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Prevalence and Intensity of Gastrointestinal Parasites and Related Risk Factors in Goats Kept by Smallholder Farmers in Juja Sub-County, Kenya

Odinga Christopher Koyan[1,2], John Kagira[1]*, Kamundia Patrick Waweru[2], Maina Naomi[3], and Osuga Isaac[1]

[1]*Department of Animal Sciences, Jomo Kenyatta University of Agriculture & Technology, P.O. Box 62000-00200, Nairobi, Kenya*
[2]*Department of Animal Health and Production, Maasai Mara University, P.O. Box 861-20500, Narok, Kenya*
[3]*Department of Biochemistry, Jomo Kenyatta University of Agriculture & Technology, P.O. Box 62000-00200, Nairobi, Kenya*
*Corresponding author's Email: jkagira@jkuat.ac.ke

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ABSTRACT

Gastrointestinal parasites (GIP) negatively impact the health and productivity of goats. Regular screening of the animals for these parasites is crucial for implementing effective control strategies. A cross-sectional study was conducted to determine the prevalence of GIP and its risk-related factors in goats owned by smallholder farmers in Juja Subcounty, Kiambu County, Kenya. A total of 210 goats consisting of both males and females, of different breeds including Boer, Toggenburg, Alpine, and Small East African were randomly sampled from 80 farms. Fresh fecal samples were collected and analyzed for parasites using McMaster techniques for egg/oocyst examination. A structured questionnaire was administered to assess the risk factors such as age, sex, breed, origin of the goats, production system, and purpose and frequency of cleaning goat houses in relation to the prevalence of the parasites. The overall prevalence of the GIP was 88.6%, with nematodes and coccidia detected in 64.3% and 74.3% of the goats, respectively. The mean eggs per gram was 67.72, while the mean oocysts per gram was 243. Goat fecal samples positive for gastrointestinal nematodes (GIN) eggs were cultured and identified after recovery of third-stage larvae (L3) using the Baermann technique, whereas the coccidian oocysts were sporulated in 2.5% potassium dichromate solution, followed by microscopic examination based on morphological features of the parasites. The identified GIN nematodes included *Haemonchus contortus*, *Trichostrongylus* spp., *Strongyloides papillosus*, *Ostertagia* spp., and *Nematodirus spathiger*, while the coccidians were *Eimeria caprina*, *Eimeria ninakohlyakimovae*, and *Eimeria hirci*. The prevalence of GIN was significantly associated with age (higher in adults), production systems (higher in intensive systems), and body condition score (higher in animals with poor body condition). For coccidia, the prevalence was associated with the animal origin (higher in goats from Murera Ward), breed (higher in small East African goats), age (higher in younger goats), body condition score (higher in goats with poor condition), and cleaning frequency (higher in goats kept in irregularly cleaned pens). In conclusion, the overall prevalence and burden of GIP reported in the study were high, with the pathogenic gastrointestinal nematodes and *Eimeria* spp. being the most prevalent parasites.

Keywords: *Coccidia*, Goat, Nematode, Prevalence, Risk factor

INTRODUCTION

Goats are highly versatile livestock species, capable of flourishing in a wide range of environments, including arid deserts, semi-arid areas, and mountainous regions. The global goat population stands at approximately 1.1 billion (Ahari and Waiz, 2024) and is largely concentrated in Asia (57.7%) and Africa (35.7%; FAO, 2018). Rearing of goats is quite popular in countries such as Kenya, where the goat population is 28 million (Park, 2022), comprising of exotic goat breeds such as Toggenburg, Saanen, and Alpine (Shivairo et al., 2013) and indigenous goats that include Galla and small East Africa and the crossbred of exotic and indigenous (Kiura et al., 2020). In rural and peri-urban Kenya, goat rearing plays a vital role in the economy, providing employment and income, and it is crucial for people's livelihoods, food security, and nutrition (Lokhit et al., 2005; Kipserem, 2011; KARLO, 2020). However, despite their benefits, goats are vulnerable to various parasitic diseases, such as gastrointestinal helminthosis and coccidiosis.

Goats reared in tropical countries suffer from a heavy burden of helminthosis and coccidiosis due to favorable conditions for parasite-host interactions, poor control strategies, and the emergence of drug resistance (Mpofu et al., 2022; Hussein et al., 2023). Infection usually occurs when animals ingest infective larvae or eggs and oocysts from contaminated environments, and transmission continues through excretion into the environment. The economic impacts

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of the two parasitic diseases include reduced meat, milk, and wool production, reduced fertility, increased mortality, and treatment costs (Shimelis et al., 2011; Siyoun and Kitaw, 2014). Previous studies have reported the prevalence of internal parasites in goats across various geographical regions, including Cameroon, 94.4% (Ntonifor et al., 2013), Zimbabwe, 92.5% (Pandey et al., 1994), South Africa, 82.25% (Gwaze et al., 2009), Ethiopia, 54.17% (Hussein et al., 2023), Nigeria 35.5% (Nwosu et al., 2007), 33% Namibia (Kumba et al., 2003), and India, 25.2% (Sharma and Mandal, 2013). In Kenya, the prevalence of gastrointestinal nematodes (GIN) in goats has been reported, with overall helminth prevalence ranging from 75% (Waruiru, 2004) to 82% (Maichomo et al., 2004) in goats reared under an extensive production system. The most common gastrointestinal tract nematode species in small ruminants include *Hemonchus contortus*, *Oesophagostomum* spp., *Trichostrongylus* spp., *Ostertagia* spp., *Nematodirus* spp., and *Cooperia* spp. (Waruiru et al., 2000; Maichomo et al., 2004). Recent epidemiological data on helminths in goats kept by smallholder farmers in Kenya are scanty.

Several studies have described the high prevalence of coccidiosis in goats across Africa. For instance, Maichomo et al. (2004), Ikpeze et al. (2010), Mohamaden et al. (2018), and Etsay et al. (2020) documented rates of 60%, 73%, 85%, and 45% in Egypt, Nigeria, Ethiopia, and Kenya, respectively. Caprine coccidiosis is caused by protozoa of the *Eimeria* genus, with the common species identified in Africa being *E. ninakohlyakimovae*, *E. hirci*, *E. arliongi*, and *E. caprina*, (Kusiluka et al.,1996; Harper and Penzhorn, 1999; Etsay et al., 2020). Investigations conducted in Kenya have reported moderate to high prevalence of coccidiosis, with infection rates ranging from 45% to 48% in goats (Maichomo et al., 2004; Kanyari et al., 2009). The main risk factors associated with gastrointestinal tract parasites include breeds, sex, age, body condition scores, production systems, and frequency of cleaning (Maichomo et al., 2004; Kanyari et al., 2009; Hussein et al., 2023).

To control these parasites, farmers keeping goats rely on symptoms and advice from animal health practitioners. However, most of the clinical signs are not pathognomonic for gastrointestinal tract parasitosis, and indeed, the proportions of asymptomatic cases are quite high. In spite of this, farmers have opted for regular use of anthelmintics (Mickiewicz et al., 2021; Potârniche et al., 2021), which led to the emergence of anthelmintic resistance and increased burden of the disease. In Kenya, there is no recent published information on helminthosis and coccidiosis, especially in areas where there are mixed intensive and extensive systems of production. Thus, the outcome of this investigation will provide baseline data on the prevalence, intensity, and risk factors associated with gastrointestinal parasites, hence informing proper control strategies among the goat farmers and policymakers. In recent years, there have been changes in production systems, the introduction of goats across different regions, the emergence of climate change and anthelmintic resistance, amongst other factors. For example, in Kenya, rearing of goats has increased in urban and peri-urban areas, and there has been a recent introduction of dairy goats in high-potential areas such as Kiambu County. A recent farmer-based study in Kiambu County, Kenya, highlighted diarrhea and helminthosis as the major conditions affecting these goats (Kagucia et al., 2020). However, no laboratory study was conducted to verify this information. The present study aimed to assess the prevalence, intensity, and associated risk factors of gastrointestinal parasites in goats reared by smallholder farmers in Juja Sub-county, Kiambu County, Kenya.

MATERIALS AND METHODS

Ethical approval

All animal and laboratory procedures were reviewed and ratified by Jomo Kenyatta University of Agriculture and Technology Institutional Scientific and Ethical Review Committee (JKU/ISERC/02317/1331).

Study area

The study was conducted in Juja Sub-County, Kiambu County, Kenya, which has five administrative wards, including Juja, Witeithe, Kalimoni, Theta, and Murera. Juja Sub-County lies between latitude 1°10'59" S and longitude 37°07'00"E**.** It has a human population of 139,853, which is growing rapidly due to proximity to urban areas such as Nairobi City, Juja Town, and Thika Town. The climate of the study area is tropical with an average annual rainfall of 840 mm (range from 468 mm to 900 mm) and average temperatures of 19.8^{o}C (ranging between 14°C-26^{o}C). Peri-urban livestock farming is common in the sub-county, with the latest census showing a population of 136,251 cattle, 17,300 pigs, 63,031 chickens, 32,000 sheep, and 12,699 goats (KNBS, 2019).

Study design and sample size

A cross-sectional survey was conducted between June and October 2024. The sample size for this study was determined using the Thrusfield formula and adjusted for small populations (Thrusfield, 2018). The expected prevalence of 75% based on the previous investigations (Waruiru, 2004) was used in the calculation. The minimum sample size was

162. In the current study, a total of 210 goats were sampled. The 210 goats were sampled using a snowballing technique from the 80 farms. The initial group of farmers provided by the local animal health providers and extension officers helped the investigators identify other farmers until the sample size was achieved. A maximum of 5 goats per farm were sampled.

Questionnaire survey

A structured questionnaire was administered to the household head to describe the farm characteristics and risk factors associated with the prevalence of GIT parasites. The questionnaire included questions on the origin of goats, sex, breed, age, goats' body condition score, and production system (intensive and extensive). However, the questionnaire of this study did not take into goats' diet. The investigators and animal health professionals assessed the body condition scores of the sampled goats. The questionnaire also covered aspects of farm management, history of helminthosis and reported clinical signs, the frequency of pen cleaning, deworming intervals and personnel involved, the types of anthelmintics used for treatment and their effectiveness, as well as the demographic details of the respondents. Animals were grouped as young (< 1 year) and adult (1 year and above). The body conditions of the goats were assessed as described by Kripali et al. (2010) and were grouped as good, medium, and poor.

Sample collection and analysis

Approximately 25 g of fresh fecal samples were collected per rectum following the procedure by Terfa et al. (2023). The fecal sample collected was labelled accordingly and placed in a cool box with ice and transported to the parasitology laboratory at Jomo Kenyatta University of Agriculture and Technology (JKUAT) for parasitological analysis. Briefly, the fecal samples were analyzed following standard parasitological procedures. Saturated sodium chloride (SG 1.20; Analytical grade, Sigma-Aldrich, MO, USA) was used as the flotation medium. Eggs/oocysts counts were analyzed using a modified McMaster technique (Whitlock Universal Slide, Australia) and examined under 10× magnification using an Olympus B 201 microscope (Optical element Corporation, Milvile, USA). Samples containing strongyle eggs were subjected to fecal culture, and the resulting larvae, which were harvested using the Baermann technique, were identified to the species level based on morphological features as described by MAFF (1986). Additionally, oocysts in the fecal samples were sporulated using 2.5% (w/v) potassium dichromate and identified to species level based on morphological features of the sporulated oocysts (Abunemeh, 2016).

Statistical analysis

The collected data were entered and managed in an MS Excel (Microsoft, USA) worksheet, and the analysis was conducted using SPSS statistical software version 17.0. Descriptive analysis was conducted, and thereafter, data were provided in the form of tables. The relationship between the independent factors and the prevalence of various GIT parasites was assessed using the Pearson Chi-square. Significance level was set at $p < 0.05$.

RESULTS

Characteristics of the respondents and farms

The farmers who participated in the study originated from Kalimoni (37.5%), Juja (20.0%), Theta (16.25%), Witeithie (13.75%), and Murera (12.5%) wards. In the wards, all participating farmers raised goats (100%), and also kept cattle (53.8%), sheep (67.5%), and poultry (56.25%) in their farms. The goats were mainly kept under an extensive system of production (73.8%). The farmers owned between 5 and 110 cattle and 2 to 260 sheep per farm. Most of the respondents were married men (70.0%), aged between 18-35 years (55.0%) in Table 1. The small East African (SEA) goat was the most common breed kept by farmers. Most farmers (46.3%) owned between 1 and 20 goats, while a few (25.0%) had 51 to 100 goats. The goats were housed in simple wooden structures (82.5%), and pens were cleaned with varying frequency, with 43.8% of farmers reporting irregular cleaning schedules.

History of helminthosis, deworming, and clinical signs

Over half (55%) of respondents reported a history of worm infections in their goats, with the most frequently observed symptoms being the presence of worms/segments in the feces (25.1%) and diarrhea (21.25%). In contrast, death and mucus presence were much less reported, each cited by only 2.5% of respondents (Table 2). The majority (83.8%) of farmers administered deworming treatments by themselves, while only 10% sought help from animal health professionals. When determining drug dosages, 52.8% of respondents estimated body weight visually, and 38.75% followed the instructions indicated on the drug bottle label or sachet. Farmers primarily relied on synthetic dewormers, including Nilzan® (Levamisole HCI and Oxyclozanide, Cooper Kenya Ltd; 38.75%), Ivermectin® (Avermectins,

Boehringer Ingelheim, Germany, 28.75%), Alben® (Albendazole, AdvaCare Pharma, India) (25%), Force One® (Levamisole HCI and Oxyclozanide, HighChem, Kenya; 16.25%), Levafas® (Levamisole HCI and Oxyclozanide, Norbrook, Kenya; 6.25%), Diamond® (3.0% Levamisole HCI and Oxyclozanide, Norbrook, Kenya; 5%) and Nefluk ® (Albendazole, Cooper Kenya; 3.75%).

Prevalence, spectrum, and intensity

The overall animal-level prevalence of GIN and coccidia was 64.29% and 74.29%, respectively. The farm-level prevalence of GIN and coccidia was 56.25% and 70.00%, respectively. The mean eggs per gram (EPG) was 67.72 (0-5600) and oocysts per gram (OPG) was 243.19 (0-7000**),** respectively. The infection rate reported for GIN in the sampled goats includes *Haemonchus contortus* (40.0%), *Trichostrongylus* spp. (28.6%), *Strongyloides papillosus* (19.5%), *Ostertagia* spp. (9.5%), and *Nematodirus spathiger* (2.4%), while the coccidia species included Eimeria *caprina* (43.3%), *Eimeria ninakohlyakimovae* (29.1%), and *Eimeria hirci* (27.6%), as shown in Table 3. The mixed infection rate recorded was 67.6%. In goats**,** the proportional distribution of the larvae from the five identified gastrointestinal nematode genera was *Haemonchus contortus* (39.4%), *Trichostrongylus* spp. (26.9%), *Strongyloides papillosus* (21.3%), *Ostertagia* spp. (11.1%), and *Nematodirus spathiger* (1.3%), while the coccidia species included *Eimeria caprina* (47.1%), *Eimeria ninakohlyakimovae* (28.5%), and *Eimeria hirci* (24.4%) presented in Figure 1. Among the GINs, *H. contortus* was the most frequently identified species in larval cultures, whereas *E. caprina* was the predominant species among the infective oocysts.

Table 1. Characteristics of farmers and goats' management in Juja Subcounty, Kenya during 2024

Variable	Category	Frequency	Percentage
Origin (ward) of farmers	Kalimoni	30	37.5
	Juja	16	20.0
	Theta	13	16.25
	Witeithie	11	13.75
	Murera	10	12.5
Gender of farmers	Male	56	70.0
	Female	24	30.0
Marital status of the respondent	Married	67	83.8
	Single	13	16.3
Age of farmers	18-35 years	44	55.0
	36- 50 years	22	27.5
	51 years and above	14	17.5
Production systems	Extensive	59	73.8
	Intensive	21	26.3
Goats' breeds	SEA	146/210	69.5
	Toggenburg	52/210	24.8
	Galla	2/210	0.95
	Boer	7/210	3.3
	Alpine	3/210	1.4
Number of goats	1-20	37	46.3
	21-50	23	28.8
	51-100	20	25.0
Housing (floor) for goats	Concrete	3	3.8
	Slighted	11	13.8
	Other	66	82.5
Frequency of pen cleaning	Daily	6	7.5
	Every 2-3 days	16	20.0
	Weekly	23	28.8
	Other	35	43.8

SEA: Small East African goat

Table 2. Occurrence of helminthosis, clinical signs, and goats management as reported by respondents in Juja Sub-County, Kenya during 2024

Variables	Categories	Frequency	Percentage
History of helminthosis	Yes	44	55.00
	No	36	45.00
Clinical signs reported	Diarrhea	17	21.25
	Weight loss	3	3.75
	Worm in the stools	20	25.1
	Presence of mucus	2	2.5
	Loss of appetite	4	5.0
	Death	2	2.5
	Rough haircoat	14	17.5
	No clinical signs	18	22.5
History of deworming	Yes	75	93.75
	No	5	6.25
Deworming interval	Every 3 months	46	57.50
	4< 6 months	13	16.25
	>6 months	11	13.75
	Every month	5	6.25
	Could not remember	5	6.25
Person responsible for deworming	Farmers (owner)	67	83.75
	Animal health professionals	8	10.00
	Could not remember	5	6.25
Determination of the dose to administer to the animals	By estimation of weights	36	45.00
	By the indications on the bottle/sachet	31	38.75
	Other methods	13	16.25
Anthelmintics used in treatment	Nilzan® (levamisole HCI and 6.0% Oxyclozanide)	26	38.75
	Ivermectin® (Avermectins)	18	28.75
	Alben® (Albendazole)	15	25.00
	Force One® (Levamisole HCI and Oxyclozanide)	11	16.25
	Levafas® (Levamisole HCI and Oxyclozanide)	5	6.25
	Diamond® (Levamisole HCI and Oxyclozanide)	3	5.00
	Nefluk ® (Albendazole)	2	3.75
Effectiveness of the anthelmintic	Effective	65	81.25
	Not effective	7	8.75
	Not sure	8	10.00

Table 3. Prevalence of gastrointestinal nematodes and coccidia in goats kept by smallholder farmers in Juja Sub-County, Kenya during 2024

Parasites	Affected goats (n)	Prevalence (%)	EPG Range	Mean	SEM
Nematodes species					
Haemonchus contortus	84(84/210)	40.0	0-5600	130.24	32.328
Trichostrongylus spp.	60(60/210)	28.6	0-3100	148.81	22.773
Strongyloides papillosus	41(41/210)	19.5	0-1000	53.33	10.719
Ostertagia spp.	20(20/210)	9.5	0-600	15.71	4.769
Nematodirus spathiger	5(5/210)	2.4	0-300	3.42	2.270
Mixed infections	142(142/210)	67.6			
Coccidians species			**OPG Range**	**Mean**	**SEM**
Eimeria caprina	91(91/210)	43.3	0-7000	462.43	60.736
Eimeria ninakohlyakimovae	61(61/210)	29.1	0-3500	143.86	27.487
Eimeria hirci	58(58/210)	27.6	0-4000	127.14	25.932

EPG: Eggs per gram; OPG: Oocysts per gram; SEM: Standard error of the mean

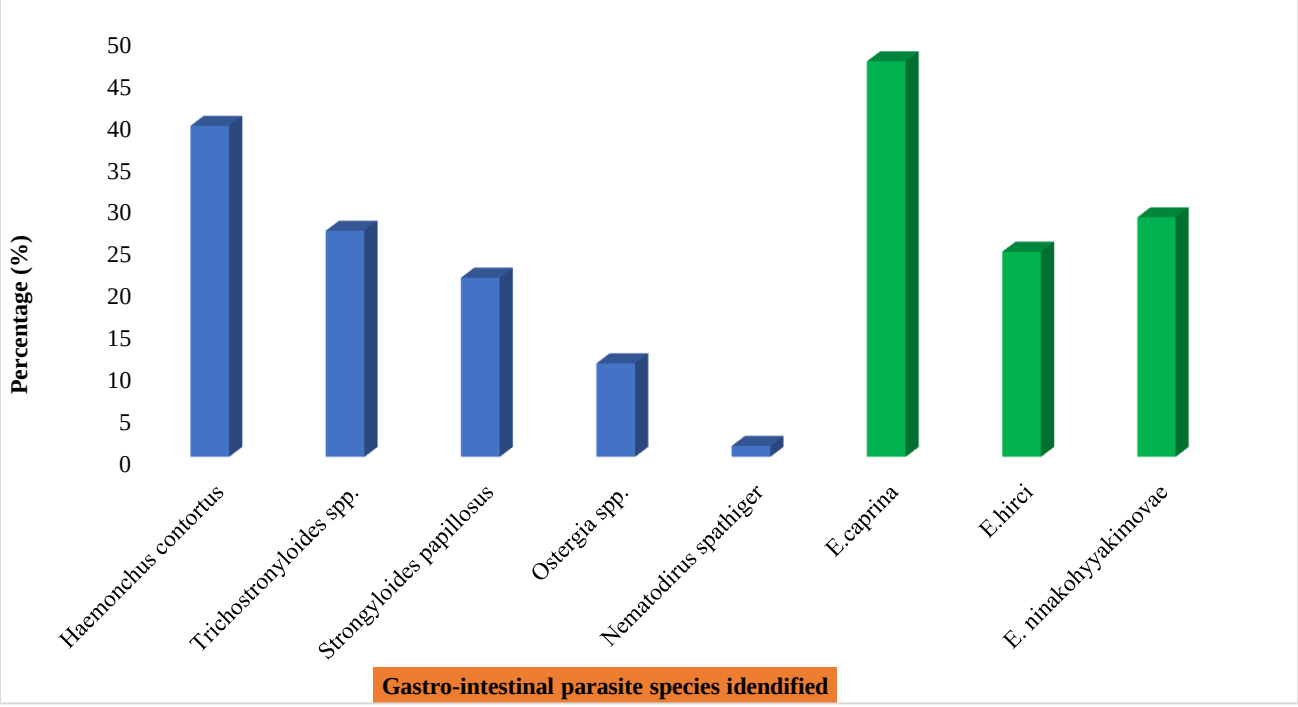

Figure 1. Proportion of the gastrointestinal tract identified in the sampled goats in Juja Subcounty, Kenya, during 2024

Assessment of caprine gastrointestinal parasites

The intensity of gastrointestinal parasite infection in goats was categorized into four levels and is presented in Table 4. Among the infected goats, 55.71% exhibited a light infection, followed by 29.05% with a moderate, and 3.81% with a heavy GIP infection. Additionally, 11.43% of the goats showed no signs of infection.

The prevalence and risk factors associated with gastrointestinal tract nematodes

The prevalence of GIN was significantly associated with age, production systems, and body condition score (Table 5). Adult goats had a significantly higher (70.1%) prevalence of GIN compared to the young ones (54.2%, p = 0.025). Further, goats kept under the extensive system of production had a significantly lower (63.1%) prevalence of GIN compared to those kept intensively (66%) (p = 0.043). Goats with good body condition scores had a significantly lower prevalence of GIN compared to those with poor body condition scores (83.8%, p = 0.023). The occurrence of GIN was not significantly influenced by the ward of origin (p = 0.405), sex (p = 0.664), production purpose (p = 0.106), or cleaning frequency (p = 0.678, Table 4).

The prevalence of gastrointestinal tract coccidia and the associated risk factors

The prevalence of coccidia was significantly associated with the origin of the goat (p = 0.049), being lowest in Kalimoni Ward (70.69%) and highest in Murera Ward (85.70%). Among breeds, SEA goats had a significantly (p= 0.023) lower prevalence (73.1 %) compared to Alpine and Galla (100.00%), Toggenburg (77.43%), but higher than Boer goats (57.1%). Adult goats had a significantly (p = 0.007) lower prevalence (67.7 %) compared to younger goats (84.3%, Table 6). Goats with a good body condition score had a significantly (p = 0.02) lower prevalence (45.6%) compared to those with poor body conditions (97.3%). Additionally, goats housed in pens cleaned daily had a significantly (p = 0.049) lower prevalence of coccidia (33.1 %) than those in pens cleaned less frequently (80.2%, Table 5).

Table 4. Assessment of the infection degree of caprine gastrointestinal parasites

Infection degree	Frequency	Percentage	Mean	Std. deviation
No infection	24	11.43	0.25	0.68
Light	117	55.71	1.66	0.49
Medium	61	29.05	3.28	0.45
Heavy	8	3.81	5.25	.89
Total	210	100		

Std. deviation: Standard deviation

Table 5. The association between prevalence and risk factors of gastrointestinal nematodes in goats kept by farmers in Juja sub-county, Kenya

Risk factors	Categories	Prevalence	p-value
Ward of origin of goats	Kalimoni	66.38	0.405
	Theta	60.00	
	Witeithie	58.33	
	Juja	80.95	
	Murera	42.86	
Age	Adult	70.10	0.025*
	Young	54.20	
Production systems	Extensive	63.10	0.043*
	Intensive	66.00	
Body condition Score	Good	47.40	0.023*
	Medium	65.50	
	Poor	83.80	
Sex	Males	62.20	0.664
	Females	65.63	
Production purpose	Milk	72.92	0.106
	Meat	63.11	
	Dual purpose	57.50	
Frequency of cleaning	Daily	33.33	0.678
	Every 2-3 days	54.29	
	Weekly	64.44	
	Others	70.69	

***** Statistically significant at $p < 0.05$

Table 6. The association between prevalence and risk factors of coccidiosis in goats kept by farmers in Juja Sub-County, Kenya

Risk factor	Categories	Prevalence	p value
Ward of origin of goats	Kalimoni	70.7	0.049*
	Theta	71.4	
	Witeithie	83.3	
	Juja	81.0	
	Murera	85.7	
Breeds	SEA	73.1	0.023*
	Galla	100.0	
	Boer	57.1	
	Toggenburg	77.4	
	Alphine	100.0	
Age	Adult	67.7	0.007*
	Young	84.3	
Sex	Males	74.4	0.574
	Females	71.1	
Production purpose	Milk	79.6	
	Meat	74.4	0.932
	Dual purpose	70.0	
Production systems	Extensive	72.5	0.292
	Intensive	80.0	
Body condition Score	Good	45.6	0.020*
	Medium	81.0	
	Poor	97.3	
Frequency of cleaning	Daily	33.3	0.049*
	Every 2-3 days	68.6	
	Weekly	75.6	
	Other	80.2	
	Could not remember	50.0	

***** Statistically significant at $p < 0.05$.

DISCUSSION

In Kenya, goat rearing offers numerous advantages, including being a valuable source of food security, income, employment, and for socio-cultural purposes in rural areas. However, GIT parasites such as helminths and coccidia affect the health and productivity of these goats. To ensure effective livestock health management, it is essential to continuously monitor the epidemiology of these parasites to enable proper intervention strategies.

Goat rearing in the area was small-scale, with the male gender being the main owners of the animals. Further, the current study noted that a significant proportion of the farmers were young, suggesting a shift toward youth engagement in agriculture, possibly driven by unemployment or agribusiness opportunities in peri-urban areas. Most farmers were married farmers, and this may reflect the role of livestock as a family livelihood asset. Like other farmers in most developing countries, the small farmers in the study area also kept cattle, sheep, and poultry for the provision of food and income. The most commonly kept goat breed by respondents was the SEA. This could be attributed to its resilience to diseases, tolerance to harsh environmental conditions, affordability, availability, and relatively high reproductive performance (Odoi et al., 2007). However, as shown in other studies (Shivairo et al., 2013; Kagucia et al., 2020; Mutunga et al., 2023), a substantial number of farmers also kept exotic goats such as Toggenburg, Galla, Boer, and Alpine, possibly for milk production.

Goats were typically housed in simple wooden structures, with pen cleaning occurring irregularly for most farms. This irregular cleaning can provide a good environment for the growth and development of parasites observed in the study. Some farmers also kept the goats under intensive production systems, where goats were confined and fed cut forages and crop residues, and supplemented with concentrates. Kagucia et al. (2020) also observed that intensive systems were favored by dairy goat farmers involved in commercial milk production. Farmers in this study reported that their goats had a history of helminth infections, showing symptoms such as diarrhea, weight loss, rough coats, and, in some cases, death. While these signs are commonly linked to parasitic diseases, they are not definitive indicators and can be compounded by poor nutrition (Kagucia et al., 2020). Additionally, farmers are generally unaware of the availability of laboratory services for fecal screening to assess worm burdens. Poor nutrition or resource constraints can weaken an animal's immune response, making them more susceptible to higher helminth burdens (Sweeny et al., 2021).

The current study shows that the prevalence of GIN was comparatively higher than that reported in Kenya at 62% (Maingi et al., 2001), Ethiopia at 54.17% (Hussein et al., 2023), Uganda at 43.0% (Nsereko et al., 2015), and Nigeria at 26.6% (Adamu and Kyari, 2023). Further, the prevalence was lower than that reported by Waruiru (2004) and Maichomo et al. (2004) in extensively reared goats from Kenya. Elsewhere, in Uganda, a high prevalence of 74.5% has been reported, with gastrointestinal nematodes being the predominant parasites (Namutosi and Higenyi, 2019). In another study in Tanzania, Haule (2015) reported a moderate prevalence (58.1%) of helminths such as nematodes, trematodes, and cestodes. Similarly, Hussein et al. (2023) reported a slightly higher prevalence (54.2%) of gastrointestinal parasite infection in Ethiopian goats. The persistently high prevalence of GIN in the current study area, in general, can be attributed to inadequate health management practices, such as poor deworming protocols, the co-grazing of ruminants, and variations in agro-ecological conditions (Maichomo et al., 2004). Additionally, suboptimal nutritional practices in the study area (Kagucia et al., 2020) may exacerbate the infection burden, since inadequate nutrition can impair the animals' ability to withstand the adverse effects of worm infestations (Sweeny et al., 2021).

The spectrum of strongyles species that were reported included *H. contortus*, *Trichostrongylus* sp., *Strongyloides papillosus*, and *Ostertagia* spp. A similar range of parasites has been reported by Waruiru et al. (2000) and Maichomo et al. (2004) from Kenya and Hussein et al. (2023) from Ethiopia. The most common gastrointestinal nematode identified in the present study was *H. contortus*, which previous studies have also cited as a major nematode affecting goats in the tropics (Bakunzi et al., 2013; Ntonifor, 2013; Zvinorova et al., 2016). The high prevalence could be attributed to the parasite's prolific egg-laying capacity, which facilitates rapid pasture contamination and subsequent transmission among grazing animals (Roeber et al., 2013). Additionally, *H. contortus* is well recognized for its strong propensity to develop resistance to anthelmintic drugs, posing significant challenges to effective parasite control (Kotze and Prichard, 2016). Generally, strongyle infections in goats contribute to substantial economic losses, primarily through reduced productivity and increased mortality (Arsenopoulos et al., 2021). Reduced productivity is associated with decreased feed intake, poor weight gain, diminished work performance, and the added financial burden of treatment and parasite control efforts (Ayaz et al., 2018). Species, such as *Haemonchus* and *Trichostrongylus* are particularly pathogenic, causing anemia and hypoproteinemia in goats due to chronic intestinal blood loss and their blood-feeding behavior (Githigia et al., 2001; Paul et al., 2020).

Identifying risk factors associated with the occurrence of gastrointestinal (GIT) parasites is crucial for developing effective intervention strategies. In this study, the prevalence of GIN was significantly linked to age, body condition score, and production system. Age-related analysis showed that adult animals had significantly higher GIN infestations

compared to young animals. This could be due to lower infections in young ones who were still suckling. Similar findings were reported in studies conducted in Ethiopia (Dabasa et al., 2017), Malaysia (Yusof and Isa, 2016), and Lesotho (Matsepe et al., 2021). However, the studies in Kenya (Githigia et al., 2005), Zimbabwe (Zvinorova et al., 2016), Ethiopia (Dagnachew et al., 2011), and Pakistan (Ayaz et al., 2013) contradicted this observation, reporting a higher prevalence of GIN in young animals compared to adults. These studies attributed the lower prevalence in adults to acquired immunity developed through repeated exposure, which enables them to expel new infestations more effectively.

In this study, goats with poor body condition exhibited a higher prevalence of GIN compared to those in good body condition, aligning with the findings from previous studies (Fayisa et al., 2020; Hussein et al., 2023). Malnourished animals are less capable of fighting infections, whereas well-fed animals are unlikely to succumb to the disease under ideal environmental conditions (Johnson et al., 2020). Further, infection of small ruminants with strongyles can result in gastroenteritis, protein-losing enteropathy, poor weight gain, and loss of body condition. Poor nutritional status compromises the animal's immune response, making malnourished goats more susceptible to parasitic infections. In contrast, well-nourished animals are generally more resilient and less likely to develop severe disease, particularly under favorable environmental conditions (Johnson et al., 2020). Moreover, strongyle infections in small ruminants are known to cause gastroenteritis, protein-losing enteropathy, reduced weight gain, and deterioration in body condition (Paul et al., 2020). Farmers and animal health professionals should be encouraged to use body scoring, among other tools, to diagnose helminthosis and other conditions.

In the current study, goats in extensive systems had a high worm burden, and this could be due to increased infections from contaminated pastures. In some cases, extensive production systems have been characterized by poor nutrition, inadequate hygiene conditions, frequent exposure to contaminated grazing areas, and insufficient health control measures (Zvinorova et al., 2016). The lower infection rates in intensive systems can be attributed to better management practices, including improved housing, feeding, and healthcare (Kagucia et al., 2020).

The present study recorded a high prevalence of coccidian infections in the examined goats, above the rates reported by Rehman et al. (2011) in Pakistan (47.09%) and Kimbita et al. (2009) in Tanzania (64.2). However, the prevalence observed was lower than that reported by Wang et al. (2010) in China (87.9%). The coccidian species identified in the study included *E. caprina*, *E. ninakohlyakimovae*, and *E. hirci.* There is a wide variation in the species of *Eimeria* found in goats in different countries. In Turkey, Deger et al. (2003) found *E. ninakohlyakimovae* (36.00%), *E. hirci* (23.42%), and *E. caprina* (18.28%) were detected. Similarly, in Turkey, Goz et al. (2006) reported *E. ninakohlyakimovae* (18.9%) and *E. hirci* (7.5%). In Iran, Kheirandish et al. (2012) identified *E. ninakohlyakimovae* (41.8%), *E. caprina* (31.7%), and *E. hirci* (11.05%) were detected. In Brazil, Cavalcante et al. (2012) detected *E. hirci* (18%), *E. ninakohlyakimovae* (16.2%), *E. caprovina* (2.8%), and *E. caprina* (1%) were detected.

Coccidiosis is recognized as an economic disease affecting goats (Yusof and Isa, 2016), often leading to chronic diarrhea, resulting in dehydration and loss of essential electrolytes and nutrients, further impairing growth and productivity. It also damages the gut lining, causing protein loss through leakage into the intestinal lumen (Agrawal et al., 2024). This disease results in reduced muscle mass and poor overall growth performance in goats.

In the present study, the prevalence of coccidia was significantly associated with origin, age, breed, body condition score, and cleaning frequency. A significant variation in coccidiosis infection rates was observed based on wards. Goats in areas closer to urban centers had higher infection rates compared to those farther away. For instance, Kalimoni Ward, situated farther from Juja Town, exhibited a lower infection rate compared to Juja, Witeithie, and Murera Wards, which are located closer to the town. This is possibly because most farming production systems in urban Juja are intensive, driven by limited land availability. These systems are often associated with poor sanitation and low levels of hygiene, which can contribute to higher coccidiosis infection rates. The higher prevalence in young animals compared to adult animals has been reported previously (Negasi et al., 2012). Young animals are highly vulnerable to coccidian and face a greater risk of exposure to oocysts shed by the dams. This increased susceptibility is likely due to their immature and underdeveloped immune systems. In contrast, adult animals typically develop immunity to coccidia, allowing them to thrive despite exposure (Paul et al., 2020).

In this study, the prevalence of coccidia infection was higher in Toggenburg breeds compared to other breeds, like SEA goats. Disparities in gastrointestinal parasitic infections among dairy goats have also been documented in Brazil, Tanzania, and Kenya (Costa et al., 2000; Odoi et al., 2007; Shija et al., 2014). The higher prevalence of coccidia among Toggenburg in this study could be attributed to the increased susceptibility of this exotic breed to coccidiosis. This study revealed a significant association between coccidia infection and the body condition of goats, with a higher prevalence observed in animals with poor body condition compared to those in better condition. Poor body condition could be attributed to factors, such as malnutrition, concurrent diseases, or the parasitic infection itself, which weakens the immune response to the parasite's infective stages. Farms in the study had varying hygiene standards, which impacted coccidia abundance. Pens that were cleaned daily had lower coccidiosis infection rates, while those cleaned less

frequently exhibited higher rates. Effective management practices, such as maintenance of cleanliness, are essential preventative measures to control coccidiosis.

In the current study, a large proportion of goats had combined helminth and coccidia infections, which was also observed in an earlier study in Kenya (Waruiru et al., 2000). It is possible that the combined infections of nematodes and *Eimeria* spp. affected the animals negatively in terms of health and productivity. It would be important for extension officers to advise farmers on the combined control of co-infections of helminthosis and coccidiosis.

CONCLUSION

The current study indicated that the prevalence and intensity of GIT helminthosis and coccidiosis are high in the study area and were closely associated with age, sex, body condition score, production purpose, breeds, production systems, and frequency of cleaning. The high infection rate of gastrointestinal nematodes (64.29%) and coccidia (74.29%) highlights potential shortcomings in current parasite control programs, as well as issues related to the animals' nutrition and management in the study area. Since helminthosis and coccidiosis often manifest similar clinical signs, farmers and animal health professionals often manage the condition as helminthosis, and this can lead to a high burden of the disease in goats. Understanding the specific species of gastrointestinal parasites and related epidemiological factors will aid in developing targeted control strategies, potentially reducing production losses and enhancing rural livelihoods. There is a need for improved collaboration between livestock extension officers and farmers to enhance effective health care programs that support regular parasite control practices on farms.

DECLARATIONS

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Ethical considerations

The author has checked the ethical issues, including plagiarism, consent to publish, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy.

Authors contributions

John Kagira conceptualized the study design, supervised the laboratory analyses, and proofread the final manuscript. Christopher Odinga conducted the study, collected data, and performed data analysis. Patrick Kamundia performed data analysis and contributed to the preparation of the first draft of the manuscript. Naomi Maina and Isaac Osuga contributed to the manuscript writing, proofreading, and preparation, supported the study design, data interpretation, and manuscript drafting. All authors reviewed and approved the final version of the manuscript for submission.

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Availability of data and materials

Inquiries regarding data availability can be directed to the corresponding author.

Competing interests

The authors declare there is no conflict of interest.

REFERENCES

Abunemeh M (2016). Methods of quantification and characterization of coccidian oocysts. Master's Thesis, University of Mississippi, United States. Available at: https://www.egrove.olemiss.edu/cgi/viewcontent.cgi?article=1636&context=hon_thesis

Adamu AH and Kyari AG (2023). The prevalence of nematode (roundworm species) in slaughtered sheep and goats in Damaturu modern abattoir. Fane-Fane International Multi-Disciplinary Journal, 7(1): 43-48. DOI: https://www.doi.org/10.1016/j.parepi.2023.e00324

Agrawal V, Swami M, Jaiswal AK, Kumar P, Singh A, and Shakya M (2024). Parasites of gastrointestinal system. Parasitic diseases of goats, 1st Edition. Bentham Science Publishing., Singapore, pp. 1-26 Available at: https://www.eurekamag.com/research/093/515/093515764.php?srsltid=AfmBOor-pwuktgZWMctNeY328gxkNcY2GtmetZGNyFfZ0gBpYRi41td9

Ahari P and Waiz HA (2024). A review on current scenario of goat population and production in Rajasthan, India. Uttar Pradesh Journal of Zoology, 45(5): 69-9. DOI: https://www.doi.org/10.56557/UPJOZ/2024/v45i53932

Arsenopoulos KV, Fthenakis GC, Katsarou EI, and Papadopoulos E (2021). Haemonchosis: A challenging parasitic infection of sheep and goats. Animals, 11(2): 363. DOI: https://www.doi.org/10.3390/ani11020363

Ayaz MM, Nazir MM, Samad N, Zubair M, Hanif M, Aziz M, and Mahmood N (2018). Parasitism in goats: Husbandry management, range management, gut immunity and therapeutic. In: S. Kukovics (Editor), Goat science. IntechOpen., London. United Kingdom, pp. 149-176). DOI: https://www.doi.org/10.5772/intechop.74203

Ayaz MM, Raza MA, Murtaza S, and Akhtar S (2013). Epidemiological survey of helminths of goats in southern Punjab, Pakistan. Tropical Biomedicine, 30(1): 62-71. Available at: https://www.pubmed.ncbi.nlm.nih.gov/23665709/

Bakunzi FR, Nkomo LK, Motsei LE, Ndou RV, and Nyirenda M (2013). A survey on anthelmintic resistance in nematode parasites of communally grazed sheep and goats in a rural area of North West Province, Republic of South Africa. Life Science Journal, 10(2): 391-393. Available at https://www.lifesciencesite.com/lsj/life1002/053_17968life1002_391_393.pdf

Cavalcante AR, Teixeira M, Monteiro JP, and Lopes CG (2012). Eimeria species in dairy goats in Brazil. Veterinary Parasitology, 183(3-4): 356-358. DOI: https://www.doi.org/10.1016/j.vetpar.2011.07.043

Costa AF, Vieira LS, Berne EA, Silva MD, Guidoni AL, and Figueiredo EP (2000). Variability of resistance in goats infected with *Haemonchus contortus* in Brazil. Veterinary Parasitology, 88(1-2): 153-158. DOI: https://www.doi.org/10.1016/S0304-4017(99)00207-1

Dabasa G, Shanko T, Zewdei W, Jilo K, Gurmesa G, and Abdela N (2017). Prevalence of small ruminant gastrointestinal parasites infections and associated risk factors in selected districts of Bale zone, South Eastern Ethiopia. Journal of Parasitology and Vector Biology, 9(6): 81-88. DOI: https://www.doi.org/10.5897/JPVB2017.0286

Dagnachew S, Amamute A, and Temesgen W (2011). Epidemiology of gastrointestinal helminthiasis of small ruminants in selected sites of North Gondar zone, Northwest Ethiopia. Ethiopian Veterinary Journal, 15(2): 57-68. DOI: https://www.doi.org/10.4314/evj.v15i2.67694

Deger S, Gul A, Ayaz E, and Bicek K (2003). The prevalence of Eimeria species in goats in Van. Turkish Journal of Veterinary & Animal Sciences, 27(2): 439-442. Available at: https://www.journals.tubitak.gov.tr/veterinary/vol27/iss2/23/

Etsay K, Megbey S, and Yohannes H (2020). Prevalence of sheep and goat coccidiosis in different districts of Tigray region, Ethiopia. Nigerian Journal of Animal Science, 22(3): 61-69. Available at: https://www.core.ac.uk/works/138569874/?t=25fc3493ce4ca5e7937883b08749c77a-138569874

Food and agriculture organization (FAO) (2018). FAOSTAT. Live animals – production of goats by country. Available at: http://www.fao.org/faostat/en/

Fayisa O, Duguma A, Temesgen M, and Lemma F (2020). Gastrointestinal parasites of sheep and goat in and around Gondar town, Northwest, Ethiopia. Biotechnology in Animal Husbandry, 36(3): 371-380. DOI: https://www.doi.org/10.2298/BAH2003371F

Githigia SM, Thamsborg SM, Maingi N, and Munyua WK (2005). The epidemiology of gastrointestinal nematodes in Goats in the low potential areas of Thika District, Kenya. Bulletin of Animal Health and Production in Africa, 53(1): 5-12. DOI: https://www.doi.org/10.4314/bahpa.v53i1.32684

Githigia SM, Thamsborg SM, Munyua WK, and Maingi N (2001). Impact of gastrointestinal helminths on production in goats in Kenya. Small Ruminant Research, 42(1): 21-29. DOI: https://www.doi.org/10.1016/S0921-4488(01)00240-1

Goz Y, Altug RI, Yuksek N, and Ozkan C (2006). Parasites detected in neonatal and young calves with diarrhoea. Bulletin-Veterinary Institute in Pulawy, 50(3): 345. DOI: https://www.doi.org/10.1016/S0921-4488(01)00240-1

Gwaze FR, Chimonyo M, and Dzama K (2009). Prevalence and loads of gastrointestinal parasites of goats in the communal areas of the Eastern Cape Province of South Africa. Small Ruminant Research, 84(1-3): 132-134. DOI: https://www.doi.org/10.1016/j.smallrumres.2009.06.013

Harper CK and Penzhorn BL (1999). Occurrence and diversity of coccidia in indigenous, Saanen and crossbred goats in South Africa. Veterinary Parasitology, 82(1): 1-9. DOI: https://www.doi.org/10.1016/S0304-4017(98)00266-0

Haule VV (2015). Prevalence of gastrointestinal helminthosis in small ruminants kept under traditional management system in Meru district, Tanzania. MSc Thesis, Sokoine University of Agriculture, Tanzania. pp 9-10. Available at: https://www.suaire.sua.ac.tz/items/4594ff81-f6e1-4a1f-8111-2692b434dbbf

Hussein HA, Abdi SM, Ahad AA, and Mohamed A (2023). Gastrointestinal nematodiasis of goats in Somali pastoral areas, Ethiopia. Parasite Epidemiology and Control, 23: e00324. DOI: https://www.doi.org/10.1016/j.parepi.2023.e00324

Ikpeze OO, Eneanya CI, and Ikerionwu PN (2009). Prevalence of Coccidiosis in West African Dwarf (Wad) Goats at Mgbakwu, Anambra State, South-Eastern Nigeria. Zoologist, 7(1): 49-54. DOI: https://www.doi.org/10.4314/tzool.v7il.52076

Johnson J, Kasimanickam VR, Kastelic JP, and Kasimanickam RK (2020). Reduced gastrointestinal worm burden following long term parasite control improves body condition and fertility in beef cows. Veterinary Parasitology, 287: 109259. DOI: https://www.doi.org/10.1016/j.vetpar.2020.109259

Kagucia AW, Kagira JM, Maina N, Karanja SM, and Njonge FK (2020). Characterisation of productivity and diseases affecting dairy goats in smallholder systems of Greater Thika region, Kenya. Journal of Agriculture and Rural Development in the Tropics and Subtropics, 121(2): 243-249. DOI: https://www.doi.org/10.17170/kobra-202010191972

Kanyari PN, Kagira JM, and Mhoma RJ (2009**).** Prevalence and intensity of endoparasites in small ruminants kept by farmers in Kisumu Municipality, Kenya. Livestock Research for Rural Development, 21(11): 202. Available at: http://www.lrrd.org/lrrd21/11/kany21192.htm

Kenya national bureau of statistics (KNBS) 2019. Economic survey 2019. Government of Kenya, Nairobi, Kenya.

Kheirandish R, Nourollahi-fard SR, and Eslah E (2012). The prevalence and pathology of ovine coccidiosis in Kerman, Iran. Eurasian Journal of Veterinary Sciences, 28(4): 194-198. Available at: https://www.dergipark.org.tr/en/pub/eurasianjvetsci/issue/24809/262101

Kimbita EN, Silayo RS, Mwega ED, Mtau AT, and Mroso JB (2009). Studies on the Eimeria of goats at Magadu dairy farm SUA, Morogoro, Tanzania. Tropical Animal Health and Production, 41: 1263-1265. DOI: https://www.doi.org/10.1007/s11250-009-9310-2

Kipserem J, Sulo T, Chepng'eno W, and Korir M (2011). Analysis of factors affecting dairy goat farming in Keiyo North and Keiyo South Districts of Kenya. Journal of Development and Agricultural Economics, 3(11): 555-560. Available at: https://www.internationalscholarsjournals.com/articles/analysis-of-factors-affecting-dairy-goat-farming-in--keiyo-north-and-keiyo-south-districts-of-kenya.pdf

Kiura JN, Abdi Yakub G, Migwi PK, and Ondiek JO (2020). Performance and genotypes of dairy goats in Kenya: Lessons learnt and the need to move beyond donor introductions. Journal of Agricultural Science and Technology, 10(3): 128-137. DOI: https://www.doi.org/10.17265/2161-6256/2020.03.003

Kotze AC and Prichard RK (2016). Anthelmintic resistance in *Haemonchus contortus*: History, mechanisms and diagnosis. Advances in Parasitology, 93: 397-428. DOI: https://www.doi.org/10.1016/bs.apar.2016.02.012

Kripali Pant K, Rajput MS, Kumar J, Sahu S, Vandna R, and Gangwar P (2009). Prevalence of helminthes in small ruminants in Tarai region of Uttarakhand. Veterinary World, 2(7): 265-266. DOI: https://www.doi.org/10.5455/vetworld.2009.265-266

Kumba FF, Katjivena H, Kauta G, and Lutaaya E (2003). Seasonal evolution of faecal egg output by gastrointestinal worms in goats on communal farms in eastern Namibia. Onderstepoort Journal of Veterinary Research, 70(4): 265-271. DOI: https://www.doi.org/10.5897/JVMAH2018.0705

Kusiluka JM, Kambarage DM, Matthewman RW, Harrison JS, and Daborn CJ (1996). Coccidiosis of small ruminants in Tanzania. Small Ruminant Research, 21(2): 127-131. DOI: https://www.doi.org/10.4102/ojvr.v70i4.291

Lokhit PP and Köhler-Rollefson I (2005). Indigenous breeds, local communities - documenting animal breeds and breeding from a community perspective. Mudra, Pune, India, p. 1-66. Available at: http://www.lpps.org/wp-content/uploads/2013/07/ikab.pdf

Ministry of agriculture, fisheries and food (MAFF) (1986). Ministry of Agriculture fisheries and food. Manual of veterinary parasitological techniques. Technical bulletin, No. 18, London, UK, p. 1-131. Availableat: https://www.openlibrary.org/works/OL19658273W/Manual_of_veterinary_parasitological_laboratory_technique

Maichomo MW, Kagira JM, and Walker T (2004). The point prevalence of gastro-intestinal parasites in calves, sheep and goats in Magadi division, south-western Kenya. Onderstepoort Journal of Veterinary Research, 71(4): 257-261. DOI: https://www.doi.org/10.4102/ojvr.v71i4.229

Maingi N, Gichigi MN, and Njoroge GK (2001). Gastrointestinal nematode infections in sheep grazing on communal land in Nyandarua District of Central Kenya in relation to deworming practices. Bulletin of Animal Health Production, 49: 153-161. Available at: https://www.erepository.uonbi.ac.ke/handle/11295/25848

Matsepe LG, Molapo S, Phalatsi M, and Phororo M (2021). Prevalence and fecal egg load of gastrointestinal parasites of Angora goats in four agro-ecological zones in Lesotho. Veterinary World, 14(2): 339-346. DOI: https://www.doi.org/10.14202/vetworld.2021.339-346

Mickiewicz M, Czopowicz M, Moroz A, Potărniche AV, Szaluś-Jordanow O, Spinu M, and Kaba J (2021). Prevalence of anthelmintic resistance of gastrointestinal nematodes in Polish goat herds assessed by the larval development test. BMC Veterinary Research, 17: 19. DOI: https://www.doi.org/10.1186/s12917-020-02721-9

Mohamaden WI, Sallam NH, and Abouelhassan EM (2018). Prevalence of *Eimeria* species among sheep and goats in Suez Governorate, Egypt. International Journal of Veterinary Science and Medicine, 6(1): 65-72. DOI: https://www.doi.org/10.1016/j.ijvsm.2018.02.004

Mpofu TJ, Nephawe KA, and Mtileni B (2022). Prevalence and resistance to gastrointestinal parasites in goats: A review. Veterinary World, 15(10): 2442-2452. DOI: https://www.doi.org/10.14202/vetworld.2022.2442-2452

Mutunga TK, Musalia LM, Gichimu BM, and Migose SA (2023). Dairy goat production in Kenya: A review. African Journal of Food, Agriculture, Nutrition and Development, 23(7): 23898-23922. DOI: https://www.doi.org/10.18697/ajfand.122.23170

Namutosi W and Higenyi J (2019). Prevalence and risk factors of gastrointestinal parasite infection in goats in Sironko district, Eastern Uganda. Uganda Journal of Agricultural Sciences, 19(1): 1-14. DOI: https://www.doi.org/10.4314/ujas.v.vl9il.1

Negasi W, Bogale B, and Chanie M (2012). Helminth parasites in small ruminants: prevalence, species composition and associated risk factors in and Around Mekelle Town, Northern Ethiopia. European Journal of Biological Sciences, 4(3): 91-95. DOI: https://www.doi.org/10.5829/idosi.ejbs.2012.4.3.65149

Nsereko G, Emudong P, Mulindwa H, and Okwee-Acai J (2015). Prevalence of common gastro-intestinal nematode infections in commercial goat farms in Central Uganda. Uganda Journal of Agricultural Sciences, 16(1): 99-106. DOI: https://www.doi.org/10.4314/ujas.v16i1.8

Ntonifor H, Shei S, Ndaleh N, and Mbunkur G (2013). Epidemiological studies of gastrointestinal parasitic infections in ruminants in Jakiri, Bui Division, North West Region of Cameroon. Journal of Veterinary Medicine and Animal Health, 5(12): 344-52. DOI: https://www.doi.org/10.5897/JVMAH2013.0209

Nwosu CO, Madu PP, and Richards WS (2007). Prevalence and seasonal changes in the population of gastrointestinal nematodes of small ruminants in the semi-arid zone of north-eastern Nigeria. Veterinary Parasitology, 144(1-2): 118-124. DOI: https://www.doi.org/10.1016/j.vetpar.2006.09.004

Odoi A, Gathuma JM, Gachuiri CK, and Omore A (2007). Risk factors of gastrointestinal nematode parasite infections in small ruminants kept in smallholder mixed farms in Kenya. BMC Veterinary Research, 3: 6. Available at: http://www.biomedcentral.com/1746-6148/3/6

Pandey VS, Ndao M, and Kumar V (1994). Seasonal prevalence of gastrointestinal nematodes in communal land goats from the highveld of Zimbabwe. Veterinary Parasitology, 51(3-4): 241-248. DOI: https://www.doi.org/10.1016/0304-4017(94)90161-9

Park SO (2022). Application strategy for sustainable livestock production with farm animal algorithms in response to climate change up to 2050: A review. Czech Journal of Animal Science, 67(11): 425-441. DOI: https://www.doi.org/10.17221/172/2022-CJAS

Paul BT, Jesse FA, Chung LT, Che'Amat A, and Mohd Lila MA (2020). Risk factors and severity of gastrointestinal parasites in selected small ruminants from Malaysia. Veterinary Sciences, 7(4): 208. DOI: https://www.doi.org/10.3390/vetsci7040208

Potârniche AV, Mickiewicz M, Olah D, Cerbu C, Spînu M, Hari A, and Kaba J (2021). First report of anthelmintic resistance in gastrointestinal nematodes in goats in Romania. Animals, 11(10): 2761. DOI: https://www.doi.org/10.3390/ani11102761

Rehman TU, Khan MN, Sajid MS, Abbas RZ, Arshad M, Iqbal Z, and Iqbal A (2011). Epidemiology of Eimeria and associated risk factors in cattle of district Toba Tek Singh, Pakistan. Parasitology Research, 108: 1171-1177. DOI: https://www.doi.org/10.1007/s00436-010-2159-5

Roeber F, Jex AR, and Gasser RB (2013). Impact of gastrointestinal parasitic nematodes of sheep, and the role of advanced molecular tools for exploring epidemiology and drug resistance-an Australian perspective. Parasites & Vectors, 6: 153. DOI: https://www.doi.org/10.1186/1756-3305-6-153

Sharma DK and Mandal A (2013). Factors affecting gastrointestinal parasite infections in goats in semi-arid rural ecosystems in India. Veterinary Science Development, 3(1): e5-e5. DOI: https://www.doi.org/10.4081/vsd.2013.4746

Shija SN, Kusiluka JM, Chenyambuga SW, Shayo D, and Lekule FP (2014). Animal health constraints in dairy goats kept under smallholder farming systems in Kongwa and Mvomero Districts, Tanzania. Journal of Veterinary Medicine and Animal Health, 6(11): 268-279. DOI: https://www.doi.org/10.5897/jvmah2014.0312

Shimelis Dagnachew SD, Asmare Amamute AA, and Wudu Temesgen WT (2011). Epidemiology of gastrointestinal helminthiasis of small ruminants in selected sites of North Gondar zone, North West Ethiopia. Ethiopian Veterinary Journal, 15(2): 57-68. DOI: https://www.doi.org/10.5897/jvmah2014.0312

Shivairo RS, Matofari J, Muleke CL, Migwi PK, and Lugairi E (2013). Production challenges and socio-economic impacts of dairy goat. Farming amongst small-holder farmers in Kenya, Food Science and Quality Management, 17: 54-61. Available at: https://www.iiste.org/Journals/index.php/FSQM/article/view/667/6810

Siyoun T and Kitaw G (2014). Comparative milk production and prevalence study of parasites and subclinical mastitis on indigenous lactating cows under different feeding regimes in central highlands of Ethiopia. Ethiopian Veterinary Journal, 18(1): 43-56. Available at: https://www.ajol.info/index.php/evj/article/view/119777

Sweeny AR, Clerc M, Pontifes PA, Venkatesan S, Babayan SA, and Pedersen AB (2021). Supplemented nutrition decreases helminth burden and increases drug efficacy in a natural host–helminth system. Proceedings of the Royal Society B, 288(1943): 20202722. DOI: https://www.doi.org/10.1098/rspb.2020.2722

Terfa W, Kumsa B, Ayana D, Bekele H, Maurizio A, Tessarin C, and Cassini R (2023). Epidemiology of gastrointestinal parasites of sheep in three agroecological zones in West Shewa Zone, Oromia State, Central Ethiopia. Journal of Veterinary Science & Technology, 14(5): 195. DOI: https://www.doi.org/10.47739/2378-931X/1241

Thrusfield M (2018). Veterinary epidemiology. John Wiley and Sons, pp. 215-217. Available at: https://www.wiley.com/en-us/Veterinary+Epidemiology%2C+4th+Edition-p-9781118280287

Wang CR, Xiao JY, Chen AH, Chen J, Wang Y, Gao JF, and Zhu XQ (2010). Prevalence of coccidial infection in sheep and goats in northeastern China. Veterinary Parasitology, 174(3-4): 213-217. DOI: https://www.doi.org/10.1016/j.vetpar.2010.08.026

Waruiru RM, Kyvsgaard, NC, Thamsborg SM, Nansen P, Bøgh HO, Munyua WK, and Gathuma JM (2000). The prevalence and intensity of helminth and coccidial infections in dairy cattle in central Kenya. Veterinary Research Communications, 24: 39-53. DOI: https://www.doi.org/10.1023/A:1006325405239

Waruiru RM (2004). The epidemiology and control of gastrointestinal nematode infections of goats in Kathiani division, in Machakos district, Kenya. Bulletin of Animal Health and Production in Africa, 53(1): 25-34. Available at: https://www.erepository.uonbi.ac.ke/handle/11295/19314

Yusof AM and Isa MM (2016). Prevalence of gastrointestinal nematodiasis and coccidiosis in goats from three selected farms in Terengganu, Malaysia. Asian Pacific Journal of Tropical Biomedicine, 6(9): 735-739. DOI: https://www.doi.org/10.1016/j.apjtb.2016.07.001

Zvinorova PI, Halimani TE, Muchadeyi FC, Matika O, Riggio V, and Dzama K (2016). Prevalence and risk factors of gastrointestinal parasitic infections in goats in low-input low-output farming systems in Zimbabwe. Small Ruminant Research, 143: 75-83. DOI: https://www.doi.org/10.1016/j.smallrumres.2016.09.005