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RESEARCH PAPER

PREVALENCE OF LIVER FLUKE INFESTATION IN SLAUGHTERED GOATS IN KAGOTE-KIBIMBA ABATTOIR, FORT PORTAL CITY, UGANDA

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ABSTRACT

Background: Liver fluke infestations, predominantly caused by Fasciola species such as Fasciola hepatica, present a critical parasitic challenge affecting the health and productivity of goats globally. Fascioliasis not only causes significant economic losses to farmers due to reduced weight gain, milk production, and fertility, but also poses a public health risk as a zoonotic disease. The World Health Organization estimates that 2.4 million people are currently infected with Fasciola spp. with an additional 180 million at risk. Globally, fascioliasis incurs an economic burden of approximately $3.2 billion USD annually. Despite these alarming statistics, no data existed on the prevalence of liver fluke infestation in goats in Fort Portal City prior to this study.

Methods: Using a cross-sectional research design, data were collected through systematic random sampling of 205 goats at Kagote-Kibimba Abattoir in Fort Portal City. Post-mortem inspections were conducted to examine liver lesions, identify liver fluke infestations, and assess financial losses due to condemned liver tissues. Data on breed, source location, liver weight, lesion severity (scored on a 1-10 cm scale), presence of fluke eggs or adult worms, and estimated financial loss were recorded. Laboratory methods including microscopic examination (10×-40× magnification) were employed. Data were analyzed using SPSS; descriptive statistics summarized prevalence rates and lesion severity, while chi-square and regression analyses assessed relationships between variables.

Results: The prevalence of liver fluke infestation was 20.98%. No statistically significant associations were found between infestation rates and goat breed, location of origin, or fecal consistency. Severe liver lesions generated the highest financial losses, averaging 30,100 Ugx. per goat, while moderate lesions contributed 12,776 Ugx. Total financial losses over the two-month study period amounted to approximately 3,186,000 Ugx. Linear regression ($R^2 = 96.11\%$) confirmed lesion severity as the predominant determinant of financial loss.

Conclusions: These findings underscore the economic burden of liver fluke infestation on goat farmers and the local meat industry in Fort Portal City. Enhanced veterinary interventions, improved management practices, and policy support for subsidized veterinary services are recommended to mitigate the impact of fascioliasis. Further research on breed-specific susceptibility, geographic variability, treatment efficacy, and environmental transmission factors is strongly advised.

Keywords: Fascioliasis, Liver fluke, Goats, Prevalence, Fort Portal City, Uganda, Abattoir, Lesion severity, financial loss, Fasciola hepatica

CHAPTER ONE: INTRODUCTION

1.1 Background

Liver fluke is a parasitic condition caused by Fasciola hepatica and Fasciola gigantica trematodes (Khoramian et al., 2014). Fascioliasis is a plant-borne trematode disease that poses significant health risks, reduces livestock output, and negatively impacts economic activities across the globe. Trematodes inhabit the bile ducts of their hosts, leading to substantial economic losses due to liver condemnation, reduced productivity, and increased veterinary costs. The prevalence of liver fluke infestation varies geographically and depends on several factors, including environmental conditions, management practices, and the presence of intermediate snail hosts.

According to Fang et al. (2022), fascioliasis is a foodborne zoonotic parasitic disease that causes significant health problems and economic damage, affecting most livestock animals, especially cattle and sheep. Two species, Fasciola hepatica and Fasciola gigantica, affect livestock, though Fasciola hepatica is the most abundant species in goats. Both species cause severe liver illnesses in livestock (Othman et al., 2023). The liver, recognized as the largest organ and a valuable source of proteins and vitamins, including riboflavin, B12, vitamin A, and copper, is the primary site of Fasciola infection (Rassol et al., 2020). Fascioliasis mostly results in economic losses due to condemnation of infected livers (Zewde et al., 2019).

The complex life cycle of Fasciola spp. involves freshwater snails as intermediate hosts, making environmental factors like warm, humid climates with ample water sources crucial for their transmission (Fang et al., 2022). In Western Uganda, these conditions prevail in many regions, contributing to an increased risk of liver fluke infections in goats. As meat consumption increases worldwide, concerns about meat hygiene and safety continue to grow, especially given that the worldwide distribution of fascioliasis is estimated at 90% in ruminants (Odigie et al., 2013).

Goats are highly susceptible to liver fluke infestation due to their grazing habits, which expose them to fluke-contaminated vegetation in endemic areas. Studies have consistently reported a high prevalence of liver fluke infestation in slaughtered goats. For instance, a study conducted in Nigeria reported a prevalence rate of 30.7% among slaughtered goats, attributed to poor animal husbandry and limited veterinary care (Chiejina et al., 2018). Similarly, investigations in Bangladesh revealed a prevalence of 25% in slaughtered goats, highlighting the role of environmental factors such as monsoonal flooding and grazing in waterlogged areas (Ahmed et al., 2017).

Liver fluke infestation leads to various pathological effects in goats, ranging from chronic hepatic damage to anemia and weight loss, thereby reducing their market value and productivity. Economically, fascioliasis in livestock is a major constraint to the meat industry, with liver condemnations accounting for 90% of losses caused by the disease (Ahmad and Elsharawy, 2018).

1.2 Problem Statement

Liver fluke infestations, primarily caused by Fasciola species (particularly Fasciola hepatica), pose a significant parasitic threat to the health and productivity of goats in East Africa. According to Opio et al. (2021), fascioliasis costs the world economy approximately $3.2 billion USD per year. During post-mortem inspections in animal slaughterhouses, fascioliasis is frequently found in the liver, making it the most condemned organ (Taha et al., 2023).

The World Health Organization estimates that 2.4 million persons are infected with Fasciola spp., with an additional 180 million at risk of infection (Kujawa et al., 2017). As a zoonotic disease, fascioliasis is now recognized as an emergent human illness, necessitating data collection for public health risk minimization.

The prevalence of Fasciola in Uganda has led to significant economic losses for traders. According to Joan et al. (2015), a cost of 231 billion Ugx. is lost annually at Kampala City abattoir due to liver condemnation, with condemned livers 84% higher than any other organ. Prior to this study, no information had been documented regarding the prevalence of goats' liver fluke infestation in Fort Portal City; a critical knowledge gap that this research directly addresses.

1.3 Objectives of the Study

1.3.1 General Objective

To assess the prevalence of liver fluke infestation in goats slaughtered at Kagote-Kibimba Abattoir in Fort Portal City.

1.3.2 Specific Objectives

- To assess the severity of lesions due to liver flukes on goats' meat liver.
- To determine the percentage of liver fluke-infested goats slaughtered at Kibimba-Kagote Abattoir in Fort Portal City.
- To evaluate the financial loss caused by liver fluke infestation in goats slaughtered for meat in Fort Portal City.

1.4 Hypotheses

Null Hypothesis (H_0): There is no significant prevalence of liver fluke infestation among goats slaughtered at Kagote-Kibimba Abattoir in Fort Portal City.

Alternative Hypothesis (H_1): There is a significant prevalence of liver fluke infestation among goats slaughtered at the Kagote-Kibimba Abattoir in Fort Portal City.

1.5 Significance of the Study

This study carries multidimensional significance spanning public health, veterinary science, economics, and agricultural policy.

Public Health: The study addresses the zoonotic potential of liver fluke, which can be transmitted to humans through contaminated water or food, causing fascioliasis. Identifying infested livers prevents unsafe meat consumption and protects public health.

Veterinary and Livestock Health: The study evaluates the health status of goats, informing targeted interventions such as regular deworming and improved grazing practices. It supports development of effective control measures to enhance livestock productivity.

Economic and Agricultural Value: It quantifies financial losses due to liver condemnations, helping stakeholders recognize the financial impact and encouraging investment in preventive measures. It also contributes to agricultural and regional development by improving goat quality in Fort Portal City.

Scientific Contribution: The study provides baseline data for future research, highlights knowledge gaps, and paves the way for more effective solutions to parasite management in the Rwenzori sub-region.

1.6 Conceptual Framework

The conceptual framework for this study identifies three categories of variables:

Independent Variables (potential influences on liver fluke prevalence) include: (i) environmental factors such as proximity to water bodies and presence of Lymnaea snails; (ii) climate conditions; areas with high rainfall and humidity support propagation of liver flukes; (iii) management practices including free-range versus stall-fed systems, deworming frequency, and access to veterinary care; and (iv) goat characteristics such as age and breed.

Dependent Variables include: (i) the prevalence of liver fluke infestation, assessed through post-mortem examinations; (ii) the severity of liver damage (lesions), ranging from mild fibrosis to severe necrosis; and (iii) economic loss due to condemnation of infested liver tissue.

Extraneous Variables include the geographical source of goats (wetter climates increase exposure), seasonal variation (rainy seasons promote snail proliferation and fluke transmission), and farmers' knowledge and practices regarding disease control and grazing management.

CHAPTER TWO: LITERATURE REVIEW

2.1 Global Status of Goat Production

The domestic goat (Capra aegagrus hircus) is among the small ruminant species widely distributed across the world, with the exception of Antarctica. In 2022, more than 1.1 billion goats were living globally, of which 93% reside in Africa and Asia (World Population Review, 2024). Globally, India leads with 150 million head and China with 132 million, followed by Nigeria with 88 million and Pakistan with 82.5 million. The top producers of goat milk in 2022 were India (6.25 million metric tons), Bangladesh (0.91 million metric tons), and South Sudan (0.52 million metric tons).

Africa raises around 35.7% of global goat production, with a significant concentration of about 60% in the sub-Saharan African region, particularly in countries like Chad and Ethiopia. Goats are kept for meat, milk, skin, and fur. Unlike sheep and cattle, goats are primarily browsers with an extremely varied plant diet, allowing them to adapt to diverse environments. According to FAO (2023), 6.37 million metric tons of goat meat are produced annually from 440 million goats slaughtered worldwide.

2.2 Uganda's Goat Production Status

In 2021, Uganda's goat population was 17.4 million, a 39.4% increase from 12.4 million in 2008. Uganda consists of both indigenous and exotic/cross breeds of goats, comprising 97.2% and 2.8% of the total population respectively (UBOS, 2023). The western region had the highest goat population of 4.6 million (26.3%), followed by the northern region with 4.1 million (23.4%). The Karamoja sub-region had the highest proportion at 15.2%, followed by West Nile (11.5%) and Ankole (11.4%).

2.3 Socioeconomic Importance of Goats

Goat farming in Africa has become a crucial agricultural activity upon which the livelihoods of millions depend. With high adaptive capacity to diverse environments, multiple benefits, and low maintenance requirements, goat rearing has emerged as a practical solution to the socio-economic challenges of Africa (ZamGoat, 2024). Goats are a source of income generation for farmers when sold for meat, milk, and other products and by-products like skins.

Goat milk is nutritionally comparable to human milk, providing important nutrients including Calcium, Potassium, and Vitamin B complex, making it suitable for lactose-intolerant persons and an immune booster for HIV patients (NAGRC&DB, 2023). Goat skin, particularly from the Mubende breed, can produce high-quality leather owing to its hardness and shiny nature (MAAIF, 2023).

2.4 Liver Fluke: Biology and Characteristics

2.4.1 Definition and Classification

Liver fluke refers to a polyphyletic group of parasitic trematodes under the Platyhelminthes phylum (Lotfy et al., 2015). These are cardinal parasites of the liver of various mammals, including humans. They are capable of moving along the blood circulation and can occur in the bile ducts, gall bladder, and liver parenchyma. When in these organs, they produce pathological lesions leading to parasitic diseases. They have complex life cycles requiring two or three different hosts, with free-living larval stages in water (Marshall et al., 2008).

2.4.2 Morphology and Biology

The body of the liver fluke is leaf-like and flattened, covered with a tegument. They are hermaphrodites, possessing complete sets of both male and female reproductive systems. They primarily feed on blood, as they have simple digestive systems. The frontal end consists of an oral sucker that opens into the mouth, which leads to a small pharynx connected to an extended, heavily branched intestine that runs throughout the body length. The anus is absent; instead, the intestine runs along an excretory canal that opens at the posterior end (Valero et al., 2018). Adult flukes reproduce via the excretory pore, and their eggs infect different species of snails as intermediate hosts.

2.4.3 Characteristics of Liver Fluke-Infested Liver

A liver fluke-infested liver exhibits several distinguishing characteristics:

- Pale or Yellow Discoloration: Commonly linked to fat deposition in liver tissue or bile duct obstruction produced by the fluke (Chai et al., 2012).
- Inflamed and Enlarged Bile Ducts: Because adult flukes live and reproduce in the bile ducts, inflammation and ductal dilation are typical complications (Mas-Coma et al., 2017).
- Liver Fibrosis and Scarring: The host's immunological response to the parasite frequently results in persistent inflammation, causing deposition of fibrous tissue and scarring, giving the liver surface a rough, bumpy texture (Espino et al., 2015).
- Liver Haemorrhage: Caused by immature flukes migrating across the liver parenchyma.

2.5 Infection Cycle of Liver Fluke

Fasciola hepatica is traditionally more prevalent in temperate regions, while F. gigantica predominates in tropical areas. Both adult species are morphologically similar, leaf-like hermaphroditic flatworms measuring 20-50mm (F. hepatica) and 24-76mm (F. gigantica). Fasciola spp. parasitize a wide range of domesticated livestock and wildlife including sheep, cattle, pigs, horses, camelids, donkeys, deer, and others (Fiss et al., 2021).

The liver fluke life cycle requires an intermediate snail host for larval development. Adult flukes in the bile ducts release eggs that exit the host through defecation. Under optimal temperature and humidity conditions, eggs hatch and release motile miracidia. Snails of genus Lymnaea, commonly Galba spp. for F. hepatica and Radix spp. are the primary transmitting snail hosts (Mas-Coma et al., 2005). Within the snail, the parasite reproduces asexually, developing from miracidium to sporocyst, then releasing cercariae. A single infected snail can shed over one hundred cercariae within days. Free-living cercariae swim and encyst as metacercaria on aquatic vegetation.

Infective metacercaria ingested by a definitive host activate within the small intestines; newly excysted juveniles (NEJs) cross the intestinal wall into the peritoneal cavity and migrate towards the liver. Extensive haemorrhaging and liver fibrosis result from immature flukes traversing the liver parenchyma. After approximately six weeks, flukes migrate to the bile ducts and mature into adults producing up to 20,000 eggs per day (Moazeni et al., 2016), completing the lifecycle.

2.6 Signs and Symptoms of Fasciolosis in Goats

2.6.1 Acute Fasciolosis

Acute fasciolosis follows relatively short-term high-level intake of metacercaria, typically due to seasonal and climatic conditions combined with a lack of fluke control measures. Animals may exhibit abdominal pain and jaundice. Death is often due to blood loss from liver haemorrhage caused by immature flukes burrowing through the liver (Boray, 2017).

2.6.2 Sub-Acute Fasciolosis

This form is characterized by jaundice and anemia. Due to the burrowing activity of liver flukes, animals experience extensive liver and tissue damage leading to severe haemorrhaging, liver failure, and death within 8–10 weeks (PrimeFact, 2017).

2.6.3 Chronic Fasciolosis

The most common form in sheep, goats, and cattle. When the fluke ingests blood in the bile ducts, severe anemia, chronic inflammation, and enlargement of the bile ducts result. Clinical signs include increasing anemia, loss of appetite, pale mucous membranes, and sub-mandibular oedema (bottle jaw). Affected animals are reluctant to move, and post-mortem examination typically reveals pale, friable liver and enlarged bile ducts packed with adult flukes (Underwood et al., 2015).

2.7 Economic Impacts of Liver Fluke

Fasciolosis is an economically important parasitic snail-borne disease of ruminant animals, with global losses in animal productivity conservatively estimated at over $3.2 billion USD per annum (Kujawa, 2000). These losses are both direct (drug costs, labor, liver condemnation at abattoirs) and indirect (replacement stock costs, reduced production and milk quality, poor growth rates, lower feed conversion rates). In the Lira municipal abattoir in Uganda, 65.7% of examined livers (142 out of 216 animals) were infested, resulting in substantial condemned and destroyed liver, generating significant financial losses for affected farmers.

2.8 Prevalence of Liver Fluke Infections

The focus of fasciolosis research has traditionally been on cattle and sheep. However, between 2006 and 2016, goats experienced the most significant increase in liver fluke infections, with a population growth of 19.3% compared to approximately 7% for both cattle and sheep (FAOSTAT, 2021). Prevalence estimates of fasciolosis in Africa range between 0.28–68.4% and 0.0-47% in Asia (Mehmood et al., 2017). In Chad (central Africa), goats had a prevalence of 12% after post-mortem examination, with the majority having light infections (Jean Richard, 2015). Ethiopia reported caprine fasciolosis prevalence of 13.6% compared to 28.6% in cattle and 20.8% in sheep. A recent study by Joan et al. (2024) at Kampala City Abattoir reported a prevalence of 84%.

2.9 Susceptibility of Goats to Liver Flukes

Although goats are highly susceptible to fluke infections, they have potential capabilities to generate protective immunity towards Fasciola gigantica infections (Martinez et al., 2019). Current studies indicate that caprine infection susceptibility aligns with the high susceptibility of ovine infections rather than the partial resistance observed in bovine infections. The high susceptibility of goats to Fasciola hepatica is due to a lack of fluke rejection during exposure with little evidence for acquired immunity in secondary infections (Martinez et al., 2019).

F. gigantica infections can cause severe pathological and immunohistochemical effects in goats, killing 9 out of 15 goats infected with trickle doses of up to 400 metacercaria (Perez et al., 2019). Studies suggest goats may develop resistance to F. gigantica with at least 50% reduction in parasite burden after approximately 2 prior drug-negated challenges, though this resistance mechanism requires further investigation (Haroun et al., 2017).

2.10 Diagnostic and Control Measures

The identification of eggs in fecal samples has traditionally been used to diagnose fasciolosis, though this approach is only useful for detecting patent infections. Advances in diagnostic techniques, including immunological and molecular methods have improved early detection and differentiation of F. hepatica from F. gigantica. Anthelmintic medicines, particularly triclabendazole, are used extensively to control liver flukes. However, the rise of drug-resistant strains has motivated research into alternate treatments, including vaccinations and natural substances with anthelmintic capabilities (Mas-Coma et al., 2022).

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Research Design

The study utilized a cross-sectional research design to collect data at a single point in time. This design ensured efficiency in determining the prevalence of liver fluke infestation, severity of lesions, financial loss, and prevalence of cysts without requiring follow-up investigations. The cross-sectional approach enabled comparisons across different goat breeds, geographic origins, and lesion severity categories.

3.2 Study Area

The research was conducted at Kagote-Kibimba Abattoir, located in Fort Portal City, Uganda (coordinates: 0.6744°N, 30.2664°E). This abattoir serves as a primary slaughtering facility for Fort Portal City and surrounding districts, with records indicating a consistent influx of goats from the surrounding regions including Mubende, Kyenjojo, Kamwenge, and Kasese districts. Fort Portal City is located in the Rwenzori sub-region of western Uganda, an area characterized by a humid climate and proximity to multiple water bodies, creating conditions that are potentially conducive to the transmission of liver flukes.

3.3 Study Population

The study targeted all goats slaughtered at Kagote-Kibimba Abattoir during the data collection period (two months). Based on abattoir records, an average of 7 goats is slaughtered daily, leading to a study population of approximately 420 goats over the two-month period.

3.4 Sample Size Determination

The sample size was calculated using the Taro Yamane formula:

$$\boldsymbol{n} = \frac{\boldsymbol{N}}{[\mathbf{1} + \boldsymbol{N}(\boldsymbol{E}^{\mathbf{2}})]}$$

Where: n = sample size; N = finite population (420 goats); E = margin of error (0.05 or 5%).

Applying this formula yielded a sample size of 205 goats.

3.5 Sampling Technique

A systematic random sampling technique was used to select goats for examination. Every 2nd goat slaughtered at the abattoir was sampled until the desired sample size of 205 goats was achieved. This method ensured an unbiased and representative selection of the population.

3.6 Data Collection Procedures

Data were collected through direct observation, laboratory analysis, and financial records to meet the study objectives.

3.6.1 Assessment of Lesion Severity

Post-mortem examinations of goat livers were conducted to examine and record the extent of lesions caused by liver flukes. Parameters recorded included lesion size, degree of liver tissue damage, and morphological traits such as discoloration, inflammation, and fibrosis. Lesions were ranked on a severity scale from 1 to 10 cm based on size and degree of tissue damage (less: 1-3 cm; moderate: 4-6 cm; severe: 7-10 cm).

3.6.2 Determination of Prevalence

Livers were examined visually, cut, and palpated to verify the existence of liver flukes. Data on the number of goats with liver fluke infections and the total number slaughtered were recorded. Gross lesions examined for each liver included: discoloration (abnormal color changes such as yellowing or darkening), fibrosis (thickening and scarring), nodules (solid, raised areas on the liver surface), and cysts (round or oval-shaped structures, often fluid-filled). Prevalence was calculated as:

$$\boldsymbol{Prevalence}\ (\%) = \frac{\boldsymbol{Number\ of\ infested\ goats}}{\boldsymbol{Total\ goats\ slaughtered}}\ \boldsymbol{x\ 100}$$

3.6.3 Financial Loss Evaluation

The procedure involved: (i) weighing infested liver tissue to quantify unusable meat; (ii) comparing the weight of infested livers to normal liver weights to estimate losses; and (iii) recording the market value of goat liver to calculate the monetary impact. Financial loss was determined using the formula:

$$\boldsymbol{Financial\ loss} = (\boldsymbol{Average\ liver\ price})\ \boldsymbol{x}\ (\boldsymbol{Weight\ of\ discarded\ livers})$$

3.6.4 Assessment of Cysts

Post-mortem inspections were supplemented with laboratory techniques to detect cysts. Simple sedimentation was used to identify liver fluke eggs and cysts. Samples were examined under a microscope at 10×-40× magnification. Tissue samples were collected from areas with suspected lesions and processed using standard histological techniques: fixation, dehydration, embedding in paraffin wax, sectioning, staining with hematoxylin and eosin, and mounting on slides. Stained slides were examined to identify fluke eggs (small, oval-shaped structures with a characteristic operculum), adult flukes (flatworms with a distinct body shape and oral sucker), and inflammatory cells indicative of host response.

3.6.5 Data Recording

A standardized data collection form was used to record the following information for each goat: identification number, age and sex, weight of the goat, weight of the liver, presence/absence of gross lesions, type and severity of lesions (less, moderate, severe), presence of fluke eggs or adult worms in tissue sections, and estimated financial loss.

3.6.6 Ante- and Post-Mortem Inspection

Ante-mortem inspections were conducted to identify signs of liver fluke infestation, including weight loss, poor appetite, and general weakness. Post-mortem inspection involved visual examination and palpation and incision of livers to identify lesions, discoloration, fibrosis, and presence of cysts or flukes in bile ducts or tissue.

3.7 Materials and Tools Used

The following materials were used during the study:

- Data collection forms, notebooks, and pens
- Weighing scale (for liver weights)
- Protective gear: gumboots and overalls
- Inspection knives (for liver incisions)
- Airtight containers (for fecal sample storage)
- Microscope (minimum 10×-40× magnification)
- Histological materials: paraffin wax, hematoxylin and eosin stains, slides and coverslips

3.8 Data Analysis

Statistical analysis was conducted using SPSS. Three levels of analysis were employed:

Univariate Analysis: Descriptive statistics (means, modes, standard deviations) were used to summarize and visualize data in tabular and graphical formats. Prevalence rates, lesion severity, and financial losses were summarized using percentages, graphs, and tables.

Bivariate Analysis: Chi-square tests were used to compare the prevalence of infestation between different groups (breeds, location of origin, severity levels). Correlation analysis assessed the relationship between the severity of lesions and weight loss.

Multivariate Analysis: Linear regression analysis modelled the impact of liver fluke infestation on financial loss, while logistic regression assessed determinants of liver fluke prevalence.

3.9 Ethical Considerations

The researcher: (i) sought permission from the local authority in charge of the abattoir; (ii) ensured humane handling of animals during the study; (iii) disposed of animal waste and tissue samples in an environmentally friendly manner; and (iv) adhered to all relevant animal welfare guidelines and regulations applicable in Uganda.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents findings on the prevalence of liver fluke infestation in goats slaughtered from Kagote-Kibimba Abattoir in Fort Portal City. Findings are presented in relation to the general and specific objectives, using three levels of analysis: univariate (descriptive statistics), bivariate (associations between variables), and multivariate analysis (modelling relationships between outcomes and predictors). Results are presented using percentages, graphics, tables, and charts.

4.2 Demographic Characteristics

4.2.1 Distribution of Goat Breeds

Three breeds of goats were investigated and observed at the Kagote-Kibimba Abattoir: Ankole goats, Boer goats, and Mubende goats. Mubende goats accounted for the highest proportion (approximately 43.41%) of goats slaughtered, followed closely by Ankole goats (approximately 30.24%) and Boer goats (approximately 26.34%).

Breed	Count (n)	Proportion (%)
Mubende	89	43.41
Ankole	62	30.24
Boer	54	26.34
Total	**205**	**100**

Table 1: Distribution of goat breeds at Kagote-Kibimba Abattoir

The predominance of Mubende goats reflects their significant presence in the western Uganda livestock market, consistent with UBOS (2023) data on the western region's goat population distribution.

4.2.2 Frequency of Locations of Goats' Origin

Goats slaughtered at the abattoir were traced to five major locations. The majority (approximately 38%) originated from Mubende district, followed by Fort Portal City (18%), Kyenjojo (16.6%), Kamwenge (15.1%), and Kasese district (12.2%).

Location of Origin	Count (n)	Proportion (%)
Mubende District	78	38.0
Fort Portal City	37	18.0

Location of Origin	Count (n)	Proportion (%)
Kyenjojo District	34	16.6
Kamwenge District	31	15.1
Kasese District	25	12.2
Total	**205**	**100**

Table 2: Frequency of locations of goats' origin

The high proportion of goats from Mubende district likely reflects established livestock trading routes and the proximity of Mubende's goat-rearing areas to Fort Portal City's market.

4.3 Quantity of Discarded Liver

After slaughter, goat livers were extracted and grossly examined. Livers identified as extremely damaged were weighed and discarded (buried) as unfit for human consumption. Analysis revealed that the majority of discarded livers fell within a range of 0 to 1 kilogram, with the median concentration around 0.5 kilograms. The highest recorded quantity of discarded liver for severely damaged cases was 2.5 kilograms. This indicates that liver fluke infestation predominantly resulted in the discard of relatively small quantities of liver per animal, with the most common quantity being approximately half a kilogram.

4.4 Financial Loss Estimation

The total financial loss from liver condemnations was approximately Ugx. 3,186,000, with an average financial loss of approximately Ugx. 15,541 per goat slaughtered at the abattoir over the two-month study period. This represents a significant economic impact from liver fluke infestations.

Financial Parameter	Value (Ugx.)
Total financial loss (2-month study period)	3,186,000
Average financial loss per goat slaughtered	15,541
Average loss per severely infested goat	30,100
Average loss per moderately infested goat	12,776
Reduction in loss for normal lesions	8,733 (reduction)

Table 3: Estimation of financial loss due to liver fluke infestation

These results relate to Lawrence George Opio et al. (2021), who revealed that one abattoir loses an estimated 38 million Ugx. annually due to condemnation of infested liver. The findings underscore the substantial cumulative economic burden when projected over an annual period.

4.5 Lesion Severity Distribution

Post-mortem examination revealed four categories of liver condition among the 205 sampled goats:

Severity Level	Count (n)	Percentage (%)	Description
Normal	162	79.02	No observable lesions
Less Severe	20	9.76	Lesion size 1-3 cm
Moderate	14	6.83	Lesion size 4-6 cm
Severe	9	4.39	Lesion size 7-10 cm
Total	**205**	**100**	**-**

Table 4: Proportions of lesion severity levels observed

The most common severity level was normal (no lesions), indicating that most goats slaughtered at the abattoir had normally functional livers. However, the 20.98% infestation rate indicates a non-trivial proportion of goats with active liver fluke infection and associated pathology.

4.6 Prevalence of Liver Fluke Infestation

Prevalence assessment based on post-mortem egg detection yielded the following results:

Infestation Status	Count (n)	Prevalence (%)
Infested (Liver Fluke Positive)	43	20.98
Non-Infested (Liver Fluke Negative)	162	79.02
Total	**205**	**100**

Table 5: Summary of prevalence rates of liver fluke infestation in goats

The 20.98% prevalence rate is consistent with findings from comparable studies in the region. Tulu and Lelisa (2016) in Ethiopia reported a comparable prevalence of 21.7% in goats, suggesting that liver fluke infestation may be influenced by similar agro-ecological conditions and intermediate host availability in tropical regions. Ahmad et al. (2020) in Pakistan observed a prevalence of 18.9% in ruminants, reinforcing that moderate prevalence rates are typical in regions with conducive environments for fluke transmission.

These findings contrast with those of Phiri et al. (2005) in Zambia, who reported a higher prevalence of 53.9% in goats attributed to the region's extensive wetland systems. Mas-Coma et al. (2009) in South America documented lower prevalence rates (approximately 8%) in areas with intensive livestock management and effective parasite control strategies. Taha et al. (2023) in Sudan found a prevalence of 42%, underscoring the impact of inadequate veterinary services and poor farm hygiene.

4.7 Association Between Financial Loss, Lesion Severity, and Infestation

The analysis of financial loss in relation to the severity of lesions and infestation status revealed that:

- Goats with severe lesions and infestation incurred the highest per-animal financial loss (UGX 30,100 average).
- Goats with moderate lesions also incurred significant losses (UGX 12,776 average).
- Normal lesions were associated with a reduction in financial loss (UGX 8,733 reduction).
- Goats with less severe lesions but non-infested had the highest total financial loss category (indicating economic impact even without confirmed infestation).

These findings underscore the need for targeted interventions focused on lesion severity reduction, even in the absence of confirmed infestation, as sub-clinical infection and associated liver damage impose meaningful economic costs on the goat value chain.

4.8 Association Between Fecal Consistency and Liver Fluke Infestation

Visual analysis suggested a tentative association between fecal consistency and liver fluke infestation. Goats with soft faeces appeared more likely to be infested, while most non-infested goats had firm faeces. However, a chi-square test found no statistically significant association ($X^2 = 1.22$, p-value = $0.2694 > 0.05$). The null hypothesis was therefore accepted: fecal consistency does not appear to have a significant association with liver fluke infestation in this study population.

4.9 Association Between Goat Breeds and Liver Fluke Infestation

Descriptive analysis revealed that:

- Ankole goats had the lowest infestation rate relative to their non-infested population.
- Boer goats appeared to have a relatively higher proportion of infested individuals compared to other breeds.
- Mubende goats showed a similar trend to Ankole goats but had the highest sampled population.
- Non-infested goats were the majority across all breeds, indicating that liver fluke infestation is not highly prevalent in the sample.

A chi-square test for independence was conducted, yielding statistically significant results ($X^2 = 6.7658$, p-value = $0.3395 < 0.05$), indicating that liver fluke infestation was significantly influenced by goat breed. Boer goats were potentially more prone to infestation than other breeds.

4.10 Association Between Breed, Location of Origin, and Infestation Severity

Heatmap analysis explored the relationship between severity of liver fluke infestation, goat breeds, and locations of origin. Key findings included:

- Mubende district and Fort Portal City recorded higher frequencies of severe infestations, particularly among Mubende and Boer goat breeds.
- Kamwenge and Kasese exhibited fewer severe cases, with most goats showing less or moderate severity levels.
- Kyenjojo displayed a balanced distribution across all severity levels, suggesting more uniform distribution of risk factors.
- Mubende and Boer goats were disproportionately affected by severe infestations in high-risk regions.
- Ankole breed experienced fewer severe cases and was more commonly associated with moderate or less severity, highlighting a potential breed-specific vulnerability differential.

4.11 Factors Influencing Financial Loss: Linear Regression Analysis

A linear regression model was fitted to estimate the relationship between financial loss (response variable) and factors including breed of goat, location of origin, and level of lesion severity. Key results:

Predictor Variable	Coefficient	p-value	Significance
Severe Lesions	+30,100 Ugx.	< 0.001	Highly Significant
Moderate Lesions	+12,776 Ugx.	< 0.001	Highly Significant
Normal Lesions	−8,733 Ugx.	< 0.001	Highly Significant
Kamwenge Origin	+1,951 Ugx.	0.053	Marginally Significant
Goat Breed (all)	-	> 0.05	Not Significant
Location of Origin (others)	-	> 0.05	Not Significant

Table 6: Linear regression results, estimators of financial loss (R^2 = 96.11%, F = 535.4, $p < 0.001$)

The model performed exceptionally well, explaining 96.11% of the variation in financial losses ($R^2 = 0.9611$). The overall model was statistically significant (F-statistic = 535.4, $p < 0.001$), highlighting the robustness of the predictors. Lesion severity was the most influential factor; differences in goat breeds and locations of origin did not result in significant variations in financial losses. These results demonstrate that financial losses are primarily determined by lesion severity, regardless of goat breed or geographic origin.

4.12 Logistic Regression, Prevalence Determinants

Logistic regression was employed to investigate associations between liver fluke prevalence (binary outcome) and predictor variables: goat breeds, location of origin, and fecal consistency.

Predictor Variable	Log-Odds Estimate	p-value	Significance
Intercept (Ankole / Fort Portal / Firm Fecal)	11.7	0.0062	Significant
Boer Goats (vs Ankole)	0.259	0.0792	Not Significant
Mubende Goats (vs Ankole)	7.43×10^6	0.989	Not Reliable (overfitting)
Location Variables (all)	~1	> 0.05	Not Significant
Soft Fecal Consistency	0.589	0.144	Not Significant

Table 7: Logistic regression, assessment of liver fluke prevalence determinants

The model suggests that liver fluke prevalence is significantly influenced by baseline conditions, but the explanatory variables tested (breeds, location of origin, and fecal consistency) show weak or non-significant associations. These results align with Joan et al. (2015), who noted that management practices and environmental factors outweigh breed-specific susceptibility. Conversely, Rana et al. (2014) reported significant breed-related differences in susceptibility in other ruminants, suggesting variability in host-parasite interactions across regions.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

5.1.1 Prevalence and Influencing Factors

The prevalence of liver fluke infestation among goats slaughtered at Kagote-Kibimba Abattoir was 20.98%, a moderate rate indicating a meaningful level of fascioliasis in the Fort Portal City goat supply chain. Logistic regression analysis revealed no strong or statistically significant associations between liver fluke prevalence and goat breed, location of origin, or fecal consistency. The odds of infestation remained highest in the reference categories (Ankole goats, goats from Fort Portal City, and those with firm fecal consistency).

5.1.2 Financial Losses

Financial losses were heavily influenced by the severity of liver lesions. Severe lesions resulted in the highest average financial loss of approximately 30,100 UGX per goat, followed by moderate lesions at 12,776 UGX. Normal lesions were associated with a reduction in financial losses. The linear regression model confirmed that neither goat breed nor location significantly influenced financial loss, with lesion severity accounting for 96.11% of variance in economic outcomes.

5.1.3 Impact of Breed and Location

Although differences in liver fluke prevalence were observed among goat breeds and locations, these factors did not demonstrate statistically significant relationships with financial losses or prevalence rates. Boer goats exhibited a marginally higher susceptibility to infestation, while Mubende goats were most frequently slaughtered at the abattoir.

5.1.4 Overall Economic Implications

The total financial loss attributed to liver fluke infestation over the study period was approximately UGX 3,186,000, representing a substantial economic burden on goat farmers and the local meat industry. Extrapolated over a full year, these losses represent a significant constraint on the goat value chain in Fort Portal City and the surrounding Rwenzori sub-region.

5.2 Recommendations

5.2.1 Enhanced Veterinary Interventions

Veterinary services should intensify efforts to treat and manage liver fluke infestations, particularly focusing on goats presenting severe lesions. Regular deworming programmes using effective anthelmintics, particularly triclabendazole, and periodic liver health check-ups should be implemented to identify and manage infections at an early stage before significant liver damage occurs.

5.2.2 Farmer Education and Capacity Building

Farmers should be educated on recognizing early signs of liver fluke infestation and the importance of maintaining proper grazing practices to avoid contamination by liver fluke larvae. This is particularly relevant in regions prone to infestation, such as areas near water bodies and swampy grazing lands in the Rwenzori sub-region.

5.2.3 Preventive Measures in High-Risk Locations

Given the observed infestation severity in Mubende district and Fort Portal City, local authorities and farmers should prioritize preventive measures, including controlled grazing, fencing off contaminated marshy areas, improving water sources for livestock, and routine snail population monitoring and control to interrupt the Fasciola lifecycle.

5.2.4 Further Research on Breeds and Geographic Variability

Although no statistically significant relationships were found between breeds or location of origin and liver fluke prevalence in this study, future research with larger datasets may uncover subtle trends. Studies focusing on genetic resistance to liver flukes across breeds could guide breeding programmes aimed at improving natural resistance to fascioliasis.

5.2.5 Policy and Institutional Support

Policy-makers should provide subsidies or incentives for veterinary services aimed at controlling liver fluke infestations. Encouraging collaboration between farmers, researchers, and veterinary institutions can help create sustainable, evidence-based solutions. National disease surveillance programmes should be expanded to include caprine fascioliasis in Fort Portal City and other western Uganda abattoirs.

5.2.6 Disposal Guidelines for Affected Livers

Standardized guidelines for disposing of infested livers should be established and enforced at abattoir level to reduce environmental contamination, prevent further spreading of liver fluke larvae into the soil and water, and protect both animal and public health.

5.3 Areas for Further Study

- Longitudinal studies: Long-term investigations into the lifecycle of liver flukes and seasonal variations in prevalence across different regions and breeds.
- Resilience of goat breeds: Comparative studies on breed-specific immunity or genetic resistance to liver fluke infections in the Rwenzori sub-region.
- Efficacy of treatment regimens: Investigating the effectiveness of different anthelmintic protocols in reducing infestation rates and improving overall goat health.

- Role of environmental factors: Assessing the role of pasture contamination, water sources, and climate factors in facilitating the transmission of liver flukes under changing climate conditions.
- Economic modelling: Full value-chain economic impact studies covering not only liver condemnation but also productivity losses, treatment costs, and market price effects attributable to fascioliasis in western Uganda.

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NYABAMU Enterprises Uganda Limited is a premier research and consultancy firm headquartered in Fort Portal City, Uganda. The company specializes in research, agricultural consultancy, environmental assessments, and capacity-building services across the Rwenzori sub-region and beyond.

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This research paper on the prevalence of liver fluke infestation in goats at Kagote-Kibimba Abattoir was conducted by NYABAMU Enterprises Uganda Limited, demonstrating the company's commitment to producing rigorous and practically relevant research outputs.

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