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ORIGINAL ARTICLE

Prevalence and climatic influence on hemoparasites of cattle and sheep in Mosul, Iraq

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ABSTRACT

Objective: Hemoparasitism is a condition commonly found in animals and it exerts negatively on the health, production, reproduction, and performance of the affected animals. This study is aimed at determining the prevalence of different hemoparasites affecting cattle and sheep in Mosul, Iraq, and to deduce the effect of climatic factors on the occurrence of these hemoparasites.
Materials and Methods: Blood samples from cattle and sheep that were submitted to the Parasitology Laboratory of the Veterinary Hospital of Ninavah between 2008 and 2018 were examined for the presence of blood parasites using the thin blood smear preparation. Data were analyzed using percentages (%), tabulations, and graphs. Spearman's rank correlation coefficient was used to measure the strength of association between the occurrence of hemoparasites of cattle/sheep and each climatic variable.
Results: *Anaplasma* spp. *Babesia* spp. and *Theileria* spp. were the hemoparasites detected among cattle and sheep in the study, with *Theileria* spp. been the most prevalent among cattle, while *Anaplasma* spp. was the most prevalent among sheep. There was no distinct pattern in the yearly and monthly prevalence of these hemoparasites among cattle and sheep. Rainfall and relative humidity negatively influenced the occurrence of hemoparasites infections, while temperature favored their occurrences.
Conclusion: This study appears to be the first to evaluate the correlation between climatic variables and the prevalence of hemoparasites of cattle and sheep in Mosul, Iraq. Climatic variables influenced the abundance of hemoparasites of cattle and sheep in the study area. The outcome of this study will add to the existing knowledge on the effect of climatic factors on the occurrence of parasitic diseases of ruminants in Middle East.

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Introduction

Hemoparasites generally are known to cause damage to the red blood cells resulting in anaemia, anorexia, jaundice, reduced weight gain, loss of production and reproduction, high morbidity, and even mortality [1,2]. Tick-borne hemoparasitic diseases, such as anaplasmosis, babesiosis, and theileriosis constitute a serious challenge to the health and wellbeing of livestock in the tropical and sub-tropical regions, including Iraq [3,4].

Anaplasmosis is an arthropod-borne disease of ruminants caused by *Anaplasma* species: a rickettsial organism of the Anaplasmataceae family. *Anaplasma* species can be transmitted biologically by ticks, or mechanically by sucking flies, especially tabanids. Mechanical transmission can also be through blood-contaminated fomites [5,6]. *Anaplasma centrale* and *A. marginale* are species that affects cattle, while *A. ovis* affects sheep. *A. phagocytophilum* affects both cattle and sheep [4,7]. Babesiosis is a tick-borne hemoparasitic disease caused by numerous species of protozoa from the genus *Babesia* [8]. These protozoans are found in the erythrocyte, and can infect a wide range of domestic and wild animals, and occasionally man [9].

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The genus *Babesia* belongs to the phylum Apicomplexa, and family Babesiidae [6]. Bovine babesiosis is caused chiefly by *Babesia bigemina* and *B. bovis*, while other species, such as *B. divergens*, *B. major*, *B. jakimovi*, *B. ovata*, and *B. occultans* may also be implicated in cattle infections [6]. Babesiosis in sheep is caused by *B. ovis*, *B. motasi* and *B. crassa* [4,10]. *Theileria* infection is caused by ticks and it is a disease of ruminants caused by a protozoan parasite of the genus *Theileria*. This protozoan is found in the blood and lymphatics of infected animals [4,11]. *Theileria orientalis* complex (*Theileria mutans*, *T. buffeli* and *T.* sergenti), *T. annulata*, *T. parva*, *T. orientalis*, *T. taurotragi* and *T. velifera* are known to cause bovine theileriosis, while *T. ovis*, *T. recondita*, *T. hirci*, (syn. *T. lestoquardi*), *T. separate*, *T. luwenshuni* and *T. uilenbergi* are known to affect sheep [4,12,13].

Cattle and sheep are of boundless economic importance, been animals that produce considerable amount of milk, meat and skin, with sheep been a good source of wool [3,14]. However, the benefits derived from these animals are well below the expected quantity and quality mainly due to low productivity caused by hemoparasitism.

Considering the importance of cattle and sheep to the economies of nations in the world, and the negative implications of hemoparasites on its productivity and reproductivity, this study is aimed to determine the prevalence of blood parasites of cattle and sheep in Mosul, Iraq and to deduce the effect of climatic factors (rainfall, temperature and relative humidity) on the occurrence of hemoparasitism.

Materials and Method

Study area

This study was conducted in Mosul, a major city in north of Iraq. The city is situated approximately 400 km of the northern part of Baghdad (the capital city of Iraq), Mosul sits on the west bank of the Tigris, opposite to the ancient Assyrian city of Nineveh on the east bank. The city is located on coordinate's 36.34°N 43.13°E and covers a total area of 180 km^2 (70 sq. mi) with a population of 664,221 persons. Mosul's climate is classified as warm and temperate. There are more rains during the winter months than the summer months. This climate is said to be the Mediterranean hot summer climate according to the Köppen–Geiger climate classification [15,16].

Sample population, blood collection and processing

About 5 ml of anticoagulated blood samples collected from 55,194 cattle and 1,773,617 sheep from Mosul and its environs were submitted to the Parasitology laboratory of the Veterinary Hospital of Ninavah (The biggest Veterinary hospital in Mosul). The blood samples were collected from the jugular vein of the animals into a labeled ethylenediaminetetraacetic acid tube and were submitted between January 2008 and December 2018.

Thin blood smears were prepared using standard method as described by Ademola and Onyiche [1]. A drop of blood was placed on one end of a clean, grease free glass slide and made into thin film with aid of a spreader (a clean glass slide). This was done by allowing the spreader to touch the blood at an angle of 45°, and then spread gently but firmly along the surface of the horizontal slide so that the blood is dragged behind the spreader to form the film with a feathered edge. The prepared thin film was then air dried, fixed in methanol for 5 min, and stained in freshly prepared 10% Giemsa stain at pH 7.2 for about 30 min. Afterward, the stained film was rinsed in buffered water and allowed to dry. The smears were examined at ×100 magnification (oil immersion) on an Olympus Microscope (made in Germany) for the presence and identification of blood parasites.

Climatic parameters

The 11 years (2008–2018) average monthly rainfall (mm), temperature (°C), and relative humidity (%) were obtained from the Iraqi meteorological organization and seismology, Weather Forecasting Department located in Mosul.

Statistical analysis

Data were entered in Microsoft office Excel version 2016. Analysis using descriptive statistics in percentages (%), tabulations, and graphs were done therein. Spearman's rank correlation coefficient was used to measure the strength of association between the occurrence of hemoparasites of cattle/sheep and each climatic variable. This was conducted using statistical package for social sciences (SPSS) version 22 (SPSS Inc., Chicago). Values of $p < 0.05$ were considered as significant. The strength of association between each hemoparasite and each climatic variable was measured as described by Mukaka [17].

Results

Of the total 55,194 cattle examined, 365, 207 and 94 were infected with *Theileria* spp., *Anaplasma* spp. and *Babesia* spp. representing 0.66%, 0.38% and 0.17% prevalence, respectively. *Anaplasma* spp. was the most prevalent hemoparasite among sheep (0.04%), while *Babesia* spp. was the least prevalent (0.01%) (Table 1).

The yearly prevalence of hemoparasites among cattle showed that *Anaplasma* spp. was the most prevalent in 2017 (1.84%) with a zero prevalence between 2010 and 2012. The prevalence of *Babesia* spp. peaked at 2010, 2015 and 2017, while the prevalence of *Theileria* spp. was the

most prevalent in 2017 (2.22%), 2018 (1.89%) and 2016 (1.05%) (Fig. 1). The yearly prevalence of hemoparasites among sheep showed uneven patterns of distribution in *Anaplasma* spp., *Babesia* spp. and *Theileria* spp. during the study period (Fig. 2).

Figure 3 shows the monthly prevalence of hemoparasites of cattle over the study period. The high prevalence of *Anaplasma* spp. was detected in August (0.718%) and July (0.522%) with low prevalences recorded in January and February. The prevalence of *Babesia* spp. ranged between 0.033% (February) and 0.612% (November). *Theileria* spp. was the most prevalent during the months of August and July and least prevalent in February and March. The monthly prevalence for hemoparasites of sheep is presented in Figure 4. The monthly prevalence of *Anaplasma* spp. showed a zigzag pattern with peaks at January, March, June, July, August and December. The prevalence of *Babesia* spp. and *Theileria* spp. ranged between 0.003% and 0.011% and 0.011% to 0.065%, respectively.

Table 1. Total prevalence (%) of haemoparasites of cattle and sheep from Mosul, Iraq.

Animal (Number)	Number positive	Prevalence (%)
Cattle (55,194)		
Anaplasma spp.	207	0.38
Babesia spp.	94	0.17
Theileria spp.	365	0.66
Sheep (1,773,617)		
Anaplasma spp.	776	0.04
Babesia spp.	134	0.01
Theileria spp.	558	0.03

The pattern of rainfall, temperature and relative humidity appears to influence the pattern of the occurrence of *Anaplasma* spp., *Babesia* spp. and *Theileria* spp. infection in cattle (Fig. 5). There was a very high correlation (negative) between rainfall and the occurrence of *Anaplasma* spp. infection in cattle (Table 2). The relationship between temperature and the occurrence of *Anaplasma* spp. infection showed a very high positive correlation, while that of relative humidity and the occurrence of *Anaplasma* spp. showed a moderate negative correlation. The association of these climatic variables and *Anaplasma* spp. occurrence were all significant ($p < 0.05$). There was a significant ($p = 0.035$), moderate positive correlation between the occurrence *Babesia* spp. infection and temperature. The correlation between rainfall and temperature with the occurrence of *Theileria* spp. infection was significant ($p < 0.05$) (Table 2).

The effects of the climatic variables influenced the prevalence of hemoparasites of sheep (Fig. 6). A moderate negative correlation was observed between rainfall and *Babesia* spp. infection in sheep and this was significant ($p = 0.041$). There was no significant ($P > 0.05$) correlation with the climatic variables and the occurrence of *Anaplasma* spp. and *Theileria* spp. infection in sheep (Table 2).

Discussion

This study appears to be the first to evaluate the association between climatic variables and the prevalence of hemoparasites of cattle and sheep in Mosul, Iraq. In this present study, we estimated the prevalence of hemoparasites of cattle and sheep and also determined the effects of climatic factors on the occurrence of hemoparasitic infections. We detected a relatively lower prevalence of *Anaplasma* spp.,

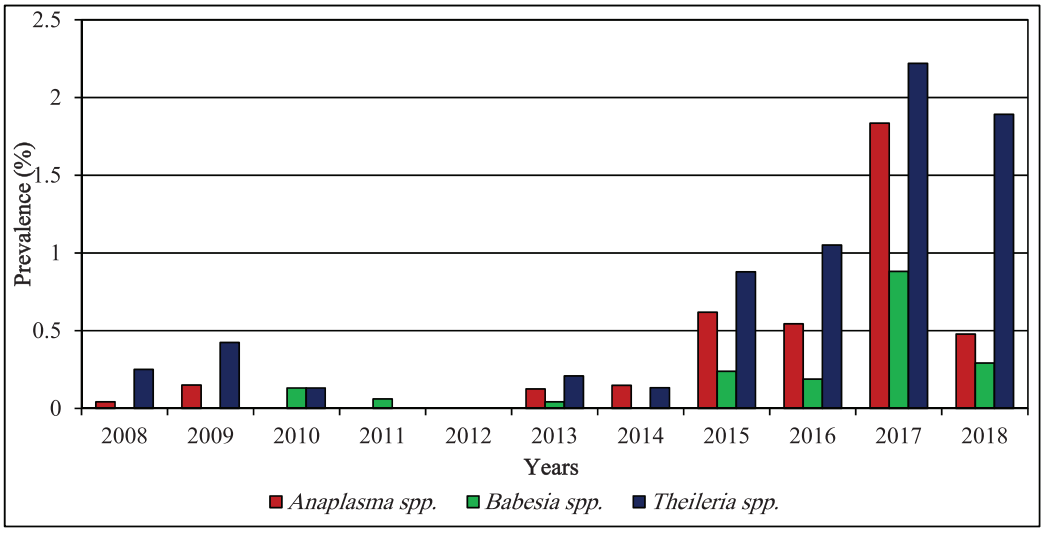

Figure 1. Yearly prevalence of haemoparasites of cattle in Mosul, Iraq (2008–2018).

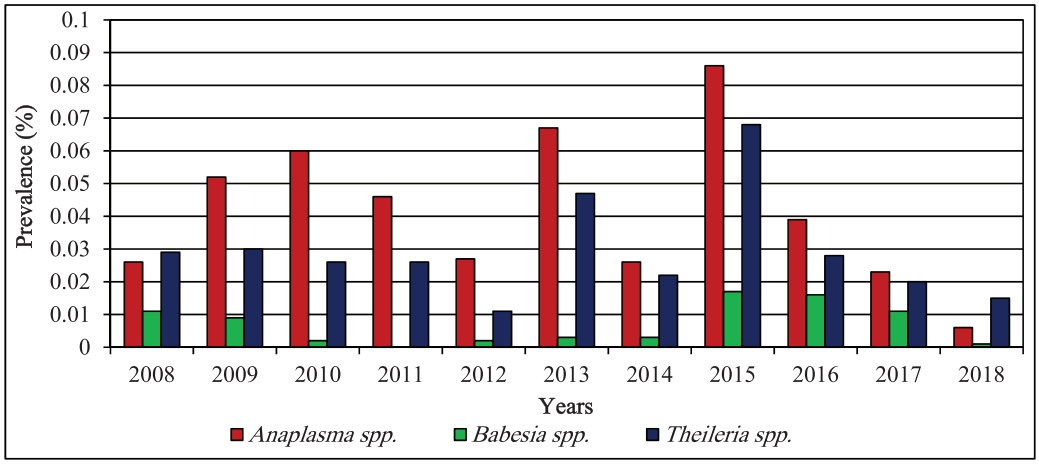

Figure 2. Yearly prevalence of haemoparasites of sheep in Mosul, Iraq (2008–2018).

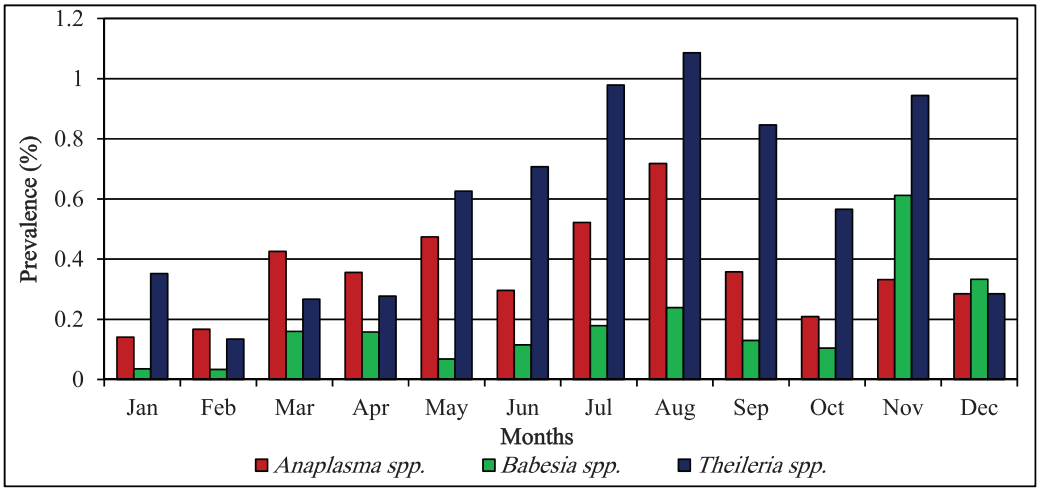

Figure 3. Monthly prevalence of haemoparasites of cattle in Mosul, Iraq (2008–2018).

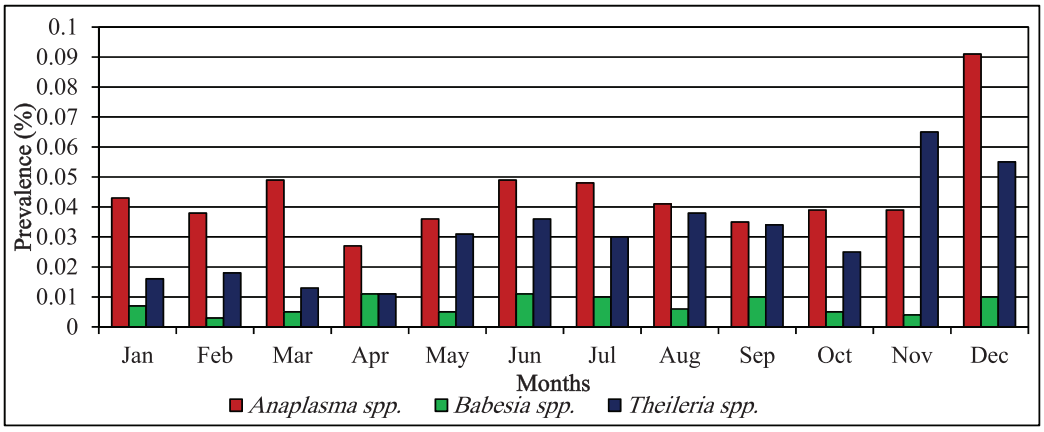

Figure 4. Monthly prevalence of haemoparasites of sheep in Mosul, Iraq (2008–2018).

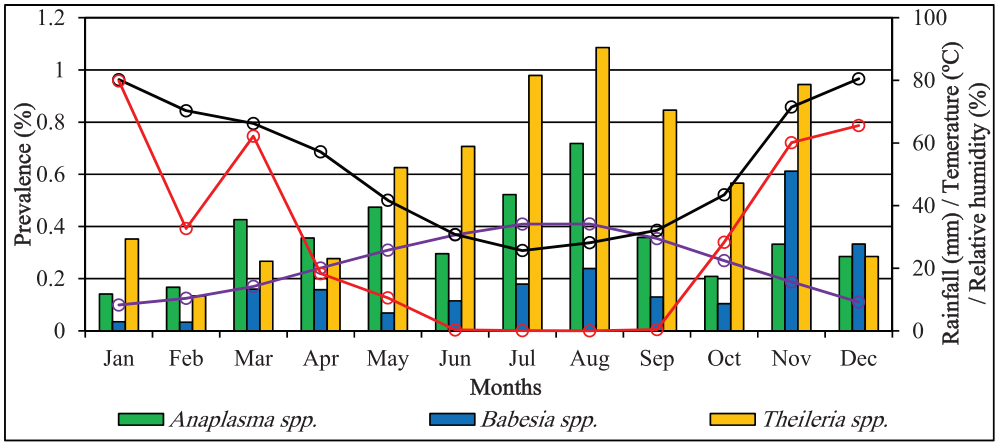

Figure 5. Relationship between the prevalence (%) of haemoparasites of cattle and climatic variables (rainfall (mm), temperature (°C), and relative humidity (%)) in Mosul, Iraq.

Table 2. Spearman's correlation (R^2 value and significance level) of the association between the occurrence of haemoparasites of cattle and sheep and climatic variables [rainfall (mm), temperature (°C) and relative humidity (%)] in Mosul, Iraq.

Animals / haemoparasites	Rainfall (mm)		Temperature (°C)		Relative humidity (%)	
	R^2	Sig	R^2	Sig	R^2	Sig
Cattle						
Anaplasma spp.	−0.92	0.000‡	0.95	0.000‡	−0.66	0.019‡
Babesia spp.	−0.54	0.067	0.61	0.035‡	−0.25	0.425
Theileria spp.	−0.83	0.001‡	0.90	0.000‡	−0.54	0.073
Sheep						
Anaplasma spp.	−0.41	0.190	0.41	0.186	−0.33	0.301
Babesia spp.	−0.60	0.041‡	0.58	0.050	−0.20	0.526
Theileria spp.	−0.34	0.276	0.39	0.208	−0.06	0.863

‡Significant at $p < 0.05$.

Babesia spp. and *Theileria* spp. among cattle and sheep in Mosul, Iraq. Higher prevalence of cattle hemoparasitism has been documented in Iraq, Nigeria, Iran, and Egypt by Ibrahim et al. [18], Ola-Fadunsin [19], Rajabi et al. [20] and Taha et al. [21] respectively. Similarly, higher prevalence of *Anaplasma* spp., *Babesia* spp. and *Theileria* spp. infection has been documented among sheep in Kurdistan Region of Iraq of [3]. Jatau et al. [22], Rjeibi et al. [8], Bilgic et al. [4], and Mohammed et al. [23] reported a higher prevalence of hemoparasites infections among sheep in Nigeria, Tunisia, Turkey, and Sudan, respectively. Disparity in time of study, breeds of animals sampled, differences in sample size, the diagnostic tool used, and the management and nutritional status of animals sampled could have resulted in the inconsistency of prevalence recorded in this study compared to those by other researchers. We observed *Theileria* spp. and *Anaplasma* spp. to be the most prevalent hemoparasites affecting cattle and sheep, respectively, in this study. Similarly, El-Matenawy [24] reported *Theileria* spp. to be the most prevalent hemoparasite affecting cattle in Saudi Arabia. In line with our finding, Renneker et al. [3] documented *Anaplasma ovis* as the most prevalent hemoparasite affecting sheep in Iraq. The fact that *Anaplasma* spp. infection in sheep can be transmitted by numerous means (biologically by ticks, mechanically by biting flies, through blood-contaminated fomites and shearing instruments) could have been the reason for our finding.

The undefined yearly and monthly prevalence of hemoparasites of cattle and sheep we observed could be attributed to the unrest and government policies in Iraq over the period of study. The effect of rainfall, temperature and relative humidity on the occurrence of hemoparasites of cattle and sheep we observed in this study is not strange, although our finding appears to the first to be reported in Iraq. *Anaplasma* spp., *Babesia* spp. and *Theileria* spp. studied are all tick-borne parasites, so their occurrence will be determined by the abundance the vector responsible for their transmission. In a recent study conducted in Kenya

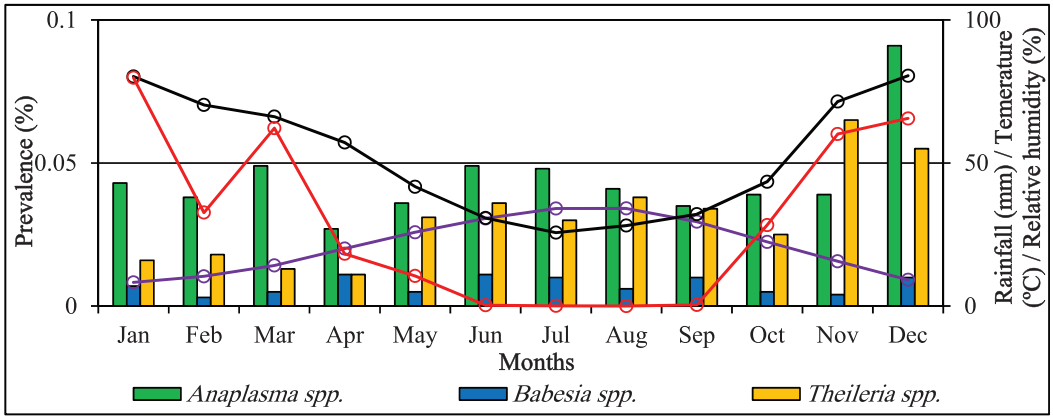

Figure 6. Relationship between the prevalence (%) of haemoparasites of sheep and climatic variables (rainfall (mm), temperature (°C), and relative humidity (%)) in Mosul, Iraq.

by Keesing et al. [25], they reported that the rainfall negatively influenced the abundance of *Rhipicephalus pulchellus* and *R. praetextatus* larvae. Also in line with our finding, Tokarevich et al. [26] reported that temperature favours the increase of ticks' population in Russian. Temperature determines the duration of the different stages of the tick life cycle. The ability of ticks to lay eggs and hatch in a season depends greatly on the sum of effective temperatures [27,28]. Generally, environmental factors, such as temperature and humidity, have been shown to influence tick abundance, availability of hosts, their survival and disease transmission [29], thereby influencing the prevalence of diseases transmitted by ticks. The prevalence obtained in our study may have been higher if a more sensitive diagnostic technique such as molecular technique was used. Molecular detection of hemoparasites using PCR is more sensitive and specific than examination of blood smears, particularly in cases of low parasitaemia [30].

Conclusion

Anaplasma spp. *Babesia* spp., and *Theileria* spp. were the hemoparasites detected among cattle and sheep in Mosul, Iraq. *Theileria* spp. was the most prevalent blood parasite among cattle, while *Anaplasma* spp. was the most prevalent among sheep. There was no defined pattern in the yearly and monthly prevalence of theses hemoparasites in cattle and sheep. Rainfall, temperature and relative humidity influenced the occurrence of these hemoparasites in Mosul, Iraq. Our finding will be useful in enriching the epidemiological data base of Iraq for better hemoparasitic diseases surveillance and control.

Acknowledgment

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Conflict of interest

The authors hereby declare that there is no conflict of interest regarding the research, authorship, and publication of this article.

Authors' contributions

Donea Abdulrazak Abdullah, Moeena Sadeq Ali, Sanna Gazei Omer, and Fawwaz Fadhil Ali did the laboratory analysis. Shola David Ola-Fadunsin did the statistical analyzed and prepared the manuscript, while Fufa Ido Gimba was involved in the statistical analysis. All authors read and approved the final manuscript.

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