

**PREVALENCE OF GASTROINTESTINAL PARASITES IN SMALL RUMINANTS
DURING THE EARLY RAINY SEASON**

Abstract

Background

Gastrointestinal (GI) parasitism is a major constraint on small ruminant production in the semi-arid zone of north-eastern Nigeria, and the onset of the rains is a period of sharp change in parasite transmission. This study determined the prevalence, diversity, intensity and host-related risk factors of GI parasites in sheep and goats at the onset of the rainy season in Maiduguri, Nigeria.

A cross-sectional survey was conducted in June, 2026 during which 170 faecal samples (sheep =100, goats 70 = goats) were collected from eight locations in Maiduguri metropolis Borno State, and examined by flotation technique using saturated salt solution. Data were analyzed using chi-square tests and multivariable logistic regression. Overall, 140 of 170 animals were positive, giving a prevalence of 82.35%. Strongyle-type eggs were the most common finding (73.57%), followed by coccidian oocysts (45.00%), *Strongyloides* spp. (14.29%) and *Fasciola*-type eggs (2.14%). Infection intensity was light in 40.00%, moderate in 25.00% and heavy in 35.00% of positive animals. Prevalence differed significantly among breeds ($p = 0.0036$) and sampling locations ($p < 0.001$). Host species ($p = 0.244$), sex ($p = 0.112$) and age category ($p = 0.087$) were not significantly associated with infection. This study shows a high burden of GI parasites, dominated by strongyle-type nematodes and coccidia, in small ruminants at the onset of rains.

Keywords: Helminths, Sheep, Goats, Early rainy season, Maiduguri, Nigeria

INTRODUCTION

Small ruminants, comprising domestic sheep (*Ovis aries*) and goats (*Capra hircus*), are an important socio-economic resource across sub-Saharan Africa. In Nigeria they serve as a liquid asset, a buffer against crop failure, and a source of animal protein, hides and manure (Mbaya et al. 2010; Karshima et al. 2018). In north-eastern Nigeria, and particularly in Maiduguri, Borno State, small ruminant husbandry is woven into the economic life of both rural and peri-urban households (Nwosu et al. 2007).

Gastrointestinal (GI) parasitism is among the foremost health constraints on these animals. It involves nematodes, trematodes, cestodes and enteric protozoa (Mbaya et al. 2010; Karshima et al. 2018; Taylor et al. 2016) and, unlike acute viral outbreaks, typically presents as a chronic, subclinical disease that gradually reduces weight gain, feed conversion, milk yield and reproductive performance (Coop & Holmes, 1996; Karshima & Karshima, 2020). Heavy burdens of blood-sucking nematodes, especially *Haemonchus contortus*, which can consume up to 0.05 mL of blood per worm per day, cause haemorrhagic anaemia, hypoproteinaemia and oedema, and may kill animals before marked emaciation is seen (Besier et al. 2016). Other strongylid nematodes damage the intestinal mucosa and cause malabsorptive diarrhoea (Mbaya et al. 2010; Taylor et al. 2016), *Eimeria* species cause coccidiosis, with severe diarrhoea and high mortality in young stressed animals (Chartier and Paraud, 2012), and liver and rumen flukes cause further tissue damage where snail intermediate hosts are present (Taylor et al. 2016; Spithill et al. 1999).

The epidemiology of these infections is driven by climate. Maiduguri lies in the semi-arid Sahelian zone, with a long dry season from October to May and a short rainy season from June to September (Alade & Bwala, 2015). During the dry months, high temperatures and low humidity desiccate parasite eggs and larvae on pasture, and parasites persist through arrested larval development in the host, dormancy in aestivating snails, and resistant oocysts (Mbaya et al. 2010; O'Connor et al. 2006). The first rains of June break this dormancy: rising moisture allows eggs to hatch and develop into infective third-stage larvae within days, snail intermediate hosts become active, and oocysts sporulate (Spithill et al. 1999; Nwosu et al. 2007). Infection levels typically continue to rise through July and August before levelling off or declining as the rains taper (Nwosu

et al. 2007; Nwosu et al. 1996). June is therefore a critical window for establishing the baseline from which the rest of the wet season develops.

Management in Maiduguri adds to this complexity. Extensive and semi-intensive flocks graze communal pastures, refuse dumps and seasonal watercourses, while many smallholders keep animals in zero-grazing or backyard confinement and feed them on stored dried feed such as groundnut haulms and cowpea residues (Fakae, 1990; Alade & Bwala, 2015). Dried forage harvested from damp areas can carry fluke metacercariae, and damp pen floors in the rains favour the development of nematode and protozoan stages (Spithill et al. 1999; Taylor et al. 2016). Animals emerging from the dry season are also often in poor nutritional condition, which weakens their ability to resist infection (Coop & Holmes, 1996).

Despite this, there is little recent information on infection at the very onset of the rains, or on how infection differs among the local breeds, namely Balami, Uda and Yankasa sheep and Red Sokoto and Sahel goats (Nwosu et al. 2007; Alade & Bwala, 2015). The most recent survey of sheep and goats in Maiduguri sampled animals in July and August, after the rains were established (Onyiche et al. 2026). Without such data, owners and veterinarians continue to rely on arbitrary drenching schedules, which promote anthelmintic resistance without reducing production losses (Kaplan, 2004; Mortensen et al. 2003). This study was therefore carried out to (i) determine the prevalence of GI parasites in sheep and goats at the onset of the rainy season (June) in Maiduguri; (ii) determine the diversity of the parasites present; (iii) quantify the intensity of infection using a qualitative scoring system based on counts per microscopic field; and (iv) evaluate the influence of host-specific intrinsic factors on prevalence.

MATERIALS AND METHODS

Study area

The study was conducted in Maiduguri metropolis, the capital of Borno State, located in the Sudano-Sahelian agro-ecological zone of north-eastern Nigeria at approximately latitude 11°50'N and longitude 13°09'E. The metropolis comprises Maiduguri Metropolitan Council and the adjoining Jere Local Government Area. The climate is semi-arid, with a long dry season from October to May and a short rainy season from June to September. Mean annual rainfall rarely exceeds 650 mm, and temperatures range from a harmattan low of about 18°C to dry-season highs above 40°C (Mbaya et al. 2010; Alade & Bwala, 2015). The vegetation is predominantly Sahel savannah, with sparse thorny shrubs, scattered *Acacia* and *Balanites* trees, and seasonally flooded

fadama lowlands along the Ngadda River and the El-Beid basin that retain moisture and support snail populations. Livestock keeping is a major economic activity, practised under extensive, semi-intensive and zero-grazing (backyard confinement) systems, with small ruminants concentrated around residential compounds, peri-urban grazing reserves and livestock markets.

Study design and selection of sampling sites

A cross-sectional design was adopted, with sampling conducted in June, the early rainy season. Sampling sites were purposively selected to capture both extensive/semi-intensive grazing and zero-grazing systems, and were distributed across representative wards within Maiduguri Metropolitan Council and Jere Local Government Area. Within each ward, sampling points (household flocks, communal grazing herds and livestock holding pens at designated markets) were selected by a systematic random approach to minimise selection bias and ensure geographic spread. A total of 170 animals (100 sheep and 70 goats) were sampled at eight locations: Maiduguri Central Abattoir, Custom Quarters, UNIMAID Staff Quarters, 777 Housing Estate, Dalori Quarters, Gwange, Mairi and Zabarmari.

Sample size determination

The sample size was determined using the standard formula for estimating prevalence in a population (Thrusfield & Christley, 2018):

$$n = Z^2P(1 - P) / d^2$$

where n is the required sample size, Z is the standard normal deviate (1.96 for a 95% confidence level), P is the expected prevalence based on comparable regional surveys, and d is the acceptable margin of error (5%). The calculated minimum sample size was adjusted upward to allow for sample attrition and for adequate stratification by host species, breed and management system.

Animal identification and recording of host factors

Before sampling, each animal was individually identified and its biodata recorded on a structured data sheet. Recorded parameters were host species (sheep or goat); breed (Yankasa, Balami or Uda for sheep, and Red Sokoto or Sahel for goats, assigned from characteristic phenotypic descriptors); sex; age, estimated from owner-reported information and dentition and categorised as young (≤ 12 months) or adult (> 12 months); body condition score on a standardised scale; and management system (extensive/semi-intensive grazing or zero-grazing). This report focuses on the intrinsic host factors (species, breed, sex and age category) and on sampling location.

Sample collection

Fresh faecal samples were collected directly from the rectum of each animal using a clean, lubricated disposable glove, to avoid environmental contamination, with approximately 10–20 g of faeces obtained where possible. Where rectal collection was not feasible or not permitted by the owner, freshly voided pellets seen to be deposited by the identified animal were collected from the ground immediately. Each sample was placed in a clean, individually labelled, airtight container carrying a unique code linked to the animal's data, and was immediately placed in an insulated cold box with ice packs to prevent egg hatching or larval development. Samples were transported to the Veterinary Parasitology Laboratory within four to six hours. Samples that could not be processed immediately were stored at about 4°C and processed within 24–48 hours.

Laboratory examination

Each sample was processed by a standardised qualitative saturated salt flotation technique (MAFF, 1977; Zajac & Conboy, 2012). Approximately 2–3 g of faeces was weighed and emulsified in a small volume of saturated sodium chloride solution (specific gravity about 1.20) in a beaker, using an applicator stick to break up faecal aggregates. The suspension was strained through a wire mesh sieve or two layers of cheesecloth into a second container to remove coarse fibre, and the filtrate was poured into a labelled test tube until a slightly convex meniscus formed. A glass coverslip was placed on the meniscus, avoiding air bubbles, and left undisturbed for 15–20 minutes so that the lighter eggs and oocysts could float and adhere to its underside. The coverslip was then lifted vertically, placed on a clean glass slide and examined systematically with a compound light microscope at $\times 10$ and $\times 40$ magnification. Eggs and oocysts were identified to genus level, where feasible, using established morphological keys.

Qualitative scoring of infection intensity

To estimate the intensity of infection, each positive slide was scored from the mean number of eggs or oocysts seen per microscopic field at $\times 10$ objective, calculated by scanning ten representative fields and averaging the counts. Samples with no eggs or oocysts in any field were classed as negative; a mean of 1–2 per field was graded light (+); 3–5 per field moderate (++); and more than 5 per field heavy (+++). This ordinal scheme allowed rapid, reproducible field-level assessment of relative intensity without the time and equipment required for the McMaster egg counting technique.

Data analysis

Data from the data sheets and laboratory records were entered into Microsoft Excel, checked against the original sheets, and cleaned, including standardising categorical entries. Five records in which the recorded breed (Sahel or Sokoto Red, both goat breeds) was inconsistent with the recorded species (sheep) were reclassified as goats, giving a final analytic sample of 170 animals (100 sheep, 70 goats). Overall prevalence, prevalence by parasite taxon and by intensity grade were expressed as frequencies and percentages. The association between each individual factor (species, breed, sex and age category) and infection status was tested with the Pearson chi-square test of independence, with significance set at $p < 0.05$. Sampling location, a management/exposure factor rather than a host-intrinsic one, was assessed in the same way. Because individual factors can confound one another, a multivariable binary logistic regression model was also fitted by maximum likelihood, with infection status as the outcome and host species, sex and age category entered together, to obtain adjusted odds ratios (AOR) with 95% confidence intervals (CI). Breed was not entered because it is nested within species (each breed belongs to only one species) and because several breeds contained no negative animals, which precludes a stable odds ratio; breed was therefore assessed by chi-square only. Overall model fit was evaluated using the likelihood ratio chi-square statistic and McFadden's pseudo- R^2 , and individual coefficients were tested using the Wald z-statistic. Analyses were performed using Python (SciPy/NumPy) and Microsoft Excel. A p-value below 0.05 was considered significant, and values between 0.05 and 0.10 were reported as borderline trends.

RESULTS

Overall prevalence of gastrointestinal parasites

A total of 170 faecal samples were collected from sheep ($n = 100$) and goats ($n = 70$) at eight locations in Maiduguri metropolis and Jere Local Government Area during the early rainy season (June). Of the 170 animals examined, 140 were positive for at least one GI parasite, giving an overall prevalence of 82.35%, while 30 animals (17.65%) were negative (Table 1).

Table 1: Overall prevalence of gastrointestinal parasites in sheep and goats during the early rainy season (June) in Maiduguri metropolis, Borno State, Nigeria.

Infection status	Frequency	Percentage (%)
Positive	140	82.35
Negative	30	17.65
Total	170	100.00

Species diversity of gastrointestinal parasites

Four broad parasite categories were identified by microscopy across the 140 positive samples (Table 2; Figs. 1–5): strongyle-type eggs in 103 samples (73.57%), coccidian (*Eimeria*-type) oocysts in 63 (45.00%), *Strongyloides* spp. in 20 (14.29%) and *Fasciola*-type (trematode) eggs in 3 (2.14%). Of the 140 positive animals, 95 (67.86%) carried a single parasite taxon and 45 (32.14%) carried two or more taxa concurrently. The proportion of mixed infections did not differ significantly between sheep and goats ($\chi^2 = 2.02$, $df = 1$, $p = 0.155$).

Table 2: Frequency of gastrointestinal parasite taxa and mono- and mixed-taxon infections among positive sheep and goats during the early rainy season (June) in Maiduguri metropolis, Borno State, Nigeria.

Category	Frequency	% of positives (n = 140)
Parasite taxon		
Strongyle-type eggs	103	73.57
Coccidian (<i>Eimeria</i> -type) oocysts	63	45.00
<i>Strongyloides</i> spp.	20	14.29
<i>Fasciola</i> -type eggs	3	2.14
Infection type		
Mono-infection (one taxon)	95	67.86
Mixed infection (two or more taxa)	45	32.14
Total	140	100.00

Percentages for parasite taxa sum to more than 100% because animals with mixed infections were positive for more than one taxon; strongyle-type eggs (order Strongylida) are reported as a group.

Severity (intensity) of parasite burden

Among the 140 positive animals, 56 (40.00%) had a light (+) infection, 35 (25.00%) a moderate (++) infection and 49 (35.00%) a heavy (+++) infection (Table 3). Infection intensity did

not differ significantly between sheep and goats ($\chi^2 = 0.38$, $df = 2$, $p = 0.829$) or between young and adult animals ($\chi^2 = 2.36$, $df = 2$, $p = 0.307$).

Table 3: Distribution of infection severity (intensity) of gastrointestinal parasites among positive sheep and goats during the early rainy season (June) in Maiduguri metropolis, Borno State, Nigeria.

Severity grade	Criterion (mean count/field)	No. of animals	% of positives
Light (+)	1–2	56	40.00
Moderate (++)	3–5	35	25.00
Heavy (+++)	>5	49	35.00
Total	—	140	100.00

Severity by host species: $\chi^2 = 0.38$, $df = 2$, $p = 0.829$; by age category: $\chi^2 = 2.36$, $df = 2$, $p = 0.307$.

Influence of host-specific factors on prevalence

Host species. Goats recorded a higher prevalence (87.14%; 61/70) than sheep (79.00%; 79/100) (Table 4). The difference was not statistically significant ($\chi^2 = 1.36$, $df = 1$, $p = 0.244$).

Breed. Prevalence differed significantly among breeds ($\chi^2 = 21.11$, $df = 7$, $p = 0.0036$) (Table 4). Among goat breeds, Sahel recorded a higher prevalence (95.24%; 40/42) than Sokoto Red (75.00%; 21/28). Among sheep breeds, Uda (4/4), Sudanese (7/7) and crossbreed sheep (2/2) each recorded 100% prevalence, followed by Balami (84.91%; 45/53) and the Balami $\times$ Yankasa cross (83.33%; 5/6), with Yankasa recording the lowest prevalence of any breed (57.14%; 16/28). Several of these breeds were represented by very few animals.

Sex. Females ($n = 104$) recorded a higher prevalence (86.54%; 90/104) than males ($n = 66$) (75.76%; 50/66), but the difference was not statistically significant ($\chi^2 = 2.53$, $df = 1$, $p = 0.112$).

Age. Young animals (≤ 12 months) recorded a higher prevalence (89.39%; 59/66) than adults (> 12 months) (77.88%; 81/104). The difference was not statistically significant ($\chi^2 = 2.93$, $df = 1$, $p = 0.087$), although it indicated a borderline trend.

Table 4: Prevalence of gastrointestinal parasites in sheep and goats by host species, breed, sex and age category during the early rainy season (June) in Maiduguri metropolis, Borno State, Nigeria.

Variables	No. examined	No. positive	Prevalence (%)	χ^2 (df)	P-value
Host species				1.36 (1)	0.244
Sheep (Ovine)	100	79	79.00		
Goats (Caprine)	70	61	87.14		
Breed				21.11 (7)	0.0036**
Sahel (Caprine)	42	40	95.24		
Sokoto Red (Caprine)	28	21	75.00		
Balami (Ovine)	53	45	84.91		
Yankasa (Ovine)	28	16	57.14		
Uda (Ovine)	4	4	100.00		
Sudanese (Ovine)	7	7	100.00		
Balami × Yankasa (Ovine)	6	5	83.33		
Crossbreed (Ovine)	2	2	100.00		
Sex				2.53 (1)	0.112
Female	104	90	86.54		
Male	66	50	75.76		
Age category				2.93 (1)	0.087
Young (≤ 12 months)	66	59	89.39		
Adult (> 12 months)	104	81	77.88		
Total	170	140	82.35		

χ^2 = chi-square test of association between each variable and infection status; df = degrees of freedom; ** = Significant at $p < 0.01$

Multivariable logistic regression analysis of risk factors

To evaluate the host-specific factors jointly and to control for confounding among them, a multivariable logistic regression model was fitted with host species, sex and age category as covariates (Table 5). Breed could not be included because it is nested within species and several breed categories (Uda, Sudanese and crossbreed) contained no negative animals. After adjusting for the other two factors, goats had 1.40 times the odds of infection of sheep (AOR = 1.40, 95% CI: 0.57–3.41, $p = 0.461$). Males had an adjusted odds ratio of 0.53 relative to females (95% CI: 0.23–1.22, $p = 0.138$), and adults an adjusted odds ratio of 0.44 relative to young animals (95% CI: 0.18–1.11, $p = 0.083$). None of the three adjusted associations was significant at the 5% level,

and the overall model was not significant (likelihood ratio $\chi^2 = 7.40$, $df = 3$, $p = 0.060$; McFadden pseudo- $R^2 = 0.047$).

Table 5: Multivariable logistic regression (adjusted odds ratios) of host-specific risk factors for gastrointestinal parasite infection in sheep and goats during the early rainy season (June) in Maiduguri metropolis, Borno State, Nigeria.

Variable	AOR	Lower	Upper	P-value
Host species				
Sheep (Ovine)	Ref			
Goats (Caprine)	1.40	0.57	3.41	0.461
Sex				
Female	Ref			
Male	0.53	0.23	1.22	0.138
Age category				
Young (≤ 12 months)	Ref			
Adult (> 12 months)	0.44	0.18	1.11	0.083

AOR = adjusted odds ratio; Lower and Upper = 95% confidence limits; Ref = reference category. Likelihood ratio $\chi^2 = 7.40$, $df = 3$, $p = 0.060$; McFadden pseudo- $R^2 = 0.047$.

Prevalence by sampling location

Prevalence differed significantly among the eight sampling locations ($\chi^2 = 48.81$, $df = 7$, $p < 0.001$) (Table 6). UNIMAID Staff Quarters, Dalori Quarters and Gwange each recorded 100% prevalence, followed by Custom Quarters (87.10%), Maiduguri Abattoir (85.42%) and Mairi (80.00%). The lowest prevalence was recorded at 777 Housing Estate (55.00%) and Zabarmari (20.00%).

Table 6: Prevalence of gastrointestinal parasites in sheep and goats by sampling location during the early rainy season (June) in Maiduguri metropolis and Jere Local Government Area, Borno State, Nigeria.

Sampling location	No. examined	No. positive	No. negative	Prevalence (%)
Maiduguri Abattoir	48	41	7	85.42
Custom Quarters	31	27	4	87.10
UNIMAID Staff Quarters	20	20	0	100.00
777 Housing Estate	20	11	9	55.00
Dalori Quarters	16	16	0	100.00
Gwange	15	15	0	100.00
Mairi	10	8	2	80.00
Zabarmari	10	2	8	20.00
Total	170	140	30	82.35

$\chi^2 = 48.81$, $df = 7$, $P < 0.001$; = Significant at $p < 0.01$

DISCUSSION

This study set out to determine the prevalence, species diversity, intensity and host-related risk factors of GI parasitism in sheep and goats in Maiduguri at the early-rainy-season (June) transition. The overall prevalence of 82.35% is high, and is consistent with the rationale for sampling at this time: the first rains break the dry-season dormancy of both host and parasite, triggering the development of hypobiotic strongyle larvae, sporulation of coccidian oocysts in moistened pens, and reactivation of snail intermediate hosts (O'Connor et al. 2006; Nwosu et al. 2007; Mbaya et al. 2010). The value is similar to the 80.0% recorded in sheep and goats in Maiduguri in July and August (Onyiche et al. 2026), and is higher than the 43.1% in sheep and 55.8% in goats reported earlier from the same semi-arid zone (Nwosu et al. 2007) and the 48% reported from Suleja, Niger State (Adamu et al. 2026). Comparisons between surveys must be made cautiously because region, season, diagnostic method and sampling design differ; for example, the Maiduguri survey used convenience sampling after the rains were established (Onyiche et al. 2026), whereas the present study used systematic random selection of sampling points at the onset of the rains. A plausible contribution to the high figure here is timing: animals emerging from a long dry season of nutritional stress meet a sudden pulse of infective larvae on newly sprouting pasture and in dampened pens.

With respect to species diversity, strongyle-type nematodes dominated (73.57% of positive animals), followed by coccidia (45.00%), *Strongyloides* spp. (14.29%) and *Fasciola*-type eggs

(2.14%). This ranking matches the earlier Maiduguri survey, in which strongyles were found in 73.5% and *Eimeria* in 41.5% of positive animals (Onyiche et al. 2026), and other coprological surveys in the area (Alade & Bwala, 2015; Biu et al. 2009), and it is consistent with the wider Nigerian literature identifying strongylid genera, chiefly *Haemonchus contortus*, as the leading GI parasites of small ruminants (Mbaya et al. 2010; Karshima & Karshima, 2020). *Strongyloides* was less frequent here than in that survey (26%) (Onyiche et al. 2026). Because flotation cannot resolve strongyle eggs to genus level, the contribution of *Haemonchus* relative to *Trichostrongylus* or *Oesophagostomum* cannot be confirmed from these data and would require faecal culture and larval identification (Zajac & Conboy, 2012; Coles, 1992). The low frequency of *Fasciola*-type eggs is consistent with the scarcity of permanent water bodies supporting the snail intermediate host in the Sahel, restricting fluke transmission mainly to fadama lowlands, but flotation in salt solution also recovers dense trematode eggs poorly, so fluke infection may be under-estimated and sedimentation would be needed to address this (Zajac & Conboy, 2012). About one-third of positive animals carried mixed infections, which is clinically relevant because concurrent strongyle and coccidian infection can act together on the intestinal mucosa, compounding blood and protein loss ([Taylor et al. 2016; Chartier & Paraud, 2012).

Infection intensity was spread fairly evenly across the light, moderate and heavy grades and did not differ by species or age category. Recorded so early in the rains, this suggests that intensity was still largely a function of each animal's recent larval intake and immune status. A repeat survey in July and August, as pasture contamination builds (Nwosu et al. 1996; Nwosu et al. 2007), would be expected to show a shift towards higher grades.

Host species was not a significant determinant of prevalence, and goats and sheep had broadly similar infection rates (87.14% and 79.00%). The earlier Maiduguri survey likewise found no significant species effect, with goats numerically higher (Onyiche et al. 2026). Under the dual management system in Maiduguri, in which both grazing and stall-fed animals are exposed, any protective advantage of goat browsing behaviour may be diluted (Alade & Bwala, 2015; Fakae, 1990). Prevalence was numerically higher in females and in young animals, in the directions expected from the literature: periparturient relaxation of immunity in females (Alade & Bwala, 2015; Barger, 1993) and the immunologically naïve status of young animals facing their first rainy-season larval challenge (Alade & Bwala, 2015; Urquhart et al. 1996). However, neither difference was significant (the age effect was borderline, $p = 0.087$), the earlier survey recorded higher values

in males and adults (Onyiche et al. 2026), and reproductive status was not recorded here, so these explanations remain inferential. The multivariable model supported the univariable results: every adjusted association pointed in the same direction as the corresponding univariable result and none was significant, indicating that the modest elevations in goats, females and young animals were not artefacts of confounding among these three factors.

Breed was the only host-intrinsic factor that differed significantly, with the highest prevalence in Sahel goats (95.24%) and the lowest in Yankasa sheep (57.14%). This is compatible with between-breed differences in resistance of the kind reported in other small ruminant populations (Bishop & Morris, 2007; Chiejina & Behnke, 2011). However, this was a field survey without controlled challenge, several breeds had very few animals, and breed may be confounded with site and management; Sahel goats, for example, may simply have been more exposed to low, wet pasture during the early rains. The breed effect therefore cannot be attributed to host genetics alone.

Sampling location showed the strongest statistical association with prevalence of any factor examined ($p < 0.001$), ranging from 100% at UNIMAID Staff Quarters, Dalori Quarters and Gwange to 20% at Zabarmari. This wide range indicates that management and environmental exposure at the level of the individual site, such as drainage, stocking density, pen hygiene and feeding system (Fakae, 1990; Taylor et al. 2016), influenced infection risk far more than any single host-intrinsic factor, although these site variables were not measured directly in this study. Site-level husbandry interventions are therefore likely to yield the greatest reduction in parasite burden.

This study has limitations. Sites were purposively selected and sampling covered a single month, so the findings describe the onset of the rains in this area and cannot be extended to the whole season. Infection was assessed by qualitative flotation with a per-field intensity score rather than quantitative egg counts, and parasites were identified by morphology without faecal culture or molecular methods (Bott et al. 2009; Roeber et al. 2012). Fluke infection may have been underestimated, as noted above.

Conclusion

This study found a high prevalence (82.35%) of GI parasitism in sheep and goats at the onset of the rainy season in Maiduguri, with strongyle-type nematodes and coccidia predominating and about a third of positive animals carrying mixed infections. Among the host-specific factors examined, breed was a significant determinant of prevalence, while species, sex and age showed

differences in the expected biological direction (higher in goats, females and young animals) that did not reach significance. Sampling location, reflecting underlying management and environmental exposure, was the strongest correlate of infection. These findings confirm that the early rains are a critical epidemiological window during which GI parasite transmission intensifies sharply.

RECOMMENDATIONS

We recommend: (1) strategic anthelmintic treatment timed to precede or coincide with the onset of the rains, guided by diagnosis rather than blanket calendar dosing; (2) prioritize early-season deworming and closer monitoring of young stock; (3) improved pen drainage, reduced stocking density and regular removal of faeces at high-prevalence sites; (4) combined anthelmintic and anticoccidial treatment where mixed infection is suspected; (5) breed-specific deworming intervals, with closer monitoring of Sahel goats and Yankasa sheep, the breeds with the highest and lowest prevalence respectively; (6) site-targeted interventions informed by local prevalence surveillance across the wards of Maiduguri and Jere, in preference to blanket treatment; and (7) follow-up surveys in July and August that include faecal culture, sedimentation and quantitative egg counts, which would also allow direct comparison with the most recent Maiduguri survey [14].

Abbreviations

GI: Gastrointestinal; AOR: Adjusted odds ratio; CI: Confidence interval; df: Degrees of freedom; LGA: Local Government Area; UNIMAID: University of Maiduguri.

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