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Research Article

Prevalence of Veterinary and Zoonotic Helminths in Sheep from Livestock Markets and Abattoirs in Gombe State, Nigeria

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ABSTRACT
A cross-sectional study was conducted between May 2023 and June 2024 to determine the prevalence and distribution of veterinary and zoonotic helminths among sheep sourced from livestock markets and abattoirs in Gombe State, Nigeria. Using a two-stage sampling approach, a total of 650 sheep were examined across six locations—four livestock markets (Gombe Central, Kwadom, Dukku, and Kumo) and two abattoirs (Gombe Main and Bajoga). Of these, 516 were infected, yielding an overall prevalence of 79.4% (95% CI: 76.1–82.3). Infection rates were higher in abattoirs (87.2%) than in markets (71.8%). Nematodes predominated (58.9%), with *Haemonchus contortus* (38.0%), *Trichostrongylus* spp. (18.9%), and *Strongyloides papillosus* (2.0%) as the principal species. Trematode infections accounted for 17.4%, mainly *Fasciola gigantica* (11.1%) and *Paramphistomum* spp. (6.3%), while the cestode *Moniezia expansa* occurred in 3.1% of cases. Age, body condition, breed, and season significantly influenced prevalence ($p < 0.0001$), with adults, poorly conditioned sheep, the Yankasa breed, and rainy-season samples showing the highest infection rates. Sex had no significant effect ($p = 0.057$). Notably, zoonotic helminths constituted 51.1% of all infections, emphasizing potential public health implications. The predominance of *H. contortus* and *F. gigantica* underscores the need for integrated helminth control strategies, improved management, and routine surveillance at the livestock–human interface in Gombe State.

Keywords: Abattoirs; Epidemiology; Helminths; Livestock markets; Sheep; Zoonosis

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INTRODUCTION

Helminth infections in sheep are among the most significant constraints to livestock productivity worldwide, particularly in developing countries (Hamid *et al*., 2023; Alkadir and Ayana, 2024). These infections cause a range of adverse effects, including poor weight gain, reduced fertility, diminished milk production, and increased susceptibility to other diseases. In addition to their economic implications, certain helminths pose a zoonotic threat, endangering public health by facilitating the transmission of diseases to humans (Salehi *et al*., 2022; Lianou *et al*., 2023). In sub-Saharan Africa, including Nigeria, the warm and humid climatic conditions favor the survival and transmission of helminth parasites, leading to widespread prevalence and substantial morbidity in sheep populations (Karshima *et al*., 2018).

Gastrointestinal helminths, including nematodes, trematodes, and cestodes, are of paramount concern in sheep farming (Salehi *et al*., 2022; Hamid *et al*., 2023). Among the nematodes, species such as *Haemonchus contortus*, *Trichostrongylus* spp., and *Ostertagia* spp. have been implicated in causing economic losses through anemia, diarrhea, and reduced productivity. Trematodes like *Fasciola gigantica* are known to compromise liver function, while cestodes such as *Taenia hydatigena* and *Echinococcus granulosus* have zoonotic potential and can lead to severe economic losses due to organ condemnation in abattoirs (Roeber *et al*., 2013; Tachack *et al*., 2022). The risk of zoonosis further emphasizes the importance of controlling these infections, particularly in regions where close interactions between humans and livestock are common.

In Nigeria, sheep are integral to the livelihoods of rural households, serving as a source of meat, milk, hides, and income. Despite their socio-economic importance, sheep are often managed under extensive and semi-intensive systems, exposing them to a range of parasitic infections due to poor grazing conditions, inadequate veterinary care, and lack of effective deworming programs (Anyanwu *et al*., 2020). The prevalence and diversity of helminths in sheep vary across regions due to differences in agroecological conditions, management practices, and the presence of intermediate hosts (Aliyu *et al*., 2020; Nuhu *et al*., 2025).

Gombe State, located in the northeastern region of Nigeria, is a key livestock hub characterized by a mixed farming system and vibrant livestock markets. Sheep reared and sold in this region are transported to various parts of the country, making them a critical point for studying helminth transmission dynamics (Mohammed *et al*., 2024). Previous studies on helminths in livestock in Nigeria have often focused on broader surveys, with limited attention to sheep in specific locations such as livestock markets and abattoirs, where infection risks may be particularly high (Karshima *et al*., 2018; Ola-Fadunsin *et al*., 2020; Ajakaye and Adejuyigbe, 2024).

This study was therefore undertaken to determine the prevalence of veterinary and zoonotic helminths in sheep from livestock markets and abattoirs in Gombe State. The findings aim to contribute to the existing body of knowledge on helminth infections in livestock, provide insights into potential zoonotic risks, and inform strategies for effective parasite control in sheep farming.

MATERIALS AND METHODS

Study Area

The study was conducted in Gombe State, northeastern Nigeria (Fig. 1), located between latitudes 10°15′N and 11°30′N and longitudes 11°00′E and 11°45′E. Gombe State lies within the Sudan Savannah ecological zone, characterized by a tropical climate with distinct rainy (May–October) and dry (November–April) seasons. The annual rainfall ranges from 850 mm to 1,200 mm, and temperatures vary between 25°C and 35°C. Livestock farming, including sheep production, is a major economic activity in the state, with sheep being sold in numerous livestock markets and processed in abattoirs.

Study Design

A cross-sectional study was conducted from May, 2023 to June 2024 to determine the prevalence of helminth infections in sheep from livestock markets and abattoirs in Gombe State. The study utilized a two-stage sampling technique, targeting major livestock markets and abattoirs in the state. Six locations were purposively selected: Gombe Central Livestock Market, Kwadom Livestock Market, Dukku Livestock Market, Kumo Livestock Market, Gombe Main Abattoir, and Bajoga Abattoir.

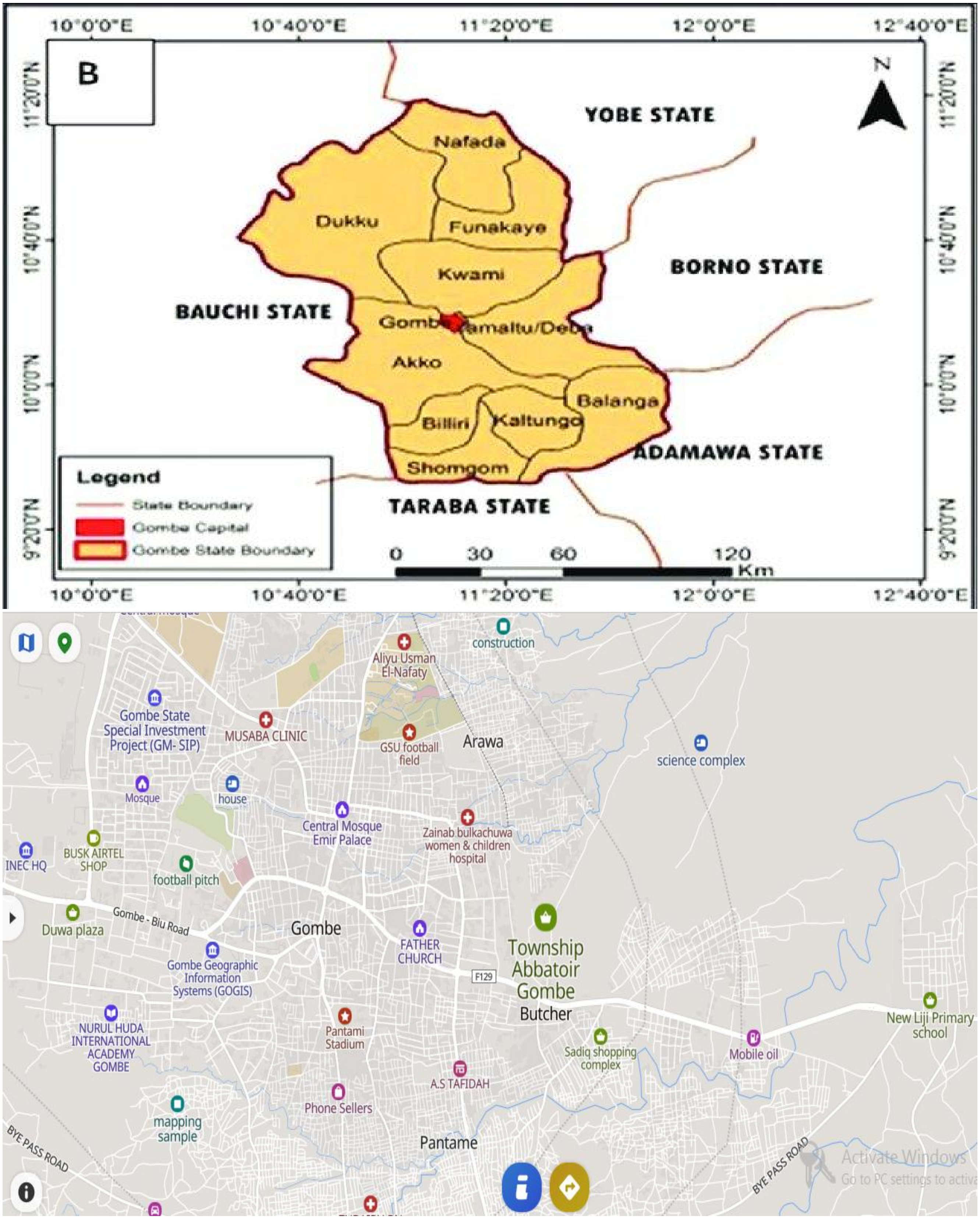

Figure-1. Map of Gombe State showing the Study Area (Mohammed *et al.*, 2019)

Sample Size Determination

The sample size was calculated using the formula for estimating proportions:

$$N = \frac{Z^2 pq}{d^2}$$

Where: N = the total sample size,

Z = 1.96 (standard normal deviate at 95% confidence level)

Therefore $Z^2 = 1.96^2 = 1.96 \times 1.96 = 3.8416$,

p = 0.5 (expected prevalence, based on 50.0% prevalence rate reported by Mohammed *et al.*, 2019 in a similar studies),

d = 0.05 (desired precision).

A minimum sample size of 584 was obtained, but 650 sheep were sampled to account for non-responses and improve statistical robustness.

Sample Collection

Fecal samples were collected directly from the rectum of each sheep using disposable gloves. Each sample was placed in a labeled sterile container, stored in a cooler with ice packs as previously described by Ragavan *et al*. (2023), and transported to the Parasitology Laboratory at Gombe State University for analysis. Additionally, visceral organs (livers, intestines, and lungs) were inspected post-mortem in abattoirs for adult helminths.

Parasitological Examination

Fecal Analysis

Fecal samples were subjected to detailed parasitological examination using standard diagnostic techniques to detect the presence of helminth eggs. Each fecal sample was processed employing both the flotation and sedimentation methods in accordance with established procedures described by Soulsby (1982) and Hansen and Perry (1994). The flotation technique, utilizing a saturated sodium chloride solution as the flotation medium, was used primarily for the detection of light nematode and cestode eggs due to its high sensitivity in concentrating lighter ova. Conversely, the sedimentation technique was applied for the detection of heavier trematode eggs, which are less likely to float in saturated solutions.

Following processing, prepared smears were examined under a light microscope at ×10 and ×40 magnifications. Helminth eggs were identified based on their morphological characteristics such as size, shape, color, and the nature of shell structures. Identification was guided by standard parasitological and taxonomic keys as outlined by Urquhart *et al*. (1996). The number and type of helminth eggs detected were recorded for each sample to determine prevalence and diversity of infection among the studied animals.

Post-Mortem Examination

Post-mortem examinations were conducted on organs collected from slaughtered animals at selected abattoirs to recover and identify adult helminths. The gastrointestinal tract, liver, lungs, and other relevant organs were carefully dissected and examined both visually and by slicing to expose potential sites of helminth localization. The contents of each organ were washed gently in physiological saline to dislodge attached parasites. The recovered helminths were then isolated, counted, and preserved in 70% ethanol to maintain their structural integrity for subsequent identification as previously described by Stella *et al*. (2022) and Kebede *et al*. (2025).

Preserved specimens were examined under a stereomicroscope and identified to the lowest possible taxonomic level based on morphological characteristics, including the shape and structure of the buccal capsule, spicules, suckers, and segmentation patterns, following standard identification keys and descriptions provided by Soulsby (1982) and Urquhart *et al*. (1996). Detailed records of helminth species composition, anatomical location, and intensity of infection were maintained for statistical and epidemiological analysis.

Data Analysis

Data were coded and cleaned in Microsoft Excel and analyzed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were computed to summarize data, with prevalence expressed as the proportion of infected animals among those examined. Associations between helminth prevalence and host factors (species, sex, age, and location) were assessed using the Chi-square (χ^2) test or Fisher's exact test where appropriate. Statistical significance was set at $p < 0.05$. Odds ratios (OR) with 95% confidence intervals (CI) were calculated to evaluate the strength of associations.

RESULTS

A total of 650 sheep were examined for gastrointestinal helminths across livestock markets and abattoirs in Gombe State, of which 516 were infected, giving an overall prevalence of 79.4% (95% CI: 76.1–82.3) (Table 1). Infection was higher in abattoirs (87.2%) than in livestock markets (71.8%). Among markets, prevalence ranged from 70.0% in Gombe Central to 74.5% in Kwadom, while Dukku recorded 71.0%. In abattoirs, Gombe Main had the highest rate (93.1%), followed by Bajoga (86.0%) and Kumo (80.0%) (Table 1).

Nematode infections predominated, with *Haemonchus contortus* being the most prevalent (38.0%; 95% CI: 34.4–41.8), followed by *Trichostrongylus* spp. (18.9%; 95% CI: 16.1–22.1) and *Strongyloides papillosus* (2.0%; 95% CI: 1.2–3.4). Collectively, nematodes accounted for 58.9% (95% CI: 55.1–62.6) of all infections (Table 2). Cestodes were relatively rare, with only *Moniezia expansa* detected (3.1%; 95% CI: 2.0–4.7), being slightly more common in abattoirs (2.0%) than in markets (1.1%).

Trematodes contributed 17.4% (95% CI: 14.7–20.5) of infections, dominated by *Fasciola gigantica* (11.1%; 95% CI: 8.9–13.7) and *Paramphistomum* spp. (6.3%; 95% CI: 4.7–8.5), indicating exposure to snail-infested habitats favorable for trematode transmission (Table 2).

Age significantly influenced infection ($\chi^2 = 47.41$, $p < 0.0001$). Among lambs (<1 year), 73.9% were infected compared to 83.2% in adults (≥1 year). Lambs had a lower overall risk (RR = 0.6631; OR = 0.4533), though *H. contortus* was slightly more frequent in lambs (41.0%) than adults (35.9%). Adults, however, harbored higher rates of *Trichostrongylus spp.*, *F. gigantica*, and *Paramphistomum spp.* (Table 3).

Sex had no significant effect ($\chi^2 = 3.623$, $p = 0.057$): prevalence in females (81.2%) was marginally higher than in males (77.4%) with similar species patterns (*H. contortus*: males 37.1%, females 38.8%; RR = 0.8776; OR = 0.8059). Seasonal variation was marked ($\chi^2 = 18.56$, $p < 0.0001$), with infections peaking during the rainy season (92.5%) compared to the dry season (66.7%). All species showed higher prevalence in the wet period, and the rainy season posed a 27% higher risk (RR = 1.270; OR = 1.634) of infection (Table 3).

Body condition and breed also showed significant associations (Table 4). Sheep with poor condition had the highest prevalence (96.1%) compared with fair (69.0%) and good (72.8%) body scores ($\chi^2 = 65.67$; $p < 0.0001$). *H. contortus* predominated among poorly conditioned animals (16.3%), followed by *Trichostrongylus spp.* (7.7%) and *F. gigantica* (4.8%).

Breed-wise, *Yankasa* sheep recorded the highest prevalence (91.6%), followed by *Balami* (89.0%) and *Uda* (54.5%) ($\chi^2 = 57.35$; $p < 0.0001$). *H. contortus* remained dominant across all breeds, with rates of 14.8%, 13.2%, and 10.0% for Yankasa, Balami, and Uda, respectively.

Zoonotic helminths were widespread (Table 5). *H. contortus* (38.0%) and *F. gigantica* (11.1%) were the major zoonotic species, while *S. papillosus* occurred in 2.0% of sheep, yielding a combined zoonotic prevalence of 51.1% (95% CI: 47.2–54.9). Among non-zoonotic helminths, *Trichostrongylus spp.* was most frequent (18.9%), followed by *Paramphistomum spp.* (6.3%) and *M. expansa* (3.1%), giving an aggregate non-zoonotic prevalence of 28.3% (95% CI: 25.0–31.9).

Table 1: Prevalence of Helminths in Sheep by Livestock Markets and Abattoirs in Gombe State, Nigeria

Sampling Unit	Sampling Location	Number of animals examined	Number (%) of animals Infected	Prevalence (%)	95% CI (LL - UL)
Livestock Market	Gombe Central Livestock Market	120	84 (70.0)	12.9	10.6 – 15.7
	Kwadom Livestock Market	110	82 (74.5)	12.6	10.3 – 15.4
	Dukku Livestock Market	100	71 (71.0)	10.9	8.8 – 13.6
Total		330	237 (71.8)	36.5	32.9 – 40.2
Abattoir	Kumo Abattoir	90	72 (80.0)	11.1	8.9 – 13.7
	Gombe Main Abattoir	130	121 (93.1)	18.6	15.8 – 21.8
	Bajoga Abattoir	100	86 (86.0)	13.2	10.8 – 16.1
Total		320	279 (87.2)	42.9	39.2 – 46.8
Overall		650	516 (79.4)	79.4	76.1 – 82.3

Key: LL – UL = Lower limit – Upper limit

Table 2. Prevalence of Helminths species in Sheep from Livestock Markets and Abattoirs in Gombe State, Nigeria Based on Fecal Analysis and Post-Mortem Examination

Helminth Group	Helminth Species Encountered	Number (%) of sample infected		Prevalence (%)	95% CI (LL – UL)
		Livestock Markets	Abattoirs		
Nematodes	*Haemonchus contortus*	120 (18.5)	127 (19.5)	247 (38.0)	34.4 – 41.8
	Trichostrongylus spp.	58 (8.9)	65 (10.0)	123 (18.9)	16.1 – 22.1
	Strongyloides papillosus	4 (0.6)	9 (1.4)	13 (2.0)	1.2 – 3.4
Total		182 (28.0)	201 (30.9)	383 (58.9)	55.1 – 62.6
Cestodes	*Moniezia expansa*	7 (1.1)	13 (2.0)	20 (3.1)	2.0 – 4.7
Total		7 (1.1)	13 (2.0)	20 (3.1)	2.0 – 4.7
Trematodes	*Fasciola gigantica*	31 (4.8)	41 (6.3)	72 (11.1)	8.9 – 13.7
	Paramphistomum spp.	17 (2.6)	24 (3.7)	41 (6.3)	4.7 – 8.5
Total		48 (7.4)	65 (10.0)	113 (17.4)	14.7 – 20.5
All Helminthes		237 (36.5)	279 (42.9)	516 (79.4)	76.1 – 82.3

Key: LL – UL = Lower limit – Upper limit

Table 3. Risk factors associated with helminths prevalence in Sheep from Gombe State, Nigeria based on Age, Sex, and Season

Risk factors/ Parameters	Number of Animal Sampled	Number (%) of Animal Infected	Number (%) of Animals infected with					
			Haemonchus contortus	***Trichostrongylus* spp.**	***Fasciola gigantica***	***Paramphistomum* spp.**	***Moniezia expansa***	***Strongyloides papillosus***
Age (year)								
Lambs (< 1)	268	198 (73.9)	110 (16.9)	42 (6.5)	25 (3.8)	13 (2.0)	6 (0.9)	2 (0.3)
Adults (≥ 1)	382	318 (83.2)	137 (21.1)	81 (12.5)	47 (7.2)	28 (4.3)	14 (2.2)	11 (1.7)
Prevalence (%)	650	516 (79.4)	247 (38.0)	123 (18.9)	72 (11.1)	41 (6.3)	20 (3.1)	13 (2.0)
X^2	47.41							
p-value	<0.0001							
RR	0.6631							
OR	0.4533							
Sex								
Male	310	240 (77.4)	115 (17.7)	60 (9.2)	34 (5.2)	18 (2.8)	8 (1.2)	5 (0.8)
Female	340	276 (81.2)	132 (20.3)	63 (9.7)	38 (5.8)	23 (3.5)	12 (1.8)	8 (1.2)
Prevalence (%)	650	516 (79.4)	247 (38.0)	123 (18.9)	72 (11.1)	41 (6.3)	20 (3.1)	13 (2.0)
X^2	3.623							
p-value	0.0570							
RR	0.8776							
OR	0.8059							
Season								
Rainy	320	296 (92.5)	140 (21.5)	70 (10.8)	42 (6.5)	24 (3.7)	13 (2.0)	7 (1.1)
Dry	330	220 (66.7)	107 (16.5)	53 (8.2)	30 (4.6)	17 (2.6)	7 (1.1)	6 (0.9)
Prevalence (%)	650	516 (79.4)	247 (38.0)	123 (18.9)	72 (11.1)	41 (6.3)	20 (3.1)	13 (2.0)
X^2	18.56							
p-value	<0.0001							
RR	1.270							
OR	1.634							

Key: X^2 = Chi-square, RR = Relative risk, OR = Odd ratio

Table 4. Risk factors associated with helminthes prevalence in Sheep from Gombe State, Nigeria based on Body Condition Score and Breed

Risk factors/ Parameters	Number of Animals Sampled	Number (%) of Animal Infected	Number (%) of Animals infected with					
			Haemonchus contortus	*Trichostrongylus* spp.	*Fasciola gigantica*	*Paramphistomum* spp.	*Moniezia expansa*	*Strongyloides papillosus*
BCS								
Poor	230	221 (96.1)	106 (16.3)	50 (7.7)	31 (4.8)	18 (2.8)	9 (1.4)	7 (1.1)
Fair	284	196 (69.0)	98 (15.1)	47 (7.2)	26 (4.0)	14 (2.2)	8 (1.2)	3 (0.5)
Good	136	99 (72.8)	43 (6.6)	26 (4.0)	15 (2.3)	9 (1.4)	3 (0.5)	3 (0.5)
Prevalence (%)	650	516 (79.4)	247 (38.0)	123 (18.9)	72 (11.1)	41 (6.3)	20 (3.1)	13 (2.0)
X^2	65.67							
p-value	<0.0001							
Breed								
Yankasa	250	229 (91.6)	96 (14.8)	58 (8.9)	39 (6.0)	20 (3.1)	11 (1.7)	5 (0.8)
Balami	200	178 (89.0)	86 (13.2)	41 (6.3)	26 (4.0)	15 (2.3)	5 (0.8)	5 (0.8)
Uda	200	109 (54.5)	65 (10.0)	24 (3.7)	7 (1.1)	6 (0.9)	4 (0.6)	3 (0.5)
Prevalence (%)	650	516 (79.4)	247 (38.0)	123 (18.9)	72 (11.1)	41 (6.3)	20 (3.1)	13 (2.0)
X^2	57.35							
p-value	<0.0001							

Key: X^2 = Chi-square; BCS = Body Condition Score

Table 5. Prevalence of Veterinary and Zoonotic Helminths in Sheep from Livestock Markets and Abattoirs in Gombe State, Nigeria

Helminth Species Encountered	Zoonotic/non-zoonotic	Number (%) of animals infected	Prevalence (%)	95% Confidence Interval (CI)
Zoonotic Helminths				
Haemonchus contortus	Zoonotic	247	38.0	34.4 – 41.8
Fasciola gigantica	Zoonotic	72	11.1	8.9 – 13.7
Strongyloides papillosus	Zoonotic	13	2.0	1.2 – 3.4
Subtotal		332	51.1	47.2 – 54.9
Non-Zoonotic Helminths				
Trichostrongylus spp.	Non-Zoonotic	123	18.9	16.1 – 22.1
Paramphistomum spp.	Non-Zoonotic	41	6.3	4.7 – 8.5
Moniezia expansa	Non-Zoonotic	20	3.1	2.0 – 4.7
Subtotal		184	28.3	25.0 – 31.9
Total		516	79.4	76.1 – 82.3

Key: LL – UL = Lower limit – Upper limit

DISCUSSION

The findings of the present study reveal a notably high prevalence (79.4%) of gastrointestinal (GI) helminth infections among sheep examined from livestock markets and abattoirs in Gombe State, Nigeria. This high level of infection indicates that helminthiasis remains a major health and productivity challenge in small ruminant production in the region. The observed prevalence aligns with reports from similar ecological zones in Nigeria, such as 62.5% in Bauchi State (Hassan, I and Jibrin, 2022), 54.0% in Borno State (Biu *et al*., 2009), 75.0% in Nassarawa State (Aliyu *et al*., 2020) and 63.6% in Plateau State (Gofwan *et al*., 2024). Comparable rates have also been reported in other African countries, such as Egypt (50.24%) (Mohamed *et al*., 2023) and Ethiopia (83.0%) (Sheferaw *et al*., 2021). The high occurrence recorded in the present study could be attributed to a combination of environmental, managemental, and epidemiological factors that favor parasite transmission, such as the warm and humid climatic conditions of Gombe State, extensive grazing systems, poor sanitation in holding pens, and the congregation of animals from multiple sources at markets and abattoirs.

The higher infection rate recorded in abattoir-sampled sheep (87.2%) compared with those from livestock markets (71.8%) suggests that abattoir-sourced animals might represent older, culled, or physiologically stressed individuals, which are often sold for slaughter after reduced productivity or health deterioration. Such animals tend to have prolonged exposure to infective larvae and lowered immunity, predisposing them to heavier parasitic burdens. Similar patterns have been documented by Isah (2019) and Oljira *et al*. (2022), who reported higher GI parasite loads in slaughtered sheep compared to market or farm populations, emphasizing the role of physiological stress and poor anthelmintic intervention in exacerbating infection.

The predominance of nematodes, particularly *Haemonchus contortus* (38.0%) and *Trichostrongylus* spp. (18.9%), corroborates earlier studies in Nigeria and other African countries, where these species are consistently recognized as the most pathogenic and economically significant GI nematodes of small ruminants (Mushonga *et al*., 2018; Karshima and Karshima, 2020). The high prevalence of *H. contortus* is of major concern due to its hematophagous nature and ability to cause severe anemia, reduced weight gain, and mortality, especially in young or malnourished sheep. Its dominance could be linked to its strong adaptability to tropical pastures and its high fecundity, which enhances pasture contamination with infective third-stage larvae. The observed high proportion of *Trichostrongylus* spp. further supports the idea of continuous exposure to contaminated grazing areas, particularly during the rainy season when moisture supports larval survival and migration on pasture vegetation.

Although cestode infection was comparatively low (3.1%), the detection of *Moniezia expansa* indicates continuous exposure to forage mites that serve as intermediate hosts. This relatively low prevalence is in agreement with previous Nigerian studies (2–5%) (Adelakun *et al*., 2021; Muqaddas *et al*., 2024), possibly due to the short lifespan of the adult cestodes and the limited distribution of intermediate hosts in arid areas. Nonetheless, the presence of *M. expansa* has zoonotic implications, particularly in poorly managed slaughter and processing environments where accidental ingestion of contaminated materials could occur.

Trematode infections constituted 17.4% of all cases, with *Fasciola gigantica* (11.1%) and *Paramphistomum* spp. (6.3%) being the dominant species. The detection of these flukes suggests significant exposure of grazing animals to snail-infested wetlands and irrigated areas that facilitate the completion of their life cycles. The finding is consistent with earlier reports from northern Nigeria (Abdullahi *et al*., 2020; Aliyu *et al*., 2020, Dey *et al*., 2022; Gofwan *et al*., 2024), where *F. gigantica* infection is commonly associated with low-lying flood plains, rice paddies, and natural water bodies serving as grazing and watering points. The occurrence of *Paramphistomum* spp. may reflect mixed grazing patterns and water contamination, as these rumen flukes share similar intermediate hosts and habitats with *Fasciola* species. These findings underscore the need for integrated snail control and proper grazing management, especially during the wet season when transmission intensity is highest.

The high overall prevalence of GI helminths observed in this study further underscores the limited implementation of sustainable parasite control strategies in small ruminant production systems across Gombe State. Infrequent or indiscriminate use of anthelmintics, absence of strategic deworming programs, communal grazing, and lack of routine veterinary supervision have likely contributed to persistent reinfection and parasite survival. Moreover, climatic and ecological conditions of the region—characterized by moderate rainfall, abundant vegetation, and warm temperature provide ideal conditions for the survival of free-living stages of most nematode and trematode parasites.

Importantly, the detection of zoonotic helminths such as *Fasciola gigantica* underscores potential public health implications. The consumption of undercooked infected liver or accidental ingestion of metacercaria-contaminated water may facilitate human fascioliasis, which remains an emerging zoonosis in parts of sub-Saharan Africa (Taira *et al*., 1997). Therefore, the findings highlight the need for a One Health–based approach integrating veterinary, public health, and environmental interventions to reduce transmission risk.

In this study, age was significantly associated with helminth infection, with adult sheep exhibiting a higher prevalence (83.2%) compared to lambs (73.9%). This finding aligns with reports by Hassan and Jibrin. (2022) and Gofwan *et al*. (2024), who observed increased parasite burdens in older small ruminants. The higher infection rate in adults could be attributed to prolonged exposure to infective larvae on contaminated pastures and the cumulative nature of helminth infections in grazing animals (Salehi *et al*., 2022). Although lambs are generally more susceptible immunologically, the slightly higher occurrence of *Haemonchus contortus* among lambs in this study may indicate early exposure to infective larvae or a lack of acquired immunity at younger ages, which agrees with Abdullahi *et al*. (2020) who reported higher prevalence in young sheep compared to the adults

Conversely, the predominance of *Trichostrongylus* spp., *Fasciola gigantica*, and *Paramphistomum* spp. in adults reflects chronic pasture contamination and the tendency of these parasites to persist under favorable ecological conditions (Kashima *et al*., 2020). Sex had no significant effect on infection rates, corroborating earlier findings in Nigeria (Aliyu *et al*., 2020; Hassan and Jibrin, 2022) and Ethiopia (Oljira *et al*., 2022), where both male and female sheep were similarly exposed to infection risks. The marginally higher prevalence among females (81.2%) may, however, be linked to physiological stress during gestation and lactation, which can suppress immunity and increase susceptibility to helminthic invasion (Salehi *et al*., 2022; Said *et al*., 2025).

Seasonal variation showed a pronounced influence on parasite prevalence, with infections peaking during the rainy season (92.5%) relative to the dry season (66.7%). This trend has been widely documented (Singh *et al*., 2017; Kashima *et al*., 2020; Salehi *et al*., 2022) and reflects the role of moisture and temperature in enhancing the survival and development of pre-parasitic stages on pasture. The wet season provides optimal microclimatic conditions for larval development and dissemination, resulting in higher pasture contamination and infection pressure. Conversely, the dry season limits larval survival, leading to reduced transmission. The 27% higher risk observed during the wet period further underscores the epidemiological importance of seasonal management in helminth control programs in tropical zones.

A strong association between body condition and helminth infection was also evident. Sheep with poor body condition exhibited the highest infection rate (96.1%), supporting the assertion that gastrointestinal helminthiasis contributes substantially to poor body condition and productivity loss in ruminants (Hassan and Jibrin, 2022; Alkadir *et al*., 2024). The predominance of *H. contortus* in emaciated animals reflects its haematophagous nature, causing anaemia and protein loss (Urquhart *et al*., 1996). Poor nutrition may also compromise host immunity, predisposing animals to higher infection intensities (Flay *et al*., 2022).

Breed differences were significant, with Yankasa sheep showing the highest prevalence (91.6%), followed by Balami (89.0%) and Uda (54.5%). This agrees with previous observations that indigenous breeds differ in their resistance or tolerance to parasitic infections (Muhammed *et al*., 2017; Sinodo *et al*., 2021). The lower infection rate in Uda sheep may be linked to their semi-nomadic behavior and possible grazing in less contaminated areas compared to the sedentary management of Yankasa and Balami breeds. Breed-based genetic resistance to GI parasites has been reported in several studies (Madziga *et al*., 2024), suggesting that selective breeding for resistance could be a sustainable control strategy in endemic regions.

The dominance of *Haemonchus contortus* across age groups, body conditions, and breeds is consistent with numerous studies in West Africa (Mushonga *et al*., 2018; Flay *et al*., 2022; Ame *et al*., 2023). Its prevalence reflects its high fecundity, rapid development in warm humid climates, and the widespread availability of infective larvae on communal grazing lands. The concurrent detection of *Trichostrongylus* spp., *F. gigantica*, and *Paramphistomum* spp. indicates mixed infections, a common phenomenon in tropical grazing systems where multiple parasite species share ecological niches (Waller and Thomas, 1981). The presence of *F. gigantica* and *Paramphistomum* spp. also signifies contamination of pastures by snail intermediate hosts, especially in low-lying and waterlogged areas common in Gombe State, which serve as habitats for *Lymnaea* spp. and *Planorbis* spp. snails (Martindah *et al*., 2023).

The overall occurrence of zoonotic helminths was 51.1%, dominated by *Haemonchus contortus* (38.0%) and *Fasciola gigantica* (11.1%), while *Strongyloides papillosus* was detected in 2.0% of animals. These findings indicate that sheep in this area serve as important reservoirs for zoonotic helminths capable of affecting both animal productivity and public health. The relatively high prevalence of these zoonotic helminths could be attributed to favorable climatic conditions in Gombe State that promote the development and survival of infective larvae, particularly warm temperatures and moderate humidity, as well as continuous grazing systems that enhance pasture contamination. Moreover, limited anthelmintic rotation and possible emergence of drug resistance among *Haemonchus* populations may have sustained the high infection rates observed.

The detection of *F. gigantica* (11.1%) among the examined sheep suggests the persistence of fasciolosis in the study area. The presence of this trematode is closely linked to ecological conditions that support the breeding of its intermediate snail hosts (*Lymnaea* spp.), particularly in poorly drained pastures and irrigation zones. The zoonotic implication of *F. gigantica* is of concern, as humans can acquire infection through ingestion of metacercariae encysted on aquatic vegetation, highlighting the need for integrated "One Health" control strategies involving veterinary and public health sectors.

Although *Strongyloides papillosus* was detected at a relatively low rate (2.0%), its zoonotic potential warrants attention, particularly among individuals who handle infected animals or come in contact with contaminated soil. Similar low but notable occurrences have been reported by Thamsborg *et al*. (2017) and Afshan *et al*. (2024), suggesting that while *S. papillosus* infections are often subclinical, their presence reflects environmental contamination and inadequate hygiene around animal holding areas.

The combined high prevalence of zoonotic and veterinary helminths (79.4%) in the present study signifies a substantial burden on small ruminant production and a potential public health hazard in Gombe State. Similar high levels of helminth infection have been documented in small ruminants from Ethiopia (52.3%) (Kebede *et al*., 2025), although slightly lower rates were observed in parts of Nigeria (65.96%) (Eke *et al*., 2019; 2024). Such variation may be due to differences in climatic conditions, grazing systems, diagnostic methods, and sampling sources.

CONCLUSION

This study revealed a high overall prevalence (79.4%) of gastrointestinal helminth infections among sheep from livestock markets and abattoirs in Gombe State, underscoring a significant parasitic burden in the region. Nematodes, particularly *Haemonchus contortus* (38.0%) and *Trichostrongylus* spp. (18.9%), predominated, reflecting their strong adaptation to local climatic and husbandry conditions. Trematodes such as *Fasciola gigantica* (11.1%) and *Paramphistomum* spp. (6.3%) indicated persistent exposure to snail-infested environments favorable for fluke transmission. Infection was notably higher in abattoirs (87.2%) than in markets (71.8%), suggesting poor ante-mortem screening and chronic infections in slaughtered animals. Age, season, breed, and body condition significantly influenced infection patterns, with adults, the rainy season, Yankasa breed, and poorly conditioned sheep showing the highest prevalence. The detection of zoonotic helminths in over half (51.1%) of examined sheep highlights a substantial public health risk, especially to abattoir workers, butchers, and consumers.

Based on the high prevalence of gastrointestinal helminths and the substantial burden of zoonotic species identified in this study, concerted control measures are urgently recommended to mitigate both animal health and public health risks. Routine strategic anthelmintic administration should be integrated with rotational grazing, improved hygiene, and proper waste disposal to interrupt parasite transmission cycles. Veterinary extension programs should prioritize farmer education on the epidemiological significance of helminth zoonoses, emphasizing the need for regular deworming, improved feeding, and avoidance of grazing in snail-infested or contaminated pastures, especially during the rainy season when infection risk peaks. Strengthened abattoir inspection and livestock market surveillance, supported by diagnostic monitoring and molecular identification of helminths, are crucial for early detection and control of emerging zoonotic threats. Sustainable helminth management should further align with a One Health framework, promoting coordinated action among veterinarians, livestock producers, and public health authorities to reduce infection pressure, enhance productivity, and safeguard food safety in Gombe State and similar endemic regions.

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Author contributions

Bello A. M. (*) — Conceptualization, study design, overall supervision, project administration, interpretation of results, and critical revision of the manuscript for important intellectual content. Served as corresponding author and is guarantor of the study. **Lawal J. R.** — Major role in fieldwork and sample collection at livestock markets and abattoirs, laboratory processing of specimens, data curation, execution of experiments, and drafting the original manuscript (writing — original draft). **Dauda J.** — Development of laboratory and analytical methods, statistical analysis and interpretation (formal analysis), preparation of tables, and contributed to writing — review and editing. **Abdullahi A. M.** — Field logistics and coordination, assistance with sample collection and on-site data recording (investigation), and contributed to the Methods section and manuscript revision. **Biu A. A.** — Literature review, provision of laboratory resources and reagents (resources), technical support during laboratory analyses, and contributed to writing — review & editing.

All authors contributed to interpreting the data, critically revised the manuscript for important intellectual content, approved the final submitted version, and agree to be accountable for all aspects of the work, ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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