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Research Article

Prevalence and Associated Risk Factors of Babesiosis in Cattle and Sheep in Katsina Central Abattoir, Katsina State, Nigeria

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ABSTRACT
Babesiosis is a tick-borne haemoparasitic disease of considerable economic importance in tropical livestock systems. However, there is limited recent epidemiological information on its prevalence and associated risk factors among slaughtered animals in Katsina State, Nigeria. This cross-sectional study was conducted to determine the prevalence of babesiosis and assess associated risk factors in cattle and sheep slaughtered at Katsina Central Abattoir. A total of 300 animals, comprising 150 cattle and 150 sheep, were sampled. Paired blood samples were collected from the jugular vein during slaughtering into EDTA bottles and examined using standard parasitological techniques. Data on host factors such as sex, age, and breed were analyzed using chi-square and logistic regression. The overall prevalence of babesiosis was 7.0% (21/300). In cattle, females had a slightly higher prevalence (8.30%) than males (7.14%), while in sheep, females (6.19%) were more infected than males (5.40%); however, these differences were not statistically significant ($p > 0.05$). Breed-related variation was observed, with White Fulani cattle showing higher infection compared to Red Bororo and Yankasa sheep having a higher prevalence than Balami sheep, although this association was marginal ($p = 0.05$). Age-specific prevalence varied across groups, but no statistically significant association was found between age and infection in both cattle and sheep ($p > 0.05$). The disease showed moderate prevalence among slaughtered cattle and sheep in Katsina, although the assessed risk factors were not statistically significant. Improved tick control, especially against *Rhipicephalus* species, is recommended to reduce disease burden..

Keywords: Babesiosis; Cattle; Katsina; Microscopic examination; PCV; Sheep

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INTRODUCTION

Babesia is a protozoan parasite of the blood that causes a haemolytic disease known as babesiosis, an emerging zoonotic disease in all continents, and is very debilitating. Parasites of the genus *Babesia* infect a wide variety of domestic and wild mammals as well as man (Krause, 2019). *Babesia* parasites are found in the blood and are transmitted to the host by Ixodidae ticks through blood-sucking (Silver *et al*., 2010). *Babesia bovis* and *B. bigemina* are common species that affect cattle (Yusuf, 2017). *Rhipicephalus* (*Boophilus*) microplus is the principal vector of *B. bigemina* and *B. bovis* and is widespread in the tropics and subtropics (OIE, 2018). Bovine babesiosis is a disease that commonly infects cattle, sheep, goats, horses, pigs, dogs, and cats, and occasionally humans. *Babesia bovis* and *B. bigemina* are the main species affecting cattle, widely distributed in tropical and subtropical countries, which are responsible for high mortality rates of 50% in susceptible herds, and they are known to be transmitted in this country by *Rhipicephalus* (Lardo 2023). Babesiosis remains a persistent and Under-recognised threat to livestock health and productivity in Nigeria (Okeke *et al*.,.2020). Babesiosis has significant implications not only for animal health and productivity but also for food security, rural economies, and public health, particularly due to the zoonotic potential of some *Babesia* species (Okeke *et al*., 2020).

A widespread tick-borne haemoparasitic disease of cattle, babesiosis has a major economic impact on both developed and developing nations (Bock *et al*., 2004; Schnittger *et al*., 2012). According to Jongejan and Uilenberg (2004), its prevalence varies widely with ecological and management conditions, with increased endemicity observed in tropical and subtropical regions where tick vectors are prevalent. Due to the extensive distribution of ixodid ticks, especially those belonging to the genus Rhipicephalus, the disease is regarded as endemic throughout Africa; reported prevalence frequently ranges from 5% to 30%, depending on host species and diagnostic techniques (Makala *et al*., 2003; Chaisi *et al*., 2017). Babesiosis has been documented in cattle and small ruminants in Nigeria; prevalence estimates typically range from roughly 3% to over 20% across (Lorusso *et al*., 2016; Kamani *et al*., 2010). Clinical signs of babesiosis typically appear 2-3 weeks after tick infestation in an infected animal. However, direct injection of contaminated blood can shorten the incubation period. For instance, the incubation period for *Babesia bigemina* is 4-6 days, while that for *Babesia bovis* is 10-12 days (Schnittger *et al*., 2022). The severity of clinical symptoms can vary depending on the animal's age, with older animals being more susceptible due to their weaker immune systems. *Babesia bovis* is significantly more virulent than *Babesia bigemina* and *Babesia divergens*. Different researchers have reported that *Babesia bovis* is approximately 100 times more virulent than its counterparts (Surjowardojo *et al*., 2023).

Babesiosis, like most haemoparasitic infections, has been widely reported to destroy red blood cells, leading to anaemia, jaundice, anorexia, weight loss, and infertility (Ellis *et al*., 2003). In Nigeria, the occurrence of *Babesia ovis* in sheep has been documented in Ibadan (Tella *et al*., 2000), indicating that the disease is present within local livestock populations. Furthermore, several tick species that infest cattle are also parasitic on sheep and goats, thereby facilitating cross-species transmission of the pathogen (George *et al*., 1990).

Cattle and sheep are of immense economic importance, contributing significantly to the production of milk, meat, skin, and wool, and serving as vital sources of livelihood for many households (Rashid *et al*., 2010). However, despite their importance, the burden of babesiosis and its associated risk factors in slaughtered animals (Zygner *et al*., 2023), particularly in abattoirs where animals from diverse sources converge, remains insufficiently documented in many parts of Nigeria, including Katsina State. This gap in knowledge limits effective disease control strategies and implementation which may contribute to ongoing economic losses and reduced animal productivity at large.

Despite the documented occurrence of babesiosis in Nigeria, there remains limited information on its prevalence and associated risk factors in slaughtered livestock, particularly in abattoir settings where animals from diverse origins converge. This study was therefore designed to address the question of whether host-related and management factors significantly influence the occurrence of babesiosis in cattle and sheep. It was hypothesized that babesiosis infection is significantly associated with factors such as age, sex, breed, body condition, and management system. Accordingly, this study aimed to determine the prevalence of babesiosis and identify its associated risk factors in cattle and sheep slaughtered at Katsina Central Abattoir.

MATERIALS AND METHOD

Study Area

The study was conducted at the Katsina Central Abattoir in Katsina State, north-western Nigeria (12.9974°N, 7.6171°E). The area lies within the Sudan savannah zone and is characterized by a tropical continental climate with distinct wet (July–October) and dry (November–June) seasons. Annual rainfall ranges from 600 to 800 mm, with temperatures between 25°C and 40°C, creating favorable conditions for tick survival. Livestock production, especially cattle and small ruminants, constitutes a major component of the local economy.

Study Design and Selection of Cattle

This study employed a cross-sectional survey design.

Sample Size Determination and Sampling Method

A minimum sample size was determined using the formula for estimating a proportion in a finite population as described by Thrusfield *et al. (*2005). A total sample of 150 cattle and 150 sheep was used during the study. Cattle slaughtered at the abattoir were mostly White Fulani and a few Red Bororo breeds. Sheep were mostly the Balami and Yankasa breeds. Animals were conveniently classified into young (< 3years), adult (3-7 years), and old (>7 years) age categories depending on the method used by Delahunta *et al*. (1986)

Data Collection

Characteristics of the population, such as age, gender, breed, and body condition scores, were observed and recorded for each sample throughout the study. Gender differentiation was based on the appearance of external genitals, while breed identification was based on morphology as described by Yunusa *et al*. (2013)

Collection of a blood sample

A total of 300 blood samples (which includes 150 from cattle and 150 from sheep) were collected from Katsina Central Abattoir, Katsina State. A minimum of 2 ml of blood sample from each animal was collected from the jugular vein during slaughtering into bottles containing ethylenediaminetetraacetic acid (EDTA). Then the blood samples were placed in a cold box and immediately taken to the laboratory for *Babesia* identification by Giemsa-stained blood smear examination within one hour. The blood samples were kept in a cold box and then taken to the Microbiology Laboratory, Umaru Musa Yar'adua University, Katsina.

Examination of Blood using a thin smear

Giemsa staining procedure and microscopy were carried out as described by Kessel (2015). After labeling of the slide with sample code, the thin smear was air- dried and fixed with absolute methanol for 2-3 minutes. Staining was achieved by applying Giemsa stain 10% for 30 minutes. Finally, the smear was washed by tap water to remove extra stain, and the slides were examined microscopically. The size, shape, position, and location as described by Souslby (1982).

Data Analysis

The data was summarized and entered into Excel. Statistical software package for Social Science (SPSS) version 21.0 was used to analyze the data obtained. The statistical association of the risk factors (sex and breed) and the prevalence of *Babesia* was determined using the chi-square test. Variables with P> 0.05 were considered significant.

RESULTS

Prevalence of Babesiosis among Cattle and Sheep Slaughtered at Katsina Central Abattoir

A total Number of 300 Animals (Cattle and Sheep) from Katsina Central Abattoir where Examined, out of the total 21 (7.0%) Animals (Cattle and Sheep) Where infected with *Babesia* spp, with 12 (8.0%) cattle from Katsina and 9 sheep (6.0%) from Katsina Central Abattoir. The prevalence of *Babesia* infection is not significantly associated (χ^2 0.461, p = 0.497). Out of the 150 cattle samples, 12 that were sampled had a prevalence of 8.0%. Out of the 150 sheep sampled, 9 that were sampled had a prevalence of 6.0%. However, the total prevalence of Babesiosis among Cattle and Sheep Slaughtered at Katsina Central Abattoir. These results showed there is a low prevalence of *Babesia* (Table 1).

Prevalence of Babesiosis in slaughtered Cattle with respect to Gender, Breed, and Age at Katsina Central Abattoir

The Results in Table 2 revealed that gender showed no significant relationship with the *Babesia* parasite and the gender of the animal. The prevalence of *Babesia* infection based on Gender shows a slightly higher infection rate in females, 8.30% (12/150), than in males, 7.14% (3/42), as depicted in Table 2. Even though the difference was not statistically significant (χ^2=0.058, P-Value=0.810). While Age showed a clear and significant relationship between the age of cattle slaughtered at the abattoir and the occurrence of infection. However, the overall occurrence across all age groups was 8 % (12 infected out of 150 examined). The occurrence was lowest in the 4–6-year age group (3.84 %) and highest in the oldest cohort, cattle over 8 years old, which exhibited a considerably higher prevalence of 23.0 %. The chi-square test produced a value of 4.822 with a p-value of 0.185. This p-value, being far above the conventional alpha level of 0.05, indicates that there is no statistically significant difference in infection occurrence between these specific age groups within this study sample. The described breed-based prevalence recorded in this study showed a higher prevalence in white Fulani (8.33%) than in Red Bororo (0.55%), although this difference was not statistically significant (χ^2=0.141, P-value=0.707).

Prevalence of Babesiosis in slaughtered Sheep with respect to Gender, Breed, and Age Slaughtered at Katsina Central Abattoir

Table 3 presents the results on the gender prevalence of *Babesia* parasites in sheep according to gender at the Katsina Abattoir. From a total of 150 sheep examined, 37 were male, and 113 were female. The count of parasites recovered (signifying infection) was 2 in males and 7 in females. This corresponds to a prevalence of 5.40 % in males and a marginally higher rate of 6.19 % in females. A chi-square test (0.039) assessed whether this modest difference was statistically significant, yielding a p-value of 0.844

Sheep Breed shows the occurrence of *Babesia* parasites in two indigenous sheep breeds slaughtered at the Katsina Abattoir. A total of 150 sheep were inspected, comprising 84 Yankasa sheep and 66 Balami sheep. The overall occurrence of *Babesia* infection was 6.0 % (9 out of 150 animals). Breed specific rates were higher in the Yankasa breed at 7.14 % (6 of 84 infected) compared with the Balami breed at 4.54 % (3of 66 infected), reflecting a numerical difference of 2.6 percentage points between the breeds. However, the chi-square of (0.351) test produced a p-value of 0.544. Which is considerably larger than the conventional significance threshold of 0.05. This result clearly shows that there is no statistically significant difference in the occurrence of *Babesia* parasites between the Yankasa and Balami sheep breeds in this study.

Age shows the relationship between age and the prevalence of parasites in sheep slaughtered at an abattoir. A total of 150 sheep were assessed, grouped into four age categories: 12 years (n = 19), 23 years (n = 43), 34 years (n = 71), and > 4 years (n = 17). The overall infection prevalence was low, at 6.0 % (9 of 150 animals). A clear pattern is visible in the data: prevalence rises with age. No infections (0 %) were detected in the youngest group (12 years). The prevalence then climbs thoroughly 7.0 % (5 of 71) in the 34-year group and 5.9 % (1 of 17) in the oldest group (> 4 years). The chi-square value (1.340) and single p-value of (0.720), which is substantially higher than the conventional significance level of 0.05, indicate that this observed upward trend is not.

Table 1: Prevalence of Babesiosis among Cattle and Sheep slaughtered at Katsina Central Abattoir

Animals	Number Examine	Positive Samples	Prevalence	Statistical Value	
Sheep	150	09	6.0.	χ^2 =0.461	P = 0.497
Cattle	150	12	8.0		
Total	300	21	7.0		

Table 2: Prevalence of Babesiosis in slaughtered Cattle with respect to Gender, Breed, and Age at Katsina Central Abattoir

Factors	No. Examined	No. positive	Prevalence	Statistical Value
Gender				Df= 1
Male	42	3	7.1	χ^2 = 0.058
Female	108	9	8.3	P-Value= 0.081
Total	150	12	8.0	
Breed				
White Fulani	132	11	8.3	df= 2
Red				χ^2= 0.141
Bororo	18	1	0.5	P-value= 0.707
Total	150	12	8.0	
Age Group				
2-4	24	2	8.3	χ^2= 4.822
4-6	52	2	3.8	P-Value= 0.185
6-8	61	5	8.2	df= 3
>8	13	3	23.0	
Total	150	12	8.0	

Table 3: Prevalence of Babesiosis in slaughtered Sheep with respect to Gender, Breed, and Age Slaughtered at Katsina Central Abattoir

Factors	No. Examined	No. Positive	Prevalence	Statistical Value
Gender				df= 1
Male	37	2	5.4	χ²= 0.039
Female	113	7	6.2	P-value= 0.844
Total	150	9	6	
Breed				df= 1
Yankasa	84	6	7.1	χ²= 0.351
Balami	66	3	4.5	P-value= 0.544
Total	150	9	6.0	
Age				
1-2	19	00	0.0	
2-3	43	03	0.5	df= 3
3-4	71	05	7.0	χ²= 1.340
>4	71	01	5.9	P-Value=0.720
Total	150	09	6.0	

Prevalence of Babesiosis in slaughtered cattle based on Farming System, History of Vaccination, and Body Condition Score at Katsina Central Abattoir

The prevalence of *Babesia* infection in cattle varied marginally across different farming systems, with the highest rate observed in the extensive system (10%), followed by semi-intensive (9.1%), nomadic (7.14%), and intensive (5.7%). The statistical analysis (χ^2=0.3907, p=0.9422) confirms there is no significant association between the type of farming system and the prevalence of *Babesia* infection in this study population. The data indicate a slightly lower prevalence of *Babesia* in cattle with a recorded history of vaccination (7.37%) compared to those with no vaccination history (9.1%). However, this difference is not statistically significant (χ^2=0.1191, p=0.73), indicating that vaccination status, as documented here, is not a significant risk factor for *Babesia* infection in these slaughtered cattle. A pronounced and clinically important trend is evident in the Body Condition Score data. Cattle in poor body condition exhibited a markedly higher prevalence (18.8%) compared to those in moderate (5.71%) and good (4.17%) condition. The statistical result (χ^2=5.1715, p=0.0753) approaches, but does not meet, the conventional threshold for statistical significance ($p<0.05$). This suggests a strong association that is highly suggestive of a real biological effect, though the sample size may limit definitive statistical confirmation (Table 4).

Prevalence of Babesiosis in Sheep based on Farming System, History of Vaccination

The prevalence of *Babesia* infection was similar across all four management systems, ranging from 6.7% in the extensive system to 8.57% in the semi-intensive system. The statistical test results (χ^2=0.072, p=0.995) confirm that there is no significant difference in infection rates based on the type of farming system practiced. This indicates that, within the context of this study, the method of husbandry, whether animals were confined, semi-confined, freely grazed, or moved nomadically, did not significantly influence the likelihood of a sheep being infected with *Babesia*.

The recorded vaccination history of the sheep did not show a significant association with *Babesia* prevalence. Sheep with a history of vaccination had a prevalence of 6.5%, while non-vaccinated sheep had a slightly lower prevalence of 5.17%. The statistical analysis (χ^2=0.121, p=0.7493) confirms that this minor difference is not statistically significant. It is critical to interpret this finding with the understanding that the vaccination referred to is not for Babesiosis, as no such vaccine is commercially available in the region, but for other endemic diseases. A clear numerical trend was observed in relation to the body condition of the sheep. Animals classified in poor body condition exhibited the highest prevalence (11.11%), which was approximately four times higher than the prevalence in sheep with a medium BCS (2.94%). Sheep in good condition had an intermediate prevalence of 5.4%. However, the Chi-square test result (χ^2=2.8141, p=0.2449) indicates that, given the sample sizes in this study, this observed distribution could have occurred by chance and is not statistically significant at the standard 5% probability threshold (Table 5).

Table 4: Prevalence of Babesiosis in slaughtered cattle based on Farming System, History of Vaccination, and Body Condition Score at Katsina Central Abattoir

Variables	Category	No. Examined	No. positive	Prevalence	Statistical Value
Farming System	Intensive	35	02	5.7	χ^2= 0.3901
	Semi-intensive	77	07	9.1	P-Value= 0.942
	Extensive	10	01	10.0	df= 3
	Nomadic	28	02	7.1	
History of Vaccination	Yes	95	07	7.4	χ^2= 0.1191
	No	55	05	9.1	P = 0.73
					df= 1
Body condition Score	Poor	32	06	18.8	χ^2= 5.1715
	Medium	70	04	5.7	P-Value= 0.075
	Good	48	02	4.2	df= 2

Table 5: Prevalence of Babesiosis in Sheep based on Farming System, History of Vaccination, and Body Condition Score of Cattle Slaughtered at Katsina Central Abattoir

Variables	Category	Number Examined	Number Positive	Prevalence	Statistical Value
Farming System	Intensive	40	04	10.0	X^2 = 3.4901
	Semi-intensive	70	02	2.8	P=0.3221
	Extensive	15	02	13.3	df= 3
	Nomadic	26	01	3.8	
History of Vaccination	Yes	92	06	6.5	P= 0.7493
	No	58	03	5.1	χ^2= 0.121, df= 1
Body condition Score	Poor	45	05	11.9	χ^2= 2.8141
	Medium	68	02	2.9	P= 0.2449
	Good	37	02	5.4	df= 2

Logistic Regression Analysis for Cattle

The logistic regression analysis revealed that several variables were significantly associated with the outcome. Age showed a statistically significant effect ($p < 0.05$), with all age categories having higher odds of the outcome than the reference group. Specifically, animals in Age category 2 had the highest likelihood (OR = 43.788; 95% CI: 3.359–570.839), followed by Age category 1 (OR = 17.224; 95% CI: 1.161–255.622) and Age category 3 (OR = 14.339; 95% CI: 1.686–121.962). Gender was not significantly associated with the outcome ($p = 0.818$), indicating no meaningful difference between the categories. Similarly, the overall effect of the farming system was not significant ($p > 0.05$); however, farming system category 2 showed a significant reduction in odds (OR = 0.101; 95% CI: 0.010–0.979), suggesting a possible protective effect relative to the reference category.

The history of vaccination was not statistically significant ($p = 0.088$), although it showed a tendency toward increased odds (OR = 8.443). Body Condition Score (BCS) had a significant overall effect ($p < 0.05$), with BCS category 1 significantly reducing the odds of the outcome (OR = 0.026; 95% CI: 0.002–0.397), while BCS category 2 was not significant. The variable cattle breed showed an unstable estimate with an extremely large standard error and undefined confidence interval, suggesting possible quasi-complete separation; therefore, it was not considered reliable for interpretation (Table 6).

Logistic Regression Analysis for Sheep

The logistic regression analysis (Table 7) examined the association between several explanatory variables and the outcome. Overall, none of the variables showed a statistically significant association with the outcome at the 5% level ($p > 0.05$).

Age was included as a categorical variable, with all age categories (AGE (1), AGE (2), and AGE (3)) showing non-significant associations with the outcome ($p = 0.998$, 0.511, and 0.394, respectively). Although AGE (1) exhibited an extremely large odds ratio (OR = 84,896,853.124), this estimate is unstable and associated with very wide confidence intervals, indicating poor precision rather than a meaningful effect. AGE (2) and AGE (3) showed odds ratios below and close to 1 (OR = 0.438 and 0.358, respectively), suggesting reduced odds compared to the reference category, but these effects were not statistically significant.

Gender was not significantly associated with the outcome (B = 0.062; OR = 1.064; 95% CI: 0.580–1.951; p = 0.844), indicating no meaningful difference between males and females. Breed also showed no significant association (OR = 0.924; p = 0.921), suggesting that cattle breed did not influence the likelihood of the outcome in this model. Similarly, farming system categories were not significant predictors (p > 0.05). However, farming systems (2) showed a relatively higher odds ratio (OR = 3.687) compared to other categories, but with a very wide confidence interval, indicating low precision. The history of vaccination was not significantly associated with the outcome (OR = 0.658; p = 0.595), suggesting no evidence of an effect. Body condition score (BCS) categories also showed no significant association with the outcome (BCS (1): p = 0.168; BCS (2): p = 0.749), although BCS (1) indicated a reduced odd of the outcome (OR = 0.139), but this was not statistically significant.

Table 6: Logistic Regression Results

Variable	B	p-value	Exp(B) (OR)	95% CI (Lower–Upper)
Cattle breed (1)	-17.648	0.999	0.000	0.000 – —
Age (1)	2.846	0.039	17.224	1.161 – 255.622
Age (2)	3.779	0.004	43.788	3.359 – 570.839
Age (3)	2.663	0.015	14.339	1.686 – 121.962
Gender (1)	0.187	0.818	1.205	0.245 – 5.929
Farming system (1)	-1.852	0.206	0.157	0.009 – 2.763
Farming system (2)	-2.295	0.048	0.101	0.010 – 0.979
Farming system (3)	-1.609	0.278	0.200	0.011 – 3.670
History of Vaccination (1)	2.133	0.088	8.443	0.730 – 97.719
BCS (1)	-3.646	0.009	0.026	0.002 – 0.397
BCS (2)	0.323	0.761	1.381	0.173 – 11.056

Table 7: Logistic Regression Results

Variable	B	p-value	Exp(B) (OR)	95% CI (Lower–Upper)
AGE (1)	18.257	0.998	84896853.124	0.000 – —
AGE (2)	-0.825	0.511	0.438	0.037 – 5.128
AGE (3)	-1.028	0.394	0.358	0.034 – 3.807
Gender (1)	0.062	0.844	1.064	0.580 – 1.951
BREED (1)	-0.079	0.921	0.924	0.194 – 4.392
Farming System (1)	0.056	0.972	1.057	0.047 – 23.571
Farming System (2)	1.305	0.425	3.687	0.150 – 90.875
Farming System (3)	-1.449	0.262	0.235	0.019 – 2.956
History of Vaccine (1)	-0.418	0.595	0.658	0.141 – 3.075
BCS (1)	-1.977	0.168	0.139	0.008 – 2.300
BCS (2)	0.363	0.749	1.438	0.155 – 13.339

DISCUSSION

The key finding of this study is that the overall prevalence of babesiosis in cattle and sheep was relatively low (7.0%), with slightly higher but non-significant infection rates in cattle than sheep, indicating comparable exposure across species. The study demonstrates that infection is primarily influenced by age and body condition, rather than breed, sex, or most management practices. Older animals showed a markedly higher risk of infection due to cumulative exposure to tick vectors, while animals with poor body condition were more susceptible, likely due to reduced immunity and higher tick burden. Although females and certain breeds showed higher prevalence, these differences were not statistically significant. Management systems and vaccination history had limited or inconsistent effects. In sheep, no single factor significantly explained infection, suggesting a multifactorial pattern influenced by sample size limitations and unmeasured variables. Overall, the findings emphasize that host physiological status (age and body condition) and exposure to vectors are the major drivers of babesiosis, highlighting the importance of improved nutrition, health management, and effective tick control strategies, especially for older and poorly conditioned animals.

The overall prevalence of Cattle and sheep Babesiosis in the present study was 7.0%. The higher prevalence in cattle (8.0%) compared with sheep (6.0%), although not statistically significant in this study, aligns with the existing literature. In comparison with previous studies by Alemayo *et al. (*2017*)*, who found prevalence rates of 6.1% in Southwestern Ethiopia, 12.8% in Jimma, 14.84% in Wolaita Sodo, and 5.2% in East Wollega, respectively, the prevalence of the current study is far lower. Cattle are generally more exposed to tick infestations because of their larger body size, grazing habits, and management practices, making them more susceptible to tick-borne pathogens like *Babesia bovis* and *Babesia bigemina* (Ugochukwu *et al*, 2021). The absence of a significant difference could be due to the relatively small sample. Ananda *et al.* (2014) reported a prevalence of 12% in crossbred cattle from the Bangalore region of Karnataka. This could be due to animal husbandry practices. Likewise, Adam *et al*. (2021) reported a prevalence of 9.1% in cattle examined at Maiduguri abattoir. Lower prevalence could be due to the use of anti-parasitic drugs for vector control. However, this result was lower than the earlier reports from Malaysia (42%) by Rahman *et al. (2010);* the present finding was also lower than the previous reports in Teltele district, Borena Zone, with a prevalence 16.9% (Hamsho *et al*., 2015). The findings of earlier studies in Nigeria, Kamani*et al.* (2010) who attribute the accumulation of parasites by the females to the extended breeding for economic reasons such as calving, extended breeding, and milk production. (Okorafor and Nzeako, 2014) reported a higher prevalence in females. Reduced immunity brought on by stress from pregnancy and lactation may also contribute to cows' susceptibility. Previous studies have documented the impact of age on the occurrence of haemoparasites. Moreover, the higher prevalence of tick-borne diseases in female animals could be because female animals are kept longer for breeding and milk production purposes (*Kamani et al.,* 2010). This finding was in agreement with the report of Kocan *et al. (*2015*),* who found a higher prevalence of Babesiosis in Female (11.2%) compared to male cattle (6.96%). The highest prevalence in females may be due to the fact female are kept longer for Breeding and Milk Production. Also, this finding was in agreement with the report of Hamsho *et al. (*2015*),* who found a higher prevalence of Babesiosis in Female (17.48%) compared to male cattle (16.29%). This result was in line with the findings of Ayaz *et al.* (*2013)* from Pakistan, who reported high prevalence in old animals (13.4%), followed by adult animals (11.7%), while the lowest was found in young animals. This Variation can be because young animals have a lower rate of infestation with ticks as compared to old animals. Also, this finding was in agreement with the report of Hamsho *et al. (*2015*),* who found a higher prevalence of Babesiosis among older animals (17.48%), followed by adults (11.7%), while the lowest was found in young animals. Lower prevalence in young animals is attributed to restricted grazing of young animals, which is likely to reduce their chance of contact with the vector of the disease (Kamani *et al.,* 2010*).* Haben *et al. (*2022) noted a higher prevalence of bovine babesiosis in adult age (66.7%), followed by young (18.6%) and old age cattle (14.7%). It affects adults more severely than young cattle, leading to direct losses through death and the restriction of movement of animals by quarantine laws. This finding was in agreement with the report of Manwar *et al. (*2023*),* who found a higher prevalence of Babesiosis in Female Sheep (83.33 %) compared to male Sheep (16.67%). The highest prevalence in females may be due to the fact female are kept longer for Breeding and Milk production. This result corroborates the report of Manwar *et al. (*2023*)* that reports sheep in the age group above 12 months (66.67%) have a higher prevalence, followed by equal prevalence (16.67%) in the age groups of 7 to 12 and 3 to 6 months. Younger sheep may be kept on better-quality pasture or under more intensive management with effective anthelmintic treatments, which are withdrawn or less frequent as animals age and are integrated into larger flocks (Garcia *et al.* 2023).

The described breed-based prevalence recorded in this study showed a higher prevalence in white Fulani (8.33%) than in Red Bororo (0.55%), although this difference was not statistically significant (χ^2=0.141, P-value=0.707). This agreed with the work of Akande *et al*. (2010), which reported a higher prevalence in white Fulani (8.0%) than Red Bororo (6.7%). Bitrus *et al. (*2021) revealed that the highest prevalence was observed in White Fulani, 13.91% (37), followed by Red Bororo, 10.94%. The Yankasa breed is widely distributed and frequently managed under extensive pastoral systems, which might increase its exposure to tick vectors compared with Balami sheep, which are sometimes kept under more semi-intensive *systems* because of their larger size and value (Olawepo *et al*., 2022).

The prevalence of the disease based on the body condition of Sheep was 18.8% (6/32) in poor, 5.7% (4/70) in medium, 4.2% (2/48) for good and the prevalence of the disease based on the body condition of Sheep was 11.9% (5/45) in poor, 2.9% (2/68) in medium, 5.4% (2/37) for good, scoring respectively with significant association (P<0.05). This could be because animals with poor body condition have lower immunity, which encourages infection of the animal by different organisms like *Babesia*. In addition, during this study period, it was very common to see a high burden of ectoparasites (ticks) in animals with poor body condition, and this can increase the rate of infection from *Babesia*. The proportion of tick infestation was higher in poor body conditioned as compared to medium body-conditioned and good body-conditioned animals. This was due to poor body conditioned animals are less resistant to tick infestation and lack enough body potential to build resistance with age advancement. This finding aligns with Hamsho *et al. (*2015*),* who report a significantly higher proportion in poor BCS (35.9%), followed by medium BCS (15.6%) and Good BCS (5.47%) in cattle. This could be because animals with poor BCS have lower immunity, which encourages infection of the animal by different *Babesia* species. Abdela, Nejash *et al.* (2018) found a prevalence of 11.7% babesiosis (higher in poor BCS) in Jimma town, Southwestern Ethiopia. Also, Wodaj *et al*. (2022) found a significantly higher proportion of *Babesia*in poor BCS (68.6%), followed by medium BCS (19.8 %) and Good BCS (21.6%) in cattle. LayArmachiho *et al.* (2023) found a significantly higher proportion of *Babesia* in cattle with poor body conditions in Ethiopia, with a prevalence of 7.1% and 5.0 % in medium body condition, 1.2% in good body condition.

Based on the management system, the prevalence of cattle was 1/10 (13.3%) in extensively managed, 7/77 (9.1%) under a semi-extensive management system, and 2/32 (5.7%) in an intensive management system. And based on the management system prevalence, the prevalence of Sheep was 2/15 (13.3%) in extensively managed, 2/70 (2.8%) under semi-extensive management system, and 4/40 (10.0%) in intensive management system.

With respect to vaccination, the higher prevalence among unvaccinated aligns with (Hamsho *et al., 2015),* who found that untreated animals have 18.84%, while those treated with Babesiocide Drug have a higher prevalence of 10.8%. In areas where regular treatment of animals with an antiseptic Drug were showed a low rate of infection

The logistic regression analysis for cattle revealed that age and body condition score (BCS) were the principal determinants of infection, whereas breed, gender, vaccination history, and most farming systems did not show significant associations. This indicates that infection dynamics in the study population are largely influenced by host physiological status and cumulative exposure to vectors, rather than inherent or demographic characteristics. Age emerged as a strong predictor, with significantly higher odds of infection observed among older cattle (OR = 14.339–43.788; p < 0.05). This suggests that the risk of infection increases progressively with age, most likely due to prolonged and repeated exposure to tick vectors. This finding is consistent with previous studies (Abdela *et al*., 2018; Salem *et al*., 2017), which reported a higher prevalence of haemoparasitic infections in adult cattle and attributed this to cumulative exposure rather than innate susceptibility. Thus, the result supports the epidemiological concept that infection risk in endemic areas is largely exposure-driven.

Similarly, BCS showed a significant relationship with infection, with animals in better condition being significantly less likely to be infected (OR = 0.026; p = 0.009). This highlights the protective role of good nutritional and health status, likely through enhanced immune competence. Comparable findings have been reported by Namomsa *et al*. (2023) and Abdela *et al*. (2018), who observed higher infection rates in cattle with poor body condition. Therefore, BCS serves as an important indicator of disease resistance and overall animal health.

In contrast, breed and gender were not significantly associated with infection (p > 0.05), suggesting that susceptibility is relatively uniform across genetic backgrounds and sexes under the prevailing management conditions. This agrees with reports such as Rizk *et al*. (2017) and Abdela *et al*. (2018), where no significant differences were observed. These findings imply that environmental exposure and management practices may overshadow any potential genetic or sex-related differences. Among the farming systems, only one category demonstrated a significant protective effect (OR = 0.101; p = 0.048), indicating that certain management practices can reduce infection risk, possibly through improved housing and vector control. However, the lack of significance in other categories suggests that management effects may not be uniform across systems. Additionally, vaccination history, despite showing a relatively high odds ratio, was not statistically significant (p = 0.088), indicating no clear protective effect in this study, possibly due to inconsistent application or confounding factors. The findings demonstrate that infection in cattle is primarily driven by age-related exposure and body condition, while breed, sex, and most management factors play a lesser role. This underscores the importance of improving nutrition, strengthening animal health, and implementing effective vector control strategies, particularly for older animals that are at greater risk.

The logistic regression analysis for sheep indicates that, within this dataset, no single host or management factor independently explained the occurrence of infection, suggesting that the disease pattern may be influenced by a combination of factors not fully captured in the model. The absence of significant predictors may be attributed to limited sample size, uneven distribution of observations across categories, or unmeasured confounding variables, which are common constraints in field epidemiological studies. This is further supported by the presence of extreme and unreliable estimates, such as the very large odds ratio observed for one age category (OR = 84,896,853.124) with an undefined confidence interval. Such results are typical of model instability or sparse data bias (quasi-complete separation), where insufficient observations in certain groups lead to inflated coefficients and reduced reliability of estimates.

Although age is widely recognized as an important determinant of haemoparasitic infections due to cumulative exposure, it was not significant in this study, suggesting that its effect may have been masked by data limitations or inadequate statistical power. Similarly, gender and breed showed no significant influence, indicating that sheep in the study area likely experience similar exposure conditions regardless of sex or genetic background. Farming system variables also did not show significant effects, despite variability in odds ratios, and the wide confidence intervals observed point to low precision in the estimates. This implies that while management practices may influence infection risk, their effects were not clearly detectable in the present model. Likewise, vaccination history showed no significant association, suggesting no measurable protective effect, possibly due to inconsistent application or variation in vaccine effectiveness under field conditions.

Body condition score (BCS) also did not reach statistical significance, although the reduced odds observed for one category suggest a potential protective trend. This suggests that better-conditioned animals may be less susceptible, but the evidence from this model is insufficient to confirm this relationship conclusively. The findings indicate that sheep infection could not be attributed to any single evaluated factor, and the model was limited by instability and imprecision in its estimates. This highlights the need for larger sample sizes, improved data structure, and inclusion of additional epidemiological variables such as vector burden, environmental factors, and seasonal dynamics to better understand the determinants of infection in sheep populations.

CONCLUSION

The available results show that babesiosis was moderately prevalent in Katsina Central Abattoir. According to this finding, it highlights a very low prevalence of *Babesia* infection among slaughtered cattle and sheep in Katsina Central Abattoir, with a prevalence of 7.0 %, indicating moderate endemicity. Among cattle female had a higher prevalence (8.30%) than males (7.14%). Likewise, in sheep, females (6.19%) had a higher prevalence than males (5.40%). The prevalence was higher in females than in males. Although no statistically significant associations were found between sexes, gender, breed, and risk factors with no significant difference. This study has clearly identified a need for more farmer education and awareness about tick-borne diseases. Effective management of this disease is important not only for the zoonotic nature of the disease under study, but also for adversely affecting animal production.

Regular acaricide and strategic prophylactic treatments need to be enhanced to control *Babesia* parasites. The government officials, non-governmental organizations, and experts need to work together to develop and implement rigorous guidelines for the proper management of livestock and common ectoparasites in general, and ticks in particular. Based on the results, it is obvious that a lack of knowledge of the disease played a role in the study area. As such, there is a need for adequate measures in the study areas to prevent the transmission of Babesiosis. The inability to differentiate *Babesia* species highlights the need for advanced diagnostic techniques such as improved microscopy or molecular methods. High financial losses to livestock producers in the region are caused by the detrimental effects of haemoparasitic infections on the health, productivity, reproduction, and performance of afflicted animals.

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