

Tick Bites on Humans in Southwestern Region of Turkey: Species Diversity

Türkiye'nin Güney Batı Bölgesinde İnsanlardaki Kene Isırıkları: Türlerin Çeşitliliği

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ABSTRACT

Objective: The aim of the present study was to determine tick species found on humans who suffered from tick bite in the Southwestern Anatolia Region, Turkey.

Methods: Between January and October 2007, ticks were collected from people admitted to the city and/or town hospitals with complaints of tick bites in nine different provinces of Turkey. Genus and/or species of the ticks in adult, larva and nymph stages were identified microscopically. Identification was done using related taxonomic keys.

Results: A total of 2.610 ticks were collected from humans who were admitted to the hospitals with complaints of tick bites in the Southwestern Anatolia Region in the present study. Of these, 1.858 samples were collected from the Aegean Region and the remaining 752 from the Mediterranean Region of the country. The ticks were identified as *Hyalomma* spp. (78.58%), *Rhipicehalus* spp. (18.89%), *Ixodes* spp. (0.88%), *Dermacentor* spp. (0.77%), *Haemaphysalis* spp. (0.61%), *Argas* spp. (0.23%), and *Ornithodoros* spp. (0.04%). Results indicated that the majority of the ticks were nymphs of *Hyalomma* spp. (n=1.582). Nymphal stage was most commonly encountered from the Aegean Region and the Mediterranean Region with a prevalence of 46.13% (n=1.204) and 14.48% (n=378) respectively. Within the collected adult ticks (n=913), the majority of the samples were identified as *H. marginatum* (n=233, 26.09%).

Conclusion: The results indicate the high diversity of tick species infesting humans in the Southwestern Anatolia Region, Turkey. So, it is crucial to publish information on tick bite prevention, which would play an important role in reducing the incidence of tick-borne diseases.

Keywords: Human, Southwestern region, tick bites, Turkey

ÖZ

Amaç: Bu çalışmanın amacı; Türkiye'nin Güneybatı Anadolu Bölgesi'nde, kene ısırmasından muzdarip insanlar üzerinde saptanan kene türlerini belirlemektir.

Yöntemler: Ocak-Ekim 2007 tarihleri arasında, Türkiye'nin 9 farklı ilinde kene ısırması şikayeti ile hastanelere başvuran insanlardan toplanan keneler incelenmiştir. Erişkin, larva ve nimf dönemindeki kene örnekleri cins ve/veya tür düzeyinde mikroskopik olarak tanımlanmıştır. Tanımlama ilgili taksonomik anahtarlar kullanılarak gerçekleştirilmiştir.

Bulgular: Bu çalışmada Güneybatı Anadolu Bölgesi'nde kene ısırması şikayeti ile hastanelere başvuran insanlardan toplam 2.610 kene örneği toplanmıştır. Bunların 1.858'i Ege Bölgesi'nden, kalan 752 örnek Akdeniz Bölgesi'nden elde edilmiştir. Keneler, *Hyalomma* spp. (%78,58), *Rhipicehalus* spp. (%18,89), *Ixodes* spp. (%0,88), *Dermacentor* spp. (%0,77), *Haemaphysalis* spp. (%0,61), *Argas* spp. (%0,23), ve *Ornithodoros* spp. (%0,04) olarak tanımlanmıştır. Sonuçlar, kenelerin büyük çoğunluğunun *Hyalomma* spp. (n=1,582) nimflerine ait olduğunu göstermiştir. Nimf aşaması çoğunlukla Ege Bölgesi'nde ve %46,13 (n=1,204) oranında bulunurken, Akdeniz Bölgesi'nde %14,48 (n=378) oranında bulunmuştur. Toplanan erişkin keneler içinde (n=913), örneklerin büyük çoğunluğu *H. marginatum* (n=233, %26,09) olarak tanımlanmıştır.

Sonuç: Sonuçlar, Güneybatı Anadolu Bölgesi'nde insanlarda enfestasyon oluşturabilecek kene türlerinin yüksek çeşitliliğini göstermektedir. Bu nedenle, kene kaynaklı hastalıkların insidansını azaltmada önemli bir rol oynayacak olan kene tutunmasının önlenmesine yönelik bilgiler yayınlamak önem arz etmektedir.



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INTRODUCTION

Ticks are obligate ectoparasites and a variety of pathogens, including *Rickettsia* and other types of bacteria, viruses and protozoa can be transmitted to humans and domestic animals (1). Ticks can cause serious health problems in humans not only by the direct effects of ticks but also as vectors for many pathogens like Crimean-Congo hemorrhagic fever, Lyme disease, Tick-borne rickettsioses and Tularemia (2). Hitherto, a total of 907 tick species including *Argasidae* (n=186), *Ixodidae* (n=720) and *Nuttalliella* (n=1) were identified throughout the world. 267 out of them have been recognized as the transmitting vectors of diseases that are responsible for the health-related problems of humans (3). Ticks are widespread throughout Turkey (4) and thousands of people are affected every year by tick bites and tick-borne diseases (2,5). Up to present, a total of 47 tick species have been identified in Turkey and 31 of them have been found on humans (2). Ticks frequently found on humans in Turkey are *Hyalomma marginatum*, *Hyalomma* spp. immatures, *Ixodes ricinus*, *Ixodes* spp. immatures, and *Rhipicephalus* spp. (5,6).

Even though ticks have host-selectivity, they have an ability to feed on various hosts (7). It is reported that 267 tick species feed on humans (3). Furthermore, population of ticks and infestation rate of the hosts differ in a given region depending on seasonal fluctuations, land structure, vegetation and climatic change in tick population. (8,9). This study aimed to determine tick species feeding on humans and the environmental factors affecting tick-host interactions in the Southwestern Anatolia Region of Turkey.

METHODS

Characteristics of Study Area

The present study was carried out in nine different provinces located in two different geographical regions of Turkey (Figure 1). A total of 2.610 ticks were examined in this study. Of these ticks, 1.858 were collected from human in the Aegean Region (Aydın, Denizli, İzmir, Manisa, Muğla and Uşak) and 752 from the Mediterranean Region (Antalya, Burdur, Isparta) of Turkey. The West Aegean Region (Denizli, İzmir, Manisa and Muğla province) has abundant superficial water resources and a mild Mediterranean climate with average temperatures of 8°C in winter and 28°C in summer. Additionally, a steppe climate is found in two neighboring provinces, namely Aydın and Uşak, in inner Western Anatolia Region. On the other hand, Burdur and Isparta provinces in Mediterranean Region are located in an area with a series of shallow tectonic lakes within the folds of the Taurus Mountains in Southwestern Anatolia, Turkey. Antalya Province, which is located on the Mediterranean coast of south-west Turkey, between the Taurus Mountains and the Mediterranean sea has a hot-summer Mediterranean climate with hot and dry summers and mild and rainy winters.

Identification of ticks and Data Analysis

Between January and October 2007, ticks were collected from people applied to the city and/or town hospitals with complains of tick bites in nine different provinces of Turkey. Adult ticks were identified microscopically on the genus/species levels using related taxonomic keys (10,11). Also, stage of larvae and nymph

were identified at the genus level, according to tick identification keys by Bakırcı et al., (2017) (12). Data including species and developmental stages of all identified ticks were recorded. For the age analysis of the patients, eight groups were formed as age groups 0-6, 7-12, 13-18, 19-25, 26-40, 41-55, 56-65 and over 65. Also, the places where the hosts were bitten by the ticks, were divided into two groups, rural and urban. The chi-squared test was used to test for association among hosts bitten by identified ticks relative to variables like sex, age and origin.

Statistical Analyses

Analyses were performed with SPSS (SPSS Inc., Chicago, IL, USA, version 22.0) and $P < 0.05$ was considered as statistically significant.

RESULTS

A total of 2.610 samples collected from humans were identified microscopically and identified tick species, their developmental stages and distribution between rural and urban areas are summarised in table 1. In the present study, 14 different tick species within seven genus were identified from human in nine different provinces of Turkey.

Obtained results showed that seven out of 2.610 ticks were (0.27 %) *Argasidae* (six *Argas persicus* and one *Ornithodoros* spp. nymph) and the remaining 2.603 were (99.73%) Ixodid.

Larvae (n=55) and nymphs (n=1.642) were identified at the genus level in 2.1 % and 62.9 % of the collected ticks, respectively. In addition to larvae and nymphs, some of the collected adult ticks have been identified at species level. Among these different developmental stages, the most prevalent species was *Hyalomma* spp. (78.79%), followed by *Rhipicephalus* spp. (18.94%), *Ixodes* spp. (0.88%), *Dermacentor* spp. (0.77%) and *Haemaphysalis* spp. (0.62%). Species like *Ornithodoros* spp. was detected in a single sample collected from İzmir province.

In the present study, ticks collected from human were mainly in the genus of *Hyalomma* and generally at its nymphal stage. *Hyalomma* spp. nymphs were most commonly detected in the Aegean (46.13%, n=1.204) and Mediterranean (14.48%, n=378) Regions. The prevalence of *Hyalomma* spp. nymph detected in Muğla was significantly higher than other provinces ($P=0.000$).

Hyalomma marginatum (n=233, 26.09%) was the most commonly identified species among the adult ticks. This was followed by *R. bursa* (n=228, 25.53%), *R. turanicus* (n=209, 23.41%), *H. aegyptium* (n=108, 12.10%), *H. excavatum* (n=35, 3.92%), *H. anatolicum* (n=21, 2.35%), *D. marginatus* (n=19, 2.13%), *I. ricinus* (n=13, 1.46%), *R. sanguineus* (n=13, 1.46%), *Haemaphysalis parva* (n=9, 1.00%), *H. scupense* (syn=*H. detritum*) (n=4, 0.45%) and *H. rufipes* (n=1, 0.11%) (Table 1). *Hyalomma marginatum* was detected in all provinces (Table 1). The highest infestation rate was found in İzmir (2.1%), while the infestation rate in Antalya (0.38%), Isparta (0.38%) and Burdur (0.49%) provinces was much lower. The prevalence of *H. marginatum* was statistically significant ($P=0.000$) among provinces.

Hyalomma excavatum was detected in all provinces, except Aydın. The prevalence of *H. excavatum* among provinces was statistically significant ($p=0.000$) and the highest prevalence was found in Uşak (0.31%). *Hyalomma rufipes* was only detected in İzmir (Table 1).

Table 1. Cases of tick bites by species, type of locality and provinces

Tick species	Type of locality		The Province									P value
	Rural	Urban	Afyon	Denizli	İzmir	Manisa	Muğla	Uşak	Antalya	Burdur	Isparta	
<i>Hyalomma</i> spp. (larvae)	34	19	-	4	9	2	26	4	6	2	-	
<i>Hyalomma</i> spp. (nymphs)	851	731	10	123	346	129	528	68	298	25	55	0.000*
<i>Hyalomma</i> spp. (adults)	14	-	-	-	6	1	-	1	3	3	-	
<i>H. marginatum</i>	164	69	32	20	55	20	51	22	10	13	10	0.000*
<i>H. aegyptium</i>	73	35	3	8	31	12	16	7	17	3	11	
<i>H. excavatum</i>	28	7	-	3	7	5	4	8	2	4	2	0.000*
<i>H. anatolicum</i>	14	7	-	4	2	1	-	9	-	2	3	
<i>H. detritum</i>	2	2	-	-	2	-	-	-	1	-	1	
<i>H. rufipes</i>	1	-	-	-	1	-	-	-	-	-	-	
<i>Rhipicephalus</i> spp. (larvae)	-	1	-	-	1	-	-	-	-	-	-	
<i>Rhipicephalus</i> spp. (nymphs)	24	18	-	4	13	2	4	4	14	-	1	
<i>R. bursa</i>	154	74	12	9	36	16	23	6	77	27	22	0.000*
<i>R. sanguineus</i>	4	9	-	3	1	-	4	-	5	-	-	
<i>R. turanicus</i>	136	73	11	14	30	7	31	11	80	10	15	0.000*
<i>Ixodes</i> spp. (larvae)	-	1	-	-	-	-	-	-	1	-	-	
<i>Ixodes</i> spp. (nymphs)	5	4	-	1	1	-	-	-	7	-	-	
<i>I. ricinus</i>	11	2	-	1	2	1	5	-	3	1	-	
<i>Dermacentor</i> spp. (nymphs)	-	1	-	-	1	-	-	-	-	-	-	
<i>D. marginatus</i>	13	6	2	-	2	-	2	2	6	3	2	
<i>Haemaphysalis</i> spp. (nymphs)	4	3	-	1	2	-	-	-	2	1	1	
<i>H. parva</i>	9	-	2	2	1	-	-	1	1	2	-	
<i>Argas persicus</i>	4	2	1	-	2	1	1	1	-	-	-	
<i>Ornithodoros</i> spp. (nymphs)	1	-	-	-	1	-	-	-	-	-	-	
Total	1.546	1.064	73	197	552	197	695	144	533	96	123	

* statistically significant (P<0.05) based on the Chi-square test

The highest prevalence of *R. turanicus* (4%) and *R. bursa* (4.8%) was found in Mediterranean region (Antalya, Burdur and Isparta) with a statistically significant difference (P=0.000) among other regions. *Rhipicephalus bursa* and *R. turanicus* were seen most commonly in Antalya province. The highest infection rate of *R. bursa* was found in Antalya (2.95%), while the infection rate in Afyon (0.45 %), Denizli (0.34 %) and Uşak (0.22 %) provinces was much lower. The prevalence of *R. bursa* among provinces was also statistically significant (P=0.000).

Ixodes ricinus was detected in Denizli, İzmir, Manisa, Muğla, Antalya and Burdur provinces with the highest prevalence

detected in Muğla (0.19%). Nymphs and larvae of *Ixodes* spp. and nymphs and adults of *D. marginatus* were abundantly identified in Antalya province.

The data showing the locations of hosts bitten by ticks were further analyzed and the obtained results indicated that out of 2.610 samples, 1.546 were coming from rural areas including villages, farms, grasslands and picnic sites (59.23%), whereas 1.064 were from urban areas (40.77%).

Ticks were found mainly attached to human body and followed by extremities, head, inguinal region and other body regions with low infestation rate. Data gathered in the present study showed

Table 2. Distribution of ticks based on the ages of the humans

Genera	Age groups								Total
	0-6	7-12	13-18	19-25	26-40	41-55	56-65	65-over	
<i>Hyalomma</i> spp. (adults)	36	24	29	33	105	104	53	32	416
<i>Hyalomma</i> spp. (nymph, larvae)	452	222	112	117	274	241	120	97	1.635
<i>Rhipicephalus</i> spp. (adults)	107	61	18	28	72	82	50	32	450
<i>Rhipicephalus</i> spp. (nymph, larvae)	24	11	-	2	-	4	-	2	43
<i>Dermacentor marginatus</i>	5	3	3	-	3	2	-	3	19
<i>Dermacentor</i> spp. (nymph)	-	-	-	-	1	-	-	-	1
<i>Ixodes ricinus</i>	3	-	2	-	4	1	1	2	13
<i>Ixodes</i> spp. (nymph, larvae)	4	4	1	-	-	-	1	-	10
<i>Haemaphysalis parva</i>	3	1	-	1	-	1	1	2	9
<i>Haemaphysalis</i> spp. (nymph)	6	-	-	1	-	-	-	-	7
<i>Argas persicus</i>	1	-	-	1	2	1	1	-	6
<i>Ornithodoros</i> spp. (nymph)	-	-	-	-	-	1	-	-	1
Total	641	326	165	183	461	437	227	170	2.610

that *Hyalomma* spp. nymphs were the main ticks attaching human in all age groups (0-6, 7-12, 13-18, 19-25, 26-40, 41-55, 56-65 and over 65). Regarding other species of ticks described in the present study, the age of the host was to be significant. (Table 2).

DISCUSSION

Ticks are the most important vectors within pests following mosquitoes (13). The cost of the control of the ticks and tick-borne disease in all over the world is estimated to be between 13.9 and 18.7 million US dollars per year (14). In order to develop effective control measures for ticks and tick-borne diseases detailed epidemiological information on the distribution and seasonal activities of ticks in a particular region should be obtained (5). In previous studies focused on ticks of animals, 47 species of ticks from seven genera were identified in Turkey. Of the 47 different species of ticks, 38 species of six genera in the family Ixodidae, viz. *Haemaphysalis*, *Hyalomma*, *Dermacentor*, *Rhipicephalus*, *Ixodes* are of medical and veterinary importance (2,5).

In the present study, 14 different tick species within seven genus were collected from human (Table 1). It should be noted that tick species that feed on people living and/or vacationing in the Aegean (Afyon, Denizli, Manisa, Muğla and Uşak) and Mediterranean (Antalya, Burdur, Isparta) regions are presented for the first time with this study. The current study showed that ticks biting on humans were mostly belonging to the genus *Hyalomma* and that nymphs of *Hyalomma* spp. was the most commonly encountered form in this genus (Table 1). These findings are in accordance with the previous studies performed on humans in which the majority of tick bites shown to be caused by nymphal form of the ticks (2,5). Furthermore, the prevalence of *Hyalomma* spp. nymph (71.2%) detected in the Aegean region was significantly higher compared to Mediterranean Region ($P=0.000$). The genus *Hyalomma* (Koch, 1844), like all other tick species, has a great importance for human as well as animal health (15). *Hyalomma marginatum* is a characteristic species of steppe, savannah and

lightly wooded hill and valley biotopes with fairly low humidity (16). In the present study, *H. marginatum* was found to be the most prevalent adult ticks collected on humans and the highest prevalence was detected in Aegean region. Obtained results in Aegean region were in parallel with the previous studies (4,5). The micro and macro habitat of the Aegean Region provides a good environment for this tick species.

In the present study the adult forms of *H. aegyptium* are also detected on humans. In general, the larvae and nymph forms of *H. aegyptium* feed on partridges, lizards and a wide variety of rodents and the adults feed on turtles (17). However, number of reports on human infestation by *H. aegyptium* are increasing (2,5,6). This fact is highlight the importance of *H. aegyptium* for both human and animal health as they are shown to be the vector of pathogens like *Borrelia burgdorferi*, *Borrelia turcica*, *Theileria annulata*, *Pasteurella tularensis*, *Rickettsia aeschlimannii* (18). It should be noted the presence of *B. turcica*, *R. africae* and *R. aeschlimannii* were shown in *H. aegyptium* and *H. marginatum* in Turkey in previous studies form (19,20).

This study was also indicated that *Hyalomma* spp. especially *H. marginatum* were detected more often in rural area than that in urban areas (Table 1). These findings are in accordance with the previous studies that *H. marginatum* adults which are known to be abundant in rural areas (10). *Hyalomma rufipes*, another tick species detected in the present study (only İzmir province), is a rare species and restricted in Aegean, Central and Marmara Regions of Turkey. However, *Hyalomma rufipes* was previously found on cattles in Manisa and İzmir provinces (20) and on horses in Bursa province (6). In Turkey, the first human infestation by *H. rufipes* which is believed to be the carrier of the Crimean-Congo hemorrhagic fever in Africa (21) was detected in Amasya province (22) where this disease is endemic (23).

The current study demonstrated that *Rhipicephalus* species were found to be the second most abundant ticks biting on humans, following *Hyalomma* species (Table 1). Data gathered in the

present study, *Rhipicephalus (Boophilus) annulatus* species could not be determined on humans in all provinces, whereas was previously found on cattles in Burdur province (24) and on dogs in Antalya province (25). The unexistence of some species such as *R. (B.) annulatus* on human, could be explain with high host specificity and one-host biology (26). During the study, *R. bursa* was commonly found on humans, particularly in Antalya province (Table 1). Not only the present study but also the previous studies showed that *R. bursa* is one of the tick species often found on humans in Turkey (5,22). *Rhipicephalus bursa* and *R. turanicus* caused more biting cases in rural areas 67.54% and 65.07% respectively, whereas *R. sanguineus* caused more biting cases in urban areas (69.23%) (Table 1). The reason for this may be related to the fact that ticks of *R. sanguineus* are urban areas to support population of these ticks. On the other hand, *R. bursa* is a two-host species preferring ruminants (especially sheep), and its biology is mostly restricted to rural areas (10). It was indicated in previous studies that *R. bursa* carries several pathogens like *R. aeschlimannii* and CCHF (20,23).

There are 244 *Ixodes* species known to exist throughout the world. Among these, 63 species (26%) have been recorded as feeding on humans (3). In this study we encountered 13 *Ixodes ricinus*, nine *Ixodes* spp. nymphs and one *Ixodes* spp. larva (Table 1). *Ixodes ricinus* was previously found on sheep in Burdur province (24), on humans in İzmir province (27), on cattles in Manisa and İzmir province (14) and on goats in Antalya province (28). It is the main tick vector involved in the Tick-borne encephalitis virus (TBEV) infections in Europe (29). In addition, *Anaplasma phagocytophilum* was detected in cattle and sheep in the Middle and Eastern Black Sea Regions of Turkey where its potential vector, *I. ricinus*, is also widespread (30). The presence of *A. phagocytophilum* and *R. monacensis* was also demonstrated in *I. ricinus* collected from human in Turkey (20,30). Similar to *Hyalomma* spp., the proportion of *I. ricinus* bites in the present study was much higher in rural areas (84.61%) than that observed in urban areas (15.39%). The genus *Dermacentor* now has 35 species in the world. Notedly, it was demonstrated that 23 (66%) of the *Dermacentor* species have been feeding on humans. (3). In the present study, we encountered 19 adult *D. marginatus* and one *Dermacentor* spp. nymph on humans in all provinces except Denizli and Manisa province (Table 1). *Dermacentor marginatus* bite rate was also higher in rural areas in comparison to that observed in urban areas (68.42 % vs. 31.58%). *Dermacentor marginatus* is limited to areas with dense vegetation and trees in the Mediterranean region of Europe (10). It favours ecologically the areas under Oak and Pine plant cover. This situation would be an explanation, partly, why *D. marginatus* was not found in Denizli and Manisa provinces in which the ecology is not suitable for this tick species. *Dermacentor marginatus* was previously found on cattle, sheep and goats in Burdur province (24), on humans and cattle in İzmir province (14,27) and on goats in Antalya province (28). *Dermacentor marginatus* is a recognized vector for *Coxiella burnetii*, *Rickettsia conorii*, *R. slovaca*, *R. sibirica* (16). Furthermore, the presence of *R. raoultii* was also demonstrated in *D. marginatus* collected from human in Turkey (20). It has been reported that *R. raoultii* species was previously detected in a *D. marginatus* that bite humans who developed TIBOLA/DEBONEL symptoms (20).

CONCLUSION

Taken together, the results obtained in the present study indicate that the prevalence and distribution of tick species on humans are common in the Aegean and Mediterranean regions where the study was conducted. The data suggest that tick species, especially *H. marginatum*, *R. bursa*, *R. turanicus* and *H. aegyptium* as well as nymphs of *Hyalomma* spp. can feed on humans more commonly than other tick species and developmental stages. The studies like the present one on monitoring of the tick bite exposure to human provide valuable information for determining the risk level of the tick borne diseases in a given area humans.

* Ethics

Ethics Committee Approval: In this study, ethical committee approval was not obtained due to the samples were taken from the patients who admit to some health facilities with complaining tick bites and sent to our department for identification.

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* Authorship Contributions

Surgical and Medical Practices: S.B., N.A., H.B.B., T.K., Concept: S.B., N.A., H.B.B., S.H., H.E., T.K., Design: S.B., N.A., H.B.B., S.H., H.E., T.K., Data Collection or Processing: S.B., N.A., S.H., T.K., Analysis or Interpretation: S.B., H.B.B., T.K., Literature Search: S.B., N.A., H.B.B., T.K., Writing: S.B.

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REFERENCES

1. Klompen JSH, Black WC, Keirans JE, Jr. Oliver JH. Evolution of ticks. *Annu Rev Entomol* 1996;41:141-61.
2. Keskin A, Keskin A, Bursali A, Tekin S. Ticks (Acari: Ixodida) parasitizing humans in Çorum and Yozgat provinces, Turkey. *Exp Appl Acarol* 2015;67:607-16.
3. Guglielmone AA, Robbins RG, Apanaskevich DA, Petney TN, Estrada-Penã A, Horak IG. The hard ticks of the world (Acari: Ixodida: Ixodidae). 1st ed. New York London: Springer Dordrecht Heidelberg; 2014.
4. Bursali A, Keskin A, Tekin S. A review of the ticks (Acari: Ixodidae) of Turkey: species diversity, hosts and geographical distribution. *Exp App Acarol* 2012;57:91-104.
5. Bakirci S, Aysul N, Eren H, Unlu AH, Karagenc T. Diversity of ticks biting humans in Aydın province of Turkey. *Ank Univ Vet Fak Derg* 2014;61:93-8.
6. Kar S, Dervis E, Akın A, Ergonul O, Gargili A. Preferences of different tick species for human hosts in Turkey. *Exp Appl Acarol* 2013;61:349-55.
7. Sonenshine DE and Roe RM. Overview: Ticks, People, and Animals. In: Sonenshine DE and Roe RM, editors. *Biology of ticks*. Volume I. 2nd ed. Oxford University Press: New York; 2014. p.3-16.
8. Gargılı A, Kar S, Yilmazer N, Cerit C, Sonmez G, Sahin F, et al. Evaluation of ticks biting humans in Thrace Province, Turkey. *Kafkas Univ Vet Fak Derg* 2010;16:141-6.
9. Gargılı A, Kar S, Yilmazer N, Ergonul O, Vatanserver Z. Different abundances of human-biting ticks in two neighboring provinces in Turkey. *Kafkas Univ Vet Fak Derg* 2011;17(Suppl A):93-7.
10. Estrada-Pena A, Bouattour A, Camicas JL, Walker AR. Ticks of domestic

- animals in the Mediterranean Region: a guide to identification of species. Spain: University of Zaragoza; 2004.
11. Durden LA and Beati L. Modern Tick Systematics. In: Sonenshine DE and Roe RM, editors. Biology of ticks. Volume I. 2nd ed. Oxford University Press: New York; 2014. p.17-58.
 12. Bakırcı S, Aktaş M, Vatanserver Z, Aydın L. Keneler (Acarina: *Ixodidae* / *Argasidae*) Vektörlükleri ve Mücadelesi. In: Ozbel Y, editors. Vektör Artropodlar ve Mücadelesi. Türkiye Parazitoloji Derneği, Yayın No: 25, (E-kitap), ISBN: 978-605-87556-6-6, İzmir, 2017. p.427-466. (article in Turkish)
 13. Parola P and Raoult D. Ticks and tick-borne bacterial diseases in humans: An emerging infectious threat. *Clin Infect Dis* 2001;32:897-928.
 14. Ghosh S, Azhahianambi P, de la Fuente J. Control of ticks of ruminants, with special emphasis on livestock farming systems in India: present and future possibilities for integrated control—a review. *Exp Appl Acarol* 2006;40:49-66.
 15. Bakırcı S, Saralı H, Aydın L, Eren H, Karagenç T. Distribution and seasonal activity of tick species on cattle in the West Aegean region of Turkey. *Exp Appl Acarol* 2012;56:165-78.
 16. Farkas R, Estrada-Pena A, Jaenson TGT, Pascucci I, Maddler M. Basic biology and geographical distribution of tick species involved in the transmission of animal pathogens, including zoonoses. In: Salman M and Tarrés-Call J, editors. Ticks and tick-borne diseases geographical distribution and control strategies in the Euro-Asia Region. CAB: Boston; 2013. p.6-26.
 17. Široký P, Erhart J, Petrzalová KJ, Kamler M. Life cycle of tortoise tick *Hyalomma aegyptium* under laboratory conditions. *Exp Appl Acarol* 2011;54:277-84.
 18. Kireççi E, Özer A, Balkaya İ, Tanış H, Deveci S. Identification of ticks on tortoises (*Testudo graeca*) and investigation of some pathogens in these ticks in Kahramanmaraş, Turkey. *KSÜ Doğa Bil Derg* 2013;16:42-6.
 19. Orkun Ö, Karaer Z, Çakmak A, Nalbantoğlu S. Identification of tick-borne pathogens in ticks feeding on humans in Turkey. *PLOS Neglect Trop D* 2014;8:e3067.
 20. Gargılı A, Palomar AM, Midilli K, Portillo A, Kar S, Oteo JA. *Rickettsia* species in ticks removed from humans in Istanbul, Turkey. *Vector Borne Zoonotic Dis* 2012;12:938-41.
 21. Bakırcı S, Saralı H, Aydın L, Latif A, Eren H, Karagenç T. *Hyalomma rufipes* (Koch, 1844) infesting cattle in the West Aegean Region of Turkey. *Turk J Vet Anim Sci* 2011;35:359-63.
 22. Turell MJ. Role of ticks in the transmission of Crimean-Congo hemorrhagic fever virus. In: Ergonul O and Whitehouse CA, editors. Crimean-Congo Hemorrhagic Fever A Global Perspective, Volume XII. Dordrecht: Springer; 2007. p.143-54.
 23. Bursalı A, Tekin S, Keskin A, Ekici M, Dundar E. Species diversity of ixodid ticks feeding on humans in Amasya, Turkey: seasonal abundance and presence of Crimean-Congo hemorrhagic fever virus. *J Med Entomol* 2011;48:85-93.
 24. Tekin S, Bursalı A, Mutluay N, Keskin A, Dundar E. Crimean-Congo hemorrhagic fever virus in various ixodid tick species from a highly endemic area. *Vet Parasitol* 2012;186:546-52.
 25. Yukarı BA and Umur Ş. The prevalence of tick species (Ixodoidea) in cattle, sheep and goats in the Burdur Region, Turkey. *Turk J Vet Anim Sci* 2002; 26: 1263-1270 (article in Turkish with an English abstract).
 26. Koç S, Aydın L, Cetin H. Tick species (Acari: Ixodida) in Antalya city, Turkey: species diversity and seasonal activity. *Parasitol Res* 2015;114:2581-6.
 27. Över L, İnceboz T, Yapar N, Bakırcı S, Gunay T, Akisu C. Investigation of the cases presenting to Dokuz Eylül University hospital with tick bites. *Türkiye Parazitoloj Derg* 2012; 36: 75-81 (article in Turkish with an English abstract).
 28. Tuncer D, Mutlu G, Karaer Z, Sayin F, Tuncer LB. Seasonal occurrence of ticks on goats and *Borrelia burgdorferi* influence in *Ixodes ricinus* in Antalya region. *Türkiye Parazitoloj Derg* 2004;28:158-60.
 29. Ergünay K, Saygan MB, Aydoğan S, Litzba N, Sener B, Lederer S, et al. Confirmed exposure to tick-borne encephalitis virus and probable human cases of tick-borne encephalitis in Central/Northern Anatolia, Turkey. *Zoonoses Public Health* 2011;58:220-27.
 30. Aktaş M, Vatanserver Z, Altay K, Aydın MF, Dumanlı N. Molecular evidence for *Anaplasma phagocytophilum* in *Ixodes ricinus* from Turkey. *Trans R Soc Trop Med Hyg* 2010;104:10-5.