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RESEARCH ARTICLE

Ixodid Ticks (Ixodoidea: Ixodidae) Infesting Wild Animals in Hatay, Türkiye

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ABSTRACT

Wild animals play an important role as amplifiers and/or reservoir hosts in the ecology of many ticks and tick-borne pathogens affecting livestock and humans. In this study, which was carried out in the Hatay province, the southernmost region of Anatolia, a total of 362 (210♀, 146 ♂, 6N) tick specimens were collected from 18 wild animals from 7 species, including white stork *(Ciconia ciconia)* (n = 1), roe deer *(Capreolus capreolus)* (n = 5), badger *(Meles meles)* (n = 2), jackal *(Canis aureus)* (n = 3), red fox *(Vulpes vulpes)* (n = 5), hare *(Lepus europaeus)* (n = 1), and wild goat *(Capra aegagrus)* (n = 1), which were obtained between 2014 and 2022. The collected ticks were identified according to morphological criteria at the level of species as *Amblyomma lepidum, Dermacentor marginatus, Haemaphysalis erinacei, Haemaphysalis inermis, Haemaphysalis kopetdaghica, Ixodes gibbosus, Ixodes kaiseri, Ixodes ricinus, Rhipicephalus kohlsi, Rhipicephalus rossicus*, and *Rhipicephalus turanicus*. With this study, *A. lepidum* was reported for the first time in Türkiye, while *R. rossicus* detected in roe deer was reported for the first time in wild animals, and the lesser-known/rare tick *H. kopetdaghica* was reported for the second time in wild goats where it was previously reported.

Keywords: *Amblyomma lepidum*, *Haemaphysalis kopetdaghica*, *Rhipicephalus rossicus*, Tick, Türkiye, Wild animals

INTRODUCTION

Human intervention in the habitats of wild animals increases contact between wild animals, livestock, and humans. Accordingly, many vector-borne bacterial, viral, and parasitic pathogens in wild animals may pose a threat to livestock and human [1]. Blood-sucking vectors, such as ticks, cause pathogens to spread among wildlife and urban life [2]. Ticks, which are the most important vector of pathogens that cause diseases in animals, are considered the most important vector of disease for humans after mosquitoes [3]. Ticks are of great importance in health research, not only because of their role in transmitting pathogenic agents to their hosts but also because they cause blood loss and tick paralysis in their hosts [4].

It is known that most wild animals are suitable hosts for ticks and play a reservoir and/or carrier role in the ecology of tick-borne pathogens affecting livestock and humans [4]. Even when their population density is low, these animals stimulate the reproduction of ticks, causing their numbers to increase and thus the spread of tick-borne pathogens [5]. Many tick-borne diseases have occurred from the past to the present, and new pathogens have been identified and continue to be identified. Lyme disease, Crimean-Congo hemorrhagic fever, tick-borne encephalitis, spotted fever group (SFG) rickettsiosis, babesiosis, theileriosis, and anaplasmosis are some of the significant tick-borne pathogens [6].

Studies and data on ticks and tick-borne pathogens in wild animals are relatively scarce. The most significant reason for this situation is that these animals, many of which (especially large mammals) are protected by law, and they are difficult to track down or catch [7]. Therefore, examining wild animals that are injured, hunted, or dead in any way in terms of tick infestations is very essential [8].

Türkiye is a country suitable for the inhabitation of ticks in terms of its sub-tropical climate zone, vegetation, domestic and wild animal diversity. The first studies reporting the presence of ticks in wild animals in Türkiye were based on individual or incidental cases. Recent studies have focused on investigating tick-host relationships [9,10] as well as pathogen relationships [6,8,11]. However, in Türkiye, where the diversity of wild animals is relatively high, there is a need for studies to reveal the presence of ticks and tick-borne pathogens [11].

This study aimed to identify tick species that infest some wild animals obtained from the Hatay province and to contribute to the tick fauna of Türkiye. First aid, treatment, intensive care, and rehabilitation services for wild animals injured or sick due to various reasons (such as traffic accidents, firearms, and trauma) in the Hatay province are carried out at Hatay Mustafa Kemal University (HMKU) Veterinary Health, Application and Research Hospital and HMKU Wild Animal Rescue and Rehabilitation Center.

Material and Methods

Ethical Approval

This study was approved by the decision of the Hatay Mustafa Kemal University Animal Experiments Local Ethics Committee (2022/07-08) and Directorate of Nature Conservation and National Parks (13/07/2023-287402).

Features of the Study Areas

Hatay, which is located at the eastern end of the Mediterranean Region and is a border province, is located between 35°52′ and 37°04′ north latitudes and 35°40′ and 36°35′ east longitudes with a surface area of 5403 km². The province is surrounded by Syria to the south and east, Gaziantep and Kilis to the northeast, Osmaniye and Adana to the north and northwest, and the Mediterranean Sea to the west [12]. Hatay province, which has a Mediterranean climate with hot and dry summers and warm and rainy winters, is surrounded by the Amik plain, in which the Asi River is located, and Amanos and Kızıl Mountains [13]. Hatay region is one of the most special areas of Türkiye in terms of biodiversity with its location and different habitat types [14].

Collection and Identification of Tick Specimens

This study was conducted in the Hatay between 2014-2022. Ixodid tick samples, which constitute the material of the study, were collected from 18 wild animals from a total of 7 species, including white stork *(Ciconia ciconia)* (n = 1), roe deer *(Capreolus capreolus)* (n = 5), badger *(Meles meles)* (n = 2), jackal *(Canis aureus)* (n = 3), red fox *(Vulpes vulpes)* (n = 5), hare *(Lepus europaeus)* (n = 1), and wild goat *(Capra aegagrus)* (n = 1) *(Table 1)*. The whole body of the wild animals brought to HMKU Veterinary Health, Application and Research Hospital and Wild Animal Rescue and Rehabilitation Center as injured, sick, or dead was carefully examined for tick infestation. The detected ticks were collected into vials containing 70% ethyl alcohol, and then sent to Ankara University, Faculty of Veterinary Medicine, Ticks and Tick-Borne Diseases Research Laboratory for species identification. The obtained ticks were diagnosed at the species level using their morphological characteristics under a stereomicroscope (Stemi 2000-C, Zeiss, Germany) equipped with an AxioCam digital camera and ZEN software with the help of species-specific taxonomic keys [15-21].

Results

A total of 362 tick samples [210♀, 146♂, 6 nymph (N)] were collected: 1 from the white stork, 131 from roe deer, 13 from badgers, 159 from jackals, 23 from red foxes, 27 from hares, and 8 from wild goats. According to the results of morphological analysis, 11 tick species were identified, including, *Amblyomma lepidum* (1♂), *Dermacentor marginatus* (1♀), *Haemaphysalis erinacei* (1♂), *Haemaphysalis inermis* (2♂, 3♀), *Haemaphysalis kopetdaghica* (1♀), *Ixodes gibbosus* (2♂, 4♀), *Ixodes kaiseri* (4N, 13♀), *Ixodes ricinus* (2N, 34♂, 56♀), *Rhipicephalus kohlsi* (1♀), *Rhipicephalus rossicus* (21♂, 12♀), and *Rhipicephalus turanicus* (85♂, 119♀) *(Fig. 1)*. Of these species belonging to the family Ixodidae, *A. lepidum* is detected only in white stork, *I. ricinus, H. inermis, R. rossicus,* and *D. marginatus* only in roe deer, *H. erinacei* only in the red fox, *I. gibbosus, H. kopetdaghica,* and *R. kohlsi* species are detected only in wild goats, while *I. kaiseri* was detected in two different hosts (badger and red fox), and *R. turanicus* species was detected in four different hosts (badger, jackal, fox, and hare). As a result, it was determined that *R. turanicus* and *I. kaiseri* from 11 tick species were infested in more than one host species, while the other 9 species were determined to be infested in only one host species.

Of the wild animals, 61.11% (11/18) were infested with a single tick species, 27.77% (5/18) with 2 tick species, and 11.11% (2/18) with 3 tick species. Those found as a single species were *A. lepidum* (stork), *R. turanicus* (hares), *I. ricinus* (1 roe deer), *R. turanicus* (1 badger), *R. turanicus* (3 jackals), and *H. erinacei, I. kaiseri, R. turanicus,* and *R. turanicus* (4 foxes). Two different species found together were *I. ricinus* + *H. inermis* (2 roe deer), *D. marginatus* + *R. rossicus* (1 roe deer), and *I. kaiseri* + *R. turanicus* (1 badger and 1 fox). Three different species found together were *I. ricinus* + *H. inermis* +*R. rossicus* (1 roe deer), and *I. gibbosus* + *H. kopetdaghica* + *R. kohlsi* (wild goat).

Rhipicephalus turanicus was the most abundant species in the study, with 56.35% (204/362) followed by *I. ricinus*

***Table 1**. Tick species, numbers and sexes infesting some wild animals in Hatay region*

Wild Animal Species and Numbers (n)	Tick Species	Tick Number and Gender	Total
Ciconia ciconia (n = 1)	*A. lepidum*	1 (1 ♂)	1
Capreolus capreolus (n = 5)	*I. ricinus* *H. inermis*	6 (4 ♂, 2 ♀) 1 (1 ♀)	7
	I. ricinus *H. inermis*	60 (2 N, 20 ♂, 38 ♀) 2 (1 ♂, 1 ♀)	62
	I. ricinus *H. inermis* *R. rossicus*	23 (10 ♂, 13 ♀) 2 (1 ♂, 1 ♀) 6 (5 ♂, 1 ♀)	31
	D. marginatus *R. rossicus*	1 (1 ♀) 27 (16 ♂, 11 ♀)	28
	I. ricinus	3 (3 ♀)	3
Meles meles (n = 2)	*I. kaiseri* *R. turanicus*	11 (4 N, 7 ♀) 1 (1 ♂)	12
	R. turanicus	1 (1 ♂)	1
Canis aureus (n = 3)	*R. turanicus*	1 (1 ♀)	1
	R. turanicus	9 (3 ♂, 6 ♀)	9
	R. turanicus	149 (59 ♂, 90 ♀)	149
Vulpes vulpes (n = 5)	*I. kaiseri* *R. turanicus*	2 (2 ♀) 1 (1 ♀)	3
	H. erinacei	1 (1 ♂)	1
	I. kaiseri	4 (4 ♀)	4
	R. turanicus	8 (3 ♂, 5 ♀)	8
	R. turanicus	7 (1 ♂, 6 ♀)	7
Lepus europaeus (n = 1)	*R. turanicus*	27 (17 ♂, 10 ♀)	27
Capra aegagus (n = 1)	*I. gibbosus* *H. kopetdaghica* *R. kohlsi*	6 (2 ♂, 4 ♀) 1 (1 ♀) 1 (1 ♀)	8
Total (n = 18)	11 tick species	210 ♀, 146 ♂, 6 N	362

N; nymph

Fig 1. Dorsal and ventral views of ticks collected in this study. *Amblyomma lepidum* (a1: male-dorsal view, a2: male-ventral view), *Dermacentor marginatus* (b1: female-dorsal view, b2: female-ventral view), *Haemaphysalis erinacei* (c1: male-dorsal view, c2: male-ventral view), *Haemaphysalis inermis* (d1: female-dorsal view, d2: female-ventral view), *Haemaphysalis kopetdaghica* (e1: female-dorsal view, e2: female-ventral view), *Ixodes gibbosus* (f1: female-dorsal view, f2: female-ventral view), *Ixodes kaiseri* (g1: female-dorsal view, g2: female-ventral view), *Ixodes ricinus* (h1: female-ventral view, h2: female-dorsal view), *Rhipicephalus rossicus* (i1: female-dorsal view, i2: female-ventral view), *Rhipicephalus turanicus* (j1: female-dorsal view, j2: female-ventral view), and *Rhipicephalus kohlsi* (k1: female-dorsal view, k2: female-ventral view)

25.41% (92/362), *R. rossicus* 9.11% (33/362), *I. kaiseri* 4.69% (17/362), *I. gibbosus* 1.65% (6/362), and *H. inermis* 1.38% (5/362), respectively. *Amblyomma lepidum, D. marginatus, H. erinacei, H. kopetdaghica,* and *R. kohlsi* species were detected as one each and became the least common species *(Table 1)*.

Discussion

Wild mammals and migratory birds may have great potential for the spread of tick and tick-borne pathogens [7,22]. Therefore, it is very significant to examine these animals, which are important parts of wildlife, in terms of ticks and tick-borne pathogens [8]. However, it is quite difficult to track and catch these animals, which are preferred as hosts by many tick species in their ecological environments. Therefore, the determination and identification of ticks infesting on wild animals are extremely valuable in terms of understanding the ecology of ticks and their vector role in the spread of pathogens [23]. Since the mammal fauna consists of species of African and desert origin and species extending along the Anatolian cross-mountain range to the peaks of the Amanos, it is the richest region of Türkiye in terms of both mammal diversity and bird diversity since it is located on an important migratory bird route in the world [14,24].

In this study sampled from the Hatay province; 362 tick samples were collected from 18 wild animals from 7 species, 6 of which were mammals and 1 of which was migratory bird, and 11 tick species were identified. These species are *A. lepidum, D. marginatus*, *H. erinacei*, *H. inermis*, *H. kopetdaghica*, *I. gibbosus*, *I. kaiseri*, *I. ricinus*, *R. kohlsi*, *R. rossicus*, and *R. turanicus*.

Rhipicephalus turanicus, the most abundant species in this study, is one of the most common tick species in Türkiye that infests humans [25] and domestic animals [26,27]. The main hosts of this tick species, which is also common in wild animals, are wild and domestic ungulates, but birds and scaly reptiles are considered exceptional hosts [28]. In studies conducted in Türkiye, *R. turanicus* species have been identified in red deer, brown bear [8], red fox [8,9], hare [6,8], wild boar [6], some mouse, hedgehog and rodent species [9]. In the current study, *R. turanicus* was determined in four wild animals namely red fox, wild rabbit, badger, and jackal, and the host range was the widest species. The presence of this tick in red foxes [8,9] and wild hares [6,8] in Türkiye has been reported in previous studies.

Roe deer, one of the areas of distribution in Türkiye is the Amanos Mountains of Hatay and is classified among the species of "Minimum concern" according to the criteria of the World Union for Conservation of Nature (IUCN)[24]. In our study, *I. ricinus, H. inermis, R. rossicus*, and *D. marginatus* species were detected only in roe deer. *Ixodes ricinus*, the second most abundant species in this study, is one of the most significant vectors in Europe and has a wide range of hosts. This species, which can select a wide variety of mammalian species including birds, reptiles, and humans as hosts, plays a role as a competent vector in the transmission of pathogens such as tick-borne encephalitis virus, *Borrelia burgdorferi* sensu lato, *Anaplasma phagocytophilum, Rickettsia monacensis, R. helvetica, Babesia divergens,* and *B. microti* [29]. In studies conducted in Türkiye, *I. ricinus*, which is generally detected in domestic animals, has been reported in humans [30], sheep and goats [26], cattle [27], jackals, some small mammals such as rats, mice, and squirrels, rodents [9]. A point to be emphasized about this species, whose existence was once again detected in roe deer in this study, is the possibility that the specimens identified as *I. ricinus* actually represent *Ixodes inopinatus*, which is very closely related and sister species to *I. ricinus*. A very recently characterized tick species, *I. inopinatus*, is a species in the *I. ricinus* complex and is closely related to *I. ricinus* both morphologically and molecularly [31]. It has been reported that the morphological distinction of both species cannot be made precisely and even some of the molecular markers (e.g. 16S rDNA) is not sufficient to distinguish [32,33]. Therefore, our relevant specimens in this study have been identified as *I. ricinus* at this stage to avoid any confusion in the future. However, considering that *I. inopinatus* adapted to more arid geographies than *I. ricinus* and spread especially in the Mediterranean region and North Africa, and that it could even be found sympatric with *I. ricinus* in such regions [31-33], it should be underlined that the Hatay province is also a geography quite suitable for *I. inopinatus*. To clarify all these, detailed molecular analyses of *I. ricinus* spreading in this region are needed in the near future.

Haemaphysalis inermis is a species whose vector capacity is poorly known and is considered to carry several zoonotic agents [34]. The presence of *Theileria orientalis* and *Rickettsia* sp. has been reported [27] in this tick species collected from cattle [27] and humans [35] in Türkiye. *Rhipicephalus rossicus* is one of the vectors of the Crimean-Congo hemorrhagic fever virus, *Francisella tularensis,* and *Coxiella burnetii*. The presence of *R. rossicus*, another member of the *Rhipicephalus sanguineus* group, in Türkiye, was first reported by Pomerantzev [36]. Later, this tick species was identified in the Tunceli province. A total of 3 tick samples obtained from dogs, cows, and plant vegetation from domestic animals were determined to be *R. sanguineus* s.l. in their morphological analysis and *R. rossicus* species in their molecular analysis [37]. In this study, 33 (21♂, 12♀) species were detected in roe deer and this species was reported for the first time from wild animals in Türkiye as far as we know. *Dermacentor marginatus* is a species that lives in habitats generally above 1000 m, is cold-resistant and adults can be active at temperatures above 0°C [17]. In this study, where the temperate Mediterranean climate prevails and its altitude is not high, *D. marginatus* 1 (♀) was found to be one of the least common tick species. This species, which is one of the most common tick species in Türkiye, has been reported in different regions in humans [25,35] and domesticated [26,27] and wild animals [6].

Ixodes gibbosus, H. kopetdaghica, and *R. kohlsi* species were identified together in a wild goat in this study. *Ixodes gibbosus* is a relatively common but little-known tick species. It was named "*I. ricinus var. gibbosus*" by Nuttall in 1916 in adult tick samples collected from domestic goats in İzmir, Türkiye. This species was later reported morphologically in domestic goats and sheep [17] in countries located in the Mediterranean basin, in wild sheep *(Ovis orientalis ophion)* in Cyprus [11], in humans [35] in Türkiye, and in wild goats by the molecular method in addition to morphological identification [11]. *Haemaphysalis kopetdaghica* is one of the rare tick species and has been included in the list of endangered tick species because it has been detected in limited numbers from past to present [38]. First identified by Kerbabaev in a wild goat, a leopard, and a horse in the Kopet mountains of Turkmenistan, this species was later reported in a wild goat in Iran, two wild goats and a wild sheep in the Kopet Mountains, and a sheep in Tajikistan. *Haemaphysalis kopetdaghica* was rediscovered after a long time in two wild goats in Kemaliye, a mountainous district of Erzincan province in the Eastern Anatolia region, by morphological and molecular methods [11]. *Rhipicephalus kohlsi* is one of the tick species that is mostly native to small ruminants such as sheep and goats and does not

have wide distribution. This tick, which has a single-host life cycle, was first described in domestic goats and sheep in Jordan [19]. This species, which has been reported from sheep and goats in different countries including Türkiye, has been reported in cattle, horses, mules, camels, and roe deer in Israel. Also, this tick species has been detected in wild goats in Iran and in Türkiye. The wild goat, also known as bezoar, Anatolian bezoar, or bezoar ibex, is one of the important creatures of wildlife. This species of goats, whose populations are known to be significantly reduced, is known to be on the IUCN red list. *Haemaphysalis kopetdaghica, D. raskemensis, I. gibbosus, R. bursa*, and *R. kohlsi* [11] species has been reported in wild goats in Türkiye in previous study. In this study, one of the lesser/rarest species *I. gibbosus, H. kopetdaghica,* and *R. kohlsi* have been reported once again by being detected together in a wild goat. Considering that it is included in the endangered species list, the detection of *H. kopetdaghica* species in wild goats in this study is a significant finding in terms of its presence in Türkiye.

Ixodes kaiseri was detected in one badger and two red foxes in this study, with the second largest host range. This species, first described in the common Egyptian fox [10], completes parasitic life cycles in carnivores, porcupines, and rodents [39]. This tick species has been recorded in Türkiye in red foxes [10], dogs [40], jackals [9] and cave environment [41].

Haemaphysalis erinacei is a species that generally prefers small and medium-sized mammals, mainly hedgehogs as its host [17], but it can also infest carnivores, rodents, bats, and birds [28]. This tick species has been found in Türkiye in white-breasted hedgehogs, Arabian rabbits, red foxes, brown bears, lynx, rock marten, humans, and cave environments [41-43]. *Haemaphysalis erinacei* 1 (♂), one of the least common species in this study and previously reported from red foxes in Türkiye [9], has once again been identified in the red fox.

Amblyomma lepidum, more common in African countries, is one of the species belonging to the *Amblyomma* lineage [44]. This species, which has a great variety of hosts, has been reported to infest sheep, goats, cattle, camels, donkeys, horses, dogs, cats [45], and rarely birds [46]. This tick species, which is especially common in livestock, has been detected in the United Arab Emirates, Sudan, Somalia, Uganda, Ethiopia, Kenya, Tanzania, Israel [47], Azerbaijan [48], Cyprus [22], and Iran [46].

Among the exotic (non-native) tick species carried by migratory birds from Africa to Europe, *A. lepidum* [22] as been reported in Marabou stork in Uganda *(Leptoptilos crumeniferus)* [49], blackbird in Cyprus *(Turdus merula)* [22], and Norfolk plover *(Burhinus oedicnemus)* [48] in Azerbaijan. In our study, *A. lepidum* (1 ♂) species detected in a white stork was reported for the first time in Türkiye. Hatay province is an important area where migratory birds, including storks, enter Türkiye by following the valley formed by the Sinai mountains by moving along the Nile River after spending the winter in Central and Southern Africa [50]. The occurrence of this tick species in the Hatay, which is adjacent to Türkiye's border with Syria, has led to the idea that *Amblyomma* ticks of African origin can be carried through transport hosts such as migratory birds. In this regard, it will be useful to conduct studies on the presence of *Amblyomma* ticks in the region.

As a result, while *A. lepidum* detected in white storks in Türkiye was recorded for the first time with this study, *R. rossicus* species detected in roe deer were detected for the first time in wild animals, one of the lesser known/rare tick species, *H. kopetdaghica* was reported for the second time in wild goats, where it was previously reported. We believe that these data will contribute to the tick fauna of Türkiye and the relevant literature.

Availability of Data and Materials

The datasets used and/or analyzed during the current study are available from the corresponding author (A. Zerek) on reasonable request.

Financial Support

The authors declared that this study has received no financial support.

Ethical Approval

This study was approved by the decision of the Hatay Mustafa Kemal University Animal Experiments Local Ethics Committee (2022/07-08) and Directorate of Nature Conservation and National Parks (13/07/2023-287402).

Conflict of Interest

The authors have no conflicts of interest to declare.

Author Contributions

A.Z., İ.E., M.Y., M.E.A., and Ö.O.: Concept, Design, Supervision, Resources, Materials Data, Collection and/or Processing, Analysis and/or Interpretation, Literature Search, Writing and Critical Reviews

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