi sivrisinek (Diptera: Culicidae) faunası, **Türkiye Parazitoloji Dergisi**, 42, 138-143, (2018).

[33] MosKeyTool, bioinfo-web.mpl.ird.fr./identiciels/moskeytool_V2.1/html, (10.12.2019).

[34] Schaffner, E., Raymond, M. and Pasteur, N., Genetic differentiation of *Anopheles claviger* s.s. in France and neighbouring countries, **Medical and Veterinary Entomology**, 14, 264-271, (2000).

[35] Kampen, H., Sterberg, A., Proft, J., Bastian, S., Schaffner, F., Maier, WA. & Seitz, H.M., Polymerase chain reaction-based differentiation of the mosquito sibling species *Anopheles claviger* s.s. and *Anopheles petragnani* (Diptera: Culicidae). **The American Journal of Tropical Medicine Hygiene**, 69, 195-199, (2003).

[36] Cancrini, G., Pietrobelli, M., Frangipane, A. and Tampieri, M.P., Mosquito as vector of *Setaria labiatopapillosa*. **International Journal for Parasitology**, 27, 1061-1064, (1997).

[37] Sona, A. and Değer, M., Van Gölü Havzası'ndaki sivrisinek (Diptera: Culicidae) türleri ve aktiviteleri üzerine araştırmalar, **Van Veterinary Journal**, 27(2), 53-56, (2015).

[38] Bueno-Marí, R. and Jiménez-Peydró, R., *Anopheles plumbeus* Stephens, 1828: a neglected malaria vector in Europe, **Malaria Reports**, 1, e2, (2011).

[39] Snow, K., Distribution of *Anopheles* mosquitoes in the British Isles, **Journal of the European Mosquito Control Association**, 1, 9-13, (1998).

[40] Kruger, A., Rech, A., Su, X.Z. and Tannich, E., Two cases of autochthonous *Plasmodium falciparum* malaria in Germany with evidence for local

transmission by indigenous *Anopheles plumbeus*. **Tropical Medicine & International Health**, 6(12), 983-5, (2001).

[41] **XIII. Uluslararası Katılımlı Ekoloji ve Çevre Kongresi**, SONUÇ BİLDİRGESİ, Edirne, (2017).

[42] Akıner, M.M., Demirci, B., Bedir, H., Öztürk, M., Demirtaş, R., Doğan, A.F., Gökdemir, A., Topluoğlu, S., Altuğ, Ü., Kurtcebe, Z.Ö. and Irmak, H., Surveillance and control of invasive Aedes species in the Eastern Black Sea area of Turkey, **Türk Hijyen ve Deneysel Biyoloji Dergisi**, 75(3), 225-238, (2018).

[43] Türkozan, S.P., Türkiye'de *Aedes (Stegomyia) albopictus* (Skuse, 1894)'un populasyon genetiği ve ekolojik niş modellemesi. Yüksek Lisans Tezi, Aydın Adnan Menderes Üniversitesi, Fen Bilimleri Enstitüsü, Aydın, (2019).

[44] Gratz, N.G., Critical review of the vector status of *Aedes albopictus*, **Medical and Veterinary Entomology**, 18(3), 215-227, (2004).

[45] Paupy, C., Delatte, H., Bagny, L., Corbel, V. and Fontenille, D., *Aedes albopictus*, an arbovirus vector: From the darkness to the light. **Microbes and Infection**, 11(14-15), 1177-1185, (2009).

[46] Vanlandingham, D.L., Higgs, S. and Huang, Y.J.S., *Aedes albopictus* (Diptera: Culicidae) and mosquito-borne viruses in the United States, **Journal of Medical Entomology**, 53(5), 1024-1028, (2016).

[47] Detinova, T.S. and Smelova, V.A., K voprosu o medicinskom znatcheniy komarov (Culicidae, Diptera) fauni Sovyetskogo Soyuza, **Meditsinskaya Parazitologiya i Parazitarnye Bolezni**, 42(4), 455-471, (1973).

[48] Lundström, J.O., Vector competence of western European mosquitoes for arboviruses: A review of field and experimental studies, **Bulletin of the Society Vector Ecology**, 19, 23-36, (1994).

[49] Kasap, H., Kasap, M., Mimioğlu, M.M. and Aktan, F., Çukurova ve çevresinde sivrisinek ve malaria üzerine araştırmalar, **Doğa Bilim Dergisi**, 5, 141-150, (1981).

[50] Kasap, H. and Kasap, M., Relative abundance of mosquitoes breeding in septic tanks in the campus of Çukurova University, **Çukurova Üniversitesi Tıp Fakültesi Dergisi**, 4, 301-310, (1983).

[51] Mimioğlu, M., Aktan, F., Kasap, M. and Kasap, H., Çukurova ve çevresinde sivrisinek ve malaria üzerine araştırmalar, **TÜBİTAK TBAG Proje**, No: 358, Rapor No: PR-1996-3358, (1981).

[52] Alten, B., Bellini, R., Caglar, S.S., Simsek, F.M. and Kaynas, S., Species composition and seasonal dynamics of mosquitoes in the Belek region of Turkey, **Journal of Vector Ecology**, 25(2), 146-154, (2000).

[53] Caglar, S.S., Alten, B., Bellini, R., Simsek, F.M. and Kaynas, S., Comparison of nocturnal activities of mosquitoes (Diptera: Culicidae) sampled by New Jersey light traps and CO_2 traps in Belek, Turkey, **Journal of Vector Ecology**, 28(1), 1-11, (2003).

[54] Muslu, H., Kurt, Ö. and Özbilgin, A., Manisa il ve ilçelerinde saptanan sivrisinek türlerinin (Diptera: Culicidae) yaşam alanları ve mevsimsel değişikliklere göre değerlendirilmesi. **Türkiye Parazitoloji Dergisi**, 35, 100-104, (2011).

[55] Kasap, M., Sivrsinek larvalarının habitat tiplerinin incelenmesi. **Türk Hijyen ve Deneysel Biyoloji Dergisi**, 42(2), 269-274, (1985).

[56] Alptekin, D. and Kasap, H., Çukurova'da sık bulunan Culicidae (Diptera) türlerinin ergin öncesi evrelerinin bulunduğu habitatlar ve bu habitatların önemli fiziksel ve kimyasal özellikleri, **Türkiye Zooloji Dergisi**, 21(1), 1-6, (1997).

[57] Alten, B. and Boşgelmez, A., Muğla ili, Ortaca ve Dalaman yörelerinde bulunan *Culex* (Diptera: Culicidae) türlerinin biyo-ekolojisi üzerine araştırmalar, **Turkish Journal of Zoology**, 20, 27-51, (1996).

[58] Kilpatrick, A.M., Kramer, L.D., Campbell, S.R., Alleyne, E.O., Dobson, A.P. and Daszak, P., West Nile virus risk assessment and the bridge vector paradigm, **Emerging Infectious Diseases**, 11(3), 425-429, (2005).

[59] Cunze, S., Koch, L.K., Kochmann, J. and Klimpel, S., *Aedes albopictus* and *Aedes japonicus* – two invasive mosquito species with different temperature niches in Europe, **Parasites & Vectors**, 9:573, (2016).

[60] Cancrini, G., Pietrobelli, M., Frangipane di Regalbono, AF., Tampieri, M.P. and della Torre, A., Development of *Dirofilaria* and *Setaria* nematodes in *Aedes albopictus*, **Parassitologia**, 37(2-3), 141-145, (1995).