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# PREVALENCE OF TICKS AND RISK FACTORS ASSOCIATED WITH THE INFESTATION OF SHEEP IN RIVER NILE STATE, SUDAN

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## Abstract

A cross-sectional study was conducted in River Nile State, Sudan, between June to August 2018 to determine the prevalence of tick infestation on sheep and the potential risk factors associated with the infestation. A total of 135 sheep from five different localities (Shendi, Al Matamah, Ad-Damer, Atbara, and Berber) were examined and, of these, 90 were tick-infested (66.7%). A total of 340 ticks (male 185, female 155) were collected and identified using zoological taxonomic keys. The most dominant tick species collected in this survey were *Rhipicephalus eversti* Neumann, 1897 (38%), followed by *Hyalomma anatolicum* Koch, 1844 (23.8%), *Rhipicephalus sanguineus* Latreille, 1806 (20.6%), *Rhipicephalus praetextatus* Gerstacker, 1873 (16.4%), and *Hyalomma dromedarii* Koch, 1844 (1.2%). The chi-square analysis showed that there was a significant association ($p \leq 0.05$) between tick infestation and localities, housing type, sex, control of ticks, and removal of manure. The highest prevalence rate was recorded in Atbara, in the open housing type, in females, in farms that did not use acaricides and did not remove the manure frequently. On the other hand, there was no significant association ($p > 0.05$) between tick infestation and herd size, rearing system, breed, age and colour of coat ($p$=0.846). This study expanded the knowledge on tick fauna and associated risk factors in the River Nile State, and it demonstrated that multiple tick species are infesting sheep with the potential to transmit several tick-borne diseases.

**Key words:** Ticks, risk factors, sheep, Sudan

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# PREVALENCIJA KRPELJA I FAKTORI RIZIKA POVEZANI SA INFESTACIJOM OVACA U DRŽAVI REKA NIL, SUDAN

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## Kratak sadržaj

Istraživanje je sprovedeno kao studija preseka u državi Reka Nil, Sudan, u periodu od juna do avgusta 2018. Cilj istraživanja bio je da se odredi prevalencija infestacije krpeljima kod ovaca i identifikuju potencijalni faktori rizika vezani za ovu infestaciju. Ispitano je ukupno 135 ovaca sa pet različitih lokacija (Šemdo, Al Matamah, Ad-Damer, Atbara, i Berber) od kojih je 90 (66.7%) bilo zaraženo krpeljima. Sakupljeno je ukupno 340 krpelja (185 muških i 155 ženskih jedinki), a identifikacija je izvršena primenom zooloških taksonomskih ključeva. Najdominantnije identifikovane vrste sakupljenih krpelja bile su *Rhipicephalus eversti* Neumann, 1897 (38%), zatim *Hyalomma anatolicum* Koch, 1844 (23.8%), *Rhipicephalus sanguineus* Latreille, 1806 (20.6%), *Rhipicephalus praetextatus* Gerstacker, 1873 (16.4%) i *Hyalomma dromedarii* Koch, 1844 (1.2%). Hi-kvadratni test pokazao je značajnu povezanost ($p \leq 0.05$) između infestacije i lokaliteta, načina držanja, pola, mera kontrole krpelja i uklanjanja stajnjaka. Najviša stopa prevalencije zabeležena je u oblasti Atbara, u otvorenim smeštajnim jedinicama, kod ženskih jedinki na farmama koje nisu primenjivale acaricide i nisu redovno uklanjale stajnjak. S druge strane, nije bilo značajne povezanosti ($p > 0.05$) između infestacije krpeljima i veličine zapata, sistema uzgoja, rase, starosti i boje krzna ($p = 0.846$). Ovo istraživanje proširilo je znanja o fauni krpelja i relevantnim faktorima rizika u državi Reka Nil i pokazalo da više vrsta krpelja napadaju ovce i potencijalno prenose ozbiljna oboljenja izazvana krpeljima.

**Ključne reči:** krpelji, faktori rizika, ovce, Sudan

## INTRODUCTION

Ticks, belonging to the family *Ixodidae*, are the most important vectors of a wide variety of pathogens including protozoa, bacteria, helminths, and viruses, which affect domestic animals and humans (Jongejan and Uilenberg, 2004). During feeding, ticks may cause direct or indirect effects on their hosts. The direct effects of ticks include the sucking of blood, which in turn leads to anaemia and damage to the skin. Consequently, these effects result in significant losses in productivity, fertility, body weight, milk and meat production, and mortality (Mapholi et al., 2014). The indirect losses of ticks are related to the infectious agents transmitted by them and the costs associated with the treatment and control (Hurtado and Giraldo-Ríos, 2018).

Ticks and tick-borne diseases are prevalent in Sudan, cause notable economic losses, and constitute major barriers to the development of animal production. Among these diseases, Theileriosis, Babesiosis, and Anaplasmosis are considered the most important diseases (El Hussein et al., 2004).

In Sudan, more than 70 tick species were identified including the most economically important ticks in Africa (Hassan, 2003).

According to Hoogstraal (1956) and Osman et al. (1982) ticks infesting livestock in Sudan are mainly *Hyalomma anatolicum, Hyalomma dromedarii, Hyalomma rufipes, Hyalomma impressum, Hyalomma impeltatum, Hyalomma truncatum, Rhipicephalus evertsi, Rhipicephalus sanguineus, Rhipicephalus praetextatus, Rhipicephalus decoloratus, Rhipicephalus annulatus, Amblyomma lepidum* and *Amblyomma variegatum*.

In a recent study conducted in Khartoum and East Darfur State, the authors reported that the most prevalent tick species were *H. anatolicum* (57.3%) and *H. rufipes* (29%), respectively (Mossaad et al., 2021).

*R. evertsi* was the dominant tick species (51.6%) in Al Gezira State (Hayati et al., 2020), while *H. anatolicum* was the predominant species (73.6%) in River Nile State (Ahmed et al., 2005). In White Nile State, *A. lepidum* was the most abundant tick species (Guma et al., 2015), whereas *H. rufipes* is the most frequent one in North Kordofan State (Mohammed-Ahmed et al., 2018). Clearly, there is a large variation in the tick prevalence among the states.

Although the distribution and prevalence rate of tick infestation have been documented previously in several states in Sudan, these data are changing dramatically due to climate changes and animal movement (Hassan and Salih, 2013). Therefore, an annual investigation is recommended to update our data and to predict which kind of "new" or emergent infectious diseases could occur in the State. Additionally, only a few studies have investigated the risk factors associated with tick infestation on livestock farms in Sudan. Therefore,

this study was aimed to estimate the prevalence of tick infestation and to determine the potential risk factors associated with tick infestation in sheep in River Nile State.

## MATERIAL AND METHODS

### *Ethical approval*

All animal procedures were carried out following the ethical standards established by the Institutional Ethics Committee of Sudan University of Science and Technology, Sudan.

### *Study area*

The study was conducted in River Nile State, which is located in the northern part of Sudan between latitude 16 - 22 °N and longitude 30 - 32 °E. The state is bordered by Khartoum State to the south, the Arab Republic of Egypt to the north, Kassala State and the Red Sea State to the east and Kordofan State to the west. Generally, the climate is semi-desert, and the temperatures range between 47 °C in summer and 8 °C in winter. The mean rainfall is between 150 and 25 mm.

### *Study design*

A cross-sectional study was performed over the time from June to August 2018 in River Nile State, Sudan (Figure 1). Five different localities, namely: Shendi, Al Matamah, Ad-Damer, Atbara, and Berber were conveniently selected and individual sheep were randomly sampled.

Figure 1. Shows the study area (River Nile State in red area).
(https://en.wikipedia.org/wiki/River Nile %28state%29)

Meanwhile, individual animal data including age, sex, breed and coat colour was recorded in a questionnaire. Moreover, the data regarding locality, herd size, housing type, rearing system, tick control, and removal of manure were also documented.

The animals were classified into three age groups, young animals (age < 6 months), adults (age between 6 months and 3 years) and old (age > 3 years). The breed of sheep was classified into two categories: crossbreed (Local breed × Saanen) and local breed. The coat colour of the examined sheep was classified into four groups, white, black, brown, and mixed colour (more than one colour). The herd size was classified into three groups: small (less than 70 animals), medium (70 - 140 animals) and large (more than 140 animals). The housing type was categorized into two groups: the open and semi-closed. The rearing system was classified into two groups: one-species rearing system (one species of animal) and a mixed rearing system (more than one species of animals).

### *Sample size*

The overall number of animals to be included in the study was calculated using a formula of Thrusfield (2007):

$$n = (1.96)^2 \times P_{exp} \times (1- P_{exp}) / d^2$$

Accordingly, the sample size of 135 sheep was determined.

### *Collection and identification of ticks*

Ticks were collected from the predilection sites of sheep's bodies (preferred regions for ticks), which included ears, tails, udders and testicles. The collection was performed using a pair of blunt forceps, and the ticks were transferred into labelled tubes that contained 70% ethanol. The tick specimen was identified using morphological keys (Hoogstraal, 1956; Walker et al., 2003).

### *Data analysis*

The statistical software program (SPSS version 16.0) was used to analyse the data. The association between the tick infestation and risk factors was analysed using the Chi-square test. In all analyses, a 95% the confidence interval (CI) was held and the *p*-value less than 0.05 ($p > 0.05$) was set for statistical significance.

## RESULTS

### *The overall prevalence of tick infestation*

Out of 135 examined sheep, 90 sheep were infested with ticks (66.7%) while 45 sheep were non-infested (33.3%).

### *Tick species*

A total of 340 ixoid ticks (185 male and 155 female) were collected. Five tick species of the two genera were identified during this study. *R. eversti* was the most abundant among the tick species collected from study animals (38%), followed by *H. anatolicum* (23.8%), *R. sanguineus* (20.6%), *R. praetextatus* (16.4%), and *H. dromedarii* (1.2%) (Table 1).

Table 1. Prevalence of tick species

| Tick species | No of ticks | | | Prevalence | Overall Male/ Female ratio |
|---|---|---|---|---|---|
| | Male | Female | Total | | |
| *Hyalomma anatolicum* | 46 | 35 | 81 | 23.8% | 1.3 : 1 |
| *Hyalomma dromedarii* | 1 | 3 | 4 | 1.2% | 0.3 : 1 |
| *Rhipicephalus eversti* | 76 | 53 | 129 | 38% | 1.4 : 1 |
| *Rhipicephalus sanguineus* | 34 | 36 | 70 | 20.6% | 0.9 : 1 |
| *Rhipicephalus praetextatus* | 28 | 28 | 56 | 16.4% | 1 : 1 |
| **Total** | 185 | 155 | 340 | - | - |

### *Prevalence of tick infestation based on risk factors*

There was significant variation ($p \leq 0.05$) in the prevalence of tick infestation among the surveyed localities. The highest prevalence rate was reported in Atbara (100%), while the lowest prevalence was documented in Al Matamah (28%) (Table 2).

Table 2. Prevalence of tick infestation on the basis of locality, herd size, housing type, raring system, breed, sex, age, colour coat, tick control, and remove of manure in sheep in River Nile State.

| Risk factor | No. of sheep | No. of infested sheep (%) | df | Chi-Square ($X^2$) | p-value |
|---|---|---|---|---|---|
| **Locality:** | | | | | |
| Shendi | 63 | 48 (76.2 %) | 4 | 26.164 | 0.000 |
| Al Matamah | 25 | 7 (28 %) | | | |
| Ad- Damer | 22 | 18 (81.8 %) | | | |
| Atbara | 7 | 7 (100 %) | | | |
| Berber | 18 | 10 (55.6 %) | | | |

| Risk factor | No. of sheep | No. of infested sheep (%) | df | Chi-Square ($X^2$) | p-value |
|---|---|---|---|---|---|
| **Herd size:** | | | | | |
| Small | 72 | 51 (70.8%) | | | |
| Medium | 45 | 27 (60%) | 2 | 1.463 | 0.481 |
| Large | 18 | 12 (66.7%) | | | |
| **Housing type** | | | | | |
| Open | 90 | 70 (77.8%) | 1 | 15.000 | 0.000 |
| Semi-closed | 45 | 20 (44.4%) | | | |
| **Rearing system** | | | | | |
| One species rearing system | 35 | 27 (77.1%) | 1 | 2.334 | 0.127 |
| Mixed rearing system | 100 | 63 (63%) | | | |
| **Animal breed** | | | | | |
| Local breed | 135 | 90 (66.7%) | - | - | - |
| **Sex** | | | | | |
| Male | 65 | 37 (56.9%) | 1 | 5.355 | 0.021 |
| Female | 70 | 53 (75.7%) | | | |
| **Age** | | | | | |
| Young | 20 | 12 (60%) | | | |
| Adult | 111 | 75 (67.6%) | 2 | 0.566 | 0.754 |
| Old | 4 | 3 (75%) | | | |
| **Coat colour** | | | | | |
| White | 47 | 29 (61.7%) | | | |
| Black | 13 | 9 (69.2%) | 3 | 0.815 | 0.846 |
| Brown | 68 | 47 (69.1%) | | | |
| Mixed | 7 | 5 (71.4%) | | | |
| **Tick control (acaricide)** | | | | | |
| Yes | 47 | 23 (48.9%) | 1 | 10.200 | 0.001 |
| No | 88 | 67 (76.1%) | | | |
| **Removal of manure** | | | | | |
| Weekly | 14 | 4 (28.6%) | | | |
| Monthly | 31 | 14 (45.2%) | 2 | 22.794 | 0.000 |
| Irregularly | 90 | 72 (80%) | | | |

The housing type and sex were also significantly associated ($p \leq 0.05$) with the prevalence of tick infestation. The prevalence of infestation in the open types was higher (77.8%) than in the semi-closed types (44.4%). Females showed the highest prevalence of infestation (75.7%) compared with males (56.9%).

Both factors, i.e., tick control and removal of the manure, were also significantly associated with the tick infestation. The highest rate of ticks infestation was observed in farms that did not use acaricide (76.1%) compared with farms that used acaricide as a control measure (48.9%). Moreover, a higher infestation of ticks was detected in farms that did not remove the manure regularly (80%) as compared with other ones.

Risk factors such as herd size, rearing system, breed, age, and coat colour were not significantly associated with the prevalence of tick infestation ($p > 0.05$) (Table 2). However, the prevalence was higher in small heard size (70.8%) compared with medium (60%) and large size (66.7%). The highest prevalence rate of infestation was observed in one-species rearing system (77.1%) than in mixed rearing system (63%). Animals of the young age (age < 6 months) showed the lowest prevalence rate (60%) followed by adult animals (age between 6 months and 3 years) (67.6%), whereas animals of old age (age > 3 years) showed the highest prevalence rate (75%) (Table 2).

During the sampling, all sheep examined were local breed. With respect to the coat colour, the prevalence rates of tick infestation ranged between 61.7% and 71.4% (Table 2).

## DISCUSSION

In Sudan, out of 70 tick species documented, 34 species are known to infest sheep and goats. These species belong to the genera *Amblyomma, Hyalomma, Rhipicephalus* (*Boophilus*) (Osman, 1997). During the current study, five species of ticks were found to infest sheep in River Nile State, Sudan. These include (in order of abundance), *R. eversti*, *H. anatolicum*, *R. sanguineus*, *R. praetextatus*, and *H. dromedarii*. These species were previously reported in sheep from River Nile State (Ahmed et al., 2005) and from Khartoum (Gad Elrab, 1986). On the other hand, Yagoub et al., (2015) identified ten tick species that infesting sheep and goats in Nyala town, South Darfur. A similar finding was also reported in North Kordofan and Kassala States, in which ten species of ticks that infest sheep were recognized (Springer et al., 2020). It is evident that the climate and ecological conditions of River Nile State do not allow for the existence and reproduction of several other ticks species that infest sheep such as *Rhipicephalus* (*Boophilus*) species and *Amblyomma* species, which exist in other states of Sudan (Osman et al., 1982).

The overall prevalence of tick infestation in sheep in the Nile River State was 66.7%. This result was comparable to those reported by Mathewos et al., (2021) in Ethiopia (68.33%) and higher than the 51.97% reported by Khan et

al., (2022) in Pakistan. The variation in the infestation rate may be attributed to varying environmental conditions, production and management factors that in turn affect the ticks' population (Norval et al., 1992).

In general, male ticks represented the majority of all species collected except for *H. dromedarii* and *R. sanguineus*. This confirms the finding of Ahmed et al. (2005) who reported that the number of male ticks usually exceeded the number of females among all species infesting sheep.

In the current study, risk factors such as locality, housing type, sex, control of ticks and removal of manure were significantly associated with tick infestation. A significant variation in the tick infestation was observed among the localities where the highest prevalence was observed in Atbara (100%), while the lowest one was reported in Al Matamah (28%). This finding confirms the results of Fesseha et al. (2022) who observed a high frequency of tick infestation in Dasenech in Ethiopia (54.9%) compared to results of Salamago (45.1%), with a statistically significant association. This could be due to the distinctions in the agroclimatic conditions of the study areas, and also to the time of sample collection. It is well recognized that tick activity can be influenced by altitude, season, rainfall, and atmospheric relative humidity (Ayalew et al., 2014).

Higher tick infestation was reported in the open type (77.8%) compared with the semi-closed type (44.4%) housing. Contrary to that, a lower prevalence of tick infestation has been observed on farms with open houses type in Pakistan (Rehman et al., 2017). One possible explanation to this difference is the construction of open housing types in Sudan. Namely, the construction of these houses is very poor, using traditional materials such as mud and wood full of cracks, which provides an optimal environment for the ticks to survive. Moreover, the animals that were raised in close or semi-closed housing types in Sudan received a proper veterinary service and more attention since the majority of them was owned by the companies. This hypothesis was confirmed by our results revealing that the prevalence of tick infestation was higher in farms that did not apply acaricide (76.1%) compared with the farm that used acaricide (48.9%). In addition, the prevalence was higher in the farms that did not regularly remove manure (80%) compared with other ones. As we know, ticks have a free-living stage, in which they are dropping down to the ground in order to complete their life cycle (Walker et al., 2003). During this time, ticks become more susceptible to many factors such as hygiene measures, which in turn reduce the tick population.

The analysis of infestation according to sex revealed that there were more tick infestations on female sheep than on male animals. Similar finding was also reported in previous study, which established that the tick infestation was

higher in females (78.1%) than in males (58.42%) (Mathewos et al., 2021). The logical explanation for this finding is that the stress factors such as pregnancy and lactation may have made the female animals more susceptible to infestation with ticks as compared with males. Adding to that, the females are generally kept for a long time for birth-giving pursuits, which raises the possibility of being infested with ticks (Mathewos et al., 2021).

This study found no significant association ($p > 0.05$) between tick prevalence and factors such as herd size, rearing system, breed, age, and coat colour. However, the proportion of tick infestation was higher in old animals (age ≥ 3 years) (75%) than in the adult (67.6%) and young (60%) age groups. This finding was strengthened by the findings of Asmaa et al. (2014) who reported higher infestation in animals aged more than 3 years. A higher prevalence of tick infestation may be due to low immunity in older animals and the long-mileage movement of older animals searching for food, which increases the probability of infesting with ticks (Fesseha et al., 2022).

Although there is no association between the herd size and tick infestation, the prevalence of infestation was higher in the small-size herds (less than 70 animals) (70.8%) as compared with the medium (60%) and large size (66.7%) herds. This was comparable with the study conducted by Sajid et al. (2020) in which they found that herds having 40 - 60 goats showed the highest ticks infestation. This might be due to the fact that a large number of ticks were fed on a few animals, which increased the rate of infestation.

No significant differences in the tick infestation rate were found between the sheep reared with other ruminants (mixed rearing system) and those reared separately (one species rearing system). This finding was in agreement with the report of Sajid et al. (2020) who found no association between the tick infestation and rearing type (with other ruminants or separately).

In the present study, sheep coat colour did not significantly influence the prevalence of tick infestation since the prevalence ranged between 61.7% and 71.4%. Contrary to that, Hayati et al., (2020) and Hassan (1997) found that the coat colour of cattle had a significant influence on the tick burdens, where animals with light coat colour carried more ticks compared to the animals with dark coat colour. The author suggested that ticks picked by cattle with dark coat colours such as black and brown die or leave before the attachment, due to the rather increased temperature in the animal skin microenvironment produced by the dark coat colour (Hayati et al., 2020). Probably such kind of effect does not exist in sheep due to the difference between sheep coats and cattle coats.

## CONCLUSION

The current study revealed a high prevalence of tick infestation in sheep in River Nile State, Sudan, and this causes a major health restraint, which results in huge economic losses. This study showed that *Rhipicephalus eversti* Neumann, 1897 was the predominant tick species followed by *Hyalomma anatolicum* Koch, 1844, *Rhipicephalus sanguineus Latreille, 1806*, *Rhipicephalus praetextatus* Gerstacker, 1877, and *Hyalomma dromedarii* Koch, 1844. The risk factor analyses showed that localities, housing type, sex, control of ticks, and removal of manure significantly affected the prevalence of tick infestations. While factors such as herd size, rearing system, breed, age and colour of coat had no influence on the prevalence of tick infestation. Due to the high prevalence of sheep ticks in the study area, the State requires prompt attention at all levels to decrease the impact of tick and tick-borne disease on the health and production of animals and thereby enhance their productivity.

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### Author's Contribution:

This work was carried out in collaboration among all authors. H.K.K. carried out the experiments. S.B.M. planned the experiments, analysed the data, wrote the manuscript and supervised the project. K.M.T contributed to the final version of the manuscript. All authors read and approved the final manuscript.

### Competing interest

The authors declare no conflicts of interest in relation to this work.

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