Volume 46[2] September, 2025

Nigerian Journal of Parasitology

Journal homepage: www.njpar.org.ng

Prevalence and Factors Associated with Gastrointestinal Parasitic Infections in Maradi breed from Major Markets in Ilorin, Kwara State, North Central, Nigeria.

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ARTICLE INFO

Keywords:
Goats, Helminth infections, Prevalence, Nigeria

Handling Editor:
Dr Olajoju T. Soniran, Akanu Ibiam Federal Polytechnic Unwana, NIGERIA

ABSTRACT

Helminth infections are a critical concern for the health and productivity of small ruminants in tropical regions. This study investigated the prevalence and determinants of gastrointestinal protozoan and helminth infections in the Maradi (*Capra hircus*) breed in major markets in Kwara State, Nigeria. A total of 132 goats from Mandate, Ipata, and Eyenkorin markets were sampled to determine the presence of gastrointestinal tract (GIT) parasites. Logistic regression was employed to analyse the association between infection status (positive/negative) and predictors, including the location, sex, and age of the goats. The interaction effects between these variables were also assessed. Model fit was evaluated using the Hosmer-Lemeshow test, and predictive performance was examined using Receiver Operating Characteristic (ROC) analysis. The overall infection rate was 84.09%, with significant variations across market locations. Eyenkorin Market exhibited the highest infection rate (100%), followed by Mandate (77.78%) and Ipata (79.17%). Although male goats showed a higher infection rate (90.00%) than females (79.17%), this difference was not statistically significant (χ^2=2.8710, p=0.09). Younger goats (6-12 months and 13-24 months) had higher infection rates, although age alone did not significantly predict the infection status. The logistic regression model was significant (χ^2=13.52, p=0.0036), indicating that location and age significantly influenced infection status. The pseudo R-squared of the model was 0.1169, suggesting that it explains 11.69% of the variance in infection status. This study indicates the substantial prevalence of gastrointestinal helminth infections among the Maradi breed in Kwara State, Nigeria, where location and age have emerged as significant predictors. These findings emphasise the need for targeted interventions to mitigate infection risks, particularly in high-prevalence areas and in younger goats. Improving management practices and implementing strategic deworming programs could effectively reduce infection rates and enhance goat health and productivity in this region.

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https://dx.doi.org/10.4314/njpar.v46i2.5
Submitted 1st December 2024; Revised 6th January 2025; Accepted 16 April 2025
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Introduction

The livestock production sector plays a significant role in Nigeria's economy, greatly contributing to the country's economic health. Over 80% of the population is engaged in some form of agriculture [1], and small ruminant production plays a crucial role in Nigeria's economy.

Gastrointestinal parasites that inhabit the gastrointestinal tract (GIT) of ruminants pose a significant challenge to meat production [2]. These parasites hinder efficient and profitable livestock farming [3]. Gastrointestinal parasitism in ruminants is primarily caused by helminths and protozoa [4]. Three major classes of helminths commonly affect the gastrointestinal tract in ruminants: nematodes, trematodes, and cestodes. Some commonly recorded species in Nigeria include *Nematodirus* spp., *Ascaris* spp., *Strongyloides* spp., *Paraphistomum* spp., *Schistosoma* spp., *Moniezia* spp., and several *Eimeria* species [5, 6]. Environmental conditions, nutritional, immunological, and grazing systems affect gastrointestinal parasites (GIP) among livestock, while limited awareness of GIP among livestock farmers creates an environment that supports the growth and proliferation of these parasites [7]. Additionally, the growing resistance of GIPs to various anthelmintics poses significant challenges that necessitate prompt and effective intervention [8, 9]. The rising incidence of gastrointestinal helminth infections in livestock, often caused by repeated exposure to contaminated grazing areas, exacerbates the issue of helminth resistance in dewormers.

Unlike cattle, which are often exposed to more GIPs by grazing over long distances, goats are likely to be exposed to fewer GIPs because they graze over short distances. However, they are still infected with parasites and reinfections are common. Among the classes of gastrointestinal helminths of veterinary importance, nematodes are most economically detrimental to livestock in Nigeria [6].

Gastrointestinal infections often present as mild subclinical conditions in healthy individuals. However, they can cause severe acute illness in young, undernourished, or immunocompromised animals. In goats and other small ruminants, acute symptoms include diarrhoea, anaemia, reduced weight gain, weakness, lower limb oedema, reduced productivity, and sometimes even death [10, 11]. The impact of parasitic infections may be intensified in areas with limited or no veterinary care and insufficient disease control policies [12]. Often, parasite burdens have been linked to impaired reproductive performance and these parasites contribute to increased loss of endogenous protein, which may explain the reduced weight gain observed in infected goats [13, 14].

Although studies on GIPs in cattle and sheep have been conducted across different regions in Nigeria: Eastern [15], north-central [16], north-east [17], western [18], and south-south [19], there is limited information on gastrointestinal parasitic infections affecting Maradi goats in Kwara State. This study aimed to investigate the prevalence, distribution, and factors associated with gastrointestinal parasites in goats in this region.

Materials and Methods

Study Area

Kwara State, situated in North Central Nigeria, is located between latitude (8° 30'N) and longitude (5° 00'E) and covers an area of 13,947.27 sq. miles (35,705 km^2) [20]. Ilorin, the capital of Kwara State, experiences a tropical climate with an average annual temperature of 28.73°C, a relative humidity of 81%, and an annual rainfall of 170 mm. Vegetation in Ilorin is characteristic of the Guinea savannah zone. In our study, we sampled three locations within the state: Mandate, Ipata, and Eyenkorin.

Sample and Data Collection

This cross-sectional study examined the intestinal parasites in goats. A total of 132 animals were randomly selected for the study and the sample size was calculated using Fischer's formula. Goats were categorised into the following age groups based on their months: 6–12, 13–24, 25–36, and 37–46 months. The breed was identified according to the criteria described by Blench [21] for traditional livestock breeds in West Africa. The sex of the breed was determined through an examination of their external genitalia, whereas the age of the goats was determined using the eruption and wear patterns of the incisor teeth, following the guidelines established by Wilson and Durkin [22]. Faecal samples from Maradi goats were collected early in the morning. Using gloves, samples were collected directly from the rectum of the animals and placed into sterilised sample containers. The collected samples were stored in a cool box at 4°C and transported to the laboratory for parasitological analysis [23].

Laboratory Examinations

The Baermann technique and flotation method were used to analyse the faecal samples of gastrointestinal parasites. In the Baermann technique, 5-10 grams of faeces was placed in a fine mesh to prevent clogging. The setup involved a funnel in which the sample was submerged in warm water to encourage larval migration. After 30-60 minutes, the water was drained into a collection jar, filtered to remove debris, and examined under a microscope for motile larvae, identification was based on their morphological features [24]. The flotation technique was employed to examine faecal samples for gastrointestinal parasite eggs. Faecal samples were emulsified in a saturated salt solution in a beaker. The resulting mixture was filtered

through a fine sieve to remove the large particles and debris. The filtrate was transferred to a sample bottle and a cover slip was placed on top for 10–15 min. The samples were then observed under a microscope to examine the morphological characteristics of the helminth ova [23].

Data Analysis

The data collected were analysed using chi-square (χ^2), performed using STATA version 14 software. Logistic regression analysis was conducted to identify contributory predictors. Wald tests were used in this study to examine the combined influence of predictor variables, providing a formal statistical evaluation of their effects. By testing specific combinations (e.g. location and sex, location and age, and sex and age), we determined whether these variables jointly influence the likelihood of goat infection beyond their single contribution. This approach enhances the robustness of our findings by considering the potential interactions and dependencies among predictors. The likelihood ratio test was used to determine whether a more complex model significantly improves fitness compared to a simpler model nested within it. We evaluated the goodness-of-fit of the logistic regression model for predicting goat infection using the Hosmer-Lemeshow test. Statistical significance was set as $p < 0.05$.

Results

Overall, the results indicated that *Eimeria* spp. was the most prevalent gastrointestinal parasite, found in 72.7% of the goats surveyed. This was followed by strongyle eggs, which were present in 29.5% of the goats. *Fasciola hepatica* was detected in 13.6% of the goats, representing roughly one in every seven animals. Other parasites were less common: *Moniezia* spp. was found in 11.4% of goats, *Dictyocaulus* spp. in 6.8%, and *Dicrocoelium* spp., *Protostrongylus* spp., *Muellerius* spp. in 4.5% of goats. The least prevalent parasite was *Nematodirus* spp., which was detected in only 2.3% of goats. These findings highlight the significant burden of the parasites (Figure 1).

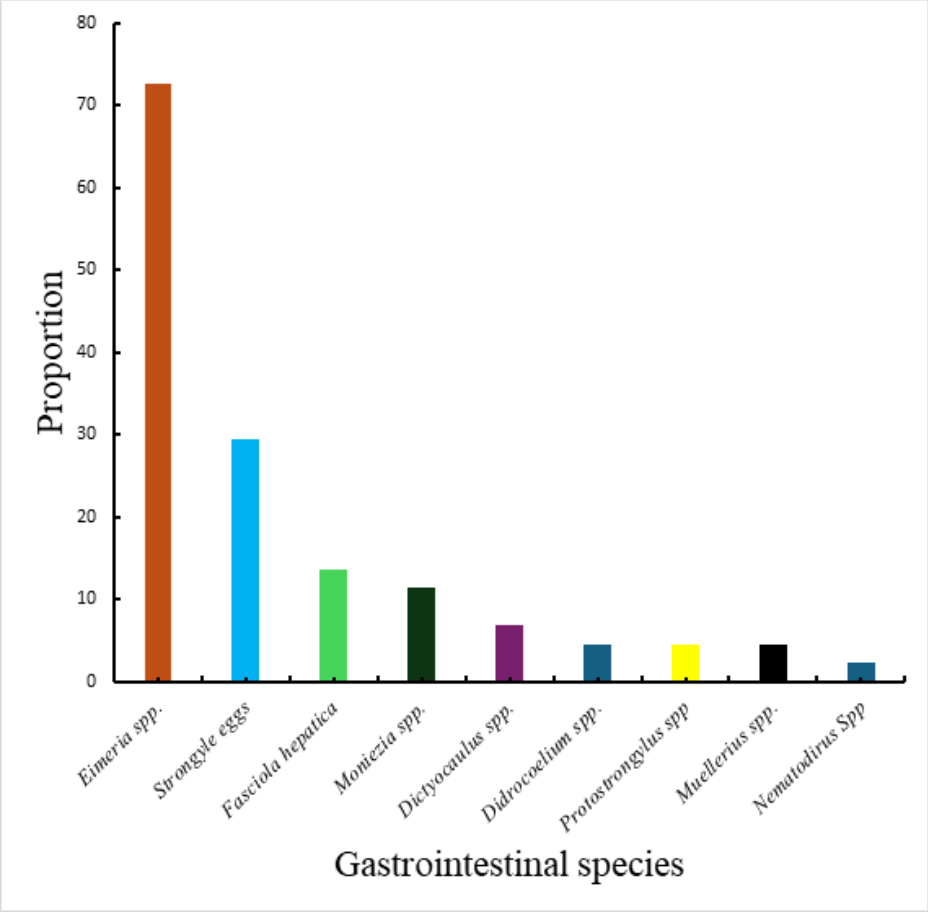


Fig. 1: Distribution of gastrointestinal parasites from the study area

In all three markets, *Eimeria* spp. was the most prevalent parasite, with the highest prevalence in Mandate (88.9%) and the lowest in Ipata (62.5%). *Strongyle* eggs were also consistently observed, with prevalence rates of 36.4%, 33.3 %, and 25.0% in Eyenkorin, Mandate, and Ipata, respectively. *Fasciola hepatica* was detected in all three locations but was most prevalent in Mandate, where it affected one-third of the goats (33.3%). In contrast, its presence was considerably lower in the Ipata group (4.2%). In Mandate, *Dictyocaulus* spp. were found in nearly a quarter of the goats (22.2%), whereas *Protostrongylus* spp. and *Nematodirus* spp. each had a prevalence of 11.1%. In Eyenkorin, *Moniezia* spp., *Dicrocoelium* spp., *Muellerius* spp., and *Dictyocaulus* spp. infected 9.1% of goats. Ipata had the lowest prevalence of most parasites, with *Moniezia* spp. affecting 16.7% of the goats, whereas *Dicrocoelium* spp., *Protostrongylus* spp., and *Muellerius* spp. each had a prevalence of 4.2% (Table 1).

Analysis of goat infection rates in the study area revealed a high prevalence of infection among the sampled population. Of the 132 goats examined, 111 (84.1 %) were found to be infected. All 33 goats sampled from Eyenkorin were infected. The chi-square test for independence indicated a significant association between market location and infection status ($\chi^2(2) = 8.3526, p = 0.015$).

Table 1: Location related Prevalence of Gastrointestinal Parasites

Location	Gastrointerstinal parasites	Prevalence (%)	χ^2	p-value
Mandate (n=27)	*Eimeria* spp.	24 (88.9)		
	Fasciola hepatica	9 (33.3)		
	Strongyle eggs	9 (33.3)		
	Dictyocaulus spp.	6 (22.2)		
	Protostrongylus spp.	3 (11.1)		
	Nematodirus spp.	3 (11.1)		
Ipata (n=72)	*Eimeria* spp.	45 (62.5)	8.3526	0.015*
	Strongyle eggs	18 (25.0)		
	Moniezia spp.	12 (16.7)		
	Fasciola hepatica	3 (4.2)		
	Didrocoelium spp.	3 (4.2)		
	Protostrongylus spp.	3 (4.2)		
	Muellerius spp.	3 (4.2)		
Eyenkorin (n=33)	*Eimeria* spp.	27 (81.8)		
	Strongyle eggs	12 (36.4)		
	Fasciola hepatica	6 (18.2)		
	Moniezia spp	3 (9.1)		
	Didrocoelium spp.	3 (9.1)		
	Muellerius spp.	3 (9.1)		
	Dictyocaulus spp.	3 (9.1)		

* Represent statistically significant ($p<0.05$)

Eimeria spp. was the most prevalent parasite in both sexes, with a higher prevalence in male goats (80.0%) than in female goats (66.7%). *Strongyle* eggs were more common in female goats (33.3 %) than in male goats (25.0 %). Among the other parasites, *Moniezia* spp., *Fasciola hepatica, Muellerius* spp., and *Dictyocaulus* spp. were found in 10.0% of male goats. In contrast, female goats had a slightly higher prevalence of *Fasciola hepatica* (16.7%) and *Moniezia* spp. (12.5%), while *Dicrocoelium* spp. and *Protostrongylus* spp. infected 8.3% of females. The chi-square test for independence indicated no statistically significant association between sex and infection status ($\chi^2(1) = 2.8710, p = 0.090$).

Table 2: Sex-related prevalence of gastrointestinal parasites.

Sex	Gastrointerstinal parasite	Freq./Prevalence (%)	χ^2	p-value
Male (n=60)	*Eimeria* spp.	48 (80.0)	2.871	0.090
	Strongyle eggs	15 (25.0)		
	Moniezia spp.	6 (10.0)		
	Fasciola hepatica	6 (10.0)		
	Muellerius spp.	6 (10.0)		
	Dictyocaulus spp.	6 (10.0)		
Female (n=72)	*Eimeria* spp.	48 (66.7)		
	Strongyle eggs	24 (33.3)		
	Fasciola hepatica	12 (16.7)		
	Moniezia spp.	9 (12.5)		
	Didrocoelium spp.	6 (8.3)		
	Protostrongylus spp	6 (8.3)		
	Dictyocaulus spp.	3 (4.2)		
	Nematodirus spp.	3 (4.2)		

Across all age groups, *Eimeria* spp. were the most prevalent gastrointestinal parasites. Its prevalence was highest in goats aged 25-36 months (90.9%) and lowest in those aged 37-46 months (50.0%). *Strongyle* eggs were observed in all age groups, with the highest prevalence in the 13-24 month group (35.7%). This parasite was also relatively common in younger goats aged 6-12 months (29.4%) and was slightly less prevalent in the 25-36 month group (27.3%). For goats aged 6-12 months, *Moniezia* spp. and *Fasciola hepatica* each had a prevalence of 17.6% (Table 3).

The highest infection rates were observed in the younger age groups (6-12 months and 13-24 months), with infection rates of 88.24% and 85.71%, respectively. The infection rate decreased in the 25-36 month age group and dropped significantly in the 37-48 month age group. The chi-square test for independence indicates no statistically significant association between age and infection status ($\chi^2(1) = 6.0773$, $p = 0.108$).

Table 3: Age related gastrointestinal parasites

Age (month)	Gastrointerstinal parasite	Prevalence (%)		p-value
6-12 (n=51)	*Eimeria* spp.	36 (70.6)	6.0773	0.108
	Strongyle eggs	15 (29.4)		
	Moniezia spp.	9 (17.6)		
	Fasciola hepatica	9 (17.6)		
	Protostrongylus spp.	3 (5.9)		
	Dictyocaulus spp.	3 (5.9)		
	Nematodirus spp.	3 (5.9)		
13-24 (n=42	*Eimeria* spp.	26 964.3)		
	Strongyle eggs	15 (35.7)		
	Fasciola hepatica	9 (21.4)		
	Muellerius spp.	9 (14.3)		
	Moniezia spp.	9 (14.3)		
25-36 (n=33)	*Eimeria* spp.	30 (90.9)		
	Strongyle eggs	9 (27.3)		
	Didrocoelium spp.	6 (18.2)		
	Dictyocaulus spp.	6 (18.2)		
	Protostrongylus spp.	3 (9.1)		
37-46 (n=6)	*Eimeria* spp.	3 (50.0)		

Logistic Regression Analysis of Infection Status and Associated Predictors

The logistic regression model was statistically significant (LR (3) = 13.52; p = 0.0036). The pseudo-R-squared value of 0.1169 in the model explains approximately 11.69% of the variance in infection status. The odds ratio for location was 0.3898 (p = 0.027), which was statistically significant. Specifically, the odds of infection were reduced by approximately 61% in certain locations, indicating an association between location and infection status. The odds ratio for sex was 2.4855 (p = 0.115) with a 95% confidence interval of 0.8003–7.7195. Although the p-value is slightly above the threshold of 0.05, this indicates marginal statistical significance. Age had an odds ratio of 1.9591 (p = 0.010), with a 95% confidence interval of 1.1707–3.2782. This indicated a significant association between age and infection status (Figure 1).

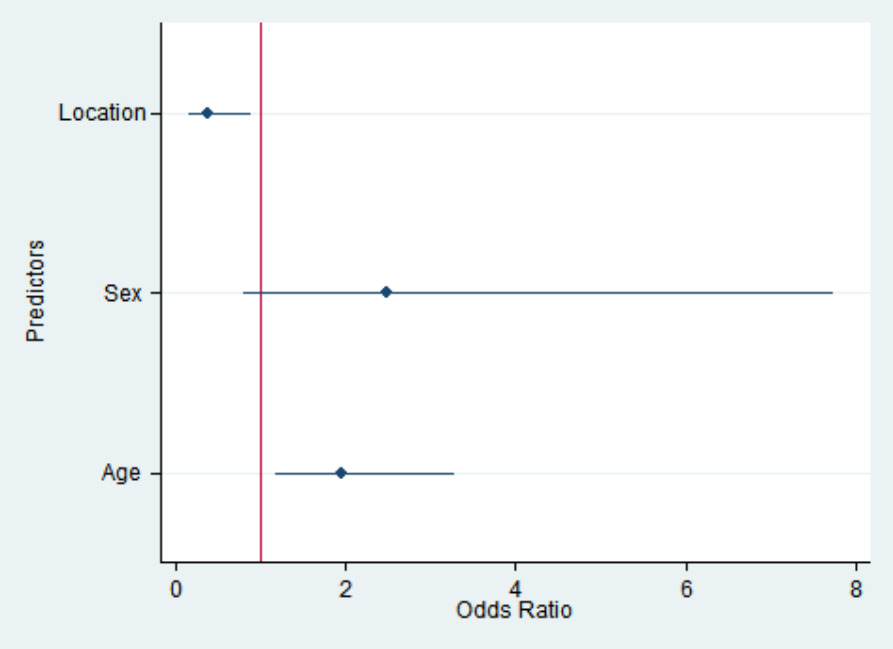


Fig. 1: Odds Ratios from Logistic Regression for Predictors

The Combined Effect of Two Categorical Variables were Examined

The test of the combined effect of location and sex resulted in an odds ratio of 0.9690 (p = 0.967), which was not statistically significant. The combined effect of location and age resulted in an odds ratio of 0.7637 (p = 0.554), which was not statistically significant. This suggests that when considering both location and age, their combined influence on infection status was not significantly different. The test of the combined effect of sex and age resulted in an odds ratio of 4.8693 (p = 0.024). This statistically significant result for the combined influence of sex and age significantly affects infection status.

Wald Test Combining the Effect of Predictors

The chi-squared statistic was 8.29 with a corresponding p-value of 0.0159, indicating that there was a significant combined effect of location and sex on infection status. Location and age showed a chi-squared statistic of 9.69 with a p-value of 0.0079, demonstrating a significant joint effect of location and age on infection status. The chi-squared statistic was 7.30 with a p-value of 0.0259, indicating a significant joint effect of sex and age on infection status.

Predictive Margins Analysis of Infection

Predictive margin analysis focuses on how the interaction between location and sex influences the predicted probability of goat infection in Kwara State. Female goats in Ipata had a predicted margin of 0.1765 (p = 0.006), indicating a moderate probability of infection; however, the predicted probability of infection for female goats in Mandate was not estimable because of model constraints. Male goats in mandate exhibited a higher predicted margin of 0.3755 (p = 0.001). Male goats in the Ipata market showed a predicted margin of 0.2012 (p < 0.001), indicating a significant probability of infection.

Likelihood Ratio and Goodness-of-Fit Tests

The likelihood ratio chi-square statistic is 6.60 with one degree of freedom, resulting in a p-value of 0.0102. This indicates that the full model significantly improves the fit over the reduced model at a significance level of 0.05. The significant likelihood ratio test suggests that the inclusion of age as a predictor, in addition to location and sex, provides a better explanation for the variation in goat infection status in Ilorin, Kwara State. Specifically, age (odds ratio = 1.9591, p = 0.010) significantly contributed to the model's explanatory power. Location (OR = 0.4507, p = 0.050) and sex (OR = 1.5976, p = 0.399) also showed varying degrees of influence, although the location's effect approached but was not statistically significant.

ROC Curve for the Analysis

The receiver operating characteristic (ROC) curve summarises the performance of the logistic regression model in predicting infection in goats. An AUC of 0.7066 indicated that the model performed better than random chance (AUC = 0.5). Specifically, there was a 70.66% chance that the model correctly differentiated between a randomly chosen infected goat and a randomly chosen non-infected goat (Figure 2).

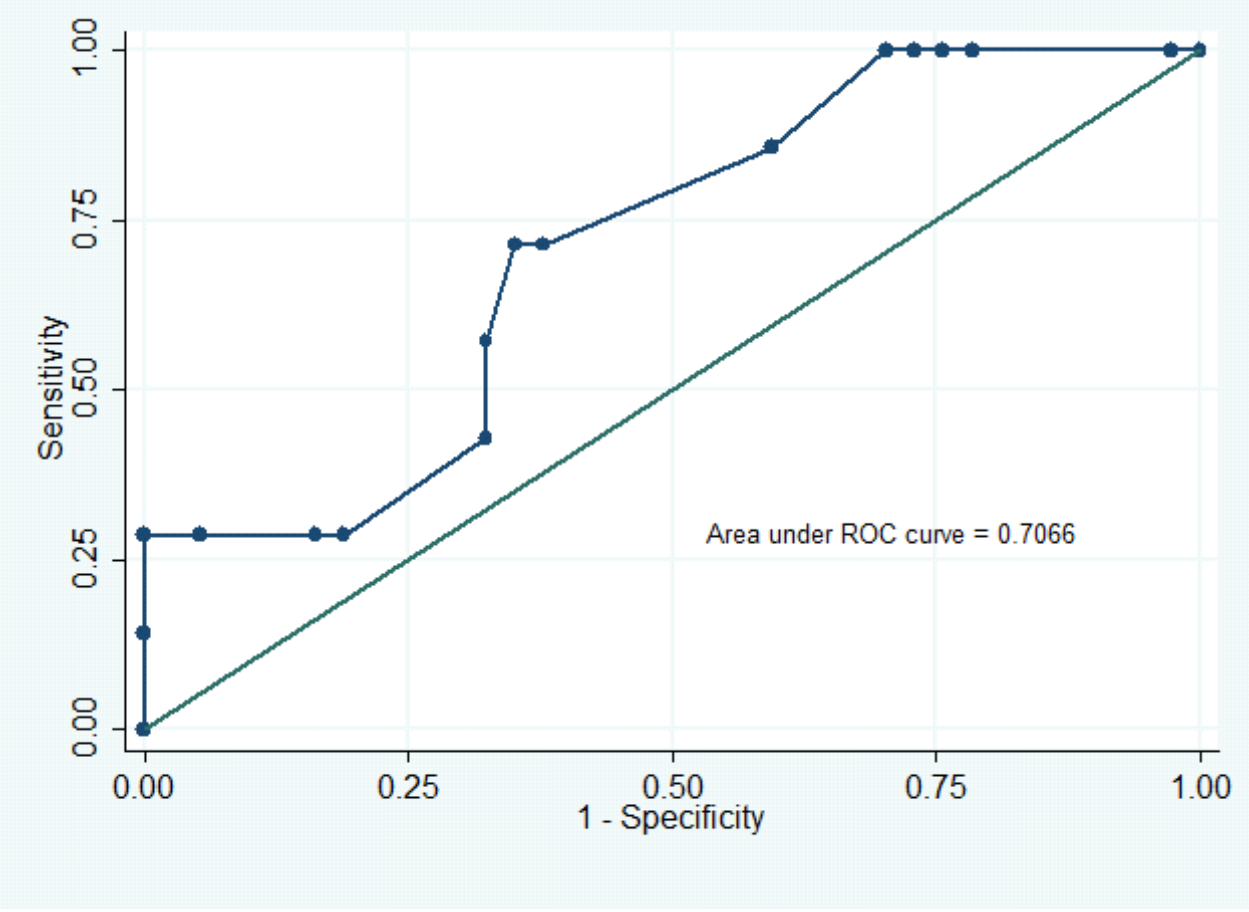


Figure 2: ROC Curve for Logistic Regression Model

Discussion

Our findings revealed an overall prevalence of 84.1% across all sampled locations, with every goat in the Eyenkorin location infected with various species of protozoa and helminths. Our findings exceed similar reports from various regions, which have indicated GIP prevalence rates ranging from 70.91 to 75.0% [22-23] in Oyo State, 37.1% in South Africa [26], and 78.6% in Malaysia [27]; however, the prevalence reported in this study is lower than that of [28], where an overall prevalence of 89.33% was reported in Egypt. The elevated prevalence of parasites observed in this study may be attributed to environmental and management practices. High tropical temperatures, humidity, and rainfall create conditions that support the spread and persistence of parasites by fostering optimal development of their pre-parasitic stages [29]. The prevalence observed in this study indicates that GIP infections continue to pose a significant threat to small ruminants as they can lead to reduced weight gain, high morbidity, and increased mortality rates, particularly among young animals.

The significant association between market location and infection status in goats suggests that different locations may have different management practices or levels of veterinary care, which can influence the prevalence of infections. The differences in gastrointestinal parasite prevalence across locations align with a study conducted in Enugu State, where the prevalence was significantly higher in the New Garky area than in other sampling locations [30]. Variations in hygiene standards, stocking densities, and access to veterinary services across different locations could lead to differences in exposure risk to parasites [12]. Additionally, geographical differences, such as climate and vegetation, can affect the life cycle of parasites and their transmission rate [31]. These factors collectively contributed to the observed significant association, indicating that the location where goats are kept or sold plays a crucial role in determining their likelihood of being infected. Therefore, there is a need for targeted interventions and management strategies that consider local conditions to effectively control and reduce the prevalence of gastrointestinal parasitic infections in goats.

While the independence test did not find a statistically significant association between sex and infection status, the odds ratio for sex (2.48) suggested that male goats might be more likely to be infected than female goats. This odds ratio indicates that the odds of infection are approximately 2.5 times higher in male goats than in female goats. Although the p-value did not reach the threshold for statistical significance, the results could still be considered marginally significant. This suggests that there might be biological or behavioural differences between male and female goats that affect their susceptibility to GIPs, such as differences in grazing behaviour or hormonal influences [32].

Male and female goats often exhibit different grazing behaviours, which can influence their exposure to GIPs. Males may be more likely to roam further in the search for food [33], especially if they are not castrated. This broader range can increase exposure to contaminated pastures or water sources where parasites are present. Additionally, males may exhibit more aggressive feeding behaviours [33], potentially leading them to ingest more contaminated vegetation or soil. An increased exposure can result in a higher prevalence of infection. Moreover, male goats may also have different social structures and interactions compared to females [34], such as being more dominant or less selective in grazing, which could contribute to a higher risk of ingesting infective stages of parasites. These behavioural differences could explain why male goats might have a higher odds ratio for GIP infection.

Logistic regression analysis indicated a significant association between age and infection status, with an odds ratio of 1.96. This suggests that with each additional year of age, the likelihood of infection increased by approximately 96%. The highest infection rates were observed in younger goats, particularly in the 6-12 months (88.24%) age group. This trend suggests that younger goats are at a higher risk of infection, which is consistent with previous observations [19]. This increased susceptibility in younger goats could be due to several factors, including an underdeveloped immune system, lack of prior exposure to parasites [35], and potentially higher exposure to contaminated environments as they explore their surroundings more actively. The immune system of young goats is still developing [14] and may not produce adequate levels of antibodies or immune cells to combat infections. This inherent vulnerability makes them more prone to infections and less capable of clearing parasites efficiently once exposed. Furthermore, young small ruminants often have limited exposure to gastrointestinal parasites compared with older goats. This lack of prior exposure could mean that they have not yet developed acquired immunity, which typically builds up over time as the animal encounters and reacts to various parasites. In older goats, repeated exposure to parasites often leads to the development of some level of immunity or tolerance [36], which can help mitigate the severity of infections.

The interaction between sex and age adds another layer of complexity to the understanding of infection dynamics in goats. Although individual factors, such as sex or age, can independently affect infection rates, their combined effects may reveal additional insights. Younger males and females may experience different infection rates owing to varying behaviours or physiological responses [37]. Assessing how sex and age interact in different locations helps to identify specific subpopulations that are at a higher risk and allows for ways to prevent and control measures. Younger males might be more prone to infections due to their more aggressive or exploratory behaviour compared to females. Conversely, older female goats often experience hormonal changes related to reproduction [38], which can affect their immune responses and make them more susceptible to infections. These changes may include fluctuating levels of reproductive hormones, which influence immune function and vulnerability to parasitic infections.

Conclusion

This study revealed that younger goats were more prone to gastrointestinal parasitic infections than older goats. This increased susceptibility in younger animals likely stems from their underdeveloped immune system and greater exposure to contaminated environments. Additionally, the interaction between sex and age significantly influenced infection risk, with certain combinations of these factors showing higher infection probabilities. Male goats in specific locations exhibited notably higher infection rates, suggesting that geographical and sex-related factors contribute to variations in infection risk. Overall, the inclusion of age, location, and sex enhances our understanding of infection dynamics in goats. These findings indicate that targeted control measures should consider the combined effects of age, sex, and location in order to effectively manage and reduce parasitic infections. These results emphasise the importance of tailored intervention strategies to address the specific needs of different goat populations and improve overall herd health management.

Acknowledgements
We sincerely appreciate the market leaders and their members for granting consent to use their animals in this study.

Declarations

Authors' Contributions

JOS conceptualised and designed the study. OGO and OIO participated in the fieldwork and data collection. OGO and OIO performed the data analysis, and JOS and OGO interpreted the data. OGO and OIO prepared the first draft of the manuscript, which was reviewed by JOS and OGO. All the authors contributed to the development of the final manuscript and approved its submission.

Ethical Consideration

This study was approved by the Ethical Review Committee of Kwara State University, Malete, Nigeria prior to its commencement (REF: MOH/KS/RERC/1063/720). We consulted a general market leader and provided information to the sectional heads of the project. Verbal consent was obtained from all participating leaders in charge of the respective zones.

Disclosure of Conflict of Interest

The authors declare that they have no conflicts of interest.

Disclosure of Funding Source

Not applicable

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Citation
Sunday, O. J., Oso, G. O., and Ojo, I. O. (2025) Prevalence and Factors Associated with Gastrointestinal Parasitic Infections in Maradi breed from Major Markets in Ilorin, Kwara State, North Central, Nigeria. https://dx.doi.org/10.4314/njpar.v46i2.5

Nigerian Journal of Parasitology
ISSN 1117 4145 Volume 46[2] September, 2025