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Distribution of *Aedes (Stegomyia) cretinus* in Türkiye

Türkiye'de Aedes (Stegomyia) cretinus'un Dağılımı

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ABSTRACT

Objective: *Aedes cretinus*, a white and black stripped *Aedes* species, shares morphological similarities with *Aedes albopictus* and *Aedes aegypti* which are among the most important vectors and invasive species in the world. Due to its limited distribution and low population density, information on the biology and ecology of the species has been limited so far. This study aimed to determine distribution of *Ae. cretinus* in Türkiye.

Methods: Field works have been carried out in the Mediterranean, Aegean and Marmara Regions of Türkiye. Larval samples were collected by larval dippers while adult mosquito catches were performed using the human landing catch method and CDC-light traps.

Results: A total of 44 different *Ae. cretinus* populations were identified in the Mediterranean, Aegean and Marmara Regions of Türkiye. The larval specimen collected from small containers, tires, tree holes and natural small habitats. A plane (*Platanus orientalis*), walnut (*Juglans regia*), Türkiye oak (*Quercus cerris*), chestnut (*Castenea sativa*) and cedar (*Cedrus libani*) tree holes are the main larval habitats in which the specimen collected. In some localities, larvae were found together with *Anopheles plumbeus, Anopheles claviger* and *Aedes geniculatus* larvae in tree holes. Human landing catch method captured a greater number of females than CDC-light traps.

Conclusion: This study determined the distribution of *Ae. cretinus* in Türkiye for the first time. Information on respective geographic distribution of *Ae. cretinus* is fundamental for effective control programmes. Further studies are needed to understand the biology and ecology of these species.

Keywords: *Aedes cretinus*, distribution, Mediterranean, Aegean, Marmara

ÖZ

Amaç: Beyaz ve siyah çizgili bir *Aedes* türü olan *Aedes cretinus*, dünyadaki en önemli ve istilacı türler arasında yer alan *Aedes albopictus* ve *Aedes aegypti* ile morfolojik benzerlikler göstermektedir. Sınırlı yayılış alanı ve düşük popülasyon yoğunluğu nedeniyle türün biyolojisi ve ekolojisi ile ilgili bilgiler şimdiye kadar sınırlı kalmıştır. Bu çalışma, *Ae. cretinus*'un Türkiye'deki dağılımını belirlemeyi amaçlamıştır.

Yöntemler: Türkiye'nin Akdeniz, Ege ve Marmara Bölgeleri'nde arazi çalışmaları yapılmıştır. Larva örnekleri larva kepçeleri ile toplanırken, ergin örnekleri toplamak için insan tuzakları ve CDC-ışık tuzakları kullanılmıştır.

Bulgular: Türkiye'nin Akdeniz, Ege ve Marmara Bölgeleri'nde toplam 44 farklı *Ae. cretinus* popülasyonu tespit edilmiştir. Larvalar küçük kaplardan, lastiklerden, ağaç kovuklarından ve doğal küçük habitatlardan toplanmıştır. Çınar (*Platanus orientalis*), ceviz (*Juglans regia*), Türkiye meşesi (*Quercus cerris*), kestane (*Castenea sativa*) ve sedir (*Cedrus libani*) ağaç kovukları örneklerin toplandığı başlıca larva habitatlarıdır. Bazı lokalitelerde larvalar ağaç kovuklarında *Anopheles plumbeus*, *Anopheles claviger* ve *Aedes geniculatus* larvaları ile birlikte bulunmuştur. İnsan tuzağı yöntemiyle CDC-ışık tuzaklarından daha fazla sayıda dişi yakalanmıştır.

Sonuç: Bu çalışma ile ilk kez Türkiye'deki *Ae. cretinus* popülasyonlarının dağılımı belirlenmiştir. *Ae. cretinus*'un coğrafi dağılımına ilişkin bilgiler etkili kontrol çalışmalarının gerçekleştirilmesi için çok önemlidir. Bu türün biyolojisini ve ekolojisini anlamak için daha fazla çalışmaya ihtiyaç vardır.

Anahtar Kelimeler: *Aedes cretinus*, dağılım, Akdeniz, Ege, Marmara

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Türkiye PARAZİTOLOJİ Dergisi

INTRODUCTION

Mosquito-borne diseases are an increasing global health challenge, threatening over 40% of the world's population (1). Approximately 40% of the world's population are at risk of dengue transmission, with an estimated 400 million infections per year resulting in 50-100 million clinical cases and 3.6 million hospitalisations (2,3).

The subgenus *Stegomyia* which is classified under the genus *Aedes* contains important human disease vector species such as *Aedes (Stegomyia) aegypti* (Linnaeus, 1762), *Aedes (Stegomyia) albopictus* (Skuse, 1895) and *Aedes (Stegomyia) cretinus* (Edwards 1921) (4). There are some microscobic differentiations related to scaling patterns of the scutum. The scutum is lyre-shaped marking of white scales and also clypeus are with scales in *Ae. aegypti*. *Ae. cretinus* has submedian narrow lines of pale scales extending from posterior of the scutal angle to the scutum with a lateral line of pale scales while *Ae. albopictus* has not got this lateral line. (5). The remarkable morphological features and bio-ecological resemblance of *Ae. cretinus, Ae. aegypti* and *Ae. albopictus* may sometimes cause confusions among public (Figure 1) (6).

Ae. cretinus is described as an anthropophilic and aggressive day time biter causing serious irritation to humans when it is around the people (7). The larvae may be found in natural habitats such as tree holes or even man-made containers such as used tyres (8,9). The distribution of *Ae. cretinus* is limited in the Mediterranean and has low population density (6). The first record of the Mediterranean representatives of "*Ae. albopictus*" in the words of Edwards (1921) was reported from Greece in 1921 (6,10,11). In the following years, *Ae. cretinus* was reported from Cyprus (12), Türkiye (Antalya) (13,14), Crete, Macedonia and some parts of Attica (7,10,15), Lebanon (16), South Ukraine, Russia (8) and Georgia (12). As it is understood from its limited distribution and low population density of *Ae. cretinus*, little is known about the bio-ecological characteristics of the species and vectorial capacity of the species is even still unknown (17). However, in the regions where it spreads, its aggressive behaviour causes discomfort and concern among the people due to its close morphological similarity to Asian tiger mosquito *Ae. albopictus*. As a result, understanding the current distribution of *Ae. cretinus* populations in Türkiye could be of importance. Understanding the distribution of the species and conducting studies on its bio-ecological characteristics have become especially important as the entry and rapid invasions of *Ae. albopictus* in to Türkiye continues in recent years. After the first detection of *Ae. albopictus* in Edirne in 2011, its distribution spread larger areas in the Marmara Region (18,19), Black Sea Region (20) and finally Aegean Region (21). However, studies on the distribution of *Ae. cretinus* have not been reported in Türkiye after it was reported in Antalya (13,14). In this study, we, for the first time, reported the distribution of *Ae. cretinus* populations in Türkiye. We believe that the information gathered by this study, is fundamental for the goal of reducing the impact of vector-borne diseases in Türkiye and managing vector control studies.

METHODS

Field works have been performed in the Mediterranean (Adana, Mersin, Antalya, Burdur, Isparta, Osmaniye, Kahramanmaraş, Hatay), Aegean (Aydın, İzmir, Manisa, Denizli, Uşak, Muğla) and Marmara (Balıkesir, Bursa, Birecik, Çanakkale) Regions of Türkiye between May-October in 2012-2021 (Figure 2). Every possible natural (tree holes, puddles) and artificial containers (human-made plastic cups, ceramic pots, used tyres) water habitats have been checked for the presence of larval samples. Larval dippers have been used for the collection of larval samples and transferred to plastic bottles. Adult specimens were caught in outdoor and indoor areas (animal stables) with CDC light traps and Human Landing Catch Method (HLCM). Collected samples were brought to vector insects laboratory of Biology Department in Aydın Adnan Menderes University. Larval samples were reared to adults under standard conditions at 26-28 °C, 12:12 h photoperiod and 70-80% relative humidity in an insectarium. Morphological identifications have been performed under stereomicroscope using an identification key (11,22).

Statistical Analysis

Statistical analysis has not been performed for this study.

RESULTS

As a result of long-term sampling studies in the Mediterranean, Aegean and Marmara Regions, *Ae. cretinus* larvae were obtained from a total of 43 localities and adult samples were collected from 31 localities (Table 1). The larvae were sampled in four different breeding habitats: Small containers, tires, tree holes and natural small habitats (Figure 3). Results obtained from the larvae sampling do not show the habitat preference of the species since the research is based on the presence/absence detection of *Ae. cretinus*. However, it has been determined that small containers and tires in urban areas, tree holes and natural small habitats in rural areas are frequently used as breeding habitats. The tree hole larvae of *Ae. cretinus* were sampled from tree holes on plane (*Platanus orientalis*), walnut (*Juglans regia*), Türkiye oak (*Quercus cerris*), chestnut (*Castenea sativa*) and cedar (*Cedrus libani*) trees. Of the 22 tree holes sampled, 13 were detected in plane, 4 in walnut (Akçatekir, Ödemiş, Yiğitali, Ayvacık), 2 in cedar (Hisarçandır, Ovacık), 2 in Turkish oak (Honaz, Uzunyurt) and 1 in chestnut tree (Tire). While *Ae. cretinus* larvae were sampled alone in all of the small container and tire habitats, they were found together

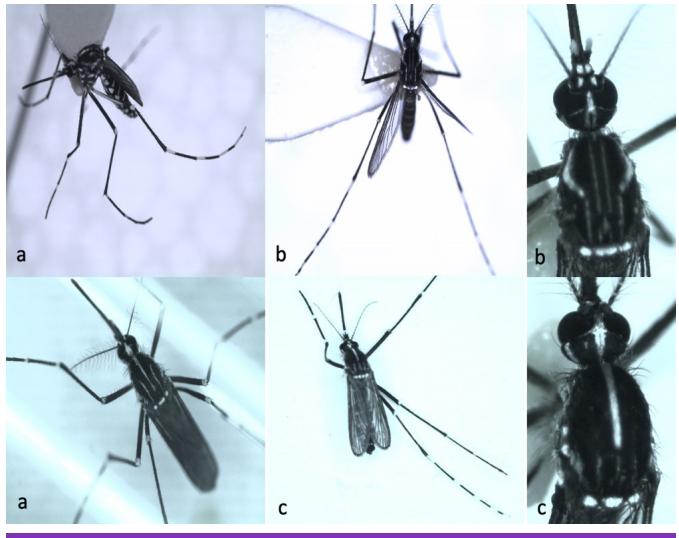

Figure 1. Female scutum patterns (a: *Aedes cretinus*, b: *Aedes aegypti*, c: *Aedes albopictus*)

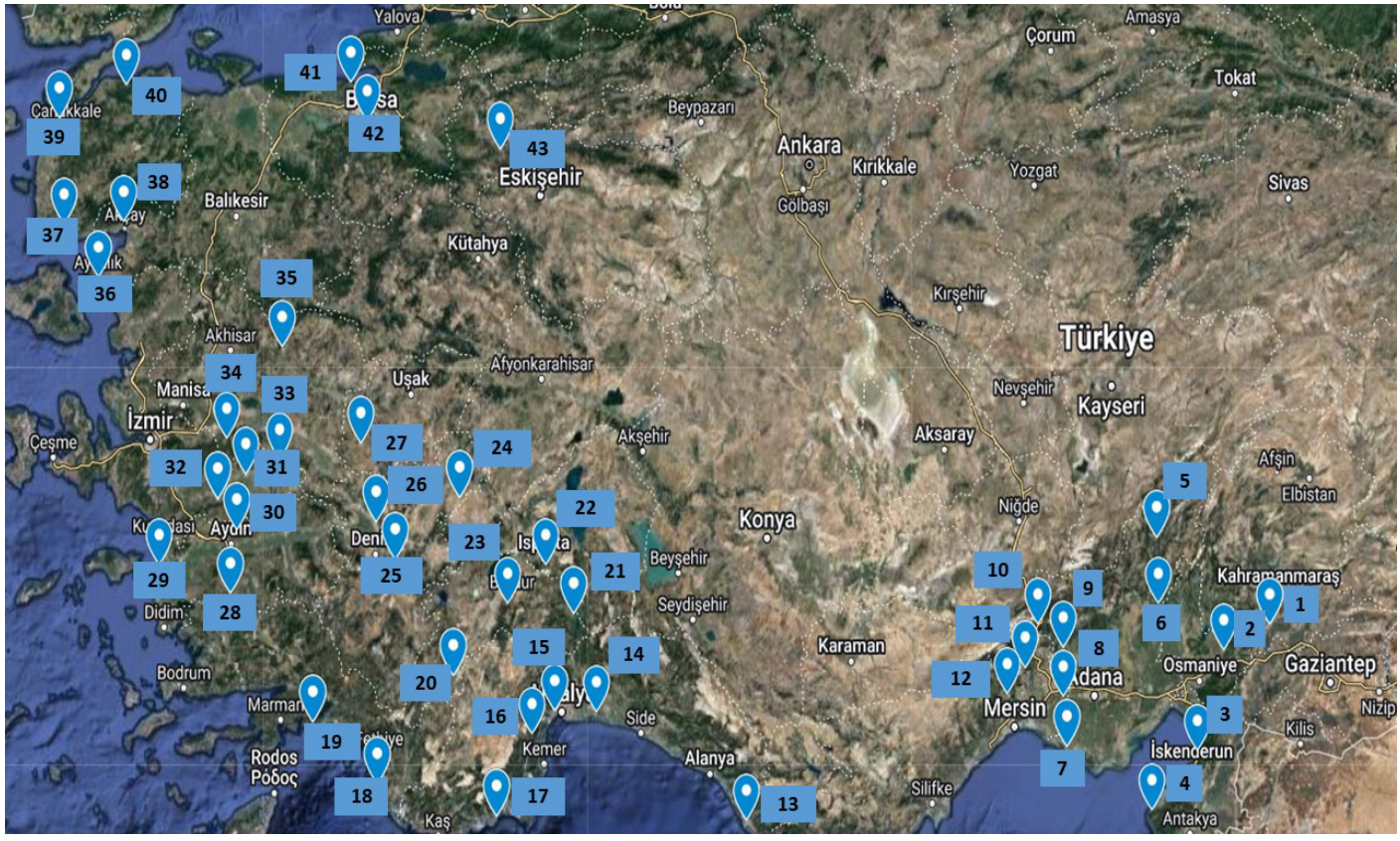

Figure 2. Sampling localities (1. Kahramanmaraş-Türkoğlu, 2. Osmaniye- Düziçi, 3. Hatay- Sarıseki, 4. Hatay-Tatarlı, 5. Adana-Feke, 6. Adana-Ferhatlı, 7. Adana-Tuzla, 8. Mersin-Yenice, 9. Adana-Karaisalı, 10. Adana-Akçatekir, 11. Mersin-Darıpınarı, 12. Mersin-Gözne, 13. Antalya-Gazipaşa, 14. Antalya-Kadriye, 15. Antalya-Pınarbaşı, 16. Antalya-Hisarçadır, 17. Antalya-Finike, 18. Muğla-Uzunyurt, 19. Muğla-Ekincik, 20. Burdur-Bölmepınar, 21. Burdur-Elsazı, 22. Isparta-Darıderesi, 23. Isparta-Yeşildağ, 24, Denizli-Bozdağ, 25. Denizli-Honaz, 26. Denizli-Karahayıt, 27. Uşak-Eşme, 28. Aydın-Karpuzlu, 29. Aydın-Güzelçamlı, 30. Aydın-Karaköy, 31. İzmir-Ödemiş, 32. İzmir-Tire, 33. Manisa- Ovacık, 34. Manisa-Ayvacık, 35.Manisa- Gördes, 36. Balıkesir-Ayvalık, 37. Çanakkale-Ayvacık, 38. Balıkesir-Kızılkeçili, 39. Çanakkale-Eceabat, 40. Çanakkale-Güreci, 41. Bursa-Mudanya, 42. Bursa-Yiğitali, 43. Bilecik-Söğüt) (Map was created using Google maps)

with other mosquito larvae in some tree holes and small natural habitats. *Ae. cretinus* larvae were found together with *Anopheles plumbeus* larvae in tree holes in Gazipaşa, Darıpınarı, Ekincik (Plane) and Akçatekir (Walnut); It has been sampled together with *Anopheles claviger* larvae in small natural habitats in Kadriye, Pınarbaşı, Gözne and Darıpınarı and with *Aedes geniculatus* larvae in cedar tree hollows in Ovacık.

Only female *Ae. cretinus* specimens were caught by outdoor and indoor CDC light traps and HLCM applied in different localities in the study area. A total of 127 females were caught with HLCM while 89 females were caught by CDC light traps. Totally 69 females were caught by CDC light traps in outdoor while 20 females were caught by the traps deployed indoor. It can be stated that the species exhibits exophilic and anthropophilic tendencies based on the results. Although *Ae. cretinus* female specimens were caught with HLCM in 28 localities in the study area, it was determined that the females caught in all localities did not show aggressive biting behaviour.

DISCUSSION

Information on respective geographic distribution of mosquito species is so precious for planning effective mosquito control strategies (23). This study determined the distribution of *Ae. cretinus* in the Mediterranean, Aegean and Marmara Regions of Türkiye. The first report of *Ae. cretinus* population in Türkiye was determined in Antalya by Şahin (13). In the following years, Alten et al. (14) also reported the distribution of the *Ae. cretinus* populations in the same area in Antalya in 2000. The incidence of *Ae. cretinus* was calculated as 9% of mosquito fauna of İstanbul between 2019-2020 (24). Since then, this study is the first report of distribution of *Ae. cretinus* populations in the Mediterranean, Aegean and Marmara Regions of Türkiye. Larval samples were collected from both tree holes, natural small habitats, small containers and tires in the study. Similarly, larvae were collected from tree holes in the South Ukraine and Russia (8) and Cyprus (12,25). Other possible breeding sites were reported as forests, open areas, potholes and small hollows in forests as well as tree holes (14) and containers such as tyres (9). In addition to tree holes and tyres in those studies, small containers were also containing *Ae. cretinus* larvae in this study. This result demonstrates that *Ae. cretinus* is not only well adapted to natural habitats but also spreads in domesticated environment. This situation refers to ability of *Ae. cretinus* to colonize habitats where it occurs (15). Interestingly, larvae were found in tree holes together with *Ae. geniculatus* in Ovacık; with *An. plumbeus* in Gazipaşa, Darıpınarı,

Table 1. Sampling localities, breeding habitats, larval and adult sampling of Aedes cretinus

Province	No	Locality	Altitude (m)	Co-ordinates	Larvae sampling								Adult sampling		
					Breeding habitats										
					Small containers	Tires	Treeholes					Natural small habitats	CDC light traps		Human landingcatch
							Po	*Jr*	*Cl*	*Qc*	*Cs*		In door	Out door	
Adana	1	Feke	840	37°48' N, 35°55' E								5			4
	2	Ferhatlı	580	37° 29' N, 35° 43'E			11								2
	3	Akçatekir	1120	37° 26' N, 34° 52'E	4			5					1	3	2
	4	Karaisalı	664	37° 15' N, 35° 00'E	4	5									
	5	Tuzla	5	36° 42' N, 35° 05'E	12	4							2	5	5
Antalya	6	Kadriye	4	36° 49' N, 30° 02'E	5	3						4	2	4	3
	7	Pınarbaşı	750	36° 14' N, 29° 39'E		12	10					5		4	5
	8	Hisarçandır	1230	36° 45' N, 30° 28'E	4				19			6			4
	9	Finike	678	36° 30' N, 30° 03'E			12								
	10	Gazipaşa	1090	36° 17' N, 32° 26' E	3		16					3		4	6
Burdur	11	Elsazı	280	37° 26' N, 30° 42'E		13						4			2
	12	Bölmepınar	915	37° 05' N, 29° 18'E	5		12					2		2	4
Hatay	13	Tatarlı	190	36° 20' N, 35° 49'E	8									2	
	14	Sarıseki	5	36° 37' N, 36° 17'E	22										3
Isparta	15	Yeşildağ	1120	37° 37' N, 31° 27'E	8										
	16	Darıderesi	1157	37° 43' N, 30° 33'E			5								
K. Maraş	17	Turkoğlu	680	37° 23' N, 36° 48'E		12						3	1	2	6
Mersin	18	Yenice	710	36° 18' N, 33° 23'E	8									3	
	19	Gözne	720	37° 04' N, 34° 13'E	4		10					2		5	3
	20	Darıpınarı	710	37° 08' N, 34° 42'E			17					5			
Osmaniye	21	Düziçi	380	37° 16' N, 36° 12'E	10								2	4	2
Aydın	22	Güzelçamlı	210	37° 41' N, 27° 11'E	8										4
	23	Karpuzlu	195	37° 33' N, 27° 49'E	10									2	6
	24	Karaköy	794	37° 54' N, 27° 53'E			8							3	2
Denizli	25	Honaz	773	37° 44' N, 29° 16'E						11				1	
	26	Karahayıt	358	37° 57' N, 29° 06'E		8									
İzmir	27	Bozdağ	1150	38° 20' N, 28° 04'E	2		5						2	3	6
	28	Ödemiş	1067	38° 18' N, 28° 01'E				7						2	3
	29	Tire	936	38° 03' N, 27° 46'E	3						18	4	3	4	8

Table 1. Sampling localities, breeding habitats, larval and adult sampling of Aedes cretinus

Province	No	Locality	Altitude (m)	Co-ordinates	Larvae sampling								Adult sampling		
					Breeding habitats										
					Small containers	Tires	Treeholes					Natural small habitats	CDC light traps		Human landingcatch
							Po	*Jr*	*Cl*	*Qc*	*Cs*		In door	Out door	
Manisa	30	Gördes	585	38° 56' N, 28° 16'E								5			
	31	Ayvacık	1008	38° 33' N, 27° 26'E	6										
Muğla	32	Ovacık	1370	36° 32' N, 29° 11'E					14			4		3	12
	33	Uzunyurt	136	36° 28' N, 29° 07'E	8					15			4	5	8
	34	Ekincik	50	36° 50' N, 28° 32'E	5		12							3	7
Uşak	35	Eşme	936	38° 24' N, 28° 56'E	6							2			
Balıkesir	36	Kızılkeçili	153	39° 37' N, 26° 54'E	3		6							2	4
	37	Ayvalık	58	39° 17' N, 26° 40'E								7			4
Birecik	38	Söğüt	824	40° 00' N, 30° 11'E	3		8								
Bursa	39	Yiğitali	570	40° 10' N, 29° 06'E				12					3	3	5
	40	Mudanya	90	40° 21' N, 28° 56'E		14									3
Çanakkale	41	Ayvacık	280	39° 37' N, 26° 25'E	4			17							
	42	Eceabat	90	40° 09' N, 26° 21'E		6						3			
	43	Güreci	230	40° 21' N, 26° 57'E	4	6									4

Po: Platanus orientalis, Jr: Juglans regia, Qc: Quercus cerris, Cs: Castenea sativa, Cl: Cedrus libani

Ekincik and Akçatekir; with *An. claviger* in Kadriye, Pınarbaşı, Gözne and Darıpınarı. This is similar to the fact that *Ae. cretinus* larvae was found in tree holes with *Ae. geniculatus*. They were also found together with *Anopheles plumbeus* and *Orthopodomyia pulcripalpis* in the South of Ukraine and Russia (8).

In the study, larvae were collected from the tree holes of plane (*Platanus orientalis*), walnut (*Juglans regia*), Türkiye oak (*Quercus cerris*), chestnut (*Castenea sativa*) and cedar (*Cedrus libani*) trees. Although, there have been no relationship between larval habitat preference and tree species in the literature, bamboo grove has been reported to be related with larval development by Gutsevich et al. (8). In addition to that, it was stated that the study area where *Ae. cretinus* was rediscovered after 66 years in Cyprus, was dominated by old and high plane trees (*Platanus orientalis*) (25). The HLCM and CDC-light traps were used to detect adult mosquitoes in this study. While few females obtained from light traps, a greater number of females were caught by HLCM. It was reported that CO_2 and New Jersey light traps were also useful to catch exophilic *Ae. cretinus* in Antalya (26). Standard New Jersey light trap, Heavy duty EVS, CO_2 Mosquito traps caught adult *Ae. cretinus* specimen at very low density in outdoors and indoors and accounted for 0.07% of the catches in monitored houses in Lebanon (16).

In this study specimen collection were carried out in a 10-year period including 2012-2021 and between May and September. Caglar et al. (26) reported that population growth was rapid during May and June but disappearance was rapid during July and *Ae. cretinus* were not found after July in Belek (Antalya). However, both larvae and adults were sampled from May to September in many localities in this study. For instance, the Sarıseki population were collected in the end of September in 2021.

Today, *Ae. albopictus* pose a great risk because it threatens public health with mainly dengue and other viral factors that it carries and it is known to invade our country rapidly (21). *Ae. cretinus* and *Ae. albopictus* shares some morphological characters in their developmental stages (11). These characteristics might be distinguished by skilled and experienced taxonomists when the specimens are not damaged and collected properly. Another way to differentiate the species is molecular techniques using reliable molecular markers such as internal transcribed spacer 2 of nuclear genome or mitochondrial cytochrome oxidase I fragments (4). The morphological resemblance between *Ae. cretinus* and *Ae. albopictus* might cause undue anxiety and concern among the public if the species distinction is not made properly based on either morphological characters or molecular techniques. Thus, this situation caused undue panic among Greek people (6).

This study is the first to reveal the distribution of *Ae. cretinus* populations in Türkiye. The study both shows the populations of *Ae. cretinus* and serves as a warning not to cause unnecessary anxiety since it

Figure 3. Larval habitats of *Aedes cretinus* (a. Mersin-Darıpınarı, b. Burdur-Bölmepınar, c. Muğla-Ovacık, d. Antalya-Hisarçadır)

can be confused with *Ae. albopictus*. Information on geographic distribution of mosquito species is an important component of controlling vector species. This study also highlights the importance of surveys and the need for mosquito identification. Further studies are needed to determine bio-ecological features of *Ae. cretinus* populations since detailed information are crucial in order to run a successful management mosquito control programmes.

CONCLUSION

This study is a clear proof of that *Ae. cretinus* rapidly invades Türkiye. As it is known, intense human mobility, passenger transportation, airports, ships, port routes, trade ships are the primary factors in the transportation of mosquito species to areas where it has not been spread before. It is also very clear that once *Ae. cretinus* enters in a new area, it will facilitate the distribution of the species due to the very favorable climatic conditions in Türkiye as well as its adaptability to man-made containers as we determined some larvae from man-made containers. We also proved the existence of the species in Osmaniye, Kahramanmaraş, Adana, Hatay, Mersin, Antalya, Burdur, Isparta, Muğla, Denizli, Aydın, İzmir, Manisa, Uşak, Bilecik, Bursa, Balıkesir and Çanakkale. It is very important to carry out field studies at regular intervals in many risky regions in other regions of Türkiye to prevent the invasion of this species. In a conclusion, it should be clearly emphasized that it is of the utmost importance to continue *Aedes* surveillance for early detection of new *Aedes*-borne disease outbreaks and prevent the invasion of the invasive species. Additionally, further studies on *Aedes* behaviour and possible role in the transmission of dengue and other *Aedes*-borne disease are needed.

* Ethics

Ethics Committee Approval: This article does not contain any studies with animals performed by any of the authors.

Informed Consent: This article does not contain any studies with animals performed by any of the authors.

Peer-review: Externally peer-reviewed.

* Authorship Contributions

Concept: F.M.Ş., Design: F.M.Ş., Data Collection or Processing: F.M.Ş., Analysis or Interpretation: S.İ.Y., Literature Search: S.İ.Y., Writing: S.İ.Y.

Conflict of Interest: No conflict of interest was declared by the authors.

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