

**MAKERERE**



**UNIVERSITY**

**THE PREVALENCE AND RISK FACTORS ASSOCIATED WITH  
GASTROINTESTINAL NEMATODES AMONG GOATS  
IN LAMIYO SUBCOUNTY AGAGO DISTRICT**

**BY**

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## DECLARATION AND APPROVAL

I, **Okot Richard Lucky**, hereby declare that this research report is a product of my own efforts and that the works of this study have never been submitted to any Institution of Higher Learning for any Award.

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## **DEDICATION**

I dedicate this work to my beloved wife Lamunu Sharon and my son Komagum Ethan Raphael.

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## LIST OF ABBREVIATIONS

|               |                                                                |
|---------------|----------------------------------------------------------------|
| <b>AOR:</b>   | Adjusted Odds Ratio                                            |
| <b>CDL:</b>   | Central Diagnostic Laboratory                                  |
| <b>CI:</b>    | Confident Interval                                             |
| <b>COR:</b>   | Crude Odds Ratio                                               |
| <b>CoVAB:</b> | College of Veterinary Medicine Animal Resource and Biosecurity |
| <b>ELISA:</b> | Enzyme-Linked Immunosorbent Assay                              |
| <b>EPG:</b>   | Eggs Per Gram                                                  |
| <b>FEC:</b>   | Fecal Egg Count                                                |
| <b>g:</b>     | Gram                                                           |
| <b>GIN:</b>   | Gastrointestinal Nematode                                      |
| <b>km:</b>    | Kilometer                                                      |
| <b>L1:</b>    | Larval stage one                                               |
| <b>L2:</b>    | Larval stage two                                               |
| <b>L3:</b>    | Larval stage three                                             |
| <b>ml:</b>    | Milliliter                                                     |
| <b>OR:</b>    | Odds Ratio                                                     |
| <b>PCR:</b>   | Polymerase Chain Reaction                                      |
| <b>PPRI:</b>  | Periparturient Relaxation of Immunity                          |
| <b>SE:</b>    | Standard Deviation                                             |
| <b>TST:</b>   | Targeted Selective Treatment                                   |

## ABSTRACT

Gastrointestinal nematodes (GIN) constraint goat production, particularly in smallholder farming systems. Despite the importance of goats to household livelihoods in Northern Uganda, there is limited information on GIN prevalence, worm burden, predominant nematode types and associated risk factors in Lamiyo subcounty, Agago District. This study determined the prevalence and infestation intensity of GIN, identified predominant nematode types and assessed the associated risk factors of gastrointestinal nematodes among goats in Lamiyo Subcounty, Agago District. A cross-sectional study was conducted from May to July 2026 in goats aged six months and above. A total of 224 goats from 54 goat-keeping households were sampled. Information on animal characteristics, housing, grazing durations and deworming history was also collected using a pretested questionnaire to assess potential risk factors. The overall prevalence of GIN infestation was 92.9% and Strongyle-type nematodes were predominant, occurring in 87.1% of goats, followed by *Strongyloides* spp. at 53.1%. The mean fecal egg concentration (FEC) was significantly higher for Strongyles (646.2 EPG) than for *Strongyloides* spp. (95.3 EPG). The GIN prevalence did not differ significantly among the four parishes ( $p > 0.05$ ). However, housing floor type and grazing duration were significantly associated with GIN infestation. Goats kept on raised floors had lower odds of infestation than those housed on earthen floors (aOR = 0.5,  $p = 0.021$ ), while goats grazing for more than 7 hours per day had lower odds of infestation than those grazing for six hours or less (aOR = 0.3,  $p < 0.001$ ). The high prevalence of GIN may be attributed to earthen housing floor type and short grazing duration (less than 7 hours). The study demonstrates that GIN are highly endemic and constitute an important constraint to goat health and productivity in Lamiyo Subcounty. Integrated control measures, including strategic and targeted deworming under veterinary guidance and use of slated housing type are recommended. Further studies should identify GIN to species level, assess seasonal variation in worm burden and investigate anthelmintic resistance across Northern Uganda.

## CHAPTER ONE

### INTRODUCTION

#### 1.1 Background

Globally, goats play a vital role in the livestock sector particularly in resource poor communities where it is a source of income, meat, milk, savings, insurance against agricultural risks and sociocultural values in practices like marriages and rituals (Lohani & Bhandari, 2021). In Uganda, goats are crucial for marginalized small-scale farmers in rural and peri-urban areas supporting their economic and social livelihoods. However, goat industry continues to face significant challenges from infectious and parasitic diseases among which gastrointestinal nematodes (GIN) posing the greatest threat to their productivity (Khan et al., 2023). Helminths affect not only the efficiencies of small ruminant production locally but also causes economic losses worldwide (Tsukahara et al., 2021). The losses are due to reduced meat and milk production, slow weight gain, increased mortality, and high treatment costs (Chagas et al., 2022). This underscores the need for effective control measures for helminthiasis.

Gastrointestinal nematode (GIN) is a diverse group of parasitic roundworms that inhabit the digestive tracts of animals. Common types of nematodes in goats include; *Ascaris*, *Hemonchus*, *Strongiloids*, *Trichostrongiloids*, *Ostertagia* and *Trichuris* (Khan et al., 2023; Nsereko et al., 2015). Previous studies revealed that effective GIN control is critical for profitable livestock production (Ali et al., 2025). Institution of effective control measures requires routine epidemiological monitoring to identify prevalent worm types, infestation levels and risk factors to develop strategic control programs (Hussein et al., 2023).

In Uganda, studies have shown high GIN prevalence in goats with regional variations such as 61.8% reported in eastern Uganda (Namutosi et al., 2019) and 43% in central Uganda (Nsereko et al., 2015). Despite the wealth of studies on GIN in Uganda, comprehensive national data on GIN prevalence in goats is still lacking with northern Uganda particularly Agago district, Lamiyo subcounty lacking data. A study in Lira district reported a 32.2% GIN prevalence in cattle (Kagenda & Angwech, 2018). However, goat-specific data in this region remains scarce limiting the development of effective helminth control strategies. Therefore, this study aims at addressing this gap by determining the prevalence and extent

of GIN infestation in goats and establish the associated risk factors for helminthiasis in Lamiyo subcounty, Agago district.

## **1.2 Problem statement**

Gastrointestinal nematodes (GIN) still continue to pose a significant threat to goat keeping communities in both developed and developing countries limiting farmers from realizing the full potential and benefits of their goat keeping effort (Tsukahara et al., 2021). Clinical reports at Agago district veterinary office revealed high mortality rates among kids associated with helminth infestation. However, effective management of helminthiasis requires comprehensive data on occurrence of common types, infestation level, prevalence and associated risk factors (Hussein et al., 2023; Nsereko et al., 2015; Zajac & Garza, 2020). Despite numerous studies on nematodes in other regions of Uganda, such data remains scarce for northern Uganda, particularly in Agago district and specifically in Lamiyo subcounty. Hence this study aims to address these gaps by investigating the prevalence of GIN, establishing the worm burden and associated risk factors among goats in Lamiyo subcounty.

## **1.3 Study objectives**

### **1.3.1 General objective**

To establish the prevalence of and the associated risk factors for occurrence of gastrointestinal nematodes among goats in Lamiyo subcounty, Agago district

### **1.3.2 Specific objectives**

- i. Identify the common nematodes affecting goats in Lamiyo subcounty Agago district.
- ii. Determine the prevalence and the extent of gastrointestinal nematodes infestation among goats in Lamiyo subcounty.
- iii. Document the associated factors predisposing goats to nematodes infestation in Lamiyo subcounty.

## **1.4 Research question**

1. What is the prevalence and extent of gastrointestinal nematodes infestation among goats in Lamiyo subcounty?
2. What are the common GIN nematodes among goats in Lamiyo subcounty?

3. What are the risk factors associated with gastrointestinal nematodes in Lamiyo subcounty?

### **1.5 Justification of the study**

Gastrointestinal nematodes severely affect goat's farming globally and locally including Uganda and Lamiyo subcounty of Agago district. They cause significant economic losses through reduced meat and milk yield, poor weight gain, high mortality rate (especially in kids) and costly treatment efforts (Namutosi et al., 2019; Tsukahara et al., 2021). There are local reports of goat deaths with suggestive symptoms such as diarrhea, emaciation, and submandibular edema which is often observed in nematode infestation (Moje et al., 2021; Taylor, 2002). This highlights the urgent need for targeted intervention in control of helminthiasis. However, effective management requires comprehensive data on common worms, infestation level, prevalence and associated risk factors (Hussein et al., 2023; Nsereko et al., 2015; Zajac & Garza, 2020).

### **1.6 Significance of the study**

This study aims to provide data on the prevalence of GIN, common types of nematodes, worm burden and associated risk factors among goats in Lamiyo subcounty, Agago district. It seeks to provide evidence-based insights to guide researchers, farmers and veterinary extension officers develop targeted worm control, treatment and sustainable strategies to enhance goat productivity and improve livelihood of small-scale goat farmer in Lamiyo subcounty.

## CHAPTER TWO

### LITERATURE REVIEW

#### 2.1 Overview of gastrointestinal nematodes in goats

Gastrointestinal nematodes (GINs) remain a major constraint to goat production worldwide particularly in tropical and subtropical regions where warm and humid conditions favour rapid development and survival (Mpofu et al., 2022). In sub-Saharan Africa including Uganda, infestations with worm species such as *Haemonchus*, *Strongyloides*, *Trichostrongylus*, *Ostertagia*, *Trichuris*, *Cooperia* and *Oesophagostomum* are highly prevalent (Khan et al., 2023; Nsereko et al., 2015). Among these helminths, *Haemonchus* spp. are considered the most pathogenic due to their hematophagous nature (Arsenopoulos et al., 2021).

Gastrointestinal nematodes contribute significantly to economic losses through reduced weight gain, poor reproductive performance, reduced milk yield and deaths (Chagas et al., 2022). The epidemiology of GIN is closely linked to environmental factors such as rainfall, temperature and humidity which enhance the survival and transmission of infective larvae on grazing lands (Dey et al., 2020; Zajac & Garza, 2020). Management-related factors including high stocking density, grazing system, housing sanitation, house floor type, access to clean water and inappropriate anthelmintic use exacerbate infestation pressure with host-related factors such as age, nutritional status, breed susceptibility and physiological stress also influencing infestation intensity and clinical outcomes (Dey et al., 2020).

Diagnostic approaches notably qualitative and quantitative techniques remain essential for assessing prevalence and infestation burden respectively although they have limitations in sensitivity and species differentiation. Understanding these interconnected epidemiological environmental, host, parasite and management determinants is critical for designing effective sustainable parasite control strategies tailored to local production systems.

#### 2.2 The epidemiology of nematodes of goats

##### 2.2.1 Common gastrointestinal nematodes in goats

Gastrointestinal nematodes (GINs) affecting goats are predominantly members of the order *Strongylida* and are characterized by direct life cycles that do not require intermediate hosts

(Mpofu et al., 2022; Wuthijaree et al., 2022). Transmission generally occurs through ingestion of infective third-stage larvae (L3) during grazing, although certain species possess additional transmission pathways (Zajac & Garza, 2020). The most important genera affecting goats include *Haemonchus*, *Trichostrongylus*, *Ostertagia*, *Strongyloides*, *Trichuris*, *Cooperia*, and *Oesophagostomum* (Namutosi et al., 2019; Nsereko et al., 2015). While many of these parasites infect multiple ruminant species, their relative pathogenicity, ecological adaptation and epidemiological importance vary between goats, sheep and cattle with *Haemonchus contortus* being the most pathogenic in small ruminants. A study in northern Uganda reported the common nematodes types in cattle (Kagenda & Angwech, 2018) however, this finding pertains to a different species. Further study reported only the prevalence of single type *Oesophagostomum* in small ruminant (Akao, 2024). This further underscore the limited research on common gastrointestinal types goats in this region. Hence the scarcity of empirical evidence on the common gastrointestinal types goats in this region limits the development of effective helminth control strategies.

### **2.2.2 Life cycle gastrointestinal nematodes**

#### ***The General life cycle of strongyle nematodes***

The life cycle of strongyle nematodes can be divided into parasitic (within-host) and free-living (environmental) phases (Zajac & Garza, 2020).

#### ***Environmental phase***

Adult nematode worms residing in the gastrointestinal tract (abomasum, small intestine, or large intestine depending on species) reproduce sexually and shed eggs in the host's faces. Female worms are highly fecund, particularly *Haemonchus contortus*, which may produce thousands of eggs per day (Zajac & Garza, 2020). This high reproductive output leads to significant pasture contamination (Pilarczyk et al., 2021).

Under favorable environmental conditions especially warm temperatures (25-30°C) and high humidity, eggs of strongyle nematodes hatch into first-stage larvae (L1) which feed on bacteria (Flay et al., 2022). The larvae then develop into second-stage larvae (L2) before maturing into third-stage larvae (L3), the infective stage. The L3 retains the L2 cuticle as a protective sheath, enhancing survival by preventing desiccation, particularly during rainy seasons. Development from egg to L3 typically occurs within 4 -7 days under optimal conditions (Zajac & Garza, 2020).

The infective L3 larvae migrate from fecal material onto surrounding herbage, where they are ingested by grazing animals hence completing the transmission cycle (Flay et al., 2022). This life cycle is characterized by rapid development, environmental resilience and direct transmission which further explains the high prevalence and continuous infestation pressure of gastrointestinal nematodes in goats, particularly in warm, humid regions (Kaur et al., 2025).

### ***Host infestation and parasitic development***

Transmission of strongyle nematodes occurs primarily through oral ingestion of infective L3 larvae while grazing on contaminated pasture (Kaur et al., 2025). After ingestion, the larvae exsheath in the rumen and migrate to their specific predilection sites within the gastrointestinal tract; *Haemonchus* and *Ostertagia* to the abomasum, *Trichostrongylus* and *Cooperia* to the small intestine and *Oesophagostomum* to the large intestine (Rizwan et al., 2023).

Within the host, the larvae develop into L4 and subsequently mature into adult worms with a short prepatent period of 2–3 weeks allowing rapid establishment and reinfestation cycles (Zajac & Garza, 2020). Certain species, such as *Ostertagia* can undergo hypobiosis (arrested larval development within gastric glands) which enables survival during unfavourable conditions and contributes to seasonal outbreaks when larvae resume development simultaneously (Agrawal et al., 2024).

Strongylids have a complex life cycle involving both parasitic and free-living stages. The parasitic phase occurs primarily in the small intestine of goats, whereas the free-living stages develop in the external environment. The adult parasitic stage consists almost exclusively of female worms that are embedded in the mucosa of the small intestine, where they reproduce parthenogenetically and produce eggs. The eggs are passed out with the host's faeces and subsequently develop in the environment (Afshan et al., 2024). After being deposited in the environment, the eggs hatch and the larvae may follow one of two developmental pathways. In the direct cycle, larvae develop through successive moults to become infective third-stage larvae (L3). These infective larvae are filariform and are capable of penetrating the skin of a susceptible goat. Alternatively, in the indirect (heterogonic) cycle, the larvae develop into free-living adult males and females in the environment. These free-living adults reproduce sexually and their offsprings subsequently

develop into infective L3 larvae. Thus, the free-living generation provides an additional route for amplification of the parasite population in the environment (Afshan et al., 2024).

Infestation of goats occurs mainly through percutaneous penetration of infective L3 larvae, although oral infestation may also occur (Adamu et al., 2026). Following skin penetration, the larvae enter the circulation and migrate through the tissues then to the lung. They penetrate the pulmonary alveoli, migrate up the respiratory tract, swallowed and subsequently reach the small intestine. There, they develop into adult parthenogenetic females and establish in the intestinal mucosa, completing the parasitic phase of the life cycle. The prepatent period of *Strongyloides papillosus* is relatively short, approximately 8-14 days, allowing rapid establishment of patent infestation and subsequent faecal egg shedding in susceptible young goats (Mpofu et al., 2020).

### **2.2.3 Transmission of gastrointestinal nematodes in goats**

The transmission dynamics of strongyle nematodes are influenced by a combination of host, parasite and environmental factors (Dey et al., 2020). Host-related determinants include immunity, age, nutritional status and periparturient relaxation of immunity all of which affect susceptibility and egg shedding (Dey et al., 2020). Parasite factors such as high fecundity, short prepatent periods, hypobiosis and the environmental resilience of L3 larvae further facilitate rapid establishment and reinfestation (Kaur et al., 2025). Environmental conditions including temperature, humidity, rainfall and grazing management play a critical role in larval development and survival (Bautista-Garfias et al., 2022). Transmission is density-dependent and climate-driven, with peaks during warm, wet seasons. Continuous grazing, high stocking densities and communal grazing increase pasture contamination and reinfestation cycles, whereas pasture rotation and strategic deworming help reduce larval burdens and interrupt transmission (Bautista-Garfias et al., 2022; Blackie, 2014).

Transmission occurs primarily when goats graze contaminated pasture and accidentally ingest infective L3 larvae attached to herbage (Dey et al., 2020). Following ingestion, the larvae migrate to their respective predilection sites in the gastrointestinal tract, where they develop through subsequent larval stages into sexually mature adults. The adults reproduce and produce eggs, which are subsequently shed in faeces, thereby maintaining the infestation cycle between the host and the environment. *Strongyloides* infestation of goats occurs mainly through percutaneous penetration of infective L3 larvae, although oral

infestation may also occur (Adamu et al., 2026). Following skin penetration, the larvae enter the circulation and migrate through the tissues then to the lung. They penetrate the pulmonary alveoli, migrate up the respiratory tract, are swallowed and subsequently reach the small intestine.

In addition to environmental transmission, *Strongyloides papillosus* may undergo transmammary transmission. Dormant larvae in the tissues of infected dams may become activated around parturition and pass through the colostrum or milk to suckling offspring. This route is particularly important in young animals because their immature immune systems make them more susceptible to infestation (Afshan et al., 2024; Pinn et al., 2022).

#### **2.2.4 Prevalence of gastrointestinal nematode in goats**

Gastrointestinal nematodes (GINs) are among the most prevalent and economically significant parasites affecting goats worldwide (Khan et al., 2023; Tsukahara et al., 2021). The incidence rate still remains high in both developed and developing country. This has attracted the attention and interest of researchers who seeks control nematodes and improve productivity and effectiveness of goat's production. Their widespread occurrence is largely attributed to their direct life cycles, high reproductive capacity, short prepatent periods (approximately 2-3 weeks) and the environmental resilience of infective L3 larvae (Zajac & Garza, 2020).

Globally, studies consistently reported high prevalence levels of gastrointestinal nematodes in goats. In tropical and subtropical regions, prevalence frequently exceeds 60-80%, largely due to warm temperatures and high humidity that favour rapid larval development and prolonged pasture survival (Dedie et al.; Sheferaw et al., 2021; Zajac & Garza, 2020). In contrast, temperate regions often report moderate (30-60%) but seasonal prevalence patterns with transmission peaks occurring during wetter and warmer months (Mpofu et al., 2020; Nabi et al., 2014; Sharma et al., 2020). As well overall GIN prevalence frequently exceeds 60-80% in many low and middle-income countries where goats are managed under extensive grazing systems (Kaur et al., 2025). This could be due to continuous pasture contamination with continuous transmission always resulting in to endemic disease state (Kaur et al., 2025; Mookho, 2024).

In Africa, gastrointestinal nematodes remain highly prevalent across diverse agro-ecological zones. Studies conducted in East, West, and Southern Africa report prevalence

ranging from approximately 60% to over 80%, depending on rainfall patterns, temperature and grazing systems (Dedie et al.; Moje et al., 2021). In countries such as Ethiopia and Tanzania, prevalence exceeding 60% has been documented, with *Haemonchus contortus* consistently identified as the predominant and most pathogenic species (Moje et al., 2021). The persistence of high infestation levels is closely linked to tropical climatic conditions, communal grazing practices, high stocking densities and inconsistent strategic anthelmintic use, all of which sustain pasture contamination and reinfestation cycles. Research also show prevalence as low as 36% in some African countries, this could be attributed to seasonal variation, management system and temperature (Mpofu et al., 2020).

In Uganda, gastrointestinal nematode (GIN) infestations are widely recognized as a significant constraint to goat production. Available studies report prevalence ranging from approximately 40% to 70%, with strongyle-type nematodes predominating the infestation profile (Namutosi et al., 2019; Nsereko et al., 2015). Regional studies demonstrate notable variation; in Eastern Uganda, prevalence has been reported at 61.8% (Namutosi et al., 2019) whereas in Central Uganda, a lower prevalence of 43% has been documented (Nsereko et al., 2015). This regional variation in prevalence can be attributed to several interacting factors which includes; difference in rainfall and humidity pattern across regions, management and grazing systems, stocking densities, differences in deworming practices and variations in study design, sampling season.

Additionally, a study reported a 32.2% prevalence of gastrointestinal nematode parasites in cattle in Lira district northern Uganda (Kagenda & Angwech, 2018). However, this finding pertains to a different species further underscoring the limited research on goats in this region. Hence the scarcity of empirical evidence on the prevalence in northern Uganda particularly Agago district, Lamiyo subcounty limits the development of effective helminth control strategies. This study therefore aims to determine the prevalence and the extent of gastrointestinal nematodes infestation hence will provide critical data to inform targeted control.

### **2.3 Diagnosis of gastrointestinal nematode**

Prevalence and worm burden estimates of gastrointestinal nematodes are strongly influenced by the diagnostic technique employed (Sabatini et al., 2023). Qualitative flotation methods are useful for detecting infestation status but lack the ability to quantify

infestation intensity and may underestimate light infestations due to limited sensitivity (Verocai et al., 2020; Zajac & Garza, 2020). More sensitive techniques such as Mini-FLOTAC and molecular assays improve detection accuracy and quantification but require specialized equipment and laboratory infrastructure, which may not be readily available in field-based epidemiological studies (Wuthijaree et al., 2022). The modified McMaster fecal egg count technique, although moderately sensitive, provides a standardized and quantitative estimate of eggs per gram (EPG) and is widely used in large-scale surveys due to its simplicity, affordability and suitability for resource-limited settings (Knoll et al., 2021; Mpofu et al., 2022). Given that the present study aims to determine both prevalence and worm burden in goats under smallholder production systems, the modified McMaster method offers an appropriate balance between accuracy, cost-effectiveness and field applicability.

### **2.3.1 Qualitative methods**

#### ***Direct smears***

The direct smear technique is a simple qualitative coprological method used for the detection of gastrointestinal parasite eggs and larvae in fecal samples. It involves placing a small amount of fresh feces on a glass slide, mixing it with a drop of water or saline, spreading it thinly, and examining it under a microscope. The method is rapid, inexpensive, and requires minimal equipment, making it suitable for preliminary screening in field conditions. However, its diagnostic sensitivity is relatively low because only a small quantity of feces is examined, which increases the likelihood of false-negative results, particularly in cases of light infestations (Verocai et al., 2020).

Compared to flotation techniques, direct smears are less effective for detecting low egg counts, as flotation concentrates eggs and improves visibility by separating them from fecal debris. Nevertheless, direct smears may be useful for detecting motile larvae or heavy infestations where egg numbers are high. Due to its limited sensitivity and lack of concentration capability, the direct smear method is generally considered supplementary rather than primary in prevalence studies of gastrointestinal nematodes in goats.

#### ***Flotation method***

The flotation technique is one of the most widely applied coprological methods for the detection of gastrointestinal nematode (GIN) eggs in small ruminants, including goats. It is particularly valuable in epidemiological studies investigating the prevalence of infestation

in field and resource-limited settings (Sabatini et al., 2023). The technique operates on the principle of differential specific gravity. Nematode eggs possess a lower specific gravity than most fecal debris and will therefore float when suspended in a dense flotation solution such as saturated sodium chloride or sugar solution (Verocai et al., 2020). Following homogenization of the fecal sample with the flotation medium, a coverslip is placed over the meniscus and subsequently examined microscopically. Eggs are identified based on morphological features including size, shape, shell thickness and internal cell structure (Mahmood et al., 2019).

Flotation is primarily a qualitative diagnostic method as it determines the presence or absence of infestation rather than quantifying egg output (Scott et al., 2019). It enables identification of certain nematode genera with distinct egg morphology, such as *Trichuris*, whose lemon-shaped eggs are readily distinguishable. However, strongyle-type eggs including those of *Haemonchus*, *Trichostrongylus*, and *Oesophagostomum* are morphologically similar at the egg stage and cannot be reliably differentiated without further larval culture or molecular characterization (Verocai et al., 2020). Despite this limitation, the technique remains highly effective for establishing overall prevalence of strongyle infestations in goat population.

When compared with other diagnostic approaches, flotation demonstrates important practical advantages. More advanced tools, including Mini-FLOTAC, polymerase chain reaction (PCR), and enzyme-linked immunosorbent assays (ELISA), offer improved sensitivity and species-specific detection; however, these methods demand well-equipped laboratories, trained personnel, reliable electricity and higher operational costs (Reslova et al., 2021). Post-mortem worm recovery, though considered the reference standard for definitive parasite identification is ethically and logistically unsuitable for large-scale prevalence surveys.

In rural and smallholder production systems such as those commonly found in sub-Saharan Africa diagnostic feasibility is a critical consideration. Limited laboratory infrastructure, financial constraints and restricted access to advanced equipment often necessitate the selection of simple, robust, and cost-effective techniques. Within this context, the flotation method provides a practical and reliable means of detecting GIN infestations using minimal equipment (microscope, slides, flotation solution) under basic laboratory conditions. Although it does not differentiate all strongyle genera at the egg stage, its diagnostic

reliability for detecting infestation status makes it well suited for prevalence studies where baseline epidemiological data are scarce.

**Table 1:** Nematode egg morphology under microscopes at x40

| Eggs                                                                                                                         | Description                                                                                                                                                                                                               |
|------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p><b>Figure 1:</b> Strongyle type egg</p> | <p>oval, with broadly rounded ends. Medium-sized egg, thin-shelled, similar poles with more or less parallel side-walls. Contains a cluster of unsegmented or dividing cells called a morula. As seen in Figure 1.</p>    |
|  <p><b>Figure 2:</b> Strongyloides</p>    | <p>Egg shell is thin, smooth, and completely transparent. Its oval shape with slightly flattened poles. The egg is embryonated, containing a fully formed, coiled first-stage (L1) larva inside. As seen in Figure 2.</p> |

Source: *Atlas of coproscopy*

### **2.3.2 Quantitative methods**

#### ***McMaster technique***

The McMaster technique is a widely used quantitative coprological method for the detection and estimation of gastrointestinal nematode (GIN) egg counts in small ruminants, including goats (Verocai et al., 2020). The method is based on the flotation principle but incorporates a specialized counting chamber (McMaster slide) engraved with a calibrated grid that allows eggs to be counted within a known volume of fecal suspension (Rashid et al., 2019). A measured quantity of faeces is homogenized in a flotation solution of known specific gravity, filtered to remove debris and then loaded into the chambers of the McMaster slide. Eggs observed within the grid areas are counted under a microscope and the number is multiplied by a correction factor to calculate eggs per gram (EPG) of faeces (Sabatini et al., 2023; Verocai et al., 2020).

Unlike qualitative methods such as simple flotation or direct smear, the McMaster technique provides an estimate of infestation intensity, making it particularly valuable in epidemiological studies assessing parasite burden and evaluating control interventions (Tachack et al., 2022). The method is relatively simple, cost-effective, and suitable for processing large sample numbers, which explains its widespread use in field-based surveys. However, its sensitivity is moderate and depends on the dilution factor used; low egg counts may go undetected, particularly in light infestations (Tachack et al., 2022). Additionally, as with other egg-based techniques, strongyle-type eggs cannot be reliably differentiated to species level without further larval culture or molecular analysis.

Despite these limitations, the McMaster technique remains a standard diagnostic tool in small ruminant parasitology due to its balance between practicality, affordability, and ability to generate quantitative data essential for epidemiological analysis.

### **2.4 Risk factors of gastrointestinal nematode infestation in goats**

Gastrointestinal nematodes (GINs) remain a major constraint to goat production systems globally, particularly in tropical and subtropical regions where climatic conditions favor continuous parasite transmission (Ndwandwe et al., 2025). In smallholder systems, the burden of infestation contributes to reduced weight gain, anaemia, poor reproductive performance, and increased mortality (Chagas et al., 2022). Despite routine anthelmintic use, recent evidence indicates persistently high prevalence rates, often exceeding 60%, alongside increasing reports of drug resistance (Saidu et al., 2025). The epidemiology of

gastrointestinal nematode in goats is multifactorial, shaped by interactions among host characteristics, environmental conditions, and management practices.

#### **2.4.1 Host-related risk factors**

##### ***Age of the host***

Age remains one of the most consistently identified determinants of GIN infestation dynamics. Young goats are generally more susceptible due to incomplete development of acquired immunity, resulting in higher prevalence and elevated fecal egg counts (EPG) compared to adults (Kaur et al., 2025). Reported EPG values in young goats frequently range between 500 and >2,000 EPG during high-transmission seasons (Zajac & Garza, 2020). However, adult goats are not exempt from infestation. Under high pasture contamination or nutritional stress, adults may exhibit substantial egg shedding, particularly during the rainy season (Zajac & Garza, 2020). This suggests that acquired immunity is partial and primarily limits worm establishment and pathogenicity rather than completely preventing reinfestation.

##### ***Sex and physiological status***

Sex-associated differences in gastrointestinal nematode (GIN) prevalence in goats have produced inconsistent findings across studies. Some studies report higher infestation rates in females, particularly during late pregnancy and early lactation, a phenomenon commonly attributed to the periparturient relaxation of immunity (PPRI). During this physiological stage, hormonal changes and the high nutritional demands associated with fetal development and milk production can temporarily suppress the immune response, resulting in increased susceptibility to nematode infestation and elevated faecal egg counts (EPG) (Zajac & Garza, 2020). Consequently, infected females may shed large numbers of parasite eggs, contributing significantly to pasture contamination and transmission within the herd (Wuthijaree et al., 2022).

In contrast, other studies have reported higher parasite burdens in males. This is often associated with the immunosuppressive effects of androgens such as testosterone, which may reduce resistance to parasitic infestations. In addition, management factors such as differential feeding, grazing behaviour and stocking practices may expose males to higher levels of infective larvae. However, unlike females whose increased susceptibility is

usually linked to specific physiological stages such as pregnancy and lactation, male susceptibility tends to be more consistent and hormonally mediated.

Overall, the variation in GIN prevalence between sexes is likely influenced by a complex interaction of physiological status, hormonal regulation, nutrition and management practices. Therefore, sex is considered as an important host-related risk factor when assessing the epidemiology of gastrointestinal nematode infestations in goats (Tariq et al., 2010).

### ***Breed and genetic resistance***

Genetic variation in resistance and resilience to GIN infestation has gained increasing attention in recent years. Indigenous goat breeds in tropical environments are frequently reported to demonstrate lower EPG and improved tolerance compared to exotic or crossbred animals under similar management systems (Onzima et al., 2017).

## **2.4.2 Environmental risk factors**

### ***Temperature***

Temperature significantly influences the development and survival of free-living larval stages. Warm and moderately humid conditions accelerate egg hatching and development to the infective third-stage (L3) larvae, increasing pasture infectivity (Tariq, 2015). In tropical climates, favorable temperatures often permit year-round transmission, although extreme heat may reduce larval viability.

### ***Rainfall and Humidity***

Rainfall and humidity are consistently identified as the strongest environmental drivers of seasonal transmission. Studies conducted across East Africa, South Asia and Southeast Asia report significantly higher prevalence and EPG during rainy seasons compared to dry periods (Atanásio-Nhacumbe & Siteo, 2019; Stadalienė et al., 2015). Prevalence estimates during peak rainy seasons frequently range between 58% and 93%, depending on geographic region and production system (Sharma et al., 2020; Stadalienė et al., 2015). Mean EPG values commonly exceed 1,000–1,500 during high-transmission months, indicating moderate to heavy infestation intensity (Atanásio-Nhacumbe & Siteo, 2019). Moisture enhances larval migration from fecal deposits to surrounding herbage, increasing ingestion risk (Zajac & Garza, 2020). Seasonal peaks in infestation intensity therefore reflect favorable environmental conditions rather than changes in host susceptibility alone.

### ***Pasture contamination and parasite species composition***

Pasture contamination is a primary risk factor influencing both the prevalence and worm burden of gastrointestinal nematodes in grazing goats. Eggs shed in feces hatch and develop into infective third-stage larvae (L3), which migrate onto herbage and are ingested during grazing (Pilarczyk et al., 2021). Under tropical conditions characterized by warm temperatures and high humidity, larval development and survival are enhanced, increasing pasture infectivity. Continuous and communal grazing systems further elevate stocking density and fecal deposition per unit area, thereby increasing exposure dose and infestation pressure (Torres-Acosta et al., 2019). Studies indicate that higher pasture larval densities are associated with increased fecal egg counts and clinical disease severity, particularly in infestations dominated by *Haemonchus contortus*, a highly pathogenic strongyle species prevalent in tropical goat production systems (Rashid et al., 2019).

#### **2.4.3 Management-Related Risk Factors**

##### ***Grazing systems***

Grazing management is a major determinant of both the prevalence and intensity of gastrointestinal nematode (GIN) infestations in goats (Zajac & Garza, 2020). Extensive, tethering and communal grazing systems have been consistently associated with higher infestation prevalence and increased faecal egg counts compared to semi-intensive or zero-grazing systems (Zajac & Garza, 2020). In communal systems, high stocking densities and shared pasture resources facilitate heavy pasture contamination with infective third-stage (L3) larvae, thereby increasing the probability of ingestion and cumulative worm burden. Lack of pasture rotation further sustains environmental contamination and promotes continuous reinfestation cycles.

Conversely, zero-grazing systems may reduce direct exposure to infective larvae; however, poor hygiene, accumulation of contaminated bedding and inadequate manure management can offset these advantages and result in persistent infestations (Namutosi et al., 2019; Tariq et al., 2010). Thus, the relationship between grazing system and GIN burden is influenced not only by grazing type but also by management quality and stocking density.

##### ***Deworming practices***

Deworming practices represent a critical management-related risk factor influencing both the prevalence and worm burden of gastrointestinal nematodes (GINs) in goats.

Anthelmintic treatment remains the primary parasite control strategy in most smallholder production systems. However, irregular treatment schedules, under-dosing, and limited veterinary supervision have been associated with higher infestation prevalence and elevated fecal egg counts (EPG) in small ruminants (Fissiha & Kinde, 2021). Such inconsistent treatment practices allow continued pasture contamination with infective larvae, thereby sustaining transmission cycles within grazing systems. Conversely, frequent blanket deworming without diagnostic monitoring accelerates the development of Anthelmintic resistance, resulting in reduced drug efficacy, treatment failure and persistent worm burdens despite routine administration (Alaro et al., 2023).

Targeted selective treatment (TST), guided by fecal egg count thresholds or clinical indicators such as anaemia scoring and body condition assessment, has been proposed as a more sustainable parasite control strategy (Mancilla-Montelongo et al., 2023). However, adoption of TST remains limited in many resource-constrained smallholder systems due to limited access to diagnostic services, cost constraints and inadequate farmer awareness (Mancilla-Montelongo et al., 2023; Valcárcel et al., 2015). Consequently, suboptimal deworming practices continue to contribute to high GIN prevalence and worm burdens in goats. Therefore, establishing the prevalence, worm burden and the predominant gastrointestinal nematode species affecting goats is essential for evidence-based parasite control. Such epidemiological information provides the basis for designing targeted treatment strategies, optimizing anthelmintic use, and implementing integrated parasite management approaches aimed at reducing infestation pressure, limiting pasture contamination, and improving goat health and productivity (Taylor, 2002; Zajac & Garza, 2020).

### ***Housing hygiene and stocking density***

Poor housing sanitation, accumulation of fecal matter, and high stocking density significantly enhance environmental contamination with infective larvae, thereby increasing both the prevalence and worm burden of gastrointestinal nematodes in goats (Dey et al., 2020). In poorly managed housing systems, moisture-retaining bedding and inadequate manure removal create favorable microclimatic conditions for egg hatching and larval survival. High stocking density further increases contact between animals and contaminated surfaces, leading to repeated exposure and reinfestation which may elevate infestation intensity (Dey et al., 2020).

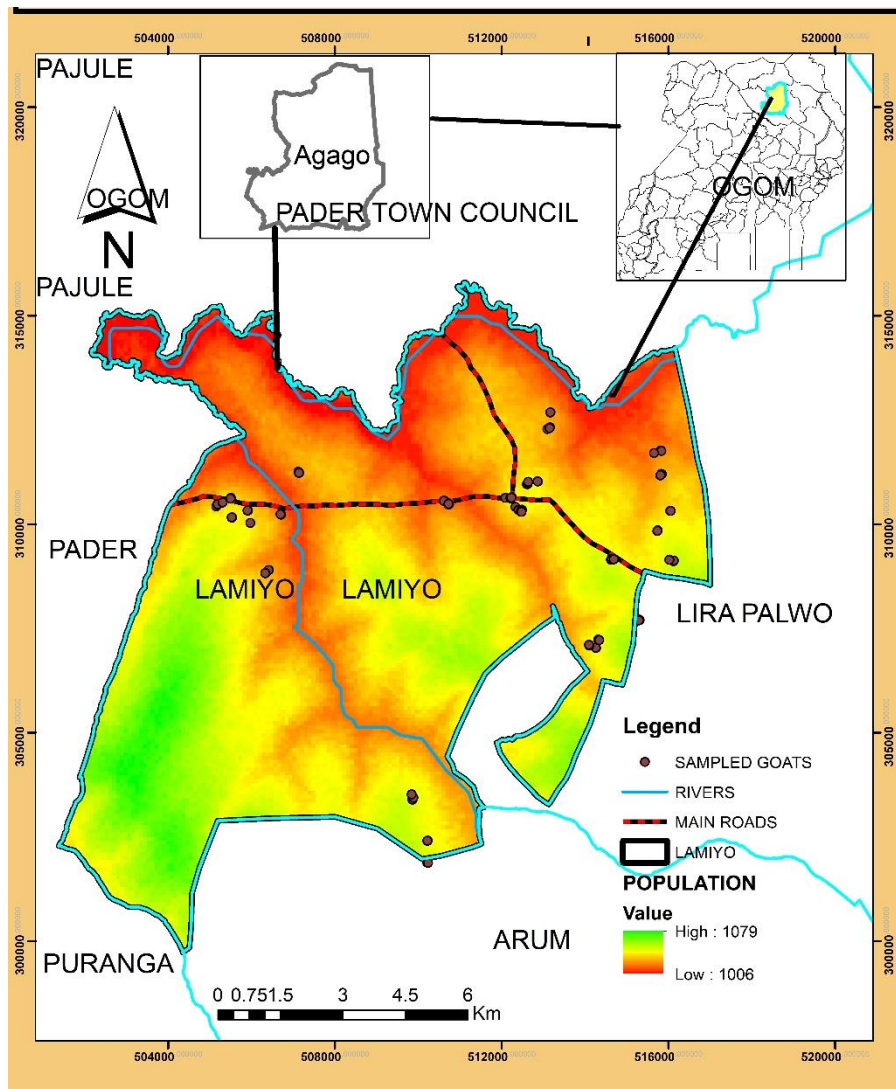
## **CHAPTER THREE**

### **MATERIALS AND METHODS**

#### **3.1 Study area**

This study was conducted in Lamiyo Subcounty, Agago District, Northern Uganda (Figure 3) located along Gulu – Moroto highway about 100 km from Gulu City, 38.4 km from Agago district head quarter. Lamiyo subcounty is approximately 1,049 meters above sea level with central coordinates of 2.80°N, 33.06°E. The subcounty is within rural savanna region of northern Uganda consisting of four parishes (Polcani, Paicam, Ojur and Otaka) and 59 villages with an estimated land area of about 300 km<sup>2</sup>. The subcounty is bordered to the East by Lira-palwo subcounty, to the South by Arum subcounty, Kilak subcounty to the west and Pader Town council northwest (Figure 3).

Lamiyo Subcounty has an estimated 792 households with approximately 3,738 goats, giving an average herd size of 4.7 goats per household. The population is predominantly Acholi, and the major socioeconomic activities are subsistence crop farming and livestock production. Goats, mainly indigenous breeds, are reared under semi-intensive management systems characterized by tethering and confinement in simple structure overnight, with limited routine veterinary care. The subcounty was purposively selected for this study because of the contribution of goats to the livelihood, goat production practices, and limited information on the prevalence and risk factors associated with gastrointestinal nematode infestations among goats.



*Source: Okot Richard Lucky*

**Figure 3:** The Map showing the study area; Lamiyo subcounty

### 3.2 Study design

The study adopted a cross-sectional design. Data for this study were collected from May to July 2026 and analysed to establish the prevalence, worm burden, associated risk factors, and the predominant types of gastrointestinal nematodes (GIN) affecting goats in Lamiyo Subcounty.

### 3.3 Study population and sample size

This study was conducted among goat keeping households in Lamiyo sub county. The required sample size was determined using Cochran formula for prevalence studies as described by William G. Cochran (Nyongesa et al., 2026).

$$n_0 = \frac{Z^2 P(1 - P)}{d^2}$$

Where;

$n_0$ = initial sample size for an infinite population,  $Z$ = Z–score corresponding to the desired confidence level (1.96 for 95% confidence interval),  $P$ = expected prevalence of gastrointestinal nematodes (80%) (Das et al., 2016) and  $d$ = desired precision (0.05)

Regional studies demonstrated notable variation in the prevalence of gastrointestinal nematodes in goats in Uganda. In Eastern Uganda, prevalence has been reported at 61.8% (Namutosi et al., 2019), while in Central Uganda a lower prevalence of 43% has been documented (Nsereko et al., 2015). Furthermore, commonly reported prevalence in many tropical African countries ranges 60 to 80% with Southwest Ethiopia reporting up to 96.7% prevalence (Moje et al., 2021). Due to the absence of specific prevalence data for Lamiyo Subcounty and to obtain a statistically reliable but manageable sample size, an expected prevalence of 80% (Das et al., 2016) was assumed.

Substituting the values into the formula

$$n_0 = \frac{(1.96)^2 \times 0.80(1 - 0.80)}{(0.05)^2} = \frac{3.8416 \times 0.16}{0.0025} = 245.86 \approx 246 \text{ goats}$$

The calculated sample size for this study was 246 goats, but 224 goats were sampled due to time and logistical limitations.

### 3.3.1 Inclusion Criteria for Goats

Households were eligible for this study if they owned at least one goat  $\geq 6$  months old and consented to participate in the study. The age of each goat ( $\geq 6$  months) sampled was determined by examination of its owner's record and dentition. The focus was on weaned or older goats.

### 3.3.2 Exclusion criteria

Goats that were heavily pregnant and those that were severely sick and had been dewormed (within 4 weeks), were excluded from the study.

### **3.4 Sampling procedure**

A multistage sampling procedure was used to select study units at different levels of the population hierarchy (sub-county, parish, village, household and goat). Lamiyo Sub-county was purposively selected from the 26 sub-counties of Agago District because of accessibility. All four parishes within Lamiyo Sub-county were included in the study. From each parish, three to four villages were selected using simple random sampling. Subsequently, four to five goat-keeping households were selected from each selected village using simple random sampling. Finally, four to five eligible goats were selected from each selected household for faecal sample collection. In households with fewer than four eligible goats, all eligible goats were sampled. This multistage approach enabled sampling to be conducted systematically across the different administrative and household levels while remaining feasible within the available logistical resources (Hazari, 2024).

### **3.5 Data collection procedures**

#### **3.5.1 Faecal Sampling for GIN Detection**

Fresh fecal samples (5-10 g per goat) were collected directly from the rectum of the selected goats using disposable gloves. Each goat was humanely restrained to minimize stress and ensure safe handling during sample collection. This was achieved by gently and securely restraining the goat between the handler's legs while holding it firmly by the neck and supporting the head with both hands to maintain it in a standing position. The examiner wore a disposable glove and lubricated the index finger using K-Y jelly before gently rubbing it around the rectum for a few seconds. The lubricated finger was then carefully inserted into the rectum to collect approximately 5-10 g of fresh fecal material.

Immediately after collection, each fecal sample was placed into a clean polythene bag, which was securely tied to prevent contamination and moisture loss. Each sample was labelled using a unique identification code consisting of the household number, followed by the goat number. The identification slip was placed inside the second polythene bag, which was then tightly sealed again to ensure proper identification throughout sample handling and transportation.

The collected samples were placed in a cool box containing ice packs and transported to the Central Diagnostic Laboratory (CDL) at CoVAB, for parasitological analysis.

### **3.5.2 Predisposing Factor Assessment**

Data on the potential risk factors associated with gastrointestinal helminth infestation in goats were collected using a pre-tested, structured questionnaire (Appendix I) programmed in the Kobo Toolbox (Kobo Collect) mobile data collection application. The questionnaire was administered during face-to-face interviews with the heads of goat-rearing households. Information collected included management practices (grazing system, grazing duration, deworming frequency, housing floor type, body condition score, house cleaning frequency and grazing intensity), animal characteristics (age, sex, and breed), and environmental factors (pasture condition, faecal contamination of goat pens, and the nature of the surrounding environment).

The questionnaire was administered in Acholi language to ensure that respondents clearly understood the questions and provided accurate responses. Each interview lasted approximately 15 minutes. Data entered into Kobo Collect were synchronized with the Kobo Toolbox server upon completion and later downloaded for cleaning and statistical analysis.

## **3.6 Laboratory assays**

### **3.6.1 Flootation Technique**

The faecal flotation technique was used to detect and identify gastrointestinal nematode eggs in goat faecal samples. Approximately 1 g of fresh faeces was weighed into a clean beaker and thoroughly homogenized in 60 ml of saturated sodium chloride used as flotation solution (specific gravity 1.20-1.30). The resulting suspension was filtered through a sieve into another clean beaker to remove large debris.

The filtered suspension was poured into a clean test tube until a convex meniscus formed at the rim of the tube. A clean coverslip was carefully placed on top of the meniscus and left undisturbed for 8 minutes to allow parasite eggs to float and adhere to the coverslip. The coverslip was then carefully removed and placed onto a clean microscope slide. The prepared slides were examined under a microscope at 40 objective lenses. Gastrointestinal nematode eggs were identified based on their morphological characteristics, including size, shape, colour, shell appearance, and internal contents. Strongyle-type eggs, representing economically important genera such as *Haemonchus*, *Trichostrongylus*, *Oesophagostomum*, *Cooperia* and *Ostertagia* were recorded as strongyle-type eggs

because they are morphologically indistinguishable. Eggs with distinctive morphological features, such as those of *Strongyloides* spp. was identified and recorded as *Strongyloides*.

### **3.6.2 Modified McMaster technique**

The Modified McMaster technique was used to determine the number of gastrointestinal nematode eggs per gram (EPG) of feces. Approximately 2 g of fresh fecal sample was weighed using a digital balance and mixed thoroughly with 28 ml of flotation solution of saturated sodium chloride to obtain a homogeneous suspension. The mixture was stirred thoroughly and strained through a tea strainer to remove large debris and obtain a uniform filtrate.

Using a Pasteur pipette, both chambers of a McMaster counting slide were immediately filled with the filtered fecal suspension, ensuring that each chamber was completely filled and free of air bubbles. The loaded slide was allowed to stand for approximately 5 minutes to enable the parasite eggs to float to the upper surface of the counting chamber.

The slide was then examined under a light microscope using the  $\times 40$  objective lens, focusing on the upper layer where the eggs were concentrated. All nematode eggs present within the engraved grids of both counting chambers were counted separately. The total number of eggs counted in the two chambers was multiplied by a factor of 50 to obtain the number of eggs per gram (EPG) of feces, as described by the Modified McMaster method.

## **3.7 Study variables**

### **3.7.1 Dependent variable**

In this study, GIT nematode infestation was the outcome variable. It was a binary categorical variable coded as yes and no.

### **3.7.2 Independent variables**

Goat attributes (age and breed) and management practices (stocking density, deworming frequency, feeding and housing) were independent variables in this study.

## **3.8 Data management and analysis**

The data obtained were organized and cleaned using Microsoft Excel version 2019. The cleaned data were imported into Stata version 14.2 for analysis. Demographics of the goats and prevalence of GIT nematodes were summarized using frequencies and percentages.

Load of GIT nematodes were computed using summary statistics (mean and standard error). Logistic regression model was used to explore the risk factors for GIT nematode infestation in the sampled goats. First a bivariable logistic model was used to identify factors associated with GIT nematode infestation and crude odds ratios obtained. This was then followed by a multivariable logistic regression model to adjust the odds ratios. Statistical significance was considered at 5 %. Results were presented using tables, figures and graphs.

### **3.9 Ethical considerations**

An introductory letter was obtained from the Dean, College of Veterinary Medicine, Animal Resources and Biosecurity, Makerere University, and presented to the District Veterinary Officer of Agago District. The District Veterinary Officer subsequently wrote a letter of clearance to allow the researcher to carry out research in Lamiyo subcounty, Agago district. This letter facilitated entry into the study area. Local Council leaders were informed about the study by Hon Kilama Geffery before data collection commenced.

Informed verbal consent was obtained from all participating household heads after explaining the purpose of the study, the voluntary nature of participation, confidentiality of the information provided, and their right to withdraw from the study at any time without any consequences. During sample collection, goats were handled humanely to minimize stress, and no invasive procedures other than the collection of fresh faecal samples were performed.

## CHAPTER FOUR

### RESULTS

#### 4.1 Attributes of the sampled goats

In this study, majority (90.2%) of the goats sampled were local, most (72.8%) of them were adult goats, almost three quarters (72.8%) of the goats were females and majority (80.4%) had a moderate body condition (Table 2).

**Table 2:** Characteristics of goats sampled in this study

| Attribute               | Category  | n (%)      |
|-------------------------|-----------|------------|
| Breed of goats          | Local     | 202 (90.2) |
|                         | Cross     | 22 (9.8)   |
| Age of goats            | ≤ 1 year  | 25 (11.1)  |
|                         | 3 years   | 163 (72.8) |
|                         | ≥ 5 years | 36 (16.1)  |
| Sex of goats            | Male      | 50 (22.3)  |
|                         | Female    | 174 (77.7) |
| Body condition of goats | Thin      | 26 (11.6)  |
|                         | Moderate  | 180 (80.4) |
|                         | Fat       | 18 (8.0)   |

#### 4.2 Prevalence of gastrointestinal nematodes in goats sampled from Lamiyo sub county, Agogo district

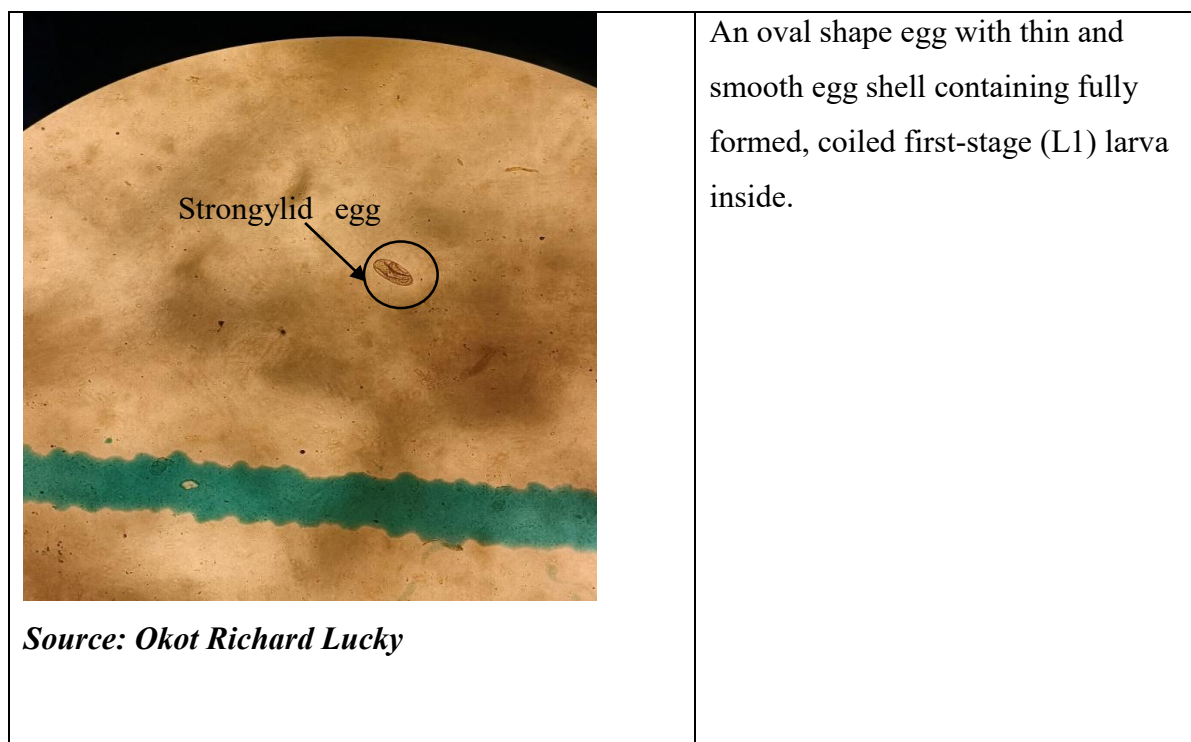
The overall prevalence of gastrointestinal nematodes in the sampled goats was 92.9%, Strongyles were the most prevalent (87.1%) nematode type, followed by Strongyloides (53.1%). The prevalence of GIT nematodes did not vary significantly by parish ( $p > 0.05$ ). These findings are summarized in Table 3; and some of the representative pictures of the detected gastrointestinal nematode eggs are shown in Figure 4.

**Table 3:** Prevalence of gastrointestinal nematodes among the sampled goats

| Parish               | Number<br>sampled | Number<br>positive (n) | Prevalence<br>(%) | 95%CI     | <i>p</i> -value) |
|----------------------|-------------------|------------------------|-------------------|-----------|------------------|
| <b>GIT nematodes</b> |                   |                        |                   |           |                  |
| Ojuu                 | 52                | 49                     | 94.2              | 83.3-98.2 | 0.062            |
| Otaka                | 25                | 20                     | 80.0              | 59.4-91.6 |                  |
| Polcani              | 58                | 54                     | 93.1              | 82.8-97.4 |                  |
| Paicam               | 89                | 85                     | 95.5              | 88.5-98.3 |                  |
| Overall              | 224               | 208                    | 92.9              | 88.6-95.6 |                  |
| <b>Strongyles</b>    |                   |                        |                   |           |                  |
| Ojuu                 | 52                | 45                     | 86.5              | 74.1-93.5 | 0.552            |
| Otaka                | 25                | 20                     | 80.0              | 59.4-91.6 |                  |
| Polcani              | 58                | 53                     | 91.4              | 80.7-96.4 |                  |
| Paicam               | 89                | 77                     | 86.5              | 77.6-92.2 |                  |
| Overall              | 224               | 195                    | 87.1              | 81.9-90.9 |                  |
| <b>Strongyloides</b> |                   |                        |                   |           |                  |
| Ojuu                 | 52                | 30                     | 57.7              | 43.8-70.4 | 0.607            |
| Otaka                | 25                | 11                     | 44.0              | 25.9-63-  |                  |
| Polcani              | 58                | 33                     | 56.9              | 43.8-69.1 |                  |
| Paicam               | 89                | 45                     | 50.6              | 40.2-60.9 |                  |
| Overall              | 224               | 119                    | 53.1              | 46.5-59.6 |                  |

\*CI – confidence interval

| Eggs identified                                                                                                                                   | Description                                                                                                                              |
|---------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
|  <p>Strongyle egg</p> <p><i>Source: Okot Richard Lucky</i></p> | <p>Oval eggs, with broadly rounded ends, thin-shell and contain a cluster of dividing cells (morula).</p> <p>This was Strongyle egg.</p> |



**Figure 4:** Nematode eggs detected during laboratory faecal analysis of goat faecal samples collected from Lamiyo Subcounty

#### 4.3 Mean load of gastrointestinal nematodes in goats sampled from Lamiyo sub county, Agogo district

From Table 4, the mean EPG of Strongyles was 646.2 while that of Strongyloides was 95.3. The mean EPGs of the two common GIT nematode genera in goats sampled were significantly different ( $p < 0.05$ ). The differences in the worm load were also statistically different within and between parishes. Goats from Ojur parish had the highest mean faecal egg count (952.9 EPG), indicating a high parasite burden, followed by Polcani (620.7 EPG) and Paicam (555.1 EPG), which indicated moderate parasite burdens. Goats from Otaka had the lowest mean faecal egg count (392.0 EPG), indicating a mild parasite burden.

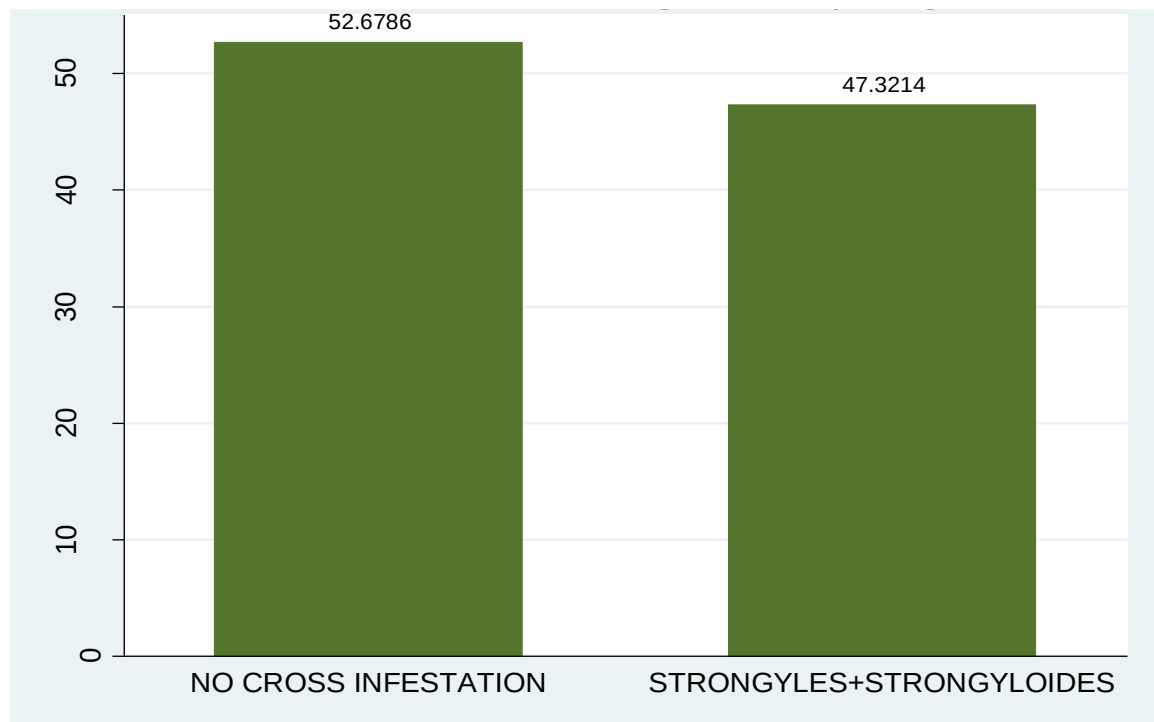
**Table 4:** Mean EPGs of Strongyles and Strongyloides in the sampled goats

| Parish         | Mean EPG (SE)       |                    | t (p-value)                    |
|----------------|---------------------|--------------------|--------------------------------|
|                | Strongyles          | Strongyloides      |                                |
| Ojuu           | 952.9 (275.2)       | 78.8 (37.5)        | 3.1 ( <b>0.002</b> )           |
| Otaka          | 392.0 (97.1)        | 56.0 (17.9)        | 3.4 ( <b>0.001</b> )           |
| Polcani        | 620.7 (92.4)        | 125.9 (40.8)       | 4.9 ( <b>&lt; 0.001</b> )      |
| Paicam         | 555.1 (78.3)        | 96.1 (47.3)        | 5.6 ( <b>&lt; 0.001</b> )      |
| <b>Overall</b> | <b>646.2 (76.2)</b> | <b>95.3 (61.2)</b> | <b>7.0 (<b>&lt; 0.001</b>)</b> |

\*t – test, SE – standard error and EPG – eggs per gram

#### 4.4 Mixed nematode infestation of goats sampled from Lamiyo sub county, Agogo district with gastrointestinal nematodes

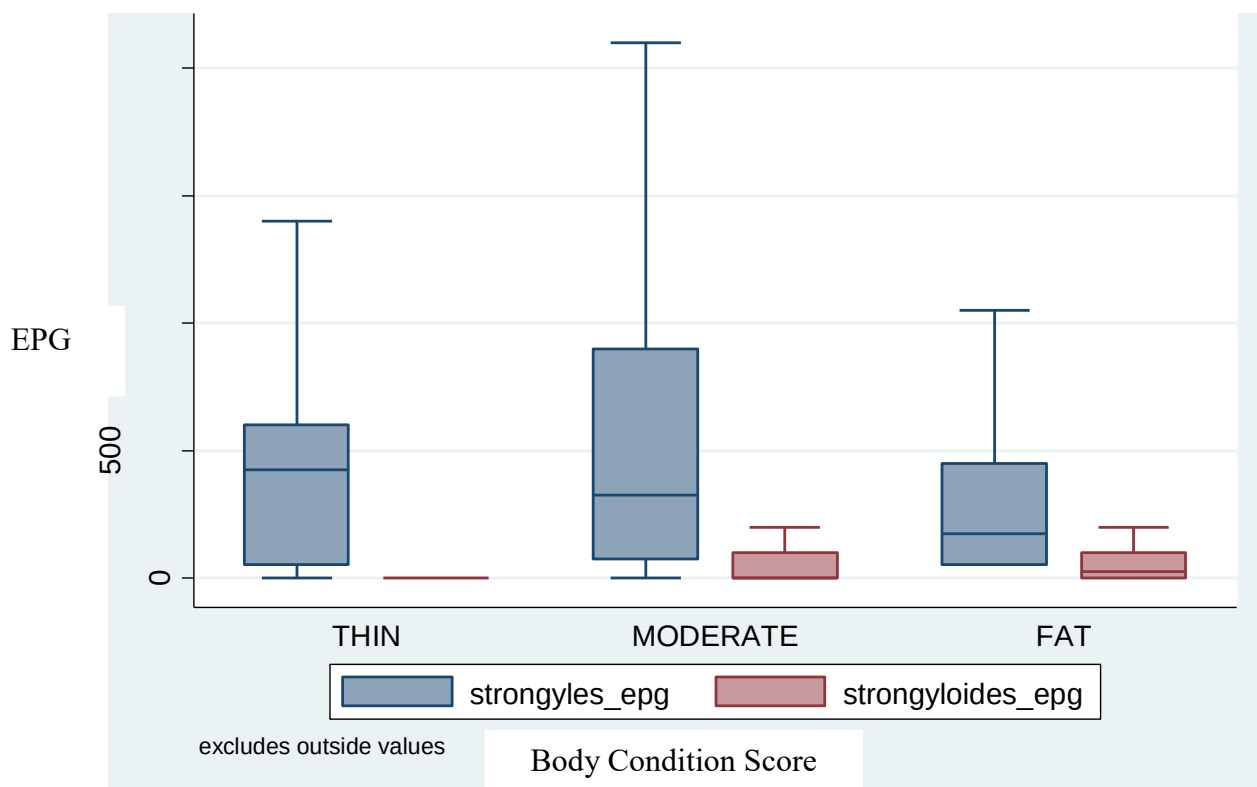
In this study, slightly less than half (47.3%) of the sampled goats carried both Strongyles and Strongyloides hence mixed infestation with two genera of nematodes (Figure 5).



**Figure 5:** Mixed nematode infestation of goats by Strongyles and Strongyloides

#### 4.5 Load of Strongyles and Strongyloides based on body condition of goats

This study showed that, as body condition improved (from thin to fat), the median EPG of Strongyles decreased Figure 6.



**Figure 6:** EPG of Strongyles and Strongyloides by body condition of the sampled goats

#### 4.6 Risk factors associated with gastrointestinal nematode infestation among the sampled goats

From Table 25, type of goat house floor and grazing duration were identified as protective factors for gastrointestinal nematodes infestation in goats. Goats housed on raised floor had less chances of having GIT nematodes compared to those housed on earthen floors (OR = 0.5,  $p = 0.021$ ). Goats that spend more than 7 hours browsing per day were less likely to have GIT nematodes compared to those that browse for 6 or fewer hours (aOR = 0.3,  $p < 0.001$ ).

**Table 5:** Factors with gastrointestinal nematodes among the sampled goats

| <b>Variable</b>                 | <b>Prevalence<br/>n (%)</b> | <b>COR [95%CI],<br/>p-value</b> | <b>AOR [95%CI],<br/>p-value</b> |
|---------------------------------|-----------------------------|---------------------------------|---------------------------------|
| <b>Age of the goat</b>          |                             |                                 |                                 |
| ≤ 1 year (n=25)                 | 11 (40.0)                   | 1.00                            | 1.00                            |
| 3 years (n=163)                 | 73 (44.8)                   | 1.03[0.4-3.0], 0.953            | 1.1[0.4-3.4], 0.825             |
| ≥ 5 years (n=36)                | 22 (61.1)                   | 2.0[0.6-6.8], 0.268             | 2.1[0.6-7.4], 0.239             |
| <b>Breed of the goat</b>        |                             |                                 |                                 |
| Local (n=202)                   | 98 (48.5)                   | 1.00                            | -                               |
| Cross (n=22)                    | 8 (36.4)                    | 0.6[0.2-1.5], 0.281             | -                               |
| <b>Stocking density</b>         |                             |                                 |                                 |
| Low (n=52)                      | 23 (44.2)                   | 1.00                            | -                               |
| Moderate (n=166)                | 79 (47.6)                   | 1.1[0.5-2.7], 0.756             | -                               |
| High (n=6)                      | 4 (66.7)                    | 2.5[0.9-7.2], 0.082             | -                               |
| <b>Type of house floor</b>      |                             |                                 |                                 |
| Earthen floor (n=210)           | 102 (48.6)                  | 1.00                            | 1.00                            |
| Raised (n=14)                   | 4 (28.6)                    | 0.4[0.2-0.8], <b>0.005</b>      | 0.5[0.3-0.9], <b>0.021</b>      |
| <b>House cleaning frequency</b> |                             |                                 |                                 |
| Daily (n=144)                   | 69 (47.9)                   | 1.00                            | -                               |
| Occasionally (n=76)             | 33 (43.4)                   | 0.8[0.4-1.6], 0.586             | -                               |
| Never (n=4)                     | 4 (100.0)                   | -                               | -                               |
| <b>Grazing duration</b>         |                             |                                 |                                 |
| 4-6 hours (n=4)                 | 3 (75.0)                    | 1.00                            | 1.00                            |
| 7-8 hours (n=216)               | 101 (46.8)                  | 0.3[0.2-0.4], <b>&lt;0.001</b>  | 0.3[0.2-0.4], <b>&lt;0.001</b>  |
| > 8 hours (n=4)                 | 2 (50.0)                    | 0.3[0.3-0.4], <b>&lt;0.001</b>  | 0.3[0.3-0.4], <b>&lt;0.001</b>  |
| <b>Deworming frequency</b>      |                             |                                 |                                 |
| Never (n=51)                    | 21 (41.2)                   | 1.00                            | -                               |
| After 2 months                  | 85 (49.1)                   | 1.4[0.7-2.6], 0.315             | -                               |

\*COR – crude odds ratio, AOR – adjusted odds ratio and CI – confidence interval

## CHAPTER FIVE

### DISCUSSION

The present study found that the majority of goats sampled were indigenous breeds (90.2%), females (77.7%), majority were adults approximately three years old (72.8%), and had a moderate body condition score (80.4%). The major production system was semi-intensive where the goats were housed under a simple structure at night and tethered during day. These findings are consistent with the production systems commonly practiced in Northern Uganda, where indigenous goats are preferred because of their adaptability to harsh climatic conditions, resistance to endemic diseases, ability to survive under low-input management systems, and relatively low maintenance costs (Onzima et al., 2017). The predominance of female goats probably reflects farmers' preference for retaining breeding females to sustain herd reproduction and increase flock size, while males are frequently sold or slaughtered at younger ages to generate household income. The predominance of adult goats observed in this study may also indicate that farmers retain mature animals for breeding purposes. Adults generally constitute a larger proportion of village herds because they have survived early-life mortality and contribute more to household livelihoods through reproduction and sale. These demographic characteristics are important because age, sex and breed have been reported to influence gastrointestinal nematode (GIN) burden (Zajac & Garza, 2020).

The present study identified Strongyles as the predominant gastrointestinal nematodes infecting goats in Lamiyo Subcounty (87.1%), followed by *Strongyloides* spp. (53.1%). Strongyle-type eggs represent several economically important genera, including *Haemonchus*, *Trichostrongylus*, *Oesophagostomum*, and *Cooperia* (Namutosi et al., 2019). This finding is consistent with reports from Eastern Uganda which reported gastrointestinal Strongyles as the dominant nematodes infecting goats under smallholder production systems (Namutosi et al., 2019). Similar observations were made in several tropical countries, where strongylid nematodes constitute the major gastrointestinal parasites of goats. This could be due to the high reproductive capacity, direct life cycle, and efficient pasture-based transmission of the Strongyles (Dey et al., 2020; Mpofu et al., 2022). In addition, warm temperatures, seasonal rainfall characteristic of Northern Uganda and irregular deworming in the study area could have facilitated the persistence and transmission of gastrointestinal nematodes (Bautista-Garfias et al., 2022). In contrast, the

comparatively lower prevalence of *Strongyloides* than *Strongyles* may be explained by differences in transmission dynamics of these nematodes. Although *Strongyloides papillosus* possesses both parasitic and free-living developmental stages, environmental conditions, host immunity and management practices are known to reduce successful transmission compared with strongyle (Mpofu et al., 2022). Nevertheless, the detection of *Strongyloides* spp. in the present study could be due to inadequate hygiene and sanitation around goat shelters as previously reported elsewhere (Bautista-Garfias et al., 2022). Overall, the findings of the present study demonstrate that strongyle-type nematodes remain the dominant gastrointestinal parasites affecting goats in Lamiyo Subcounty. This highlights the need for integrated parasite control programmes that combine targeted selective treatment, strategic deworming, regular rotation of tethering sites, improved hygiene of goat shelters, and routine parasitological monitoring. Such integrated approaches are recommended to reduce pasture contamination, and improve the health and productivity of goats under smallholder production systems (Maqbool et al., 2017).

The overall prevalence of gastrointestinal nematodes recorded in this study was 92.9% which indicates that GIN infestation are highly endemic among goats in Lamiyo Subcounty. This prevalence is considerably higher than previous reports from Eastern Uganda (61.8%) by Namutosi et al. (2019) and Central Uganda (43%) by Nsereko et al. (2015). Similarly, it exceeds the 60–80% prevalence commonly reported in many tropical African countries. Furthermore, the current prevalence was lower than the previous reports from Southwest Ethiopia 96.7% (Moje et al., 2021). The high prevalence of gastrointestinal nematode (GIN) infestation observed in this study may be attributed to the grazing practices commonly used in Lamiyo Subcounty, where most farmers practice tethering without regular rotation. This confines goats to the same grazing areas for prolonged periods, restricts selective grazing, increases pasture contamination, and forces animals to feed close to the ground where infective third-stage (L3) larvae are concentrated, thereby sustaining transmission and increasing the risk of infestation (Moiloa, 2017). Seasonal conditions may have further contributed to the high prevalence, as sampling was conducted during the dry season when reduced pasture availability likely compelled goats to graze closer to the soil surface, increasing exposure to infective larvae. Additionally, the existing difference in the prevalence could also relate to the variations in geographical and climatic condition, management difference and the difference of health care activity as these factors influence

the epidemiology, transmission, and intensity of gastrointestinal nematode infestations in goats (Avery et al., 2025).

The study found no statistically significant variation in gastrointestinal nematode prevalence among the four parishes ( $p > 0.05$ ). This suggests that the epidemiology of GIN infestation is relatively uniform across Lamiyo Sub-county. The absence of significant geographical variation is probably because the parishes share similar ecological conditions, grazing systems, rainfall patterns and management practices. Farmers across the sub-county predominantly semi-intensive production system with tethering as the main grazing system, use similar housing structures and have comparable access to veterinary services. Consequently, goats are exposed to similar infestation pressures irrespective of their parish of origin. This finding indicates that parasite control interventions should target the entire sub-county rather than specific parishes.

Fecal egg count (FEC) is a vital indicator of fecal parasitic load, and degree of pasture contamination (Paul et al., 2020). The mean faecal egg count of Strongyles (646.2 EPG) was significantly higher than that of Strongyloides (95.3 EPG). The observed difference demonstrates that Strongyle nematodes contributed the greatest parasite burden among infected goats. An average strongyle egg count of approximately 646 EPG indicates a moderate level of infestation (Kaplan et al., 2023). This is epidemiologically important because infected animals continuously shed eggs onto pasture, maintaining environmental contamination and facilitating transmission to susceptible animals. The finding agrees with the national survey of dairy goats in Australia which reported that most infected goats harboured moderate strongylid faecal egg counts (Ali et al., 2026). They further identified deworming history, climatic conditions, management and co-infestations as major determinants of faecal egg counts. Similarly, the moderate parasite burden observed in the present study may reflect the semi-intensive tethering system practised in Lamiyo Subcounty, where repeated grazing on the same tethering sites, coupled with irregular deworming, permits continued exposure to infective larvae without necessarily resulting in heavy infestations in all animals. In contrast, the worm load in the present study was lower than the parasite burdens reported by Sharma et al. (2024), who found significantly higher strongyle faecal egg counts in diarrheic goats than in goats with normal faeces. The relatively lower mean faecal egg count observed in the present study may be because most goats sampled were apparently healthy compared with goats experiencing active clinical disease. This is well demonstrated in a box plot that typically showed that as the body

condition increases from thin to fat the mean EPG reduces. These findings underscore the importance of maintaining integrated parasite control programmes because even goats with moderate faecal egg counts contribute substantially to pasture contamination and sustain the transmission cycle within smallholder production systems.

The present study identified nature of goat house floor and grazing duration as significant protective factors associated with gastrointestinal nematode (GIN) infestation in goats. Goats housed on raised floors had significantly lower odds of GIN infestation than those housed on earthen floors (OR = 0.5,  $p = 0.021$ ). The findings of this study agree with that reported in Ghana, which observed that goats on earthen floors had significantly higher gastrointestinal parasite burdens than those housed in raised structures (Squire et al., 2019). This finding is biologically plausible because raised floors reduce direct contact between goats and faeces by allowing urine and dung to fall beneath the housing structure, thereby minimizing environmental contamination with infective third-stage (L3) larvae. In contrast, earthen floors retain moisture, warm and organic matter, creating favourable conditions for the development and survival of nematode eggs and larvae (Dey et al., 2020). However, this finding disagrees with Chakraborty et al. (2023) who reported no statistically significant association between housing floor type. In the Bangladesh study, most goats were managed under relatively similar husbandry conditions, which may have reduced the influence of housing floor type as an independent risk factor while goats in Lamiyo Subcounty are predominantly reared under semi-intensive systems where earthen floors are often poorly drained and contaminated with faeces, creating favorable conditions for the development and survival of infective third-stage (L3) larvae. These findings emphasize the importance of improving housing hygiene as part of integrated parasite control programmes. The study further revealed that goats that grazed for more than seven hours per day had significantly lower odds of gastrointestinal nematode infestation than those grazed for six hours or less (aOR = 0.3,  $p < 0.001$ ). This finding is contrary to the conventional understanding that prolonged grazing increases the risk of ingesting infective third-stage (L3) larvae present on contaminated pastures (Taylor et al., 2016; Zajac et al., 2021). A plausible explanation is that goats grazing for six hours or less in the study area are often confined in shelters for longer periods before being released to pasture. As a result, they are likely to be hungry and immediately graze intensively around the shelter, where pasture is heavily contaminated with faeces because of frequent animal congregation.

Hunger may also reduce the goats' natural selective browsing behavior, causing them to consume herbage close to the ground where infective L3 larvae are most abundant.

### **5.1 Limitation of the study**

1. Resource and time limitations; The calculated sample size was 246 goats; however, only 224 goats were sampled due to time and logistical constraints. This reduction may have decreased the statistical power of the study to detect some associations, particularly for risk factors with small subgroup sizes.
2. Seasonal limitation; Data collection was conducted during a limited period of the year. Because environmental conditions such as rainfall, temperature and humidity influence the development and survival of infective nematode larvae, the findings may not represent GIN prevalence and faecal egg output throughout all seasons.
3. Limitations of faecal examination method used; The study relied on faecal examination to detect GIN infestation. Although flotation and modified McMaster techniques are useful for detecting and quantifying nematode eggs, they may not detect all infestations, particularly infestations with low egg output and larvae of the nematodes.
4. Cross-sectional study design; The study was conducted at a single point in time and therefore provides information on GIN prevalence and associated factors during the study period only. The design does not establish temporal or causal relationships between the identified risk factors and GIN infestation.
5. Limited identification of nematodes to species level; The nematodes were identified mainly based on the morphological characteristics of eggs observed during faecal examination. Some GIN genera produce morphologically similar eggs, particularly strongyle-type eggs, making species-level identification difficult using routine coprological methods. Therefore, the study could not accurately determine the species composition of all GIN detected.

## CHAPTER SIX

### CONCLUSION AND RECOMMENDATIONS

#### 6.1 Conclusion

This study established that Strongyle-type nematodes were the predominant gastrointestinal nematodes affecting goats in Lamiyo Subcounty, followed by *Strongyloides* spp., indicating that Strongyles remain the major parasitic challenge in the area. The overall prevalence of gastrointestinal nematode infestation goats in Lamiyo subcounty was high (92.9%), with a moderate mean Strongyle faecal egg count (646.2 EPG) and mild Strongylid faecal egg count (95.3 EPG).

Appropriate goat housing and sufficient period of grazing goats were associated with reduced prevalence of nematodes infestation and worm load. Goats housed on raised floors had a lower likelihood of nematode infestation than those kept on earthen floors, while goats that were well fed (graze for more than seven hours daily) had reduced odds of infestation compared to those poorly fed (graze for shorter periods per day). Therefore, appropriate housing and feeding of goats reduced the burden of gastrointestinal nematodes among goats under smallholder production systems in Lamiyo Subcounty.

#### 6.2 Recommendations

1. Goat farmers in Lamiyo Subcounty should adopt integrated gastrointestinal nematode control strategies, including strategic deworming under veterinary guidance, routine faecal examination where possible, in addition to other good practices to minimize nematodes infestation.
2. Farmers should be encouraged by extension officers at the subcounty and local leaders to improve goat housing by replacing or modifying earthen floors with raised or well-drained floors where feasible. Such improvements will reduce contact between goats and contaminated faeces, thereby lowering the risk of gastrointestinal nematode infestation.
3. Future broader research should identify gastrointestinal nematodes in goats to species level and investigate seasonal variation in worm burden and anthelmintic resistance pattern in goats in the entire northern Uganda.

## REFERENCES

- Adamu, A. Y., Amuga, G. A., Ombugadu, R. J., & Adamu, F. (2026). Epidemiology of Gastrointestinal Helminthes of Sheep and Goats in Suleja Local Government Area of Niger State, North Central, Nigeria. *FUDMA Journal of Sciences*, 10(5).
- Afshan, K., Liu, Y., & Viney, M. (2024). The genetic diversity of *Strongyloides papillosus* in Pakistani goats revealed by whole genome sequencing. *Parasites & vectors*, 17(1), 527.
- Agrawal, V., Swami, M., Jaiswal, A. K., Kumar, P., Singh, A., & Shakya, M. (2024). Parasites of gastrointestinal system. In *Parasitic Diseases of Goats* (pp. 26-61). Bentham Science Publishers.
- Akao, P. M. (2024). *Prevalence of Oesophagostomum among small ruminants slaughtered in Lira city abattoir*. Special project report, Busitema University.
- Alaro, T., Dulo, F., Wodajo, W., & Mathewos, L. (2023). Anthelmintic resistance of gastrointestinal nematodes of communally-grazing goats in Humbo District, Southern Ethiopia. *Veterinary Medicine: Research and Reports*, 185-194.
- Ali, E. A., Abbas, G., Beveridge, I., Baxendell, S., Squire, B., Stevenson, M. A., Ghafar, A., & Jabbar, A. (2025). Knowledge, attitudes and practices of Australian dairy goat farmers towards the control of gastrointestinal parasites. *Parasites & vectors*, 18(1), 25.
- Ali, E. A., Ghafar, A., Abbas, G., Mustafa, B. E., Baxendell, S., Ling, E., Gauci, C., Beveridge, I., Stevenson, M. A., & Jabbar, A. (2026). A national survey of gastrointestinal nematodes in Australian dairy goats using faecal egg counts and deep amplicon sequencing. *Current Research in Parasitology & Vector-Borne Diseases*, 100390.
- Atanásio-Nhacumbe, A., & Siteo, C. F. (2019). Prevalence and seasonal variations of eggs of gastrointestinal nematode parasites of goats from smallholder farms in Mozambique. *Science*, 2576, 9510.
- Avery, R. H., Urie, N. J., Branan, M. A., Wiedenheft, A. M., Dennis, E., Marshall, K. L., Burke, J. M., & Miller, J. E. (2025). A national survey of the gastrointestinal

- nematode control practices used by goat producers in the United States. *Veterinary parasitology*, 334, 110375.
- Bautista-Garfias, C. R., Castañeda-Ramírez, G. S., Estrada-Reyes, Z. M., Soares, F. E. d. F., Ventura-Cordero, J., González-Pech, P. G., Morgan, E. R., Soria-Ruiz, J., López-Guillén, G., & Aguilar-Marcelino, L. (2022). A review of the impact of climate change on the epidemiology of gastrointestinal nematode infestations in small ruminants and wildlife in tropical conditions. *Pathogens*, 11(2), 148.
- Blackie, S. (2014). A review of the epidemiology of gastrointestinal nematode infestations in sheep and goats in Ghana. *Journal of Agricultural Science*, 6(4), 109.
- Chagas, A. C. d. S., Tupy, O., Santos, I. B. d., & Esteves, S. N. (2022). Economic impact of gastrointestinal nematodes in Morada Nova sheep in Brazil. *Revista brasileira de parasitologia veterinária*, 31, e008722.
- Chakraborty, M., Shohana, N. N., Begum, N., Dey, A. R., Rony, S. A., Akter, S., & Alam, M. Z. (2023). Diversity and prevalence of gastrointestinal parasites of Black Bengal goats in Natore, Bangladesh. *Journal of advanced veterinary and animal research*, 10(1), 80.
- Das, A., Ajit Kumar, A. K., Sinha, R., & Samantray, S. (2016). Incidence of gastrointestinal helminth parasites in goats and their therapeutic management.
- Dedie, P., Tchaou, Y. Z., Belga, F., Miron, L., Radu-Rusu, R., Djitie-Kouatcho, F., & Ndjonka, D. Review of the prevalence of gastrointestinal nematodes in ruminants across tropical Africa.
- Dey, A. R., Begum, N., Alim, M. A., Malakar, S., Islam, M. T., & Alam, M. Z. (2020). Gastro-intestinal nematodes in goats in Bangladesh: A large-scale epidemiological study on the prevalence and risk factors. *Parasite Epidemiology and Control*, 9, e00146.
- Fissiha, W., & Kinde, M. Z. (2021). Anthelmintic resistance and its mechanism: a review. *Infestation and Drug Resistance*, 5403-5410.
- Flay, K. J., Hill, F. I., & Muguiro, D. H. (2022). A Review: *Haemonchus contortus* infestation in pasture-based sheep production systems, with a focus on the

- pathogenesis of anaemia and changes in haematological parameters. *Animals*, 12(10), 1238.
- Hazari, A. (2024). Sampling types and methods. In *Research methodology for allied health professionals: A comprehensive guide to thesis & dissertation* (pp. 31-39). Springer.
- Hussein, H. A., Abdi, S. M., Ahad, A. A., & Mohamed, A. (2023). Gastrointestinal nematodiasis of goats in Somali pastoral areas, Ethiopia. *Parasite Epidemiology and Control*, 23, e00324.
- Kagenda, G. A., & Angwech, H. (2018). Cross-sectional prevalence of gastrointestinal helminth parasites in cattle in Lira District, Uganda. *Tropical animal health and production*, 50(7), 1599-1604.
- Kaplan, R. M., Denwood, M. J., Nielsen, M. K., Thamsborg, S. M., Torgerson, P. R., Gilleard, J. S., Dobson, R. J., Vercruysse, J., & Levecke, B. (2023). World Association for the Advancement of Veterinary Parasitology (WAAVP) guideline for diagnosing anthelmintic resistance using the faecal egg count reduction test in ruminants, horses and swine. *Veterinary parasitology*, 318, 109936.
- Kaur, A., Kaur, N., Chauhan, K., Jyoti, Singh, H., & Singh, N. K. (2025). Epidemiology of caprine gastrointestinal nematodes and associated efficacy of anthelmintic drugs in Punjab districts, India. *Scientific Reports*, 15(1), 5211.
- Khan, A., Jamil, M., Ullah, S., Ramzan, F., Khan, H., Ullah, N., Ali, M., Rehman, A. U., Jabeen, N., & Amber, R. (2023). The prevalence of gastrointestinal nematodes in livestock and their health hazards: A review. *World's Veterinary Journal*, 13(1), 57-64.
- Knoll, S., Dessì, G., Tamponi, C., Meloni, L., Cavallo, L., Mehmood, N., Jacquiet, P., Scala, A., Cappai, M. G., & Varcasia, A. (2021). Practical guide for microscopic identification of infectious gastrointestinal nematode larvae in sheep from Sardinia, Italy, backed by molecular analysis. *Parasites & vectors*, 14(1), 505.
- Lohani, M., & Bhandari, D. (2021). The importance of goats in the world. *Professional Agricultural Workers Journal (PAWJ)*, 6(2), 9-21.

- Mahmood, O., Muhsin, S., & Hussein, M. (2019). Morphological Diagnosis for Some Eggs of Gastrointestinal Nematodes from Sheep. *Tikrit Journal for Agricultural Sciences*, 19(3), 6-9.
- Mancilla-Montelongo, G., Gonzalez-Pech, P. G., Miranda-Miranda, D. Y., Castaneda-Ramirez, G. S., Encalada-Aguilar, P. A., Can-Celis, A., Galera-Chan, I. E., Ortiz-Dominguez, G. A., & de Jesús Torres-Acosta, J. F. (2023). Targeted treatment strategies for the control of gastrointestinal nematodes in a goat flock with anthelmintic resistant worm populations and poor nutrition. *Small Ruminant Research*, 227, 107062.
- Maqbool, I., Wani, Z., Shahardar, R., Allaie, I., & Shah, M. (2017). Integrated parasite management with special reference to gastro-intestinal nematodes. *Journal of Parasitic Diseases*, 41(1), 1-8.
- Moilola, M. J. (2017). *Gastrointestinal parasites of Angora goats in Lesotho: Prevalence and control methods. Master's Thesis* National University of Lesotho].
- Moje, N., Gurmesa, A., & Regassa, G. (2021). Gastro-intestinal tract nematodes of small ruminants: prevalence and their identification in and around Alage, Southern Ethiopia. *Animal and Veterinary Sciences*, 9(3), 65-72.
- Mookho, J. M. (2024). *Prevalence and Risk Factors of Gastrointestinal Parasites in Sheep in Kajiado North Sub-county, Kenya. Master's Thesis* University of Nairobi].
- Mpofu, T. J., Nephawe, K. A., & Mtileni, B. (2020). Prevalence of gastrointestinal parasites in communal goats from different agro-ecological zones of South Africa. *Veterinary World*, 13(1), 26.
- Mpofu, T. J., Nephawe, K. A., & Mtileni, B. (2022). Prevalence and resistance to gastrointestinal parasites in goats: A review. *Veterinary World*, 15(10), 2442.
- Nabi, H., Saeed, K., Shah, S. R., Rashid, M. I., Akbar, H., & Shehzad, W. (2014). Epidimiological study of gastrointestinal nematodes of goats in district swat, khyber pakhtunkhwa, pakistan. *Science International*, 26(1).
- Namutosi, W., Higenyi, J., Kizito, E., & Omodo, M. (2019). Prevalence and risk factors of gastrointestinal parasite infestation in Goats in Sironko District, Eastern Uganda. *Uganda Journal of Agricultural Sciences*, 19(1), 1-14.

- Ndwandwe, K. C., Chimonyo, M., Tsotetsi-Khambule, A. M., & Marufu, M. C. (2025). Knowledge, Attitudes and Practices of Communal Goat Farmers on the Prevalence and Control of Gastrointestinal Nematodes in Northern KwaZulu-Natal, South Africa. *Journal of Parasitology Research*, 2025(1), 1443083.
- Nsereko, G., Emudong, P., Mulindwa, H., & Okwee-Acai, J. (2015). Prevalence of common gastro-intestinal nematode infestations in commercial goat farms in Central Uganda. *Uganda Journal of Agricultural Sciences*, 16(1), 99-106.
- Nyongesa, E. N., Namusonge, G. S., & Nambuswa, E. M. (2026). The Impact of Metering and Billing Revenue Systems on Revenue Collection in Public Water Companies. *International Academic Journal of Economics and Finance (IAJEF)* | ISSN 2518-2366, 5(3), 34-56.
- Onzima, R., Mukiibi, R., Ampaire, A., Benda, K., & Kanis, E. (2017). Between-breed variations in resistance/resilience to gastrointestinal nematodes among indigenous goat breeds in Uganda. *Tropical animal health and production*, 49(8), 1763-1769.
- Paul, B. T., Jesse, F. F. A., Chung, E. L. T., Che' Amat, A., & Mohd Lila, M. A. (2020). Risk factors and severity of gastrointestinal parasites in selected small ruminants from Malaysia. *Veterinary sciences*, 7(4), 208.
- Pilarczyk, B., Tomza-Marciniak, A., Pilarczyk, R., Bombik, E., Seremak, B., Udała, J., & Sadowska, N. (2021). A comparison of the prevalence of the parasites of the digestive tract in goats from organic and conventional farms. *Animals*, 11(9), 2581.
- Pinn, T. L., Forrestal, A. M., Duhamel, G. E., Crouch, E. E., Thompson, B. S., & Lejeune, M. (2022). *Strongyloides papillosus* causes sudden death in weaned calves on New York dairies. *Journal of the American Veterinary Medical Association*, 260(2), 244-250.
- Rashid, M. H., Beveridge, I., Vaughan, J. L., & Jabbar, A. (2019). Worm burdens and associated histopathological changes caused by gastrointestinal nematodes in alpacas from Australia. *Parasitology research*, 118(3), 1031-1038.
- Reslova, N., Skorpikova, L., Kyrianova, I. A., Vadlejch, J., Höglund, J., Skuce, P., & Kasny, M. (2021). The identification and semi-quantitative assessment of gastrointestinal

- nematodes in faecal samples using multiplex real-time PCR assays. *Parasites & vectors*, 14(1), 391.
- Rizwan, H. M., Sajid, M. S., Bano, F., Tahir, U. B., Riaz, A., Younus, M., Maqbool, M., Butt, A., & Zohaib, H. M. (2023). Goat parasitism, diagnosis, and control. In *Goat Science-From Keeping to Precision Production*. IntechOpen.
- Sabatini, G. A., de Almeida Borges, F., Claerebout, E., Gianechini, L. S., Höglund, J., Kaplan, R. M., Lopes, W. D. Z., Mitchell, S., Rinaldi, L., & von Samson-Himmelstjerna, G. (2023). Practical guide to the diagnostics of ruminant gastrointestinal nematodes, liver fluke and lungworm infestation: interpretation and usability of results. *Parasites & vectors*, 16(1), 58.
- Saidu, A., Paul, B. T., Jesse, F. F. A., Kamaludeen, J., Mustafa, S., Malahubban, M., Hakim, A. H., & Stephen, J. (2025). Anthelmintic resistance in gastrointestinal nematodes of sheep and goats: A systematic review. *Journal of Advanced Veterinary Research*, 15(3), 397-405.
- Scott, H., Gilleard, J., Jelinski, M., Barkema, H., Redman, E., Avramenko, R., Luby, C., Kelton, D., Bauman, C., & Keefe, G. (2019). Prevalence, fecal egg counts, and species identification of gastrointestinal nematodes in replacement dairy heifers in Canada. *Journal of dairy science*, 102(9), 8251-8263.
- Sharma, D. K., Paul, S., & Gururaj, K. (2020). Gastrointestinal helminthic challenges in sheep and goats in afro-asian region: a review. *Journal of Animal Research*, 10(1), 1-18.
- Sheferaw, D., Mohammed, A., & Degefu, A. (2021). Distribution and prevalence of gastrointestinal tract nematodes of sheep at highland and midland areas, Ethiopia. *Journal of Parasitic Diseases*, 45(4), 995-1001.
- Squire, S., Robertson, I., Yang, R., Ayi, I., & Ryan, U. (2019). Prevalence and risk factors associated with gastrointestinal parasites in ruminant livestock in the Coastal Savannah zone of Ghana. *Acta Tropica*, 199, 105126.
- Stadalienė, I., Höglund, J., & Petkevičius, S. (2015). Seasonal patterns of gastrointestinal nematode infestation in goats on two Lithuanian farms. *Acta Veterinaria Scandinavica*, 57(1), 16.

- Tachack, E. B., Oviedo-Socarrás, T., Pastrana, M. O., Pérez-Cogollo, L. C., Benavides, Y. H., Pinto, C. R., & Garay, O. V. (2022). Status of gastrointestinal nematode infestations and associated epidemiological factors in sheep from Córdoba, Colombia. *Tropical animal health and production*, 54(3), 171.
- Tariq, K., Chishti, M., & Ahmad, F. (2010). Gastro-intestinal nematode infestations in goats relative to season, host sex and age from the Kashmir valley, India. *Journal of helminthology*, 84(1), 93-97.
- Tariq, K. A. (2015). A review of the epidemiology and control of gastrointestinal nematode infestations of small ruminants. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences*, 85(2), 693-703.
- Taylor, M. (2002). Parasites of goats: a guide to diagnosis and control. *In Practice*, 24(2), 76-89.
- Taylor, M., Coop, R., & Wall, R. (2016). Veterinary Parasitology, 4th edn John Wiley & Sons. Ltd Atrium South Gate Chichester West Sussex PO19 8SQ UK.
- Torres-Acosta, J., Hoste, H., Sandoval-Castro, C. A., Torres-Fajardo, R. A., Ventura-Cordero, J., González-Pech, P. G., Mancilla-Montelongo, M. G., Ojeda-Robertos, N. F., & Martínez-Ortíz-de-Montellano, C. (2019). The art of war against gastrointestinal nematodes in sheep and goat herds of the tropics. *Revista Acadamica Ciencia Animal*, 17(supl 1), 39-46.
- Tsukahara, Y., Gipson, T. A., Hart, S. P., Dawson, L., Wang, Z., Puchala, R., Sahlu, T., & Goetsch, A. L. (2021). Genetic selection for resistance to gastrointestinal parasitism in meat goats and hair sheep through a performance test with artificial infestation of *Haemonchus contortus*. *Animals*, 11(7), 1902.
- Valcárcel, F., Aguilar, A., & Sánchez, M. (2015). Field evaluation of targeted selective treatments to control subclinical gastrointestinal nematode infestations on small ruminant farms. *Veterinary parasitology*, 211(1-2), 71-79.
- Verocai, G. G., Chaudhry, U. N., & Lejeune, M. (2020). Diagnostic methods for detecting internal parasites of livestock. *Veterinary Clinics: Food Animal Practice*, 36(1), 125-143.

- Wuthijaree, K., Tatsapong, P., & Lambertz, C. (2022). The prevalence of intestinal parasite infestations in goats from smallholder farms in Northern Thailand. *Helminthologia*, 59(1), 64.
- Zajac, A. M., Conboy, G. A., Little, S. E., & Reichard, M. V. (2021). *Veterinary clinical parasitology*. John Wiley & Sons.
- Zajac, A. M., & Garza, J. (2020). Biology, epidemiology, and control of gastrointestinal nematodes of small ruminants. *Veterinary Clinics of North America: Food Animal Practice*, 36(1), 73-87.

## APPENDICES

### Appendix I: Questionnaire

#### THE PREVALENCE AND RISK FACTORS ASSOCIATED WITH GASTROINTESTINAL NEMATODES AMONG GOATS IN LAMIYO SUBCOUNTY AGAGO DISTRICT

My name is OKOT Richard Lucky a BVM 5 student at Makerere University College of Veterinary Medicine Animal Resource and Biosecurity. I am carrying out a study on round worms in goats in Lamiyo subcounty. Your answers will help us understand how environment, climate and farm management influences worm burden and prevalence. Your participation is voluntary and your answers will be kept confidential. There are no right or wrong answers and honest answers will help us provide better recommendations for keeping goat's health. This exercise will only take a few minutes.

Do you consent to participate in this study? \_\_\_\_\_

☐ Yes ☐ No

#### SECTION A: QUESTIONNAIRE IDENTIFICATION

Date of the interview \_\_\_\_\_

Sub county

☐ Lamiyo

Parish

☐ Polcani ☐ Ojuu ☐ Otaka ☐ Paicam

Village \_\_\_\_\_

Location of the farm/farmer \_\_\_\_\_

Latitude (x.y °)

---

Longitude (x.y °)

---

Altitude (m)

---

Accuracy (m)

---



## SECTION B: FARMER DEMOGRAPHIC INFORMATION

What is the house hold id? \_\_\_\_\_

How old are you? \_\_\_\_\_

How long have you been keeping goats?

☐ <1 years

☐ 2 years

☐ 3 years

☐ 4 years

☐ 5 years and above

## SECTION C: HERD AND GOAT ATTRIBUTES

How many goats do you currently own?

☐ 1–10

☐ 11–20

☐ 21–50

☐ >50

What breeds of goats do you keep? (as observed)

☐ Local breed ☐ Cross breed ☐ Exotic breed

What is the id of the goat to be sampled? \_\_\_\_\_

What is the age of the goat?

☐ 0 - 3 months

☐ 3 - 5 Months

☐ 6 - 12 months

☐ 1 - 5 years

☐ more than 5 years

What is the sex of the animal to be sampled? (as observed)

☐ Male ☐ Female

What is the general body condition of the herd in the scale of 1- 5? (as observed)

☐ 1 (emaciated)

☐ 2 (thin)

☐ 3 (moderate)

☐ 4 (fat)

☐ 5 (obase)

#### **SECTION D: GOAT MANAGEMENT SYSTEM**

What type of production system is practiced at the farm?(as observed)

☐ Extensive system

☐ semi intensive system ☐ intensive system

What type of grazing system do you practice at the farm?

- ☐ Free range
- ☐ Rotational grazing/paddock ☐ Communal grazing
- ☐ Tethering ☐ Zero grazing

How much land have you allocated for grazing goat? (in acres) \_\_\_\_\_

How would you describe the stocking density of goats per acre of your grazing area?

- ☐ Low (Less than 5 goats) ☐ Moderate (5–10 goats) ☐ High (More than 10 goats)

#### SECTION E: HOUSING AND HYGIENE

18: Do you provide housing for your goats at night?

- ☐ Yes ☐ No

If yes; what is the type of housing floor?

- ☐ Earth floor
- ☐ Raised wooden floor ☐ Concrete floor

How often do you clean the goat house?

- ☐ Daily ☐ Weekly
- ☐ Occasionally ☐ Never

#### SECTION G: DEWORMING HISTORY

Do you deworm your goats?

- ☐ Yes ☐ No

how often do you deworm your goat?

- ☐ Every month
- ☐ Every after two months ☐ Every after three months ☐ Sometimes
- ☐ Not at all

When did you last dewormed your goat?

☐ Less than 3 month ☐ More than 3 month

#### SECTION H: ENVIRONMENTAL CONDITION AND GRAZING PRACTICE

During which season were the animal sample?

☐ Dry season ☐ Rainy season

What time do you usually take your goat for grazing?

☐ Early morning (dew present) ☐ Mid-morning

☐ Afternoon

☐ Throughout the day

How long do goats spend grazing per day?

☐ less than 4 hours ☐ 4 - 6 hours

☐ 6 -8 hours

☐ More than 8 hours

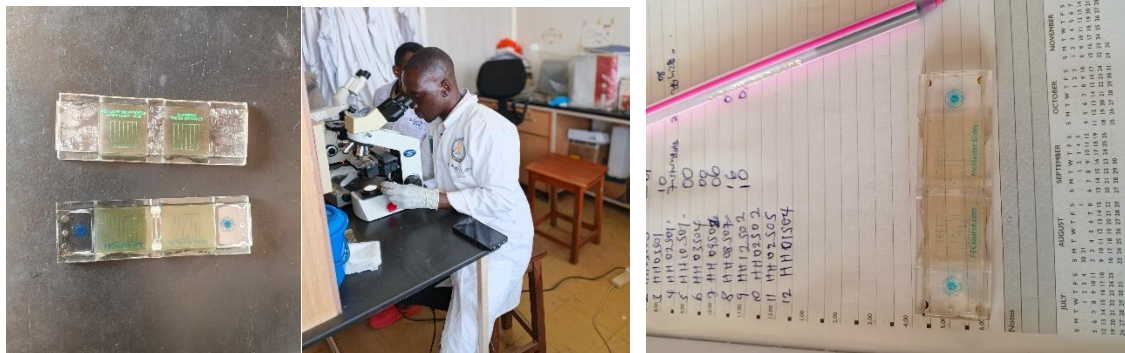
## Appendix II: Research Pictorial evidences



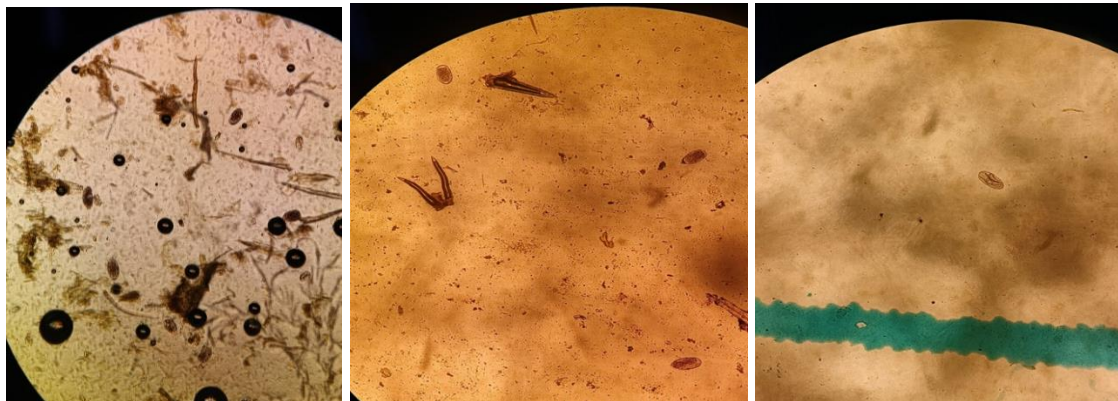
*Sample collection*



*Preparation of samples for micrposcopy*



*Laboratory analysis and examination*



*Strongyle eggs*

*Strongyloides eggs*

### Appendix III: Research and data collection clearance letter

Telephone:  
District Chairperson  
Chief Administrative Officer  
Deputy Chief Admin. Officer  
Principal Assistant Secretary  
District Production Officer  
District Agricultural Officer  
District Veterinary Officer  
Animal Husbandry Officer  
E-mail No: [agagodlg2010@gmail.com](mailto:agagodlg2010@gmail.com)  
Fax .....

0777985738  
0774162885  
0774289487  
0774850157  
0782138317  
0782437711  
0782842253  
0782311628



AGAGO DISTRICT LOCAL GOVERNMENT  
OFFICE OF THE  
DISTRICT VETERINARY OFFICER  
P.O. BOX 1  
AGAGO  
UGANDA

Date: 13<sup>TH</sup> MAY 2026

IN ANY CORRESPONDENCE ON  
THIS SUBJECT PLEASE QUOTE NO:

OKOT Richard Lucky  
Makerere University.

#### RE: CLEARANCE TO COLLECT RESEARCH DATA

Reference is made to your letter dated 6<sup>th</sup> May 2026 requesting for permission to collect research data for your academic study titled "Prevalence and risk factors associated with gastrointestinal nematodes among goats in Lamiyo sub-county, Agago district."

The Office of the District Veterinary Officer, Agago district local government, has no objection to your study and hereby grants you clearance to collect the required research data from Lamiyo sub-county, Agago district, subject to observing all relevant ethical, administrative and animal welfare requirements. We shall assign the field veterinarian in charge of Lamiyo sub-county to accord you the necessary assistance.

We therefore request that you provide a copy of the final research report to Agago district Veterinary Office, as the findings may contribute to improved understanding and control of gastrointestinal nematode infections among goats in the district as well as helping to back up our surveillance system and guide future course of action.

Yours in Service,

AKENA WALTER

FOR DISTRICT VETERINARY OFFICER - AGAGO DISTRICT

