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Research Article

Ticks (Acari: Ixodidae) Infesting Domestic and Wild Mammalians on the Riyadh Province, Saudi Arabia

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Abstract

Background and Objectives: Ticks are the major vectors of different pathogens to humans and animals. The aim of this study was to determine the current status of tick species infesting domestic and wild animals and their seasonal population dynamics. **Materials and Methods:** This survey on tick species composition was carried out in Riyadh province, Saudi Arabia between January and December, 2017. Ticks were collected from the bodies of 18 domestic and wild animals. A total of 11,587 ixodid ticks (6,247 females; 4,585 males; 755 nymphs) were collected and preserved in 70% alcohol and then identified as to species. **Results:** The identified specimens belonged to ten species, including two genera of *Hyalomma* and *Rhipicephalus*. In domestic animals, the *Hyalomma* species comprised 68.3% and *Rhipicephalus* species 31.7%. *Hyalomma dromedarii* (39.9%) was the most common and abundant species, followed by *Rhipicephalus turanicus* (34.9%), while *Rhipicephalus sanguineus* was the most common species in wild hosts (83.0%). In addition, tick populations were most prevalent during summer and spring (36.0 and 31.6%, respectively). **Conclusion:** The results of this study showed that some tick species have expanded their distribution elsewhere to their previously recognised locations in Saudi Arabia. Moreover, the results of this study provide new data that government authorities can implement to take prevention measures for diseases transmitted by ticks.

Key words: *Hyalomma*, *Rhipicephalus*, domestic animals, wild animals, Riyadh province

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Ticks are globally significant vectors of an array of viral, bacterial and protozoal pathogens resulting in a wide range of animal diseases¹. In some cases, tick-borne pathogens are zoonotic and a direct threat to human health. Other effects of tick feeding include: anaemia, paralysis, immunosuppression and invasion of tick bite wounds by secondary bacterial pathogens. Hence, through the combined direct and indirect deleterious effects, ticks and tick-borne disease pose a major threat to the health and welfare of domestic livestock and food security².

In Saudi Arabia, the agriculture and livestock sector contributed 2.7% to the country's gross domestic product (GDP)³ and the livestock populations are estimated at more than 27 million heads. Furthermore, thousands of livestock are imported annually from neighbouring countries such as Sudan, the Arabian Gulf countries and others such as Turkey, Argentina, Pakistan, Australia and Uruguay⁴. Camel, sheep, goat and cattle production plays an integral part in the agricultural sector and culture and contribute significantly to

the food security of the country. On top of this, Saudi Arabia has one of the most species-diverse wild mammal populations in the Middle East, including the Arabian wolf, red fox, rock hyrax and various species of rodent that also play roles in the ecosystem of Saudi Arabia⁵.

Previous studies have recorded 15 ixodid species and subspecies infesting domestic and wild animals in different regions of Saudi Arabia⁶⁻¹⁴. However, there is no data available more recently than 2007 on the tick's prevalence and distribution in Riyadh province. Therefore, the objective of this study was to determine the current status of tick species infesting domestic and wild animal hosts from that province.

MATERIALS AND METHODS

Study areas: The investigation was conducted between January and December, 2017 in the Riyadh province of Saudi Arabia, which has an area of 404,240 km² and is located in the central part of Saudi Arabia between 24°38'N and 46°43'E. The region is divided into 19 governorates (Fig. 1). The province has one of the largest livestock populations in



Fig. 1: Location of the study area in Saudi Arabia

Saudi Arabia, accounting for 20% of the country's camels, 33% of its cattle, 17% of its sheep and 14% of its goats⁴. Additionally, the province has one of the most diverse populations of wild mammals, including species such as the Arabian wolf, red fox, rock hyrax and various rodents^{5,15}.

Climatological data: The seasons were defined as follows: Summer: June, July and August; Autumn: September; October and November; Winter: December, January and February and Spring: March, April and May. Mean monthly minimum and maximum temperatures, mean rainfall and relative humidity for the Riyadh region was obtained from the Presidency of Meteorology and Environment (PME), available at <https://www.pme.gov.sa>. Riyadh province has a very hot summer with temperatures often approaching 50°C. The average high temperature in July is 45°C. Winters are cold with windy nights. The overall climate is arid, receiving very little rainfall (around 21.4 mm as an average) and with relative humidity ranging from 10-47% throughout the year. The region is also known to have many dust storms.

Study design: Ticks from camels, cattle, sheep, goats, horses, donkeys, rabbits were collected monthly from different locations in Riyadh province between January and December, 2017. The sample sizes varied at each visit: samples from sheep and goats numbered between 60 and 155 per visit, camels 20-60 and 10-15 horses and donkeys 10-15, on average (Table 1). Ticks from the Arabian wolf and red fox were

obtained from hunters who collected them during the winter season. Meanwhile, rock hyrax, dogs, cats and rodents were trapped in the summer and winter seasons using live bait traps and examined *in situ* for tick infestations (Table 1).

Ticks collection and morphological identification: Ticks were collected from each animal and placed into 24100 mm vials containing 70% alcohol. Each vial was labeled and sent to the Parasitological Laboratory at Shaqra University, Saudi Arabia, as well as to the Parasitological Laboratory at Plymouth University, UK. Ticks were identified under a stereo microscope according to their morphological characteristics. This was done using taxonomic keys^{1,16,17}.

Statistical analysis: All data was processed using SPSS version 18 software. The differences in parasite prevalence between different groups, ages, sexes and localities were analysed using the Chi-square test and the mean values were considered significantly different when $p \leq 0.05$.

RESULTS

In this study, 5522 out of 8435 domestic and wild animal hosts (65.5%) were found to be infested with ixodid ticks. A total of 11587 tick specimens (6247 females, 4585 males and 755 nymphs) were collected from 7944 domestic animals and 491 from wild animals (Table 1). All the ticks belonged to the family Ixodidae. The identified tick specimens belonged to

Table 1: Total numbers of animals and prevalence of ticks found in Riyadh province (January-December, 2017)

Animals	Total No. of examined		Total No. of infected		Ticks infesting animals		χ^2	p-value
	Male	Female	Male	Female	Total infection	Prevalence (%)		
Camels	411	723	367	599	965	85.20	48.0000	0.0344
Sheep	970	1022	714	874	1588	79.10		
Goats	820	1140	544	911	1455	74.20		
Cattle	211	618	163	411	574	69.20		
Horses	186	211	95	109	204	51.40		
Donkeys	44	63	28	51	79	74.30		
Rabbits	420	317	88	107	195	26.50		
Dogs	127	83	69	35	104	49.50		
Cats	355	223	47	33	80	13.80		
<i>G. nanus</i>	70	26	24	12	36	37.50		
<i>M. lybicus</i>	24	32	15	9	24	42.80		
<i>P. obesus</i>	16	27	16	27	43	100.00		
<i>A. dimidiatus</i>	23	29	11	14	25	48.10		
<i>A. russatus</i>	18	41	7	22	29	49.10		
Hedgehog	51	76	43	51	94	74.00		
Rock Hyrax	13	31	8	11	19	43.10		
Red fox	6	2	2	2	4	50.00		
Arabian waif	5	1	3	0	3	50.00		
Total	3770	4665	2244 (59.5%)	3278 (70.3%)	5522	65.50		

Table 2: Numbers and prevalence of ticks collected from domestic animals in Riyadh province January-December, 2017

Tick species	Hosts										Total	Percentage	χ^2	p-value
	Camels	Sheep	Goats	Cattle	Horses	Donkeys	Rabbits	Dogs	Cats					
<i>Hy. dromedarii</i>	2414	423	330	140	311	182	85	19	12		3916	34.93	1675.80927	<0.001
<i>Hy. M. turanicum</i>	23	141	201	79	20	0	0	0	0		464	4.14		
<i>Hy. anatolicum</i>	711	179	107	311	74	0	0	0	0		1382	12.33		
<i>Hy. excavatum</i>	514	285	3	39	114	127	0	0	0		1082	9.60		
<i>Hy. schulzei</i>	40	0	0	0	0	0	0	0	0		40	0.40		
<i>Hy. impeltatum</i>	311	170	141	104	33	18	0	0	0		777	7.00		
<i>R. sanguineus</i>	2	0	0	0	0	0	3	99	46		150	1.30		
<i>R. turanicus</i>	176	1681	1063	17	6	0	111	7	3		3064	27.30		
<i>R. camicasi</i>	21	0	0	0	0	0	9	0	0		30	0.30		
<i>R. evertsievertsi</i>	0	184	119	0	0	0	0	2	0		305	2.70		
Total	4212	3063	1964	690	558	327	208	127	61		11210	100.00		

ten species, including two genera of *Hyalomma* and *Rhipicephalus*. *Psammomys obesus* and camels were the most tick-infested animals with prevalences of 100 and 85.20% respectively, while infestation of ticks in cats and rabbits was far less prevalent at 13 and 26.50% (Table 1). *Hyalomma dromedarii* (n = 3916, 34.43%) was the most common and abundant tick species, followed by *Rhipicephalus turanicus* (n = 3064, 27.30%), while *Hyalomma schulzei* was found only in camels with a prevalence of 0.40% (Table 2). In wild hosts, *Rhipicephalus sanguineus* was the most common species (n = 313, 83.0%) (Table 3). In the current study, tick populations were more prevalent during summer and spring with incidences of 4171(36.0%) and 3665 (31.6%), respectively (Table 4). Animals of both genders were infected with ticks, at different percentages (Table 5).

DISCUSSION

Overall, a tick infestation rate of 65.5% is in general agreement with previous studies from Saudi Arabia^{1,8-10,12,18,19}. Ticks belonging to genus *Hyalomma* are dominant in the present study and found to be the most diverse group. *Hyalomma dromedarii* is wide spread in North Africa, Middle Eastern countries and Central and South Asia¹. This study is in agreement with previous studies which indicated that this species is the most abundant tick in Saudi Arabia and is found in all are as investigated^{18,10,20,21}. Generally *Hy. dromedarii* infests camels but can also infest cattle, sheep, goats, horses, donkeys and mules²². Many other animals can also be occasional hosts, including dogs, rodents and other wild animals^{23,24}. *H. impeltatum*, *H. anatolicum*, *H. excavatum* and *H. turanicum* infestations in Saudi Arabia were most frequently found infesting camels, cattle, sheep and horses^{9,10,12,20}, though the composition of tick species differ elsewhere, especially in regions geographically far from Saudi Arabia such as Europe, Brazil and South and Central Africa. For example, Grech-Angelini *et al.*²⁵ surveyed ticks on cattle, small ruminants, domestic carnivores and wild animals

on the French Mediterranean island of Corsica. *Rhipicephalus bursa* was found to be the main tick species infesting cattle, goats and sheep in this area, while *H. marginatum* was the main tick species on horses. Low numbers of other tick species were found on cattle and small ruminants, such as *H. marginatum*, *H. scupense*, *I. ricinus*, *H. punctata*, *R. sanguineus*, *R. (Boophilus) annulatus* and *D. marginatus*. The findings also reported that *Rh. sanguineus* was the main tick species on dogs and cats, though a small number of *H. marginatum* and *I. ricinus* ticks were found on those animals also. It was noticed that the tick *D. marginatus* was the main tick species found on wild boars on Corsica, while *R. bursa* was the main tick species on mouflons. Only *I. ricinus* was found on deer. In Brazil, Acosta *et al.*²⁶ found the following seven tick species for the first time in Espírito Santo: *Amblyomma aureolatum*, *Amblyomma coelebs*, *Amblyomma ovale*, *Amblyomma rotundatum*, *Amblyomma varium*, *Haemaphysalis juxtakochi* and *Ornithodoros hasei*. They also reported that despite being previously recorded there, the species *A. longirostre* seemed to have disappeared. Horak *et al.*²⁷ determined the species composition of ticks infesting white and black rhinoceroses in southern Africa. Nineteen tick species were recovered, of which two *Amblyomma rhinocerotis* and *Dermacentor rhinocerinus* are known to prefer rhinos as hosts. Turner *et al.*²⁸ collected twelve ixodid tick species from mammals, birds and reptiles in central and northern Namibia, as follows: *Amblyomma exornatum* from lizards, *Amblyomma latum* from snakes, *Amblyomma marmoreum* from reptiles, *H. rufipes* and *H. truncatum* from domestic and wild ungulates, *Rhipicentor bicornis* from wild and domestic carnivores, *Rhipicentor nuttalli* from hedgehogs, porcupines, leopards, other wild carnivores and domestic dogs, *R. gertrudae* from larger herbivores, *R. sulcatus* from black-backed jackals and plains zebras, *R. theileri* from yellow mongooses, meercats and cape ground squirrels and finally *R. turanicus* which was collected from wild hosts including several large carnivores, hares and various ground-feeding birds.

Table 3: Numbers and prevalence of ticks collected from wild animals in Riyadh province (January-December, 2017)

Tick species	Wild animal hosts										Total	Percentage	χ^2	p-value
	<i>G. nanus</i>	<i>M. lybicus</i>	<i>P. obesus</i>	<i>A. dimidiatus</i>	<i>A. russatus</i>	Hedgehog	Rock Hyrax	Red fox	Arabian wolf					
<i>H. dromedarii</i>	0	0	0	0	0	0	0	0	0	0	0	0.00	1681.22	<0.001
<i>H. m. turanicum</i>	0	0	0	0	0	0	0	0	0	0	0	0.00		
<i>H. anatolicum</i>	0	0	0	0	0	0	0	0	0	0	0	0.00		
<i>H. aexcavatum</i>	0	0	0	0	0	0	0	0	0	0	0	0.00		
<i>H. schulzei</i>	0	0	0	0	0	0	0	0	0	0	0	0.00		
<i>H. impeltatum</i>	11	6	6	9	6	14	3	3	0	0	58	15.40		
<i>R. sanguineus</i>	45	27	51	33	27	82	22	9	7	0	313	83.00		
<i>R. turanicus</i>	0	0	0	0	0	2	0	0	0	0	2	0.50		
<i>R. camicasi</i>	0	0	0	0	0	0	0	1	3	4	4	1.10		
<i>R. evertsiervtsi</i>	0	0	0	0	0	0	0	0	0	0	0	0.00		
Total	56	33	67	42	33	98	25	13	10	377	100.00			

This study is the first to report *H. schulzei* in camels in the Riyadh province. This tick is the most abundant to parasitize camels in the arid northern frontier region of Saudi Arabia¹² and has been reported in Southern Iraq near the Saudi Northern frontier border²⁹ as well as in other neighbouring countries such as Iran^{30,31}. The occurrence of *H. Schulzei* in camels from the Riyadh province may be attributed to camel movements, as they travel through deserts, villages and towns and could acquire many different ticks during their journeys.

The only tick to be recovered from all wild hosts in this study, with the exception of the Arabian wolf, was *H. impeltatum* from genus *Hyalomma*, a species which is found in western, eastern and Northern Africa, as well as the Middle East. In Saudi Arabia, juvenile stages have been found on *Acomysdimidiatus*, *Merioneslybicus* and *Merionesrex*, *Psammomy sobesus* and *Paraechinus aethopicus*^{13,14,19}. *Hyalomma* spp. are well known vectors of numerous human and animal pathogens across Africa, Europe and Asia and they are of significant veterinary and medical importance due to their role in the transmission of pathogenic microorganisms³². In Saudi Arabia, both Sindbis and Dhori viruses (causing human febrile illnesses) have been identified in *H. Impeltatum*³³. This tick has also been confirmed as a vector of Crimean-Congo Haemorrhagic Fever Virus³⁴ of which there was an outbreak in 1990 involving seven individuals in the west of Saudi Arabia³⁵. In addition it has also been implicated in the fatal transmission of *Theileriahirci* to sheep in Saudi Arabia³⁶. *Hyalomma anatolicum* could be the vector of *Theleriaovis* and *Theileriahirci* in Saudi Arabia's sheep³⁷. Furthermore, *Hyalomma* spp may be a possible vector of *Babesiacaballi* and *Theleriaequi* in Saudi horses^{38,39}.

This study found that *Rhipicephalus* ticks comprise four species, which is in agreement with findings of Diab *et al.*²¹, Al-Khalifa *et al.*¹⁹ and Asiry and Fetoh¹⁴, who reported *R. sanguineus*, *R. turanicus*, *R. evertsiervtsi* and *R. camicasi* on both domestic and wild animals in Saudi Arabia. *R. turanicus* is widespread among domestic animals. In a nationwide survey, Diab *et al.*¹⁰ found *R. turanicus* to be the tick species which most often infests sheep and goats, with prevalences of 41.2 and 55.6%, respectively. This species was also reported in cattle and camels¹⁰. This species is being reported for the first time in hedgehogs in Saudi Arabia, although Youssefi *et al.*⁴⁰ previously found this tick in hedgehogs in Iran. In Saudi Arabia, previous studies have recorded *R. sanguineus* and juvenile stages of *H. impeltatum* in hedgehogs¹³, which are animals that are widely distributed in Saudi Arabia and are already identified as hosts for a wide variety of zoonotic pathogens⁴¹.

Table 4: Numbers and the prevalence of ticks in different seasons collected from domestic and wild hosts in Riyadh province (January-December, 2017)

Tick species	Season				Total and prevalence (%)	χ^2 786.96	p-value <0.001
	Spring	Summer	Autumn	Winter			
<i>H. dromedarii</i>	1097	1311	814	694	3915 (33.8)		
<i>H. marginatum</i>	146	182	91	45	464 (4.0)		
<i>H. anatolicum</i>	307	630	276	169	1382 (12.0)		
<i>H. excavatum</i>	310	397	211	164	1082 (9.3)		
<i>H. schulzei</i>	40	0	0	0	40 (0.3)		
<i>H. impeltatum</i>	398	275	101	61	835 (7.2)		
<i>R. sanguineus</i>	179	196	61	27	463 (4.0)		
<i>R. turanicus</i>	1035	1114	591	326	3066 (26.5)		
<i>R. camicasi</i>	32	2	0	0	34 (0.3)		
<i>R. evertsievertsi</i>	121	64	87	33	305 (2.6)		
Total and prevalence (%)	36-65 (31.6%)	4171(36.0%)	2232 (19.3%)	1519 (13.1%)	11587 (100.0)		

Table 5: Tick preferences by gender of animal species in Riyadh province (January-December 2017)

Animals	Total infection Prevalence (%)	Total No. of infected	
		Male (%)	Female (%)
<i>P. obesus</i>	100.00	37.21	62.79
Camels	85.20	37.99	62.01
Sheep	79.10	44.96	55.04
Donkeys	74.30	35.44	64.56
Goats	74.20	37.39	62.61
Hedgehog	74.00	45.74	54.26
Cattle	69.20	28.40	71.60
Horses	51.40	46.57	53.43
Red fox	50.00	50.00	50.00
<i>A. russatus</i>	49.10	24.14	75.86
<i>A. dimidiatus</i>	48.10	44.00	56.00
Rock Hyrax	43.10	42.11	57.89
Arabian wolf	50.00	100.00	00.00
Dogs	49.50	66.35	33.65
<i>M. lybicus</i>	42.80	62.50	37.50
<i>G. nanus</i>	37.50	66.67	33.33
Rabbits	25.50	45.13	54.87
Cats	13.80	58.75	41.25

Rhipicephalus sanguineus was reported previously in Saudi Arabia in rodents and wild animals^{13,14,19,42}, with the Arabian wolf and red fox showing 50% infestation rates. This is not surprising since their diet includes mammals, reptiles and birds, which constitute potential hosts for immature stages of ticks^{43,44}.

Rhipicephalus evertsievertsi was reported previously in small ruminants from western and south western provinces of Saudi Arabia^{11,35}. This tick has been described as preferring hosts such as horses, mules and donkeys¹⁷ and having the capability to tolerate a broad diversity of climatic conditions⁴⁵. *Rhipicephalus camicasi* has rarely been reported in Saudi animals compared with other *Rhipicephalus* groups. In previous studies *R. camicasi* was observed in two native sheep in the western province of Saudi Arabia³⁵ and Harrison *et al.*¹³ reported this species infesting *Acomysdimidiatus* at the

National Wildlife Research Centre (NWRC) in Taif, in the west of the country. In addition, Abdel-Shafy⁴⁶ found *R. camicasi* on camels in Egypt. Species belonging to genus *Rhipicephalus* are vectors of a wide range of pathogens diseases such as babesia, the leria, rickettsia and Q fever¹⁷, which affect both humans and livestock in Saudi Arabia.

The frequency of ticks encountered during this study varied from season to season and was found to be highest in spring and summer, which is in agreement with previous studies^{47,48}. Ticks are highly susceptible to climate change, largely as a result of the duration of their off-host life-cycle stages. Life-cycle processes such as development and survival are highly temperature- and moisture-dependent⁴⁹. Depending on the relative effects of temperature on development and mortality at different stages of development, the outcome in terms of abundance are likely to vary, especially when seasonality is taken into account⁵⁰. For most vectors, the greatest effect of climate change on transmission is likely to be observed at the extremes of the range of temperatures at which transmission occurs^{51,52}. Therefore, Saudi Arabia's environment is suitable for the rapid development of various tick species due to its wide range of climatic conditions.

CONCLUSION

Numerous tick species are spread throughout the Riyadh province and these include those of veterinary and economic significance. Several of the vector tick species have expanded their area of coverage outside that which has been previously recorded; this may lead to the expansion of tick-borne diseases to new areas, where outbreaks of disease are expected to be radical. Further epidemiological research should be carried out in the country to monitor the distribution of tick species and suggest effective control strategies.

SIGNIFICANCE STATEMENT

This is the first study recording the infestation of wild animals by various tick species in the Riyadh province and the first to report *Hy. Schulzei* and *Rh. evertsievertsi* in domestic animals there, though they have previously been recorded in other areas. This study will help researchers and government authorities in Saudi Arabia to develop their understanding and application of control strategies that can best prevent humans and animals from tick infestations.

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