

Original Paper

Assessing the Influence of Seasonal and Climatic Variations on Livestock Tick Incidence in Tehran Province, Iran: Cross-Sectional Study

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Abstract

Background: Ticks are well-known ectoparasites of domestic animals, causing significant economic losses and playing a crucial role in the transmission of pathogens within the livestock industry worldwide, including in Iran. Understanding the distribution and diversity of ticks is essential for effective control strategies, especially in regions like Tehran province, where livestock plays a vital role in the economy.

Objective: This study aimed to determine the frequency and distribution of livestock ticks across different seasons and climatic zones in Tehran province.

Methods: In 2019, a total of 1623 domestic animals infested with ticks were examined, including chickens, sheep, camels, cows, pigeons, and dogs. A total of 806 ticks were collected, comprising 121 (15%) soft ticks and 685 (85%) hard ticks. Tick species were identified and categorized based on their occurrence in mountainous and plain climate regions.

Results: Out of the 806 collected ticks, 44.8% (n=361) were found in the mountainous region and 55.2% (n=445) were found in the plain region. The most abundant species was *Rhipicephalus sanguineus* (n=307, 38.1%), while *Rhipicephalus (Boophilus) annulatus* was the least common (n=3, 0.4%). Seasonal variation indicated peak infestation in the spring (n=486, 60.3%) and the lowest infestation in the winter (n=77, 9.6%).

Conclusions: The study highlights the significant diversity and abundance of both soft and hard ticks in livestock across various regions of Tehran province. These findings emphasize the need for targeted tick control measures, considering the differences in tick distribution between mountainous and plain climate regions.

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KEYWORDS

impact of climate; seasonal change; frequency; livestock; ticks; Tehran

Introduction

Ticks are of outstanding medical and veterinary importance because they transmit severe and dangerous diseases to humans and animals [1]. In humans, most diseases caused by spirochetes and rickettsia are transmitted by ticks. In addition, these arthropods cause severe diseases such as paralysis, encephalitis, and tularemia [2]. Moreover, ticks cause livestock financial losses worldwide and in Iran, where the annual impairment caused by ticks is estimated at US \$13.9 to US \$18.7 billion [3].

Ticks on livestock cause localized bite-site lesions and systemic effects. They can lead to anemia, paralysis, and even death by transmitting diseases like theileriosis and babesiosis [4]. On the other hand, global climate change has significantly impacted the stability and distribution of their life cycles [5], and climate conditions are the most critical factor determining tick distribution [6]. The tick-borne diseases associated with wildlife and climate change favor the re-emergence of diseases and the possible risk of the emergence of new ones [7-9].

Although the parasitic fauna of *Argasidae* and *Ixodidae* ticks and some of their ecological characteristics have been studied in a few areas of Iran [10], the various species from all regions of Iran in general and Tehran province in particular and especially the seasonal activity are not thoroughly studied. Tehran province is located between mountainous and plain regions [11]. Three factors—humid westerly winds, the province's extent, and the Alborz mountain range—play an essential role in Tehran province's climate. The Alborz mountain range has tempered the climate of Tehran province. It is mountainous: temperate in the north and semiarid in the lowlands. Tehran province features a diverse geography, encompassing mountainous and plain areas with distinct climates. In the mountainous region, such as Shemiranat, the average annual temperature ranges from 10 °C to 12 °C, with increased precipitation of 350 to 400 mm annually. Winters are cold, with substantial snowfall, while summers are mild. Conversely, the plain areas like Varamin have hotter conditions, averaging from 18 °C to 20 °C annually, with lower rainfall of 150 to 250 mm. These plains experience hot summers and milder winters, characterized by a semiarid climate [12,13].

This study was conducted to determine the seasonal and climatic frequency of tick species in Tehran province on the body surface of livestock, involving chickens, camels, cattle, dogs, pigeons, and sheep in different areas. The importance and current status of tick control in this region will become more evident when we know the distribution of ticks, their location, and presence in each region, and the epidemiological situation can be determined. In Tehran province, so far, not much research has been done on the climatic and seasonal distribution of different species of ticks.

Also, the published information about livestock infested with ticks in this area is not complete, so the purpose of this study is to provide an accurate scientific report of the situation of livestock infested with hard and soft ticks in different climates and during different seasons of the year; this information can be used in macroplanning to combat foreign parasites.

Methods

Geographical Area

The study was conducted in two different environments: plain and mountainous regions within 20 selected villages in Tehran province, which were located between 34° to 36.5° N and 50° to 53° E.

Sampling

The sample size was calculated using the Cochran formula for prevalence studies. Given an estimated prevalence (p) of 30% and a precision (d) of 4.5%, the final sample size was determined to be 800 ticks, ensuring statistical reliability [14]. To ensure representative sampling, a cross-sectional study was conducted, covering both mountainous and plain regions. The selection of livestock was randomized among those showing visible tick infestation, with veterinary supervision ensuring consistency in sample collection across different geographical zones. The chosen method aligns with established epidemiological studies on tick distribution.

$$n_0 = \frac{Z_{1-\alpha/2}^2 p(1-p)}{d^2}$$

The prevalence value ($p=0.3$) was selected based on prior studies on tick prevalence in similar regions in Iran, indicating an estimated infestation rate of 30%. The margin of error ($d=0.045$) was determined considering a 95% confidence level, ensuring a balance between precision and the feasibility of sample collection.

Study Area

The study was performed in two separate climatic zones, including 6 mountainous villages and 14 plain villages. After collecting geographical and ecological information, 1623 domestic animals were selected [14]. Using a cross-sectional study design, the distribution of ticks was studied in different study areas from spring to the end of winter of 2019. Ticks were collected using curved forceps from the host body (livestock's earlobes, groin, tail base, and back, and poultry's underarms, groin, and abdomen). To identify the collected ticks' genus and species, valid diagnostic keys were used [15]. The tick species were identified using the diagnostic keys outlined by Jongejan et al [15] and Camicas et al [16], which provide detailed morphological descriptions and illustrations for the identification of both soft and hard ticks. These keys are widely recognized for their accuracy and reliability in the identification of tick species in the Middle East and neighboring regions [16,17]. Based on the distribution of ticks in the study area, the prepared maps, the identification of infested carriers, climate conditions, and host animals of these tick species were analyzed, providing an understanding of the existing situation in the province [16-20]. Two professional stereo microscopes were used to identify tick species: the Leica S9i and the Zeiss Stemi 508. The Leica S9i has 10× to 60× magnification and includes a 10 megapixel camera, while the Zeiss Stemi 508 offers 8× to 50× magnification with superior optical quality. Both tools are essential for the detailed investigation of tick morphology in entomological research.

Results

Determining the Frequency of Livestock Ticks by Climate Type

In this study, 1623 domestic animals infested with ticks were studied, including chickens, camels, cattle, dogs, pigeons, and sheep. A total of 806 ticks were collected, and 685 (85%) and 121 (15%) of them were detected as hard ticks and soft ticks,

respectively. The distribution of collected ticks indicates that out of 806 collected ticks, 361 (44.8%) belonged to the mountainous region, and 445 (55.2%) belonged to the plain region (Table 1). In the mountainous region, the genus *Rhipicephalus*, with 51.2% (185/361), was the most frequent, and the genera *Hyalomma* and *Ornithodoros* were the least frequent. In the plain region, the genus *Hyalomma*, with 66.3% (295/445), was the most frequent, and the genera *Haemaphysalis* and *Boophilus* were the least frequent (Table 1).

Table 1. The number and frequency of ticks caught by genera according to climatic topography, Tehran province, 2019.

Genera	Mountainous region, n (%)	Plain region, n (%)	Total, n (%)
<i>Rhipicephalus</i> (n=307)	185 (60.3)	122 (39.7)	307 (100)
<i>Hyalomma</i> (n=295)	0 (0)	295 (100)	295 (100)
<i>Argas</i> (n=102)	93 (91.2)	9 (8.8)	102 (100)
<i>Haemaphysalis</i> (n=80)	80 (100)	0 (0)	80 (100)
<i>Ornithodoros</i> (n=19)	0 (0)	19 (100)	19 (100)
<i>Rhipicephalus</i> (<i>Boophilus</i>) (n=3)	3 (100)	0 (0)	3 (100)
Total (n=806)	361 (44.8)	445 (55.2)	806 (100)

Argas persicus from the genus *Argas*, *Rhipicephalus bursa* and *Rhipicephalus sanguineus* from the genus *Rhipicephalus*, and all species from the genera *Boophilus* and *Haemaphysalis* were found in the mountainous region of Tehran province. Among the ticks found in the mountainous region, *R sanguineus*, with 48.8% (176/361), was the most frequency. In comparison, *Rhipicephalus* (*Boophilus*) *annulatus*, with 0.8% (3/361), was the least frequent (*Hyalomma marginatum*, *Hyalomma asiaticum*, *Hyalomma dromedarii*, *Hyalomma anatolicum*, *Ornithodoros lahorensis*, *Argas reflexus*, and *Hyalomma detritum* were not found in the mountainous region). All *Ornithodoros* species, all *Hyalomma* species, *A reflexus*, and *R*

sanguineus were collected from the plain region. Among the tick species found in the plain region, *Hy marginatum*, with 34.3% (152/445), was the most frequent, and *Hy detritum*, with 1.3% (6/445), was the least frequent (*A persicus*, *Haemaphysalis sulcata*, *Haemaphysalis inermis*, *Haemaphysalis erinacei*, *R bursa*, and *R* (*B*) *annulatus* were not found in the plain region; Table 2).

The results show that 38.7% (628/1623) and 6.13% (995/1623) of studied animals belonged to the mountainous and plain regions, respectively (Table 3). Of the 230 infested animals, 97 (42.2%) and 133 (57.8%) belonged to the mountainous and plain regions, respectively.

Table 2. The number and frequency of ticks caught by species according to climatic topography, Tehran province, 2019.

Species	Mountainous region, n (%)	Plain region, n (%)	Total, n (%)
<i>Rhipicephalus sanguineus</i> (n=298)	176 (59.1)	122 (40.9)	298 (100)
<i>Hyalomma marginatum</i> (n=152)	0 (0)	152 (100)	152 (100)
<i>Argas persicus</i> (n=93)	93 (100)	0 (0)	93 (100)
<i>Hyalomma anatolicum</i> (n=21)	0 (0)	21 (100)	21 (100)
<i>Hyalomma dromedarii</i> (n=49)	0 (0)	49 (100)	49 (100)
<i>Hyalomma asiaticum</i> (n=67)	0 (0)	67 (100)	67 (100)
<i>Haemaphysalis sulcata</i> (n=47)	47 (100)	0 (0)	47 (100)
<i>Ornithodoros lahorensis</i> (n=19)	0 (0)	19 (100)	19 (100)
<i>Haemaphysalis inermis</i> (n=24)	24 (100)	0 (0)	24 (100)
<i>Haemaphysalis erinacei</i> (n=9)	9 (100)	0 (0)	9 (100)
<i>Argas reflexus</i> (n=9)	0 (0)	9 (100)	9 (100)
<i>Rhipicephalus bursa</i> (n=9)	9 (100)	0 (0)	9 (100)
<i>Rhipicephalus</i> (<i>Boophilus</i>) <i>annulatus</i> (n=3)	3 (100)	0 (0)	3 (100)
<i>Hyalomma detritum</i> (n=6)	0 (0)	6 (100)	6 (100)
Total (n=806)	361 (44.8)	445 (55.2)	806 (100)

Table 3. The number and frequency of animals infested by ticks in different climate regions, Tehran province, 2019.

Climate region	Collected ticks (n=806), n (%)	Infested animals (n=230), n (%)	Studied animals (n=1623), n (%)
Mountainous	361 (44.8)	97 (42.2)	628 (38.7)
Plain	445 (55.2)	133 (57.8)	995 (61.3)

When analyzing the data, it was found that domestic animals had the highest rate of tick infestation in the spring, while the lowest rate of infestation was observed in the winter. It indicates a seasonal variation in tick distribution and infestation rates among domestic animals. In the spring, all genera (except *Boophilus*) were found. The genera *Rhipicephalus* and

Hyalomma were distributed in the summer. In the autumn, the genus *Hyalomma* was the most abundant, and in the winter, the species *A persicus* (belonging to the family of soft ticks) had a high abundance (Table 4). The frequency of all 6 ticks (4 hard ticks and 2 soft ticks) in different seasons of the year is described below.

Table 4. The number and frequency of ticks caught according to the season (n=806), Tehran province, 2019

Species	Seasons				
	Spring, n	Summer, n	Autumn, n	Winter, n	Total, n (%)
<i>Rhipicephalus sanguineus</i>	251 (31.1)	23 (2.9)	18 (2.2)	6 (0.7)	298 (37)
<i>Hyalomma marginatum</i>	74 (9.2)	53 (6.6)	14 (1.7)	11 (1.4)	152 (18.8)
<i>Argas persicus</i>	34 (4.2)	0 (0)	41 (5.1)	18 (2.2)	93 (11.5)
<i>Hyalomma asiaticum</i>	33 (4.1)	22 (2.7)	9 (1.1)	3 (0.4)	67 (8.3)
<i>Hyalomma dromedarii</i>	11 (1.4)	13 (1.6)	7 (0.9)	18 (2.2)	49 (6.1)
<i>Haemaphysalis sulcata</i>	28 (3.5)	15 (1.9)	0 (0)	4 (0.5)	47 (5.8)
<i>Hyalomma anatolicum</i>	14 (1.7)	0 (0)	0 (0)	7 (0.9)	21 (2.6)
<i>Ornithodoros lahorensis</i>	12 (1.5)	3 (0.4)	4 (0.5)	0 (0)	19 (2.4)
<i>Haemaphysalis erinacei</i>	9 (1.1)	0 (0)	0 (0)	0 (0)	9 (1.1)
<i>Haemaphysalis inermis</i>	12 (1.5)	0 (0)	12 (1.5)	0 (0)	24 (3)
<i>Argas reflexus</i>	3 (0.4)	0 (0)	6 (0.7)	0 (0)	9 (1.1)
<i>Rhipicephalus bursa</i>	3 (0.4)	0 (0)	0 (0)	6 (0.7)	9 (1.1)
<i>Rhipicephalus (Boophilus) annulatus</i>	0 (0)	3 (0.4)	0 (0)	0 (0)	3 (0.4)
<i>Hyalomma detritum</i>	2 (0.2)	0 (0)	0 (0)	4 (0.5)	6 (0.7)
Genera	13 (N/A) ^a	7 (N/A)	8 (N/A)	9 (N/A)	14 (N/A)
Total	486 (60.3)	132 (16.4)	111 (13.8)	77 (9.6)	806 (100)

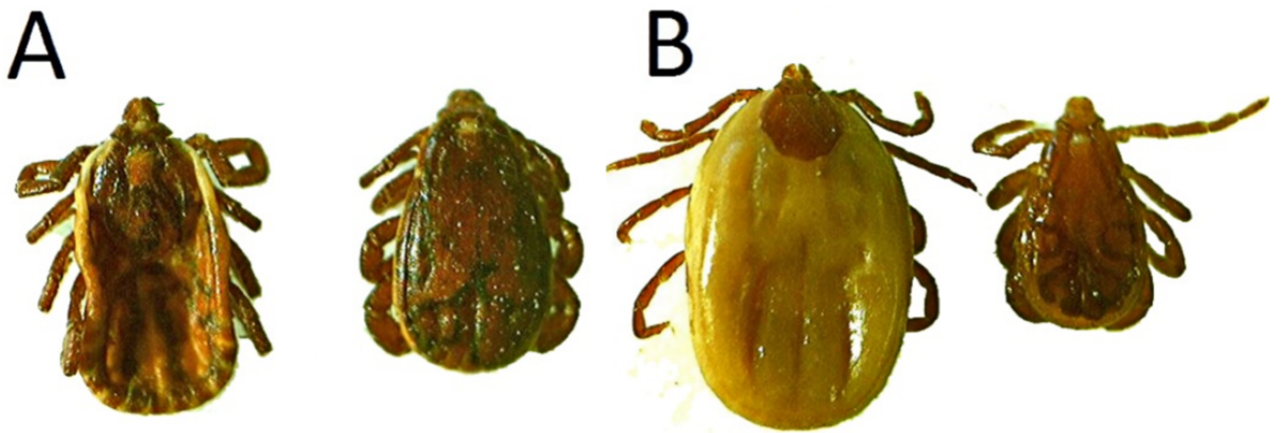
^aN/A: not applicable.

Seasonal Activity and Fauna of *Rhipicephalus* (Hard Ticks)

In this study, 307 ticks of the genus *Rhipicephalus* were caught, which was 38.1% (307/806) of the total sample collected (the

highest frequency among the genera). *R sanguineus* of this genus was caught in all seasons, while *R bursa* was only caught in the spring and winter (Figure 1).

Figure 1. Rear view of (A) *Rhipicephalus sanguineus* (male on the right and female on the left) and (B) *Rhipicephalus bursa* (original; male on the right and female on the left).

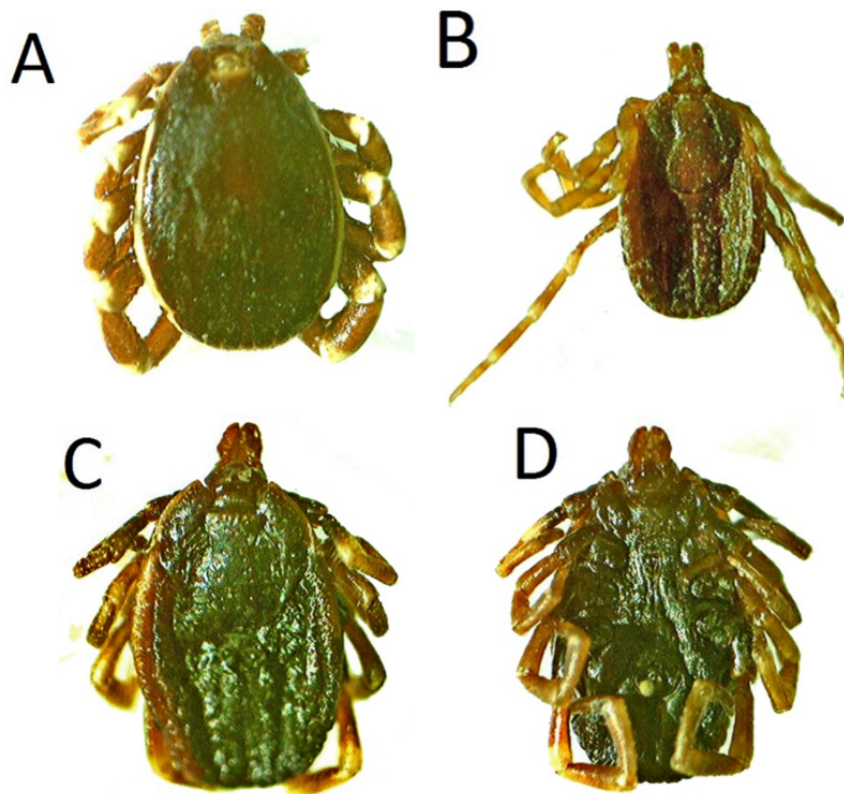


Seasonal Activity and Fauna of Hyalomma (Hard Ticks)

The genus *Hyalomma*, with 295 ticks, was the second most abundant genus, accounting for 36.6% (295/806) of the total

sample. *Hy marginatum*, *Hy asiaticum*, and *Hy dromedarii* were caught in all seasons, but *Hy anatolicum* and *Hy detritum* were only caught in the spring and winter (Figure 2).

Figure 2. Rear view of (A) male and (B) female *Hyalomma marginatum*; and (C) dorsal view and (D) abdominal view of female *Hyalomma detritum* (original).

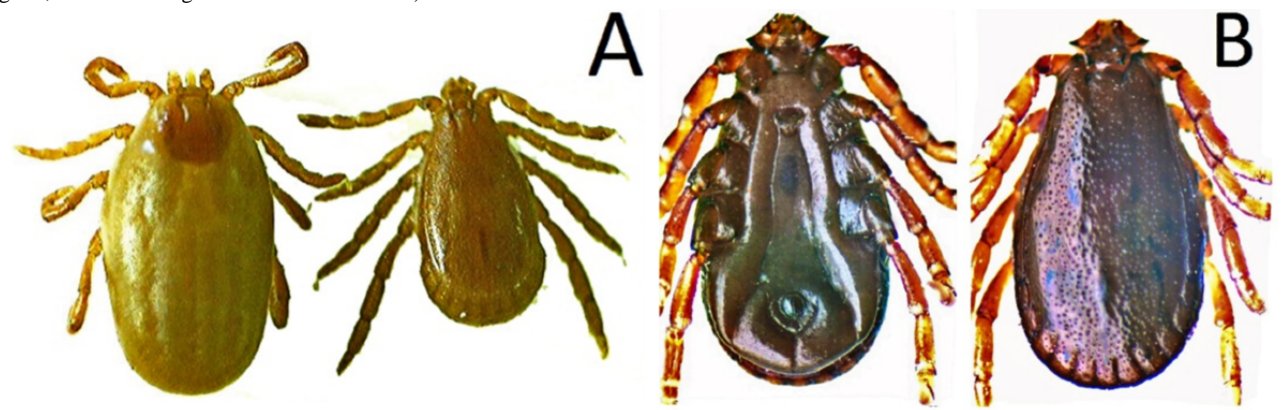


Seasonal Activity and Fauna of Haemaphysalis (Hard Ticks)

The genus *Haemaphysalis* was the third genus of the hard tick family detected in this study, and it has 3 species of *Hae sulcata*,

Hae inermis, and *Hae erinacei*; a total of 80 ticks were caught, with a frequency of 9.9% (80/806). *Hae sulcata* was found in all seasons except for autumn, *Hae inermis* was found in the spring and autumn, and *Hae erinacei* was only caught in the spring (Figure 3).

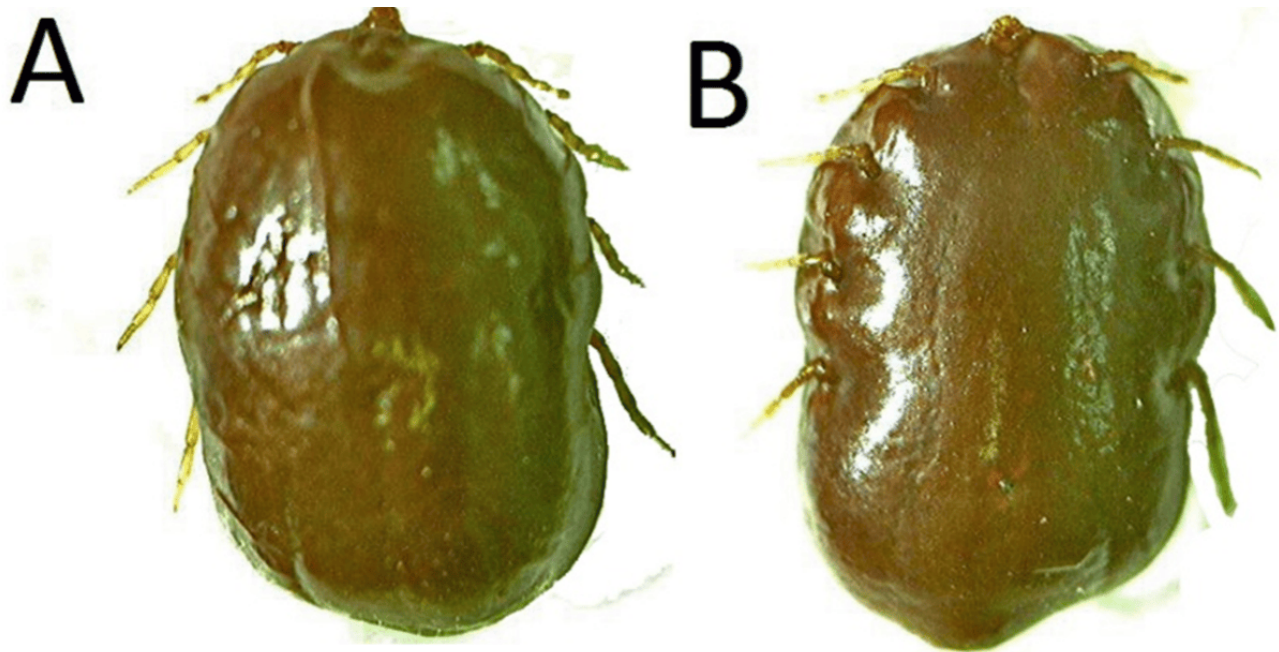
Figure 3. (A) Rear view of *Haemaphysalis sulcata* (male on the right and female on the left) and (B) abdominal view of *Haemaphysalis erinacei* (original; male on the right and female on the left).



Seasonal Activity and Fauna of Rhipicephalus (Boophilus) (Hard Ticks)

In this study, the genera *Boophilus* was only caught in the summer with 1 species, *R (B) annulatus*, with an abundance of 3 ticks (Figure 4).

Figure 4. (A) Rear view and (B) abdominal view of female *Rhipicephalus (Boophilus) annulatus* (engorged; original).



Seasonal Activity and Fauna of Argas and Ornithodoros (Soft Ticks)

In this study, 121 (15% of the total 806) ticks belonging to the soft tick family were caught, which included the genus *Argas* with 2 species, *A persicus* and *A reflexus* (102/121, 84.3%), and

the genus *Ornithodoros* with only 1 species, *O lahorensis* (19/121, 15.7%). *A persicus* was caught in all seasons except for the summer, *A reflexus* was caught in the spring and autumn, and *O lahorensis* was caught in all seasons except for the winter (Figures 5 and 6).

Figure 5. (A) Rear view and (B) abdominal view of *Argas persicus* (original).



Figure 6. (A) Rear view and (B) abdominal view of *Ornithodoros lahorensis* (original).



Discussion

Principal Findings

This study is the only codified and comprehensive study on *Ixodidae* and *Argasidae* ticks and their climatic and seasonal activities during 2019 in Tehran province. The *Ixodes* genus was not found in our study because this genus is more distributed in the country's northern provinces, such as Gilan, Mazandaran, and Golestan provinces [21].

A study in Pakistan confirmed the dominance of the tick species of *R. (B) annulatus* and *Hy anatolicum*, also prevalent in Tehran

province, particularly impacting sheep and cattle. In contrast, a study done in Turkey highlighted that *Ixodes ricinus* is predominantly found in humid regions, which differs from Tehran province's dry climate. Studies from India are also aligned with the findings from Tehran province, showing *R. sanguineus* as the most common species. Conversely, Japan reported *Haemaphysalis longicornis* as the most frequent species, influenced by temperate climates. Southern Europe exhibits some similarities with Tehran province, particularly regarding *R. sanguineus*; however, it shows higher *I. ricinus* prevalence. Northern Europe shows a dominance of *I. ricinus* due to temperate climates, differing from Tehran province's dry conditions. In North Africa, tick species like *Hy anatolicum* can

be found, which aligns with the findings from Tehran province, while sub-Saharan Africa presents contrasting species like *Amblyomma variegatum*, which thrive in humid climates. Overall, the analysis emphasizes how climate and ecology influence tick species composition and host preferences across regions [22-28].

The observed seasonal trend aligns with the biological cycles of tick species. Hard ticks such as *R sanguineus* and *Hymarginatum* exhibited peak abundance in the spring and summer due to higher temperatures and increased host activity. Conversely, soft ticks (*Apersicus*) showed resilience during colder months, likely due to their ability to survive in sheltered environments. This seasonal variability highlights the importance of targeted tick control strategies, particularly in warm seasons when the transmission risk of tick-borne diseases is the highest [29-31]. Furthermore, this genus is more distributed in the cold and wet seasons of the year. In our study, different cities in Tehran province did not have high humidity compared to the northern provinces. Therefore, it is assumed that high humidity is a limiting factor in the distribution of this tick in our study area.

In a study in Golestan province, 6 genera and 15 species of ticks, including soft and hard ticks, were reported [32], which is considerably similar to our study conducted in Tehran province. This may be due to the climatic similarities of the two

provinces and the proximity and parallelism of research. *A persicus* soft ticks have been caught in Shemiranat city in Tehran province, which has a mountainous climate, with a frequency of 11.5%. *A persicus* is caught in all seasons except for the summer. Its highest frequency was observed in the autumn, which is consistent with studies conducted in the cities of Sanandaj, Boyer-Ahmad, and Bijar in Kurdistan province [33-35].

R sanguineus was the most abundant among the ticks caught in Tehran province. This species has been caught in the cities of Tehran, Islamshahr, Shemiranat, Shahreri, Pakdasht, and Varamin from both plain and mountainous climate regions, which is consistent with other studies carried out in Ghaemshahr, Mazandaran province [36]. In general, the results of this study agree with the studies of other researchers due to the similarity of climate conditions. However, slight differences were observed between the results, which can be attributed to climatic diversity and the susceptibility of different breeds of livestock.

Conclusions

The distribution of collected ticks indicated that out of 806 collected ticks, 44.8% and 55.2% belonged to the mountainous and plain regions, respectively. This study demonstrated significant abundance and diversity of *Ixodidae* and *Argasidae* ticks in livestock in different places of Tehran province.

Acknowledgments

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Data Availability

All data obtained from this research are included in the paper's main text.

Authors' Contributions

EA designed the study, collected the ticks, identified tick species, recorded geographic coordinates and area information, wrote the manuscript, and confirmed and submitted the paper.

Conflicts of Interest

None declared.

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