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Diversity of hard ticks parasitizing farm animals in the Qarabulli region, Northwestern Libya

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Abstract
Background: There are 26 species of ticks known to exist in Libya. Despite the presence of a number of investigations on ticks in Libya, there are no published studies on ticks in the Al-Qarboulli area.
Aim: The aim of this study was to identify the tick species infesting farm animals in the Qarabulli region.
Methods: Ticks were collected manually on a monthly basis from the examined hosts (cattle, sheep, dogs, and camels) that were selected randomly in the period between July 2021 and June 2022.
Results: A total of 717 ticks were collected on 775 hosts, eight tick species were encountered: *Hyalomma excavatum* (41.00%), *Rhipicephalus sanguineus* (23.43%), *Hyalomma dromedarii* (12.13%), *Hyalomma marginatum* (9.21%), *Hyalomma anatolicum* (8.51%), *Rhipicephalus annulatus* (5.30%), *Hyalomma rufipes* (0.28%), and *Boophilus microplus* (0.14%). The mean prevalence of all species was 22.32%. The mean intensity of all species was 0.93 ticks per host. The presence of ticks among the months of the year varied among tick species.
Conclusion: The results showed high tick infestation in farm animals of Qarabulli, Libya, suggesting an increased risk of tick-borne diseases. This highlights the need for preventative measures and public awareness to reduce tick populations. Further studies are recommended to understand the spread of tick-borne diseases in the area.
Keywords: Ticks, Infestation, Livestock, Qarboulli, Libya.

Introduction

Ticks are parasitic organisms that may infect a variety of species, such as birds, mammals, reptiles, and amphibians (Hoogstraal, 1956; Burgdorfer *et al*., 1982). During blood feeding process, ticks have the ability to transmit viruses, bacteria, protozoa, and fungi to animals and humans (Tonbak *et al.*, 2006; M'ghirbi *et al.*, 2010; Mashebe *et al.*, 2014). Emerging or re-emerging infectious diseases are important global health problems with great concern for human as well as animal health. With the increase in antimicrobial resistance among bacterial pathogens, there has been an increase in the incidence of zoonotic diseases, sometimes causing large outbreaks of disease in domestic and wild animals and humans, leading to an increased fatality rate. Therefore, ticks and the diseases they transmit pose an increasing threat to public health and animal husbandry (Perveen *et al*., 2021).

A few studies on ticks and tick-borne diseases were conducted in Libya. During the Italian occupation period in the late nineteenth century, many reports were published by Italian entomologists, physicians, and public health workers (Gabaj *et al*., 1992).

Hoogstraal and Kaiser (1960) reported details regarding fourteen species of ticks in Libya, in some areas including Benghazi, Misrata, Sebha, and Jadu. Gabaj *et al*. (1992) reported 13 species of hard ticks and two species of soft ticks that were collected and recorded on 20,391 animals during a 3-year survey that included 58 farms in Libya.

Recently, numerous studies have been conducted in Libya on tick diversity; either infesting farm animals (Elsaid *et al.*, 2013; Hador, 2015; Abdulsalam, 2017; Kharwat, 2018; Alfitory, 2021) or wild animals and captured animals (Hosni and Maghrbi, 2014; Alzanati *et al.*, 2020), or on pathogens in ticks (Saadawi, 2017). Twenty-six species of ticks have been recorded in Libya (Hoogstraal and Kaiser, 1960; Gabaj *et al.*, 1992; Hador, 2015; Abdulsalam, 2017). It was found that there was a difference in the species recorded in the studied areas in Libya due to the different environments in those areas. Environmental and climatic factors have a significant impact on the distribution of ticks and the zoonotic diseases they transmit in various ecosystems (Mehlhorn, 2012).

The Qarabulli area, located in northwest Libya, is characterized by a hot-summer Mediterranean climate.

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It is also characterized by its rural agricultural lands, and its environment of plains and valleys provides a suitable habitat for many species of animals and birds. Many factors increase the importance of the Qarabulli area as a suitable environment for ticks or enhance the contact between ticks and humans; the valley of Targhat in the north of the area offers a suitable habitat for migratory birds.

The spread of ticks and the pathogens they transmit has become a major cause of concern for residents of the region, especially after the increasing incidence of spotted fever infections during seasonal tick activity, which has led to the death of some cases as a result of infection and delayed diagnosis and treatment. Despite this, to date, there have been no studies on the tick fauna in the area.

The aim of this study was to identify the species of ticks that infect farm animals in the Qarabulli region, located in northwestern Libya.

Materials and Methods

Study area

The study area was the municipality of Qarabulli, which is located in the northwestern part of Libya, in the northeastern part of the Al-Jafara plain between longitudes 13° 36' 32" E and 13° 49' 56" E and between latitudes 32° 40' 34" N and 32° 48' 32" N, bordered by the Mediterranean Sea to the north, the Tarhuna and Sidi Al-Sayeh regions to the south, the Qasr Al-Akhiar region to the east, and Tajoura to the west. It is approximately 65 kilometers east of the capital, Tripoli. The area of the Qarabulli municipality is about 250 km^2, with about 47,000 inhabitants.

The majority of the region's surface is flat, with the exception of a gentle incline; neither high altitudes nor hills are present, and the elevation of the area ranges between 0 and 180 meters above sea level (Al-Deeb and Al-Naami, 2019). The area is characterized by wide areas of agricultural land. Moreover, the vegetation of the area consists of various types of trees, such as conifers, cypresses, olive trees, palm trees, orange trees, almond trees, and many fruit trees.

According to Elaalem *et al.* (2016), this area is characterized by a moderate climate, dominated by a Mediterranean climate, and the largest amount of precipitation falls in the period from November to January, then gradually decreases from February to April, while temperatures generally drop in the winter, reaching their lowest levels in January, and then gradually rise to reach their highest levels in the summer. Regarding relative humidity, the maximum humidity in the region is in January (72%), while the lowest humidity is in June (59%), and it increases in the coastal areas.

The study area was divided into two parts to include the various types of environments that exist in the study area based on altitude and distance from the sea. The northern part is adjacent to the Mediterranean coast and is at a lower elevation; it includes agricultural activity and the main residential complex. The southern part is characterized by the presence of highlands, where the primary activity of the population is livestock raising. Five farms were selected from each part based on the density of livestock and the willingness of farm owners to participate in the survey.

Collection and identification of ticks

Ticks were collected manually on a monthly basis from the examined hosts (cattle, sheep, dogs, and camels), all ticks on each examined host were collected. Hosts were selected randomly in the period between July 2021 and June 2022. Ticks were stored at room temperature in vials filled with 70% ethanol. For every sample, information was gathered on the host type, the location, and the collection date. Collected ticks were sent to the Research Lab for Parasites and Vector Borne Diseases at the National Center for Disease Control, for morphological identification. Under a dissecting microscope, the ticks were put on petri dishes and identified at the species level using a tick taxonomy key (Walker *et al.*, 2003).

Data analysis

Data were classified according to type of host, region, date of collection, and species of tick. The data obtained were analyzed using Statistical Package for the Social Sciences (SPSS), version 26 (IBM SPSS Statistics). In the case of normal distributed data, parametric statistical tests were used: ANOVA and the independent samples *T* test. The Kruskal-Wallis test and Mann-Whitney *U* test were used for non-normal distributed data. Significant differences were considered when the *p*-value was ≤ 0.05.

Ethical approval

Not needed for this study.

Results

A total of 775 hosts were screened; among them, 173 were infected with ticks. The overall average of infection rate was 22.32% of the total animals examined; most of the samples were collected from cattle (83.26%), then dogs (11.02%), sheep (5.44%), and camels (0.28%) (Table 1). The mean intensity of all species was 0.93 ticks per host. There were no significant differences regarding the infection rate between hosts ($p = 0.154$).

A total of 717 ticks were collected; all samples were adults (69% male, 31% female). The collected ticks belong to eight species of hard ticks: *Hyalomma excavatum* (41.00%; 294/717), *Rhipicephalus sanguineus* (23.43%; 168/717), *Hyalomma dromedarii* (12.13%; 87/717), *Hyalomma marginatum* (9.21%; 66/717), *Hyalomma anatolicum* (8.51%; 61/717), *Rhipicephalus annulatus* (5.30%; 38/717), *Hyalomma rufipes* (0.28%; 2/717), and *Boophilus microplus* (0.14%; 1/717). We found all tick species parasitizing cattle, while other hosts were infested by one or two tick species (Table 1).

Table 1. Number of ticks collected from investigated hosts.

Species	Cattle	Sheep	Dogs	Camels	Total
Hyalomma excavatum	289	5	0	0	294
Rhipicephalus sanguineus	55	34	79	0	168
Hyalomma dromedarii	86	0	0	1	87
Hyalomma marginatum	66	0	0	0	66
Hyalomma anatolicum	60	0	0	1	61
Rhipicephalus annulatus	38	0	0	0	38
Hyalomma rufipes	2	0	0	0	2
Boophilus microplus	1	0	0	0	1
Total	597	39	79	2	717

Table 2. Number of ticks collected from hosts. The numbers in brackets indicate relative abundance.

Species / Month	*H. excavatum*	*R. sanguineus*	*H. dromedarii*	*H. marginatum*	*H. anatolicum*	*R. annulatus*	*H. rufipes*	*B. microplus*
July	7 (4.14%)	60 (35.50%)	67 (39.65%)	0 (0%)	0 (0%)	35 (20.71%)	0 (0%)	0 (0%)
August	63 (39.13%)	45 (17.95%)	19 (11.8%)	33 (20.50%)	0 (0%)	0 (0%)	0 (0%)	1 (0.62%)
September	67 (65.68%)	22 (21.56%)	1 (1.00%)	4 (3.92%)	8 (7.84%)	0 (0%)	0 (0%)	0 (0%)
October	24 (45.28%)	11 (20.76%)	0 (0%)	16 (30.19%)	0	0 (0%)	2 (3.77%)	0 (0%)
November	18 (39.13%)	0 (0%)	0 (0%)	11 (23.91%)	14 (30.44%)	3 (6.52%)	0 (0%)	0 (0%)
December	7 (87.5%)	0 (0%)	0 (0%)	0 (0%)	1 (12.5%)	0 (0%)	0 (0%)	0 (0%)
January	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
February	9 (56.25%)	0 (0%)	0 (0%)	1 (6.25%)	6 (37.50%)	0 (0%)	0 (0%)	0 (0%)
March	22 (66.67%)	0 (0%)	0 (0%)	1 (3.03%)	10 (30.30%)	0 (0%)	0 (0%)	0 (0%)
April	26 (76.47%)	0 (0%)	0 (0%)	0 (0%)	8 (23.53%)	0 (0%)	0 (0%)	0 (0%)
May	25 (42.37%)	23 (38.98%)	0 (0%)	0 (0%)	11 (18.65%)	0 (0%)	0 (0%)	0 (0%)
June	26 (72.22%)	7 (19.45%)	0 (0%)	0 (0%)	3 (8.33%)	0 (0%)	0 (0%)	0 (0%)

Not all tick species were recorded every month of the year (Table 2); *H. excavatum* was collected in 11 months. Some species were recorded in 1 month only (*H. rufipes* and *B. microplus*), while no ticks were collected in January. There were significant differences regarding tick abundance between months ($p = 0.001$).

Discussion

This is the first study to investigate ticks associated with farm animals in Qarabulli. Eight species were recorded in Qarabulli. These species were among the 26 species of ticks that were reported in Libya (Abdulsalam, 2017; Gabaj *et al.*, 1992; Hador, 2015; Hoogstraal and Kaiser, 1960).

Hyalomma excavatum was the most abundant species; the majority of this species was collected from cattle. This result is in agreement with what has been reported in previous studies in Libya (Gabaj *et al.*, 1992; Hador, 2015). The infestation of *H. excavatum* in this study continued for most of the year, but Hador (2015) found that this species was collected every month of the year. Moreover, it has been reported that *H. excavatum* is

found on livestock throughout the year in North Africa (Walker *et al.*, 2003).

Rhipicephalus sanguineus was collected from three different hosts; domestic dogs are the preferred host for it, but despite that, we found it on other hosts except camels. It has been collected in Libya from cattle, sheep, dogs, and goats (Gabaj *et al.*, 1992; Hador, 2015). Also, it may be found in other hosts: cattle (Marcellino *et al.*, 2011; Walker *et al.*, 2003), sheep and goats (Salim-Abadi *et al.*, 2010), and camels (El Tigani and Mohammed, 2010). *Rhipicephalus sanguineus* was collected from spring to autumn. This finding is in agreement with the results of previous studies in Libya (Hador, 2015) and Turkey (Gargili *et al.*, 2010).

In our study, *H. dromedarii* was collected from cattle and camels. Camels are the preferred hosts of *H. dromedarii*, but cattle, sheep, goats, horses, birds, reptiles, hedgehogs, hares, and wild rodents can also be infested (Hoogstraal, 1956; El Tigani and Mohammed, 2010). In areas where camels are less common, it seems that cattle can support populations of this tick species (Walker *et al.*, 2003). Previous studies in Libya found *H. dromedarii* infested camels throughout the year (Abdulsalam, 2017; Kharwat, 2018), but in our study, this species was recorded in the summer months only. As clarified by Kharwat (2018), 5.6% of *H. dromedarii* collected from camels were positive for *Rickettsia* spp.

Hyalomma marginatum was previously recorded in Qarabulli (Hoogstraal and Kaiser, 1960). It was collected in our study from cattle only. It was mentioned in previous studies that *H. marginatum* infests camels, cattle, sheep, and goats (Gabaj *et al.*, 1992; Salim-Abadi *et al.*, 2010). Hador (2015) recorded this species in the period from April to October in Al-Baida, Libya, while we found it mainly between August and November.

Hyalomma anatolicum was collected from cattle and camels. It was found previously in Libya on cattle, sheep, camels, and goats (Gabaj *et al.*, 1992; Hador, 2015). We found that *H. anatolicum* was collected in most of the months, infesting mainly the cattle. Chhillar *et al.* (2014) reported that this species was found on buffalo and cattle in India throughout the year and was reduced in winter. In Iran, the summer abundance of *H. anatolicum* was reported and reduced in numbers in the winter (Salim-Abadi *et al.*, 2010). Hasson (2012) found *H. anatolicum* on sheep and cattle in Iraq during the months of April to October, with the highest number of individuals collected in July.

Rhipicephalus annulatus is called a cattle tick; it is found mostly on cattle (Walker *et al.*, 2003). We reported that most specimens were collected in July. While in Al-Baida, *R. annulatus* infestation showed two peaks in August and November (Hador, 2015). In North Africa, this tick species activity begins in late summer and extends from September to January, with a peak in October (Walker *et al.*, 2003).

Hyalomma rufipes and *B. microplus* were found parasitizing cattle in small numbers in October and August, respectively. The adults of both species are most numerous during the early part of the wet season. The main hosts of the adult stage of this species are cattle; also, sheep, goats, horses, and wild ungulates can be infested (Walker *et al.*, 2003).

Rhipicephalus sanguineus and *H. rufipes* are considered as main vectors of *Rickettsia* (Idris *et al.*, 2000; Parola *et al.*, 2005), as they might play a role in the rickettsiosis circulation that happened in Qarabulli (NCDC, 2021).

The results of this study clearly show that the farm animal population in the region of Qarabulli is significantly burdened with tick infestation, increasing the likelihood of tick-borne diseases. These results might add to our knowledge of the local tick epidemiology. Thus, implementing appropriate preventative measures, and raising public knowledge of animal health services, might all help to effectively decrease tick populations in the field. We recommend implementing studies on tick-borne diseases in the Qarabulli area to clarify their epidemiological status.

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Authors' contributions

SAS and TS: conception, design, and organization of the study. SAS, TS, and AMA: conducted the study; SAS and WKS: acquisition of data; SAS and TS: analysis and interpretation of data; SAS and TS: drafting of the manuscript and critiquing the output for important intellectual content. All authors discussed the results and commented on the manuscript.

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Conflict of interest

The authors have no conflict of interest to declare.

Data availability

The data used in this study are accessible in the manuscript, and the corresponding author can provide any further information upon reasonable request.

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