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Spatio-temporal epidemiological survey reveals high infestation and extensive species diversity of hard ticks infesting camels from Pakistan

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Abstract

Camel production is severely hampered in Pakistan by a wide range of diseases, including ticks and tick-borne pathogens (TBPs). Camels serve as hosts for various tick-borne pathogens that can lead to human illnesses. Thereby, it was necessary to identify tick species and their infestation prevalence on camels before recommendation of any tick control measures. A total of 1800 engorged and semi-engorged ticks were collected from 1000 camels. In total, tick infestation intensity and abundance were 3.191 and 1.8 ticks per animal, respectively. The ticks belong to six genera (*Hyalomma*, *Rhipicephalus*, *Dermacentor*, *Haemaphysalis*, *Amblyomma*, and *Ixodes*) and 13 species (*Hyalomma dromedarii*, *Hy. anatolicum*, *Hy. excavatum*, *Haemaphysalis bispinosa*, *Hae. punctata*, *Rhipicephalus sanguineus* sensu lato, *R. annulatus*, *R. microplus*, *Dermacentor raskimensis*, *D. marginatus*, *D. circumguttatus*, *Amblyomma variegatum*, *Ixodes ricinus*). Female camels recorded more infested hosts than males in the study area. The perineum was found to be a predilection site for ticks, while legs were not. According to camel breeds, Bagri/booja camels carried a high tick load, followed by marecha/mahra, brela/thalocha, gaddi, dhatti/thari, ghulmani, khader and maya types, while the lowest load was observed on the campbelpuri breed. A statistically significant difference was recorded in body conditions; ages were similar. Poor body condition implied a higher tick burden. Summer was considered the most favourable month for tick infestation, while winter was the least. These findings pave the way for more investigations on camels located in the studied regions as well as other parts of the country.

Keywords: ticks; camels; distribution, species diversity, seasonal dynamics; Pakistan
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1. Introduction

Camels can survive harsh and hospitable conditions better than any other domestic animal and can make better use of marginal areas (Abbas & Ali 2001; Dirie & Abdurahman 2003). Due to their unique physiological and anatomical adaptations, they play an important role in arid and semi-arid ecosystems (Pual *et al*., 2016).

These animals can serve a variety of purposes, such as providing meat, milk, leather, wool, hide, providing live camels for export, serving as an important resource for sports, and creating animals for the packaging, transport, and riding (Giwda *et al*., 2012). A total of 0.24 million tons of camel milk is produced in Pakistan every year, valued at 2.4 billion rupees (Rs). The annual camel meat production stands at 50,000 tons, worth Rs. 250 million (Ahmad *et al*., 2010; Faraz *et al*., 2020).

People use camels to draw water from wells; to plough and level the land; to work in mini-mills to extract oils; to crush wheat, corn, and sugar cane; and to pull carts to transport goods and people. There are approximately 24 million camels in the world (Faraz *et al*., 2020). There are approximately one million camels in Pakistan. In terms of camel herding countries, Pakistan ranks eighteenth (Faraz *et al*., 2021).

There are two types of camels (Mountain and Riverine) found in Pakistan, which has several breeds (Raziq and Younas, 2006). Among the provinces with the highest number of one-humped camels (*Camelus dromedarius*), Baluchistan comes first (41%), followed by Punjab (27%), Sindh (25%), and NWFP (7%).

Camel productivity can be reduced by various ecto- and endoparasites. These arthropods and their associated pathogens affect the productivity, performance, and health of camels through various diseases. These illnesses caused irritation, blood loss, inflammation, and damage to skin and hide of camels (Wall, 2007).

Of the ectoparasites, ticks are one of the most important parasites across all camel-herding countries globally (Wondimu & Baya, 2021). Tick infestations on camels have been observed in Pakistan in recent years, so it was necessary to identify them and determine their prevalence in the various camel breeds found there.

The country as a whole and the study area do not have information on tick species. This is the first study to be conducted in these regions of Pakistan in order to identify tick species and to estimate tick infestation prevalence rates on camels. Consequently, in order to successfully control ticks, it is crucial to identify them before proceeding with any control strategy.

2. Materials and methods

A longitudinal study was conducted from April 2019 to April 2021 in four different districts of Pakistan, i.e., Dera Ismail Khan, Bannu, Bhakkar and Mianwali (Figure 1).

Dera Ismail Khan District is located in Khyber Pakhtunkhwa province, Pakistan (Figure 1). It has a hot, desert climate with sweltering summers and warm winters. Rain falls mainly in two distinct periods: in the late winter and early spring from February to April, and in the monsoon in July and August. The hottest month of the year in Dera Ismail Khan is June, with a daily mean temperature of 12.2 °C and the coldest month of the year is January with a daily mean temperature of 34.2 °C. The minimum rainfall is recorded during the month of November (2.1 mm) while July is the month with the most precipitation (60.8 mm).

Bannu district also belongs to Khyber Pakhtunkhwa Province in Pakistan (Figure 1). In Bannu, the summers are long, sweltering, and clear and the winters are short, cool, dry, and mostly clear. During the year, the temperature generally varies from 10 to 40 °C and is rarely lower than 6 °C or higher than 45 °C. The hottest month of the year in Bannu is June, with an average high of 40 °C and a low of 27 °C. The coldest month of the year in Bannu is January, with an average low and high of 11 °C and 18 °C, respectively. The minimum rainfall is recorded during the month of November (10.2 mm) while July is the month with the most precipitation (60.4 mm).

Mianwali district is located in Sargodha division of Punjab province, Pakistan. It has an extreme climate, with a long, hot summer season and cold, dry winters. Summer lasts from May to September and winter lasts from November till February. June is the hottest month with average temperatures of 42 °C (highest recorded temperature 52 °C); in winter, December and January monthly average temperatures can be as low as 3 to 4 °C. The average rainfall in the district is ~385 mm.

Bhakkar district is located in the west of the province of Punjab, Pakistan (Figure 1). Located at an elevation of 168.55 meters above sea level, Bhakkar has a subtropical desert climate. The district's

yearly temperature is 31.97 ºC and it is 11.08% higher than Pakistan's averages. Bhakkar typically receives about 22.86 mm of precipitation and has 48.92 rainy days annually.

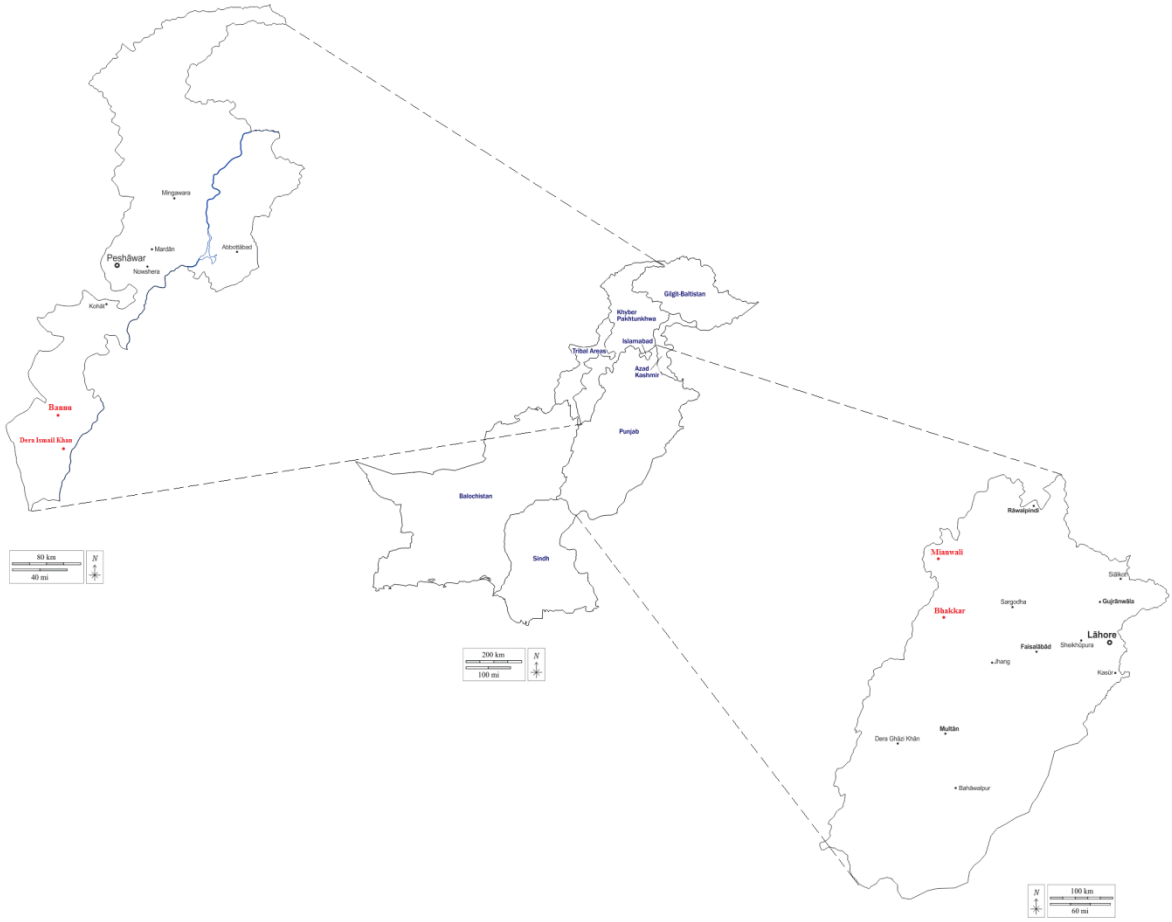

Figure 1 Map of Pakistan showing the four studied districts (Dera Ismail Khan, Bannu, Bhakkar and Mianwali) located in Punjab and Khyber Pakhtunkhwa provinces

A total of 1000 camels were selected for tick collection from Dera Ismail Khan (n = 106), Bannu (n = 189), Mianwali (n = 340), and Bhakkar (n = 365). Sex, breed, approximate age, and physical condition were noted for each animal. Thus, a total of 550 males and 450 females were examined with a sex ratio (M:F) estimated at 1.22. Camels belonged to thirteen breeds regrouped as follows: Marecha/mahra (n = 260), Bagri/booja (n = 212), Brela/thalocha (n = 160), Gaddi (n = 105), Dhatti/thari (n = 90), Ghulmani (n = 67), Khader (n = 63), Campbelpuri (n = 25), and Maya (n = 18). All camels were divided into two age groups of ≤5 years (n = 470) and >5 years (n = 530).

Prior to collection, camels were properly restrained and the whole body of the camel was examined. A total of 1800 tick specimens were collected from different body parts of camels of different breeds in the Dera Ismail Khan, Bannu, Bhakkar and Mianwali districts. Tick and data collection was carried out on a seasonal basis during the study period. Tick collection was carried out using fine forceps; ticks were collected in vials and all data about the camel host were marked on the vials in label form (e.g., location, age, sex, breed, body site, body condition, and number of collected ticks). Collected tick specimens were preserved in 70% ethyl alcohol and stored in the laboratory at room temperature. All tick specimens were identified at the sex and species levels by using the published morphological keys of Walker *et al*. (2013).

The results were expressed using three parasitological indicators (Bush *et al*., 1997):

Infestation prevalence (%) = 100 × number of infested animals/total number of animals (1)
Infestation intensity = number of ticks/number of infested animals (2)
Abundance = number of ticks/total number of animals (3)

Exact confidence intervals (CI) for tick infestation prevalence rates at the 95% level were calculated. Comparison of the prevalence of tick infestation in camels according to risk factors (e.g., season, region, sex, age, breed, and body condition) were performed with Epi Info 6.01 (CDC, Atlanta), using the $\chi 2$ test and Fisher's exact test with a threshold value of 0.05. In order to consider any confusion factor, a chi square Mantel–Haenszel test was performed.

3. Results

A total of 1800 engorged and semi-engorged ticks were collected from 1000 camels (Table 1). In total, tick infestation intensity and abundance were 3.191 and 1.8 ticks per animal, respectively (Table 1). The ticks belonged to six genera (*Hyalomma, Rhipicephalus, Dermacentor, Haemaphysalis, Amblyomma,* and *Ixodes*) and 13 species (*Hyalomma dromedarii, Hy. anatolicum, Hy. excavatum, Haemaphysalis bispinosa, Hae. punctata, Rhipicephalus sanguineus sensu lato, R. annulatus, R. microplus, Dermacentor raskimensis, D. marginatus, D. circumguttatus, Amblyomma variegatum, Ixodes ricinus*) (Table 1). The highest infestation intensity and abundance were recorded for *Hy. Dromedarii*, estimated at 0.957 and 0.540 ticks/animal, respectively, while the lowest values were reported in *D. circumguttatus* (0.015 and 0.009 ticks per animal, respectively) (Table 1).

Table 1

Tick species	Overall distribution (rate, %)	Infestation intensity (ticks/animals)	Abundance (ticks/animals)
Hy. dromedarii	37 (2.05)	0.957	0.540
Hy. anatolicum	63 (3.50)	0.785	0.443
Hy. excavatum	58 (3.22)	0.299	0.169
Hae. bispinosa	71 (3.94)	0.221	0.125
Hae. punctata	9 (0.50)	0.209	0.118
R. sanguineus s.l.	125 (6.94)	0.154	0.087
D. raskimensis	118 (6.55)	0.125	0.071
R. annulatus	540 (30.00)	0.111	0.063
D. marginatus	443 (24.61)	0.102	0.058
R. microplus	169 (9.38)	0.090	0.051
A. variegatum	29 (1.61)	0.065	0.037
I. ricinus	51 (2.83)	0.051	0.029
D. circumguttatus	87 (4.83)	0.015	0.009
Total	1800 (100)	3.191	1.800

Infestation intensity = number of ticks / numbers of infested camels
Abundance = number of ticks / numbers of examined camels

The highest number of ticks was reported in D. I. Khan district while the lowest number of ticks was recorded in Bannu district (Table 2). *Hyalomma dromedarii* was the most collected species in the four districts with distribution percentages of 32.68 to 26.23% (Figure 2). Tick species distribution data showed the absence of *A. variegatum* in Bannu, *D. circumguttatus* in Bannu and Mianwali, and *I. ricinus* in D. I. Khan (Table 2).

Table 2: Tick distribution of each tick species on camels overall and according to study area

Tick species	Study area (number of tick specimens, distribution rate in %)				
	D. I. Khan	Bhakkar	Bannu	Mianwali	Total
A. variegatum	16 (0.89)	11 (0.61)	0 (0)	10 (0.55)	37 (2.05)
R. annulatus	19 (1.05)	16 (0.89)	13 (0.72)	15 (0.83)	63 (3.50)
D. marginatus	14 (0.78)	13 (0.72)	19 (1.09)	12 (0.66)	58 (3.22)
D. raskimensis	20 (1.11)	18 (1.00)	16 (0.89)	17 (0.94)	71 (3.94)
D. circumguttatus	6 (0.33)	3 (0.17)	0 (0)	0 (0)	9 (0.50)
Hae. bispinosa	34 (1.89)	31 (1.72)	29 (1.61)	31 (1.72)	125 (6.94)
Hae. punctata	31 (1.72)	29 (1.61)	27 (4.00)	31 (1.72)	118 (6.55)
Hy. dromedarii	167 (9.27)	160 (8.89)	101 (5.61)	112 (6.22)	540 (30.00)
Hy. anatolicum	123 (6.83)	121 (6.72)	99 (5.50)	100 (5.55)	443 (24.61)
Hy. excavatum	48 (2.66)	42 (2.33)	39 (2.17)	40 (0.54)	169 (9.38)
I. ricinus	0 (0)	11 (0.61)	8 (0.44)	10 (0.55)	29 (1.61)
R. microplus	12 (0.66)	15 (0.83)	11 (0.61)	13 (0.72)	51 (2.83)
R. sanguineus s.l.	21 (1.17)	25 (1.39)	23 (1.28)	18 (1.00)	87 (4.83)
Total	511 (28.39)	495 (27.5)	385 (21.39)	409 (22.72)	1800 (100)

Abbreviations: D. I. Khan: Dera Ismail Khan; *R. sanguineus s.l.: Rhipicephalus sanguineus sensu lato*

In total, the percentage of female ticks collected (39.44%) was greater than that of male ticks (60.55%) (Figure 2). In addition, the highest percentages of male and female ticks were recorded in D. I. Khan (11.17 and 17.22%, respectively), while those reported in Bannu were the lowest (8.94 and 12.44%, respectively) (Table 3). At the species level, the rates of male and female ticks of *Hy. dromedarri* (12.72 and 17.28%, respectively) and *Hy. anatolicum* (8.61 and 16.00%, respectively) were the highest compared to those of other tick species (Table 3).

Table 3 Tick distribution according to camel sex, overall and according to sampling area

Tick species	Study area (number of tick specimens, distribution rate, %)									
	D. I. Khan		Bhakkar		Bannu		Mianwali		Total	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
A. variegatum	6 (0.33)	10 (0.55)	5 (0.28)	6 (0.33)	0 (0)	0 (0)	3 (0.17)	7 (0.38)	14 (0.77)	23 (1.28)
B. annulatus	10 (0.55)	9 (0.50)	4 (0.22)	12 (0.22)	6 (0.33)	7 (0.38)	6 (0.33)	9 (0.50)	26 (1.44)	37 (2.06)
D. marginatus	4 (0.22)	10 (0.55)	4 (0.22)	9 (0.50)	9 (0.50)	10 (0.55)	5 (0.28)	7 (0.38)	21 (1.17)	37 (2.06)
D. raskimensis	12 (0.66)	8 (0.44)	7 (0.38)	11 (0.61)	7 (0.38)	9 (0.50)	6 (0.33)	11 (0.61)	32 (1.78)	39 (2.17)
D. circumguttatus	2 (0.11)	4 (0.22)	1 (0.05)	2 (0.11)	0 (0)	0 (0)	0 (0)	0 (0)	3 (0.17)	6 (0.33)
Hae. Bispinosa	12 (0.66)	22 (1.22)	10 (0.55)	21 (1.17)	14 (0.78)	15 (0.83)	12 (0.22)	19 (1.05)	48 (2.67)	77 (4.28)
Hae. Punctata	14 (0.77)	17 (0.94)	12 (0.22)	17 (0.94)	12 (0.22)	15 (0.83)	10 (0.55)	21 (1.17)	48 (2.67)	70 (3.89)
Hy. dromedarii	65 (3.61)	102 (5.67)	76 (4.22)	84 (4.67)	45 (2.50)	56 (3.11)	43 (2.39)	69 (3.83)	229 (12.72)	311 (17.28)
Hy. anatolicum	45 (2.5)	78 (4.33)	31 (1.72)	90 (5.00)	35 (1.94)	64 (3.55)	44 (2.44)	56 (3.11)	155 (8.61)	288 (16.00)
Hy. excavatum	19 (1.05)	29 (1.61)	19 (1.05)	23 (1.28)	15 (0.83)	24 (1.33)	17 (0.94)	23 (1.28)	70 (3.89)	99 (5.50)
I. ricinus	0 (0)	0 (0)	4 (0.22)	7 (0.38)	3 (0.17)	5 (0.28)	4 (0.22)	6 (0.33)	11 (0.61)	18 (1.00)
R. microplus	4 (0.22)	8 (0.44)	7 (0.38)	8 (0.44)	5 (0.28)	6 (0.33)	5 (0.28)	8 (0.44)	21 (1.17)	30 (1.67)
R. sanguineus s.l.	8 (0.44)	13 (0.72)	8 (0.44)	17 (0.94)	10 (0.55)	13 (0.72)	5 (0.28)	13 (0.72)	31 (1.72)	56 (3.11)
Total	201 (11.17)	310 (17.22)	188(10.44)	307 (17.06)	161 (8.94)	224 (12.44)	160 (8.89)	249 (13.83)	710 (39.44)	1090 (60.56)

Abbreviations: D. I. Khan: Dera Ismail Khan; *R. sanguineus s.l.: Rhipicephalus sanguineus sensu lato*

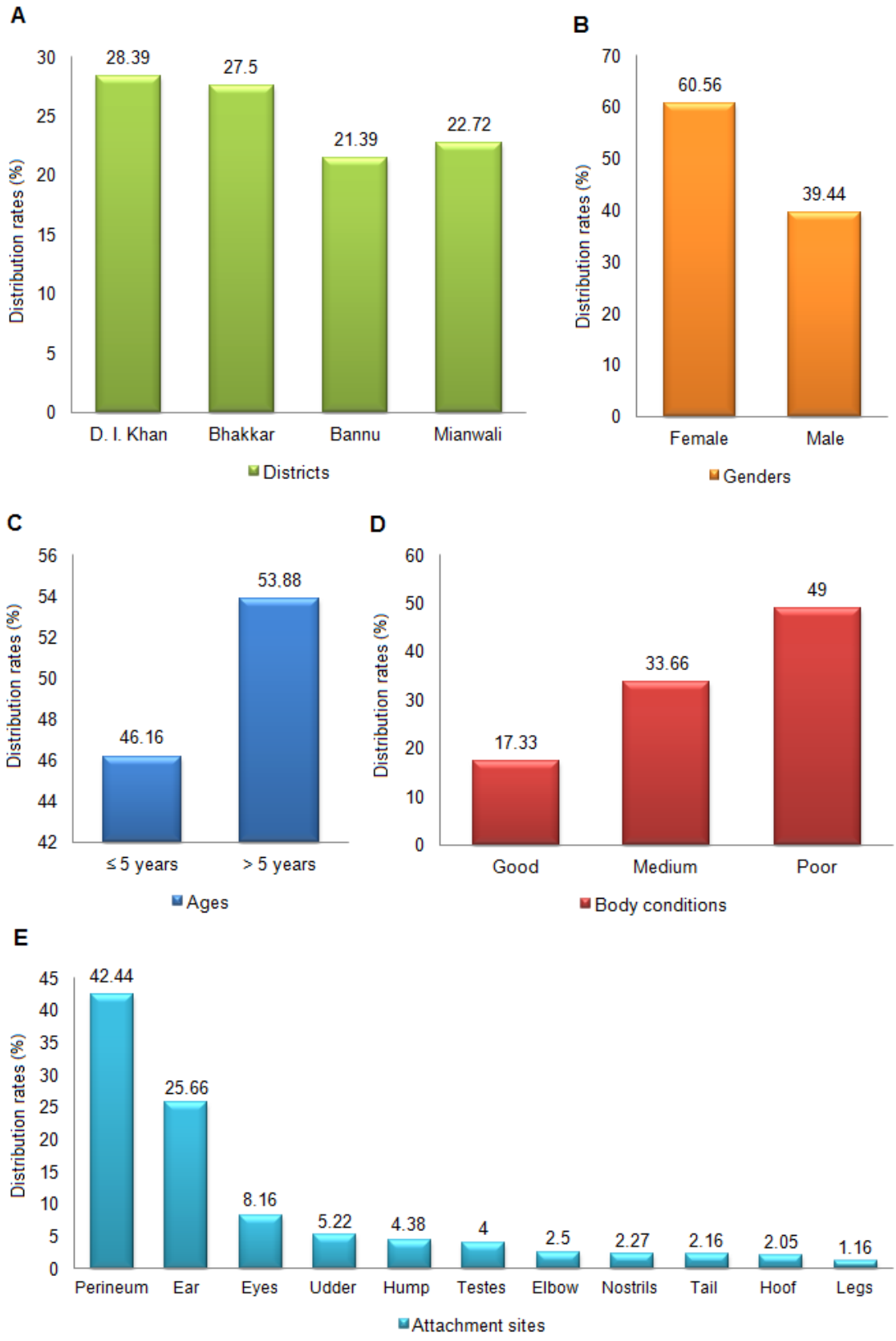

Figure 2: Tick distribution rates according to districts (A), camel sex (B), age (C), body condition (D), and predilection site (E)

The distribution data showed that 53.9% of ticks were collected from camels older than 5 y (Figure 2). The percentage of specimens of each tick species collected from camels older than 5 y was greater than that collected from animals ≤5 y (Table 4). For both age classes, *Hy. dromedarii* was the most present species with distribution rates estimated at 13.94 and 16.22% in camels aged ≤5 y and >5 y, respectively (Table 4).

Table 4 Tick distribution according to age and body condition of camels

Tick species	Age (number, %)		Body condition (number, %)		
	≤ 5 years	> 5 years	Good	Medium	Poor
A. variegatum	11 (0.61)	26 (1.44)	7 (0.38)	10 (0.55)	20 (1.11)
R. annulatus	31 (1.72)	32 (1.77)	8 (0.44)	21 (1.16)	34 (1.88)
D. marginatus	26 (1.44)	31 (1.72)	12 (0.66)	15 (0.83)	30 (1.66)
D. raskimensis	33 (1.83)	38 (2.11)	14 (0.77)	25 (1.38)	32 (1.77)
D. circumguttatus	3 (0.16)	6 (0.33)	2 (0.11)	3 (0.16)	4 (0.22)
Hae. bispinosa	57 (3.16)	67 (3.72)	19 (1.05)	43 (2.38)	63 (3.50)
Hae. punctata	54 (3)	64 (3.55)	23 (1.27)	38 (2.11)	57 (3.16)
Hy. dromedarii	251 (13.94)	292 (16.22)	57 (3.16)	203 (11.27)	283 (15.72)
Hy. anatolicum	215 (11.94)	228 (12.66)	90 (5.00)	142 (7.88)	211 (11.72)
Hy. excavatum	75 (4.16)	94 (5.22)	41 (2.27)	59 (3.27)	69 (3.83)
I. ricinus	14 (0.77)	15 (0.83)	8 (0.44)	9 (0.50)	12 (0.66)
R. microplus	24 (1.33)	27 (1.50)	14 (0.77)	16 (0.88)	21 (1.16)
R. sanguineus s.l.	37 (2.05)	48 (2.66)	17 (0.94)	22 (1.22)	46 (2.55)
Total	831 (46.16)	969 (53.83)	312 (17.33)	606 (33.67)	882 (49.00)

Parasitological results showed that 49% of ticks were collected from camels with a poor body condition (Figure 2 and Table 4). For all tick species reported in this study, the percentage of specimens of each tick species collected from camels with a poor body condition was greater than that collected from animals of medium and good body conditions (Table 4). For camels in good body condition, the most infesting species was *Hy. anatolicum* with an estimated rate of 5.00%, while for camels with medium and poor body conditions, the most infesting species was *Hy. dromedarii* with at 11.27 and 15.72%, respectively (Table 4).

The tick distribution according to various attachment sites showed that 42.44% of ticks were collected from the perineum (Figure 2). The second tick attachment site was the ear with a percentage of 25.66%. However, the attachment site that showed the lowest distribution rate was the leg, estimated at 1.16% (Table 5).

Table 5 Infestation of different tick species on various attachment sites of camels located in Pakistan

Attachment sites of camels	Number of tick specimens	Distribution rate (%)
Perineum	764	42.44
Ear	462	25.66
Eyes	147	8.16
Udder	94	5.22
Hump	79	4.38
Testes	72	4.00
Elbow	45	2.50
Nostrils	41	2.27
Tail	39	2.16
Hoof	37	2.05
Legs	21	1.16
Total	1800	100

Overall tick infestation prevalence was 54.4% (564/1000) (Table 6). Tick prevalence was low (54.89%) during the spring, then increased during the summer (55.68%) and the autumn (57.14%), reaching a maximum during the winter (71.42%) (P = 0.001) with an average of 59.78% (Table 6).

A difference between tick infestation rates was noted among the four districts (P = 0.002). The highest prevalence was observed in Bannu district (64.55%, 122/189); camels from Mianwali district (49.11%, 167/340) were the less infested with ticks (Table 6).

Moreover, the tick prevalence was higher in females (61.11%, 275/450) than male camels (52.54%, 289/550) (P = 0.006; Table 6). Furthermore, camels of Ghulmani (92.54%, 62/67), Khader (92.06%, 58/63), and Gaddi (90.48%, 95/105) breeds were more infested with ticks (P < 0.001) than other breeds (Table 6).

Camels with a good body condition score (36.46%, 214/587) were less infested with ticks than those with medium (87.21%, 201/257) and poor (95.51%, 149/156) body conditions (P <0.001; Table 6). Tick prevalence was similar in young camels (≤5 y) (57.23%, 269/470) and in adults (>5 y) (55.66%, 295/530) (P = 0.616; Table 6).

Table 6 Tick infestation rates according to different risk factors

Factors	Classes	Total	Infested camels	Prevalence (%)	p-value
Season	Autumn	287	164	57.14±0.05	0.001*
	Summer	501	279	55.68±0.04	
	Winter	28	20	71.42±0.16	
	Spring	184	101	54.89±0.07	
Region	Dera Ismail Khan	106	67	63.21±0.09	0.002*
	Bhakkar	365	208	56.99±0.05	
	Bannu	189	122	64.55±0.06	
	Mianwali	340	167	49.11±0.05	
Sex	Female	450	275	61.11±0.04	0.006*
	Male	550	289	52.54±0.04	
Age	≤ 5 years	470	269	57.23±0.04	0.616
	> 5 years	530	295	55.66±0.04	
Breed	Brela/thalocha	160	75	46.87±0.07	0.000*
	Bagri/booja	212	96	45.28±0.06	
	Campbelpuri	25	08	32.00±0.18	
	Dhatti/thari	90	40	44.44±0.10	
	Gaddi	105	95	90.48±0.05	
	Ghulmani	67	62	92.54±0.06	
	Khader	63	58	92.06±0.06	
	Marecha/mahra	260	120	46.15±0.06	
	Maya	18	10	55.55±0.22	
Body condition	Good	587	214	36.46±0.03	0.000*
	Medium	257	201	87.21±0.05	
	Poor	156	149	95.51±0.03	
Total		1000	564	56.4±0.03	

Abbreviations: * Significant (P <0.05); sex ratio (M/F): 1.127

4. Discussion

In this study, thirteen species belonging to six genera were identified, i.e., *Amblyomma variegatum, Boophilus annulatus, Dermacentor marginatus, D. raskimensis, D. circumguttatus, Hae. bispinosa, Hae. punctata, Hy. dromedarii, Hy. anatolicum, Hy. excavatum, Ixodes ricinus, Rhipicephalus microplus* and *Rhi. Sanguineus*, whereas only two species (*Hy. truncatum and Hy. dromedarii*) had been found on camels in an earlier report (Aktas, 2014).

In the current study, *Hy. truncatum* was not collected, probably due to geographical and bioclimatic variations. *Hyalomma dromedarii* was widespread in the studied regions, consistent with a previous report from Egypt (Abdullah *et al*., 2016). The *Hyalomma* genus is widely distributed and has diverse groups around the world and is considered an important parasite of wild and domestic livestock. Ticks

can survive harsh environmental conditions, such as temperature, humidity, rainfall and can live with or without hosts.

The current study showed that summer was the most favourable season for tick distribution and infestation with an infestation rate of 50.10%. Similar results were shown by Perveen *et al*. (2020) and Gharbi *et al*. (2013). They reported the highest infestation rate during the months of June and July, while it was lowest in January. A slight variation in tick infestation rates was recorded in the current study and earlier reports conducted in various countries and can be explained by various factors such as changes in breeds, and geographical and climatic conditions (Gharbi *et al*., 2013). In Egypt and the UAE, tick infestation rates of 95.6 and 98% have been recorded (Van Straten and Jongejan 1993; Al-Deeb *et al*., 2020), while in the present study, an overall rate of 30.00% was recorded. In addition, more female ticks were collected.

Female camels were more loaded with ticks than males, while animals in poor body condition had the most ticks, followed by the medium and good body condition score camels. Poor health conditions (weak immune system), low immunity, and diseases can make camels more susceptible to tick infestation (Perveen *et al*., 2020).

Our results are in line with previous findings, but also inconsistent with some reports, in which males were more susceptible to tick infestation (Perveen *et al*., 2020; Ullah *et al*., 2022). The poorly conditioned animals carried a higher number of ticks than well and moderately conditioned body animals. Well-conditioned animals are protected due to the accumulation of lipids (fats and oil) in the skin and are less susceptible to tick attachment (Manabe *et al*., 2010). Al-Salihi (2018) reported similar findings on tick infestation in camels. It has been reported in many studies that females are more heavily infested with tick species than males (Ramzan *et al*., 2020; Jamil *et al*., 2021; Jamil *et al*., 2022; Ullah *et al*., 2022). However, the researchers recorded tick infestation in domestic animals, such as buffaloes, cattle, goats, and sheep, and not camels.

5. Conclusion

Arthropods are very efficient vectors for a variety of pathogens such as protozoa, bacteria, and viruses. Ticks were widely distributed in the investigated regions, and are well-known to cause significant economic loss, either by spreading disease or causing damage to hide and skin. In this study, camels were infested with several tick species, such as *Hyalomma dromedarii*, which is the most common tick found in this animal species. Further studies are needed to identify the pathogens transmitted by these tick vectors in camels in the studied Pakistani regions.

Conflict of interest

Authors have no conflict of interest.

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