PREVALENCE AND RISK FACTORS OF GASTROINTESTINAL HELMINTHS AMONG RUMINANTS IN VETERINARY TEACHING FARM, UMK BACHOK, KELANTAN

By

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2025

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ABSTRACT

An abstract of the research paper presented to the Faculty of Veterinary Medicine, Universiti Malaysia Kelantan, in partial requirement of the course DVT 55204 – Research Project.

Gastrointestinal helminthiasis is a common infection in ruminants, leading to reduced productivity and increased disease susceptibility. A comprehensive screening of the entire herd has never been conducted although eggs of gastrointestinal parasites have been detected in some ruminant livestock at the Veterinary Teaching Farm, UMK Bachok. A cross-sectional study was conducted in October 2024 to investigate the prevalence, level of infection and risk factors of gastrointestinal parasitic infection among the ruminants in Veterinary Teaching Farm, UMK Bachok. Fecal samples were collected per rectum from cattle (n=16), buffaloes (n=1) and goats (n=16) in the farm. Gastrointestinal parasites were detected by performing the modified McMaster method, which serves the purpose of quantifying the strongyle eggs and oocysts per gram of faeces. The severity of infection was classified as low (0-500), moderate (501-2000), and severe (>2000). Fecal sedimentation was performed to detect the eggs of trematodes. Moreover, the identification and differentiation of infective stage larvae (L3) of the strongyles was carried out by performing fecal culture. Coprological examination reveals overall prevalence of 21.12% (CI = 0.641-22.744). Single infection with *Eimeria* (18.18%; CI =0.020-0.281) has the highest prevalence followed by strongyles (15.15%; CI =0.037-0.312). Coinfection with *Fasciola* spp. and *Paramphistomum* spp. recorded the lowest prevalence at 3.03% (CI = 0.114–0.421). Quantitative analysis revealed that 60% of strongyle infections were at a low level, while 40% were at a moderate level. The risk factors studied were not significantly associated with the prevalence of

gastrointestinal helminthiasis. The L3 of *Haemonchus* sp. and *Trichostrongylus* sp. were identified based on their morphology features. In conclusion, gastrointestinal parasites occur at low levels among ruminants in Veterinary Teaching Farm, UMK Bachok.

Keywords: Gastrointestinal parasites, Fecal sedimentation, McMaster method

ABSTRAK

Abstrak kertas penyelidikan yang dibentangkan kepada Fakulti Perubatan Veterinar, Universiti Malaysia Kelantan, sebagai keperluan sebahagian daripada kursus DVT 5504 – Projek Penyelidikan

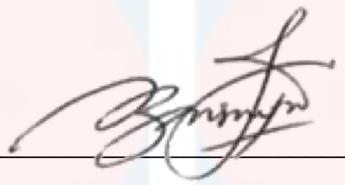
Parasit gastrousus adalah salah satu jangkitan pada ruminan yang boleh menyebabkan kehilangan produktiviti dan peningkatan kerentanan terhadap penyakit. Telur parasit gastrousus pernah dikesan daripada beberapa ekor ruminan di Ladang Pengajar Veterinar, UMK Bachok. Walaubagaimanapun, pemeriksaan yang menyeluruh terhadap keseluruhan kumpulan tidak pernah dijalankan. Kajian keratan rentas telah dijalankan pada Oktober 2024 untuk menyiasat prevalens, tahap jangkitan dan faktor riskio jangkitan parasit gastrosus di kalangan ruminan daripada Ladang Pengajar Veterinar, UMK Bachok. Sampel najis telah dikumpulkan melalui rektum daripada lembu (n=16), kerbau (n=1) dan kambing (n=16). Parasit gastrousus telah dikesan dengan mejalankan modified McMaster method, yang berfungsi untuk mengukur telur strongyles dan oosit setiap gram najis. Tahap jangkitan dikelaskan sebagai rendah 0-500), sederhana (501-2000), dan tinggi (> 2000). Fecal sedimentation dilakukan untuk mengesan telur trematoda. Selain itu, pengenalpastian dan pembezaan larva peringkat infektif (L3) strongyles telah dijalankan dengan melakukan kultur najis. Pemeriksaan koprologi mendedahkan prevalens keseluruhan sebanyak 21.12% (CI = 0.641-22.744). Jangkitan tunggal dengan *Eimeria* (18.18%; CI =0.020-0.281) mempunyai prevalens tertinggi diikuti oleh *Strongyles* (15.15%; CI =0.037-0.312). Koinfeksi dengan *Fasciola* spp. dan *Paramphistomum* spp. mencatatkan prevalens terendah pada 3.03% (CI = 0.114–0.421). Analisis kuantitatif mendedahkan bahawa 60% jangkitan strongyles berada pada tahap rendah, manakala 40% berada pada tahap sederhana. Selain itu, semua jangkitan *Eimeria*

berada pada tahap yang rendah (100%). Faktor risiko yang dikaji tidak banyak dikaitkan dengan kelaziman helminthiasis gastrousus. Larva peringkat infektif (L3) *Haemonchus* sp. dan *Trichostrongylus* sp. dikenal pasti berdasarkan ciri morfologinya. Kesimpulannya, parasit gastrousus berlaku pada tahap rendah dalam kalangan ruminan di Ladang Pengajaran Veterinar, UMK Bachok.

Kata kunci: Parasit gastrosus, Fecal sedimentation, McMaster method

CERTIFICATION

This is to certify that we have read this research paper entitled 'Screening, Identification And Risk Factors of Gastrointestinal Helminths Among Ruminants in Veterinary Teaching Farm, UMK Bachok, Kelantan' by Ding Tian Yang, and in our opinion, it is satisfactory in terms of scope, quality, and presentation as partial fulfillment of the requirements for the course DVT 55204–Research Project.



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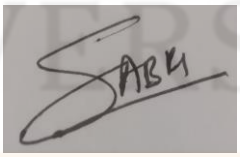

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LIST OF ABBREVIATIONS

spp.	species (plural)
sp.	species (singular)
H	*Haemonchus*
T	*Trichostrongylus*
F	*Fasciola*
P	*Paramphistomum*
M	*Moniezia*
EPG	Eggs per gram
OPG	Oocysts per gram
FEC	Fecal egg count
CI	Confidence intervals
BCS	Body condition score
L1	First stage larvae
L2	Second stage larvae
L3	Infective stage larvae
n	Sample size

CHAPTER 1

1.0 INTRODUCTION

Gastrointestinal helminths infection, also known as helminthiasis, is caused by the infestation of nematodes, trematodes and cestodes in the gastrointestinal tract, by which nematodes and liver flukes infection are common among cattle in South East Asia (Saleha, 1991; Holland et al., 2000). Helminth infection was one of the most important factors of morbidity and mortality among small ruminants in Malaysia (Chandrawathani & Nurul Aini, 2012; Premaalatha B. et al., 2014). In Malaysia, the warm and humid climates throughout the year favors the development of the infective larvae of the gastrointestinal helminths, which are commonly found on the pasture for grazing animals (Geurden et al., 2008; Chandrawathani et al., 2009). More than 15 species of nematodes are described to inhabit the gastrointestinal tract of the cattle, with *Haemonchus* spp. and *Oesophagostomum* spp. as the most common genus in the tropical and subtropical region (Taylor et al., 2007). Severe infection by gastrointestinal nematodes either singly or in combination causes parasitic gastroenteritis (PGE). In Malaysia, the most common species of gastrointestinal nematodes causing PGE are *Haemonchus* spp., and *Trichostrongylus* spp. (Abdullah et al, 2016). Based on a cross-sectional study on the prevalence of helminthiasis among cattle in Terengganu, Peninsular Malaysia, the predominant genus of nematodes identified was *Haemonchus* spp. (81.0%), followed by *Trichostrongylus* spp. (15.0%) and *Oesophagostomum* spp. (4.0%). Meanwhile, based on a study conducted on three farms in Peninsular Malaysia by Dorny et al. (1995), which found out that *Haemonchus contortus* and *Trichostrongylus* spp. were the most important strongyles in goats and sheeps.

Flukes or trematodes are gastrointestinal parasites that infect the ruminants, in many regions throughout the world. Two major types of trematodes commonly infect the ruminants are the liver flukes and rumen flukes. Liver fluke infection, also known as fascioliasis, is one of the most important diseases of cattle, buffalo, sheep and goats (Valero et al., 2009). Fascioliasis in ruminants is caused by two species of liver flukes, which are *Fasciola hepatica* and *Fasciola gigantica*. *Fasciola hepatica* affects sheep and cattle and is widely distributed in Africa, Asia, Europe, Oceania, North and South America (Adarosy et al., 2013). Meanwhile, *Fasciola gigantica* commonly affects cattle and buffaloes in tropical zones, including Malaysia (Adarosy et al., 2013). In Malaysia, fascioliasis was identified in all states of Peninsular Malaysia (Rajamanickam et al., 1996). In a cross-sectional study on prevalence of bovine fascioliasis in Kelantan, the fecal examination revealed 14.6% cattle were positive for *Fasciola* spp. eggs (Ahmad-Najib et al., 2021). On the other hand, based on a study on prevalence of fascioliasis and paramphistomosis among small ruminants in Terengganu (Khadijah et al., 2017), *Fasciola* spp. egg was not detected in any of the fecal samples (n=267).

Rumen fluke infections in large rupfuminants occur worldwide in tropical and temperate regions of Australia, Asia, Africa and Europe (Huson et al., 2017; Pfukenyi & Mukarawatirwa, 2018), which causes significant economic losses (Nazir et al., 2022). The prevalence of rumen fluke infections is high in tropical countries and subtropical countries as the humid and temperate climates which favors the growth of the intermediate host freshwater snails (Gordon et al., 2013). In Asia, there is a high prevalence of rumen fluke infections due to *Paramphistomum* spp. widespread in Southeast Asia (Debbra et al., 2018). Based on a cross- sectional study on prevalence of *Fasciola* spp. and *Paramphistomum* spp. infection among small ruminants in

Terengganu (Mursyidah et al., 2017), 4% (n=267) of the fecal samples were positive with *Paramphistomum* spp. *eggs.*

Ruminants can be co-infected with *Fasciola* spp. and *Paramphistomum* spp. as multispecies parasitism is common in ruminant livestock (May et al., 2019). There are increasing reports regarding ruminant livestock being co-infected by *Fasciola* spp. and *Paramphistomum* spp., which could be due to their similar biological features and intermediate hosts (Yabe et al., 2008). The prevalence of *Fasciola* sp. and *Paramphistomum* spp. co-infection in bovine was 23.7% (n=237) in a cross-sectional study around Taiping, Malaysia (Che-Kamaruddin, 2023).

Other than nematodes and trematodes, gastrointestinal helminthiasis can also be caused by cestodes. At least 12 species of cestodes have been identified in wild and domestic ruminants based on their morphological structure (Diop et al., 2015). Among the 12 species of cestodes, *Moniezia expansa* and *Moniezia benedeni* are the most common tapeworms affecting the ruminants (Guo, 2017). Based on a cross-sectional study of monieziasis in domestic ruminants in Perak, Malaysia as carried out by Veterinary Research Institute, Department of Veterinary Services (Fazly et al., 2021), the coprological examination reveals low cases of cestode infections in cattle (3.69%) and buffaloes (1.10%) from 2010 to 2017. Meanwhile, the prevalence of monieziasis in goats was much higher at 94.10% from 2010-2017 based on the same study.

1.1 RESEARCH PROBLEM STATEMENT

The eggs of gastrointestinal helminths have been detected from the fecal samples of a few ruminants in Veterinary Teaching Farm, UMK Bachok during clinical rotation by the veterinary students. However, screening tests for gastrointestinal helminths have

never been conducted in the herd. It is important to determine the occurrence and prevalence of gastrointestinal helminths among the ruminants as helminthiasis can impact the herd health negatively. Besides that, helminthiasis contributes to economic losses by causing reduced productivity, lower resistance to other diseases, costs of anthelmintics and even mortality in case of severe infection.

1.2 RESEARCH QUESTIONS

1. What is the prevalence of gastrointestinal helminthiasis among cattle, buffaloes and goats in Veterinary Teaching Farm UMK?

2. What are the genera of gastrointestinal helminths that can be isolated and identified from the fecal samples of cattle, buffaloes and goats in Veterinary Teaching Farm UMK Bachok, Kelantan?

3. What are the risk factors associated with gastrointestinal helminthiasis in cattle, buffaloes and goats in Veterinary Teaching Farm UMK Bachok, Kelantan?

1.3 RESEARCH HYPOTHESIS

1. The prevalence of gastrointestinal helminthiasis is low among cattle, buffaloes and goats in Veterinary Teaching Farm, UMK Bachok, Kelantan.
2. *Haemonchus*, *Trichostrongylus*, *Moniezia*, *Fasciola* and *Paramphistomum* are the gastrointestinal helminths that can be isolated and identified from the cattle, buffaloes, and goats in Veterinary Teaching Farm, UMK Bachok, Kelantan.
3. There is an association between the risk factors of age, sex, body condition score, physiological status, immunological status, management system and species with

gastrointestinal helminthiasis in cattle, buffaloes and goats in Veterinary Teaching Farm UMK Bachok, Kelantan.

1.4 RESEARCH OBJECTIVES

1. To determine the prevalence of gastrointestinal helminths among cattle, buffaloes and goats in Veterinary Teaching Farm, UMK Bachok, Kelantan.

2. To identify the genus of gastrointestinal helminths that can be isolated from the fecal samples of cattle, buffaloes and goats in Veterinary Teaching Farm UMK Bachok, Kelantan.

3. To investigate the association between the risk factors and occurrence of gastrointestinal helminthiasis among cattle, buffaloes and goats in Veterinary Teaching Farm, UMK Bachok, Kelantan.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 HAEMONCHOSIS

Haemonchus spp. is a genus of parasitic nematodes belonging to the family of Strongylidae, which affects cattle, sheep, goats and other wild ruminants. In domestic ruminants, four species of *Haemonchus* spp. genus are recognized: *Haemonchus contortus* (Rudolphi, 1803) found in sheep and goats; *Haemonchus placei* (Place, 1893) found in cattle and *Haemonchus longistipes* (Hussein, 1909) found in camels. Cattle are more commonly affected by *H. placei* while *H. contortus* mainly infect sheep and goats. However, there is increasing evidence that these two different species are the single species of *H. contortus* with only strain adaptation for cattle and sheep (Coop et al., 2016). Grossly, fresh specimens of adult females have white ovaries winding spirally the blood-filled intestine, giving them a "barber's pole" appearance (Coop et al, 2016). *Haemonchus* spp. has a direct life cycle, which consists of two phases: an exogenous phase characterized by development of eggs to larval L3 stage in the environment (pasture) and an endogenous phase inside the host manifested by development from L3 to adults (Jacquiet, 1997). The endogenous phase begins excretion of eggs with the feces into the pasture by the final host, by which the eggs hatch into free-living first stage larvae, L1 with favorable environmental conditions, which is high temperature and humidity between 25 and 30°C (Urquhart et al., 1996). L1 larvae then molts into free-living second stage larvae, L2 and subsequently the infective stage larvae, L3 in a period as short as 5 days but may delay for weeks and months under cool environments. The initiation of exogenous phase is followed by ingestion of infective stage L3 by a final host, by which the larvae undergo exsheathment in the rumen and released from the

sheath by the chemical composition and the pH of abomasum (Hertzberg et al., 2002). The infective L3 then penetrates into the glands of the abomasal mucosa, mainly in the fundal region where they molt into L4 and eventually into L5, which is the adult stage.

Pathogenicity of haemonchosis is associated with the blood sucking habits of the worms, causing acute hemorrhagic anemia, by which massive infection results in rapid fatality (Hoste et al., 1997). Intramucosal phase of the larvae and hematophagous feeding of the adults via their piercing lancet, causing local traumatic injury to the gastric wall. Damages to the gastric wall disrupt the abomasal digestive functions, which results in reduced dietary protein degradation, malabsorption, weight loss and can lead to secondary bacterial infection (Sylvestre & Cabaret, 2001).

2.2 TRICHOSTRONGYLOSIS

Trichostrongylus spp. also belongs to the family of Strongylidae that affects cattle, goat, sheep and other ruminants, by which *Trichostrongylus axei* and *Trichostrongylus colubriformis* are the species infecting the cattle, goats and sheep. Adults of *Trichostrongylus* spp. are small, light brownish red and hair-like, giving them the name of "hairworm" (Coop et al, 2016). *Trichostrongylus* spp. have direct lifecycle as there is no involvement of intermediate hosts for completion of the life cycle. Adult females lay eggs in the host's intestine and excrete the eggs into the environment via the feces. With suitable environmental conditions (warm and humid), the eggs hatch into L1 and molts twice into the infective larva stage (L3) in 5 days and may remain viable in the environment for up to 6 months (Levine & Anderson, 1973). Cattle becomes infected via ingestion of infective L3 during grazing, by which L3 ex-sheath and releases into the stomach lumen. In the abomasum, infective L3 of *T. axei* penetrates the wall of abomasal lining and molts twice into the adult worms. Meanwhile, L3 of *T. colubriformis* migrates

to the small intestine and penetrates the intestinal mucosa, by which they form subepithelial tunnels and molt into L4 (Shaw et al., 2003). The subepithelial tunnels then rupture and release L4 into the small intestinal lumen, molting into the L5 adult stage.

Pathogenicity of *Trichostrongylus* spp. is contributed by the penetration and damage to the lining of the abomasum and small intestine. Rupture of subepithelial tunnels during liberation of the L4 causes considerable damage to the intestinal mucosa, resulting in enteritis. Meanwhile rupture of the subepithelial tunnels also cause hemorrhage, and loss of plasma protein into the intestinal lumen, resulting in hypoalbuminemia and hypoproteinemia and lead to edema (Coop, 2016). Heavy infestation is characterized by diarrhea and increased intestinal epithelium turnover rate, leading to impairment of protein metabolism for growth, which can be reflected by weight loss of the affected animals (Coop, 2016).

2.3 FASCIOLOSIS

Liver fluke infection affects sheep, goats, cattle and buffaloes, which is mainly caused by two species, *Fasciola hepatica* and *Fasciola gigantica* (Valero et al., 2009). The *F. gigantica* is more common in large ruminants whereas *F. hepatica* is more common in small ruminants. Both species have a complex life cycle which involves a carrier such as aquatic plants, intermediate host for the development into cercariae, and final host by which the flukes attain sexual maturity (Ahmad-Najib et al., 2021). The most common intermediate hosts for *F. gigantica* are *Radix natalensis* and *Radix auricularia*; whereas intermediate hosts for *F. hepatica are* lymnaeid snails (Cwiklinski et al., 2016). Infective hosts excrete the *Fasciola* spp. eggs within their feces into the water bodies, by which the eggs hatch into larval stage of miracidia in 7-15 days provided with optimal temperature and humidity (Junquera, 2022). The miracidia swims actively and locates

the suitable intermediate hosts via chemotaxis, followed by penetration of the intermediate hosts (Howell et al., 2020). Once inside the snail's body cavity, miracidia develop into sporocysts, which in turn give rise to up to 200 rediae whilst each rediae produces about 20 cercariae (Howell et al., 2020). Cercariae leaves the snails, which encysts onto vegetations or water surface and develops into the infective stage, metacercariae (Howell et al., 2020). Cattle and buffaloes become infected via ingestion of the infective metacercariae. Enzymatic action of pepsin in abomasum and trypsin in small intestine weakens the cyst wall, allowing emergence of immature flukes from the cysts. Within a few hours, the immature flukes cross the intestinal wall and migrate towards the liver through the peritoneal cavity (Junquera, 2022). After reaching the liver, the juvenile flukes migrate through the hepatic parenchyma towards the biliary duct for up to 6-8 weeks (Junquera, 2022; Howell et al, 2020). Once in the biliary duct, the juvenile flukes complete development into sexually mature adult flukes, by which the reproduction cycle begins and new eggs are produced and shed into the feces via the bile (Dixon, 1966). The adults of *F. hepatica* are leaf-shaped, gray brown and are around 2.5-3.5 cm in length and 1.0 cm in width. On the other hand, adult *F. gigantica* is larger than *F. hepatica*, reaching up to 7.5 cm in length and 1.5 cm in width (Coop et al, 2016).

Migration of immature flukes through the liver parenchyma causes considerable amount of tissue damage, which is associated with hemorrhage and fibrosis (Coop et al, 2016). Meanwhile, damage to the biliary mucosa is attributed by the hematophagic activity of the adult flukes and their cuticular spines, which results in thickened bile ducts and cholangitis with hyperplasia of the biliary epithelium (Williams 2020; Coop et al, 2016). Moreover, juvenile and adult flukes feed by producing protease which degrades blood and liver parenchyma (Williams 2020).

2.4 PARAMPHISTOMOSIS

There are several genera of rumen flukes such as the *Paramphistomum* spp., *Cotylophoron* spp., *Bothriophoron* spp., *Orthocoelium* spp., and *Giganocotyle* spp., by which ruminants are most commonly infected by *Paramphistomum* spp. (Coop et al., 2016). Similar to *Fasciola* spp., *Paramphistomum* spp. has a complex life cycle that involves aquatic vegetations, intermediate hosts and definitive hosts. The intermediate hosts for *Paramphistomum* spp. consist of various genus of freshwater snails such as the Planorbis, Bulinus, Lymnaea, Galba, and Gyraulus (Coop et al., 2016). Following excretion of *Paramphistomum* eggs with the feces into the water bodies, the eggs hatch into miracidia over a period of 12-21 days, releasing miracida into the environment, under suitable environmental temperatures and humidity (Bhatia et al., 2016; Hajipour et al., 2021). Within 24 hours, motile miracidia swims and searches for suitable freshwater snails as intermediate hosts, by which the miracidia locate and penetrates soft tissue of the snails via innate behavior, chemotaxis or random chance (Tandon et al., 2014). Once inside the snail's body cavity, miracidia undergo three developmental stages, which are sporocysts, rediae and cercariae. Under stimulation by strong sunlight, the mature cercariae is released from the snail, by which they attach to vegetations and encyst into metacercariae, remaining viable for up to 6 months (de Waal, 2010). Infection ensues following ingestion of the infective metacercariae by the definitive hosts, with excystment takes place in the small intestine, and immature flukes attach to the intestinal mucosa, by which they feed aggressively and migrate towards the rumen within the period of 3 to 6 months (de Waal, 2010). Once within the rumen, the juvenile flukes attach to the papillary surface of the rumen and undergo maturation into adults and begin to lay eggs (Taylor et al., 2007). Grossly, adult *Paramphistomum* spp. are small, conical

or pear shaped, maggot-like about 1.0 cm long and light red in color when fresh (Coop et al., 2016).

The pathological and anatomical changes are associated with the migration pathway of the juvenile flukes in the small intestine and abomasum, and also the attachment sites in the rumen. Immature fluke causes catarrhal to necrotic inflammation of the small intestine, with thickening and ulceration following 9 days exposure to infected pasture (Chaudhry et al., 2017). Adult *Paramphistomum* sp. is non-pathogenic and harmless as proposed by many studies, but some experimental studies have shown that it is associated with ruminal papillae atrophy and ulceration at the attachment site in the cases of heavy infestation (Fuertes et al., 2015).

2.5 MONIEZIASIS

Moniezia sp. is a cestode belongs to the family of Anoplocephalidae, which is one of the most important helminth diseases of domestic and wild ruminants (Shangaraev et al., 2018), with *Moniezia expansa* found in sheep and goat while *Moniezia benedeni* found in cattle and buffalo. Grossly, *Moniezia* sp. is long and wide, and may attain length of up to 600 cm, by which the segment is broader than long with two sets of genital organs visible along the lateral margin of each segment (Coop et al., 2016). *Moniezia* sp. has an indirect life cycle as there is involvement of an intermediate host for the completion of the life cycle. Eggs are shed with the feces from the final host into the pasture, which are protected in proglottids. These proglottids are then ingested by the intermediate hosts, namely the oribatid mites; by which the eggs reach the gut of the mite within one day to prevent desiccation (Yadav et al., 2019). The oribatid mites feed on the mites by breaking the egg shell using their chelicerae and ingest the oncosphere, or the developing embryo. Following ingestion, the oncosphere penetrates the midgut wall and develops into

cysticercoid in about one to four months (Urquhart et al., 1987). Cattle become infected following ingestion of oribatid mites with the grasses or forages, by which the cysticercoids are released into the small intestinal lumen once the mites are digested. Cysticercoids then attach to the wall of the small intestine by which they grow and mature into adults in about 5-6 weeks (Soulsby, 1982). Adult *Moniezia* spp. begin to release egg filled proglottids with rice grain like appearance that passed in the host's feces (Deepak et al., 2020). Generally, light infection causes little pathogenic significance, which causes delayed growth and development in young animals and reduced productivity in adults (Abdelhamid et al., 2021). Meanwhile, heavy infestation causes unthriftiness, diarrhea and even intestinal obstruction as indicated in several reports from eastern Europe and New Zealand (Coop et al., 2016).

2.6 DIAGNOSIS OF GASTROINTESTINAL HELMINTHS BY COPROLOGICAL EXAMINATION

The diagnosis of gastrointestinal helminths can be carried out via detection of the helminth eggs from the fecal samples via coprological examination. The eggs of nematodes and cestodes can be detected via simple floatation technique, with the principle of suspending the parasitic ova in a liquid with specific gravity higher than of the eggs, allowing the eggs to float on the surface (Coop et al, 2016). Under microscopic examination, *Haemonchus* spp. eggs appear as regular broad ellipses with barrel-shaped side walls and contain 16-32 blastomeres (Coop et al, 2016; Junquera, 2022). *Trichostrongylus* spp. eggs are irregular ellipses in shape with a thin shell and embryonated when shed (Junquera, 2022). Meanwhile, *M. expansa* eggs are triangular in shape with well-developed pyriform apparatus while *M. benedeni* eggs are square-shaped with well-developed pyriform apparatus.

On the other hand, a simple flotation technique is not suitable for the detection of trematode ova as they are heavier with higher specific gravity, which sinks to the bottom of the suspension instead of floating. Among the coprological tests, fecal sedimentation methods are the most accurate for detecting eggs of the trematodes in the feces (Horak, 1971). Under microscopic examination, trematodes eggs are oval, large and have an operculum at one end. *Fasciola* spp. eggs are brownish in color with operculum at the blunt end, and slightly larger in size (Deplazes et al, 2020). On the other hand, *Paramphistomum* spp. eggs are light gray to greenish in color and appear to be transparent, with the operculum at the sharp end (Coop, 2016).

McMaster technique is the most widely used method for counting helminth eggs in the fecal samples (Azima et al., 2020). McMaster technique is a quantitative technique used to estimate worm burdens by counting the number of eggs or larvae per gram of feces (Coop et al., 2016).

2.7 RISK FACTORS OF GASTROINTESTINAL HELMINTHIASIS

There are numerous risk factors that contribute to the occurrence of gastrointestinal helminthiasis, which includes age, sex, climatic conditions, body condition score and management systems (Olkeba et al., 2016). Age of the host is one of the risk factors of gastrointestinal helminthiasis among the ruminants. The exposure and pathogenicity of gastrointestinal helminthiasis are greater in young animals as compared to adults (Pfukenyi et al., 2007). However, several studies noted incidence of gastrointestinal helminthiasis increases with age (Qureshi et al., 2009). Differences of prevalence of gastrointestinal helminthiasis among different age groups may be related to animal's immunological status, variations in grazing area, and management practices (Regassa et al, 2006).

Higher prevalence of gastrointestinal helminths in cattle with poor body condition score as compared to those with favorable body condition score (Etsehiwot 2004; Cheru 2014). Poor body condition score is associated with weaker immunity, which makes such animals to be more susceptible to parasitic infection (Gunathilaka et al, 2018).

Female goats had higher prevalence of gastrointestinal parasitic infections as compared to males (Jesse et al., 2020). The prevalence of helminths in male and female cattle is similar, with females having a slightly higher likelihood of being infected with helminths (Olubukola et al., 2014). Some evidence shows male animals are more susceptible than females to helminth infections (Coop et al., 2016).

Physiological status is associated with the immune status of the animal. Animals during late gestation or lactation are more susceptible to gastrointestinal parasitic infection due to periparturient relaxation of immunity (Coop et al., 2016).

The cattle that are reared in an extensive management system has markedly high prevalence of gastrointestinal parasites as compared to semi-intensive management systems (Tiele et al., 2023). Under an extensive management system, ruminants have higher risk of acquiring gastrointestinal parasitic infection via ingestion of contaminated pastures (Keyyu et al., 2006).

Species differences can also affect the occurrence of gastrointestinal helminthiasis among the ruminants. Cattle are more tolerable to fascioliasis as compared to sheep which could cause severe disease and even death (Coop et al., 2016). Goats appear to be much more susceptible to *Trichostrongylus* spp. infection as compared to cattle and sheep (Coop et al., 2016)

CHAPTER 3

3.0 MATERIALS AND METHODS

3.1 ETHICAL CONSIDERATIONS

Ethical approval for using animals in the current study was applied from the Animal Ethics Committee of the Universiti Malaysia Kelantan (UMK/FPV/ACUE/FYP/008/2024).

3.2 STUDY DESIGN

This study employed a cross-sectional survey design to collect samples and essential management data simultaneously during farm visits. The Veterinary Teaching Farm at UMK Bachok was visited in October 2024, to collect fecal samples and gather management-related information. Prior to sampling, each animal underwent a physical examination to determine its age, sex, and body condition score (BCS). Age determination for caprine species was based on dentition, categorizing them as young (<1 year old) or adult (>1 year old). For bovine species, age groups were classified as young (<2 years old) or adult (>2 years old). The BCS was evaluated through visual inspection of the ribs, hip bones, and paralumbar fossa. Animals were then categorized into five BCS groups: emaciated (1), thin (2), average (3), fat (4), or obese (5) (Roche et al., 2009; Ghosh et al., 2019).

3.3 SAMPLE COLLECTION & PREPARATION

A totalof 33 fecal samples were collected per rectum from cattle (n=16), buffaloes (n=1) and goats (n=16) in the Veterinary Teaching Farm, UMK Bachok. Each Each goat was first

restrained by straddling it in between the restrainer's legs whereas cattle and buffaloes were restrained within a chute. The fecal samples were then collected with a lubricated, gloved hand, by inserting the index and middle fingers into the goat's rectum while a few fingers were used to collect the fecal samples from the cattle's rectum. Adequate amount of fecal samples was evacuated and transferred into labeled containers or gloves, which was then stored in a polystyrene box filled with shredded ice. The samples were transported to the Parasitology Laboratory, Faculty of Veterinary Medicine, UMK within the same day of sampling.

3.4 COPROLOGICAL PROCEDURES

3.4.1 FECAL SEDIMENTATION

Before starting the procedure, all of the apparatus and equipment required (e.g. plastic containers, pasteur pipettes, weighing balance, spatula, tea strainers, falcon tubes, methylene blue, glass slides, coverslips), were prepared beforehand. The procedure begins with weighing approximately 3 grams of feces into Container A followed by pouring 50 mL of tap water into Container A. The feces and water will be mixed thoroughly using a spatula. After that, the fecal suspension will be filtered through a tea strainer into Container B. The resultant filtered material in Container B is poured into a conical flask, by which the filtrate is allowed to sediment for about 5 minutes until the supernatant becomes clearer. The supernatant is then discarded to allow separation from the sediment. The conical flask with the sediment will be refilled with tap water, allowing the filtrate to sediment again for another 5 minutes until the supernatant is clearer. This is continued until the supernatant becomes crystal clear. Once a crystal-clear supernatant is obtained, the supernatant will be

discarded, leaving the sediment. Few drops of methylene blue are added to stain the sediment. A small drop of stained sediment is then transferred onto a microscopic slide by using a pipette and covering the droplet with a coverslip. This is followed by examination of the sediment by using a compound microscope for detection of trematode ova.

3.4.2 MODIFIED MCMASTER METHOD

This method is modified from the original McMaster method by Gordon and Whitlock (1939). Before starting the procedure, all of the apparatus and equipment required (e.g. plastic containers, pasteur pipettes, weighing balance, spatula, tea strainers, falcon tubes, saturated sodium chloride, McMaster slides) were prepared beforehand. Firstly, 3.0 g of feces was weighed and placed into Container A. 10 mL of saturated NaCl solution is added into Container A. The feces was broken up using a spatula. 35 mL of saturated NaCl solution was added into Container A. The fecal suspension was stirred with a spatula. The fecal suspension was filtered through a tea sieve into Container B. The filtrate in Container B was stirred and an aliquot was withdrawn with a pipette. The aliquot was pipetted to fill a chamber of McMaster slide. The filtrate was stirred again, an aliquot was again pipetted and another chamber of McMaster slide was filled. The slide was allowed to stand for 2-3 minutes. The McMaster slide was then examined under a compound microscope. The grid of the McMaster slide was focused under 4X magnification and switched to 10X magnification. Only the eggs within the McMaster grids were identified and counted, while ignoring the eggs outside of the grids.

3.4.3 CALCULATION AND INTERPRETATION OF THE MODIFIED MCMASTER METHOD

The eggs that were counted within the grids of both the chambers were calculated using the formula below to obtain the number of egg per gram (EPG) or oocyst per gram (OPG) of feces.

Egg per gram of feces = $\frac{Total\ number\ of\ eggs\ counted}{Weight\ of\ feces}\ x\ \frac{Volume\ of\ NaCl}{2(0.15)}$

Table 1. Severity of gastrointestinal parasites infection

Fecal egg count (EPG/OPG)	Severity of infection
0-500	Low level of infection with no clinical signs.
501-2000	Moderate level of infection
>2000	High level of infection

(Chandrawathani et al., 2014)

3.4.4 FECAL CULTURE

3.4.4.1 PREPARATION OF FECAL CULTURE

Before starting the procedure, all of the apparatus and equipment required, such as spatula, mortar and pestles, distilled water, containers and gauze, were prepared beforehand. Firstly, the leftover feces were broken with mortar and pestles until it has a crumbly mix consistency. The feces were then transferred into a container, which was then packed in the container with a gloved hand. The fecal culture was covered with a piece of gauze and tightened with a rubber band. The fecal culture was stored at room temperature for 7 days in a dark area. The fecal culture was checked daily and sprinkled the fecal culture with distilled water when it appeared dry.

3.4.4.2 HARVESTING OF L3

The gauze covering the fecal culture was removed on the 7th day. The distilled water was heated until 40 °C by using a digital hot plate. The container was then filled with lukewarm distilled water until a meniscus is formed. The container was covered with a petri dish and invert. After that, the petri dish was filled with lukewarm distilled water and allowed to stand for 30 minutes for L3 migration from the culture. After 30 minutes, the distilled water containing L3 was pipetted into a specimen bottle or falcon tube. The specimen bottles containing the L3 stock were stored in a fridge at 4 °C.

3.4.4.3 DIFFERENTIATION OF L3

The L3 was pipetted from the specimen bottle into a petri dish, which was then examined under a stereomicroscope. Under the stereomicroscope, L3 can be seen swimming in the

distilled water. L3 was killed by adding a few drops of Lugol's iodine. A drop of killed L3 was then pipetted onto a glass slide and covered with a coverslip. The glass slide was observed under the microscope for the morphology of L3. The L3 were identified based on the morphology described in the Manual of Veterinary Parasitological Laboratory Techniques provided by Ministry of Agriculture, Fisheries and Food of Great Britain (1986).

3.5 STATISTICAL ANALYSIS

The prevalence of gastrointestinal parasites and their corresponding 95% confidence intervals (CI) were calculated using EpiTools® statistical calculators. Data were organized in Microsoft Excel® and analyzed using the Statistical Package for Social Sciences (SPSS) software, version 16.0. A univariable analysis was conducted using the Fisher's exact test to assess risk factors, with a significance level set at 5% ($p < 0.05$). The status of parasitic infection served as the dependent variable, while epidemiological factors were considered independent variables.

CHAPTER 4

4.1 OVERALL PREVALENCE OF GASTROINTESTINAL PARASITES DETECTED AMONG RUMINANTS FROM VETERINARY TEACHING FARM, UMK BACHOK

The qualitative fecal analysis revealed 21.12% (CI = 0.641-22.744) overall prevalence of gastrointestinal parasitic infection among ruminants examined in Veterinary Teaching Farm, UMK Bachok. There was a 35.3% prevalence among bovine, which is higher than that of caprine at 12.5%. Single infection of *Eimeria* spp. has the highest prevalence (18.18%, CI = 0.020-0.281), which is followed by single infection of strongyles (15.15%, CI = 0.037-0.312). Mixed infection of strongyles and *Eimeria* (12.12%, CI = 0.056-0.343) was also detected.

Coinfection of *Fasciola* spp. and *Paramphistomum* spp. has the lowest prevalence (3.03%, CI = 0.114-0.421). Figure 1 shows the eggs of *Fasciola* and *Paramphistomum*. The distinct differences between these parasites' eggs were the shape, colour and size. *Fasciola* egg is golden to yellowish brown in colour, rounded shaped and is slightly larger in size. Meanwhile, *Paramphistomum* egg is light gray or transparent, more oval in shape and slightly smaller in size.

Table 2. Overall prevalence of parasitic infection among ruminants in the Veterinary Teaching Farm, UMK Bachok

Variables	Tested (n)	Positive	Prevalence (%)	95% CI
Bovine	17	5	35.3	0.083-1.506
Caprine	16	2	12.5	0.909-2.011
Overall/ Total	33	7	21.12	0.641-22.744

n=33, CI = 95% confidence interval

Table 3. Prevalence of gastrointestinal parasite infections among ruminants in the Veterinary Teaching Farm, UMK Bachok

Categories of Infection	Positive	Prevalence (%)	95% CI
Strongyles	5	15.15	0.037-0.312
Eimeria	6	18.18	0.020-0.281
Coinfection of trematodes (*Fasciola* and *Paramphistomum*)	1	3.03	0.114-0.421
Co-infection of strongyles and *Eimeria*	4	12.12	0.056-0.343

CI = 95% confidence interval

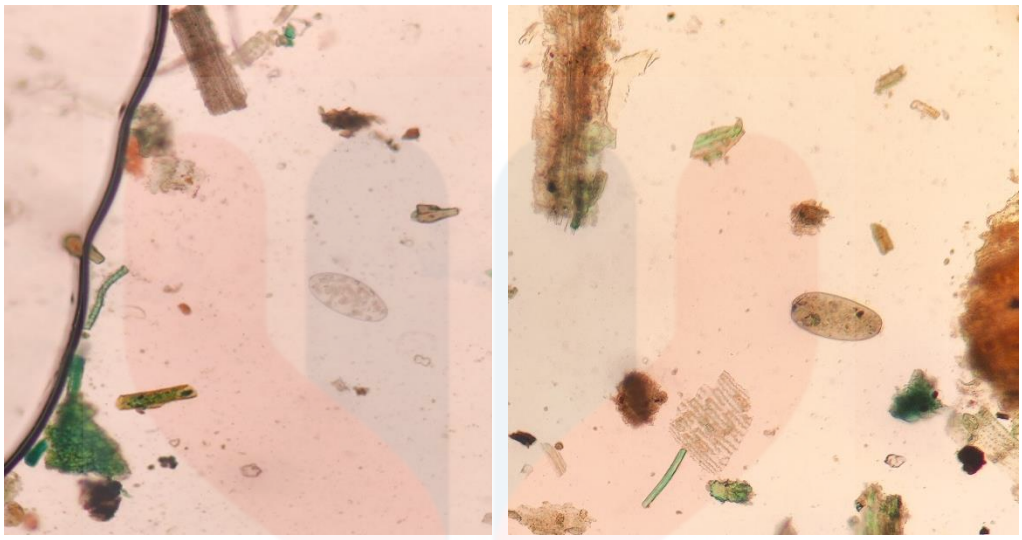

Figure 1: *Paramphistomum* sp. egg (left), *Fasciola* sp. egg (right) at 10x magnification

4.2 SEVERITY OF PARASITIC INFECTION AMONG RUMINANTS FROM VETERINARY TEACHING FARM, UMK BACHOK

Quantitative fecal analysis showed that among the 5 animals (15.15%) positive for strongyles, 60% exhibited a low level of infection, while 40% had a moderate level of infection. Notably, both animals with moderate infection levels were bovines. Similarly, the analysis revealed that all 6 animals (18.18%) positive for *Eimeria* had a low level of infection.

Table 4. Severity of strongyle infections among ruminants in the Veterinary Teaching Farm, UMK Bachok

Egg per gram (EPG)	Prevalence (%)	95% CI
Low infection (0-500 EPG)	60%	
Moderate infection (501-2000 EPG)	40%	0.815-3.409
High infection (>2000 EPG)	0	

CI = 95% confidence interval

Table 5. Severity of *Eimeria* infections among ruminants in the Veterinary Teaching Farm, UMK Bachok

Oocyst per gram (OPG)	Prevalence (%)	95% CI
Low infection (0-500 OPG)	100%	
Moderate infection (501-2000 OPG)	0	-
High infection (>2000 OPG)	0	

CI = 95% confidence interval

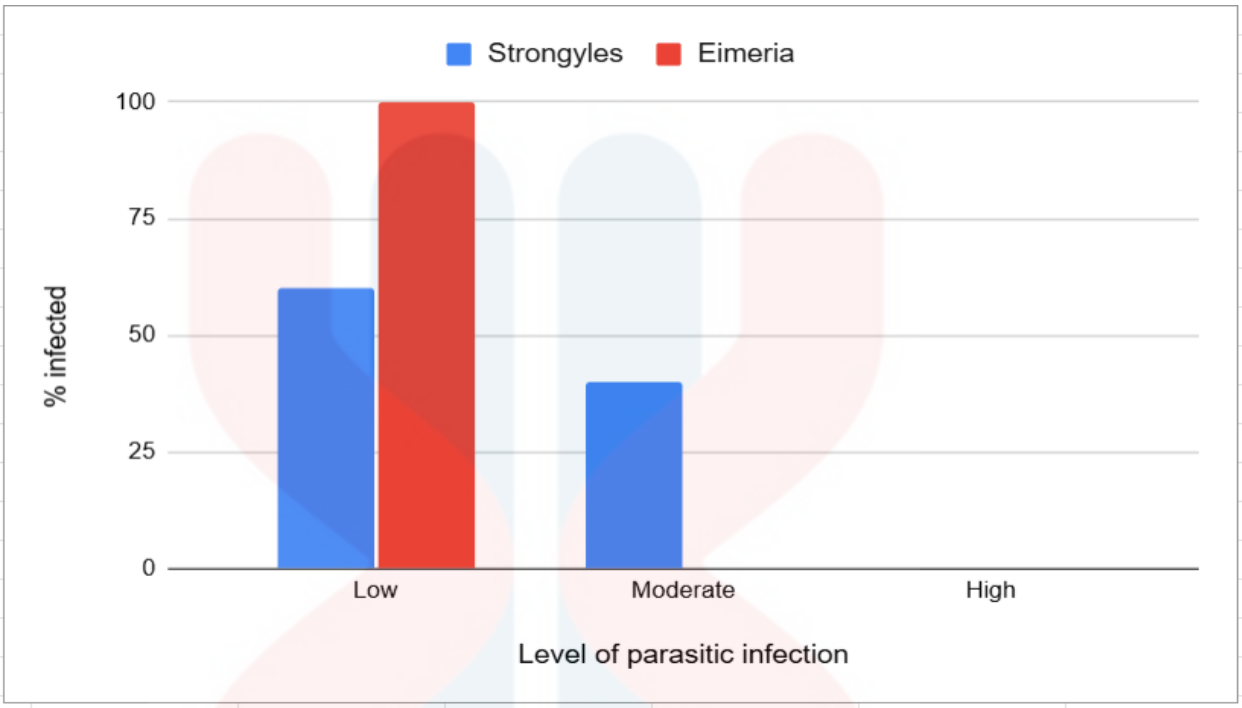

Figure 2. Prevalence of different severity levels of parasitic infection among ruminants in the Veterinary Teaching Farm, UMK Bachok

4.3 RISK FACTORS OF GASTROINTESTINAL PARASITIC INFECTION AMONG RUMINANTS FROM VETERINARY TEACHING FARM, UMK BACHOK

The results of the analysis shows that species (x^2 = 2.332, p = 0.225), age (x^2 = 0.259, p = 0.673), sex (x^2 = 1.011, p = 0.366), and body condition score (x^2 = 6.653, p = 0.053) were not associated with the risk of parasitic infection among the ruminants from Veterinary Teaching Farm, UMK Bachok.

Table 6. Risk factors of parasitic infections among ruminants from Veterinary Teaching Farm, UMK Bachok

Variables	Tested (n)	Positive	Prevalence (%)	x^2	p-value	Odd ratio	95% CI
Species							
Caprine	16	2	12.5	2.332	0.225	3.818	0.641-22.744
Bovine	17	6	35.3				
Age (years)							
Young (< 2)	10	3	30.0	0.259	0.673	0.648	0.121-3.466
Adult (> 2)	23	5	21.7				
Sex							
Female	25	5	20.0	1.011	0.366	2.400	0.423-13.601
Male	8	3	37.5				
Body condition score							
Thin (2)	2	2	100				
Average (3)	31	6	19.5	6.653	0.053	5.167	2.519-10.599
Fat (4)	0	0	0				

n = 33, CI = 95% confidence interval

4.4 IDENTIFICATION AND DIFFERENTIATION OF INFECTIVE STAGE LARVAE (L3) OF GASTROINTESTINAL NEMATODES AMONG RUMINANTS IN VETERINARY TEACHING FARM, UMK BACHOK

Infective stage larvae (L3) of two genus of strongyles are identified from the fecal culture, namely *Haemonchus* sp. (Figure 3) and *Trichostrongylus* sp. (Figure 4). The distinct differences between these two parasites are based on the shape of their head and the length of their sheath tail. The L3 of *Haemonchus* sp. has a narrow head with a medium length sheath tail, which is kinked. On the other hand, L3 of *Trichostrongylus* sp. has a more rounded head with a shorter sheath tail as compared to the L3 of *Haemonchus* sp.

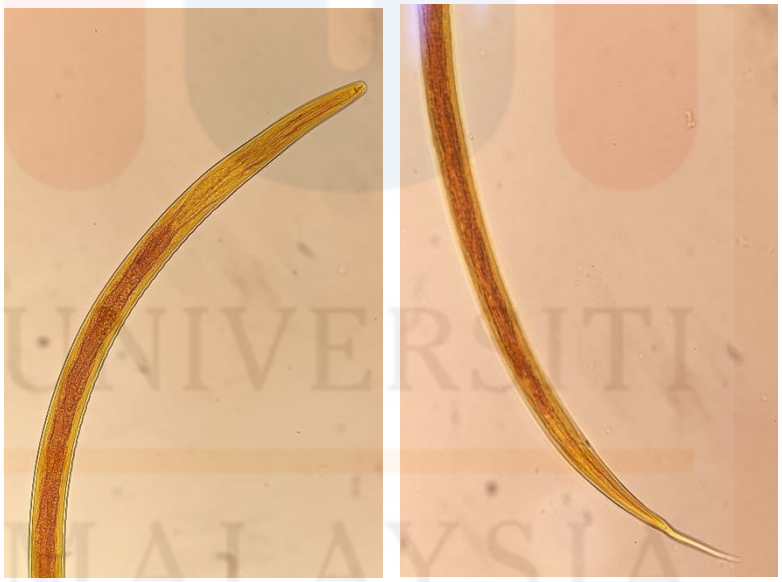

Figure 3. Infective stage larvae (L3) of *Haemonchus* spp. from bovine fecal sample at 40x magnification

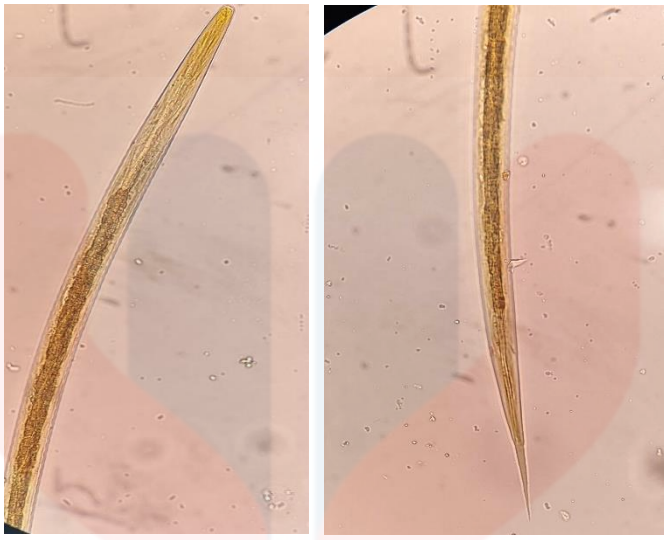

Figure 4. Infective stage larvae (L3) of *Trichostrongylus* spp. from bovine fecal sample at 40x magnification

CHAPTER 5: DISCUSSION

At the outset of this study, it was hypothesized that gastrointestinal helminths were present among goats, cattle, and buffaloes at the Veterinary Teaching Farm, UMK Bachok. The study aimed to investigate the prevalence, risk factors, and severity level of infection caused by gastrointestinal helminths in this setting. The findings revealed that 35.3% (6/17) of cattle and 12.5% (2/16) of goats tested positive for gastrointestinal parasites (Table 2). These results differ significantly from the higher prevalence rates reported in other studies, such as 78.6% among goats on selected farms in Malaysia (Jesse et al., 2020) and 55% among cattle in Terengganu (Mursyidah et al., 2017).

The examination of fecal samples revealed several species of gastrointestinal parasites namely the *Haemonchus* sp., *Trichostrongylus* sp., *Eimeria* sp., *Fasciola* sp. and *Paramphistomum* sp. The most prevalent parasites identified in the study area were *Eimeria,* which are followed by strongyles as shown in Table 3. Meanwhile, *Fasciola* and *Paramphistomum* were found exclusively in sampled cattle. The diversity of intestinal parasites observed in goats aligns with findings from previous studies in Malaysia (Jesse et al., 2020; Khor et al., 2018). However, parasites such as *Trichuris* and and *Moniezia* were not detected in this study, contrary to findings from studies in Malaysia (Azima et al., 2020; Jesse et al., 2020). The absence of *Fasciola* spp. in sampled goats also contrasts with a Malaysian study (Mursyidah et al., 2017), which reported *Fasciola* and *Paramphistomum* in sheep and goats. Conversely, the variety of intestinal parasites identified in cattle is consistent with studies conducted in Malaysia (Che-Kamaruddin et al., 2023).

Fecal egg count (FEC) is carried out to monitor helminthiasis burdens in the herds and determine the degree of pasture contamination (Coles et al., 1992). The severity of the gastrointestinal parasitic infection is evaluated based on the numbers of EPG/OPG of feces as shown in Table 1. Table 4, Table 5 and Figure 2 showed overall low level of parasitic infection in this study, particularly in the sampled goats can be associated with the management practices. The goats were raised in an intensive system without access to pasture, minimizing their risk of exposure to infective helminths since infections are primarily associated with grazing (Chandrawathaniet al., 1999). Additionally, the herd of goats was treated with albendazole a month before sampling, suggesting the helminths' susceptibility to the treatment, as evidenced by the low worm burden observed.

Furthermore, *Fasciola* spp. and *Paramphistomum* spp. were found exclusively in the sampled cattle, with no detections among the sampled goats. This difference can be attributed to the management practices. As the cattle and buffaloes are reared extensively, they are allowed to graze freely, which increases their risk of ingesting the intermediate host (snails) or vegetations which may be contaminated by the infective metacercariae, as compared to the goats that are kept under intensive system. A significant association was observed between grazing and fascioliasis with more than 4 times the odds compared to silage feeding (Ahmad-Najib et al., 2021). Moreover, cattle and buffaloes have access to swampy or marshy areas, increasing their risk of exposure to infective metacercariae or intermediate hosts. Regions with high rainfall and areas where animals can access streams, ditches, ponds, wetlands, and marshy environments are associated with a higher prevalence of *Paramphistomum* infections (Fenemore et al., 2021).

The risk factors for gastrointestinal parasitic infections include the host, the parasite, and environmental factors (Odoi, 2007). The results of this study indicate no significant association between the prevalence of gastrointestinal parasitic infections and the sex of the animals (Table 6). This aligns with findings from studies in Nigeria (Olubukola et al., 2014), which reported similar infection rates between males and female bovine. Therefore, the findings of this study suggest that male and female animals are equally susceptible to exposure to gastrointestinal parasites. Furthermore, there is no significant relationship between gastrointestinal parasitic infections and the age of the animals, which contrasts with a study in Malaysia (Jesse et al., 2020). Pfukenyi et al. and Regassa et al. observed a higher prevalence of gastrointestinal parasites among younger animals, indicating that they experience greater exposure and susceptibility to gastrointestinal parasitic infections compared to mature animals. In contrast, adult goats that are kept for extended periods may accumulate exposure over time and develop adaptive immunity, enabling them to cope with and thrive despite a heavy worm burden (Jesse et al., 2020).

Besides, this study shows that there is no significant difference between the gastrointestinal parasitic infection and body condition score of the animals, which is contrary to several studies in Malaysia (Jesse et al., 2020) and Ethiopia (Mathewos et al., 2022). This may be associated with overall low FEC, which indicates low worm burden among the sampled animals. The occurrence of gastrointestinal parasitic infection is more common in cattle with poor body condition score than in animals with ideal body condition score (Cheru et al., 2014; Regassa et al., 2006). Animals with poor body condition scores have weaker immunity, which renders them more susceptible to gastrointestinal parasitic infection (Etsehiwot, 2004).

Based on Table 2., the prevalence of gastrointestinal parasitic infections is higher among the sampled cattle (35.3%) compared to goats (12.5%), aligning with findings from studies conducted in Ghana (Robertson et al., 2019). This difference can be attributed to variations in management and deworming practices. In this study, the goats were kept intensively in a raised housed with slatted floors without access to grazing, whereas the cattle were managed under an extensive system that allowed grazing. The prevalence of gastrointestinal parasitic infections tends to be higher in extensive systems compared to intensive ones, indicating that infections are primarily acquired from pastures or grazing areas (Squire et al., 2019). Additionally, adequate moisture, temperature, and humidity, which are conditions essential for the development of most parasitic oocysts and eggs into infective stages (Taylor et al., 2016) — are more frequently encountered in extensive grazing systems.

The larval identification results revealed *Haemonchus* sp. and *Trichostronglys* sp. as shown in Figure 3 and Figure 4, respectively. *Haemonchus* sp. was the sole genus of strongyles identified in the caprine fecal samples. On the other hand, *Haemonchus* sp. and *Trichostrongylus* sp. were identified in the bovine fecal samples. The infective stage larvae (L3) of *Haemonchus* sp. was identified based on their morphological characteristics of narrow rounded head with a medium length sheath tail ending in a fine point (Taylor et al., 2016; Abu-Elwafa et al., 2016). Meanwhile, infective stage larvae (L3) of *Trichostrongylus* sp. was identified based on their rounded head, short sized and short sheath tail (Taylor et al., 2016; Abu-Elwafa et al., 2016). *Haemonchus* sp. and *Trichostrongylus* sp. are recognized as the most prevalent and pathogenic parasites affecting livestock, especially small ruminants (Chandrawathani et al., 2014). *Haemonchus contortus* is widely regarded as the most notorious gastrointestinal parasite in ruminants, attributed to its high

reproductive potential and blood-sucking capability (Getachew et al., 2007). Infection by *Hemonchus contortus* may lead to clinical signs of anemia, inappetance, lethargy, weight loss, dehydration, edema and death as a sequela of the disease (Francisco et al., 2007). Cattles are predominantly infected by *Haemonchus placei*, which may be differentiated from *Haemonchus contortus* based on the morphological characteristics. *Haemonchus placei* L3 is longer, more robust and with longer sheath tail than *H. contortus* (Van-Wyk et al., 2004).

CHAPTER 6: CONCLUSION & RECOMMENDATION

In summary, gastrointestinal parasites identified among the ruminants at the Veterinary Teaching Farm, UMK Bachok, included *Haemonchus* sp., *Trichostrongylus* sp., *Eimeria* sp., *Fasciola* sp., and *Paramphistomum* sp. The study also investigated the risk factors associated with the occurrence of these parasites, but no significant associations were found. The overall worm burden among the ruminants was low, reflecting effective management and deworming practices.

In conclusion, the study successfully achieved its objectives. Improvements to the current study could be made by increasing the sample size to include the entire herd, enabling a more comprehensive evaluation of the overall prevalence of gastrointestinal parasitic infections across all animals. Additionally, further risk factors could be investigated, such as the physiological status of the host, FAMACHA score, hematocrit levels, and eosinophil counts, as these have been shown to correlate with the status of gastrointestinal parasitic infections. Additionally, molecular methods like polymerase chain reaction (PCR) can be carried out to allow the identification of the infective stage larvae (L3) up to the species level.

7.0 APPENDIX

Figure 5. Collection of fecal samples from a goat

Figure 6. Storage of fecal samples in an icebox

Figure 7. Conducting the Modified McMaster method

Figure 8. Oocyst of *Eimeria* under at 10x magnification

Figure 9. Strongyle egg at 10x magnification

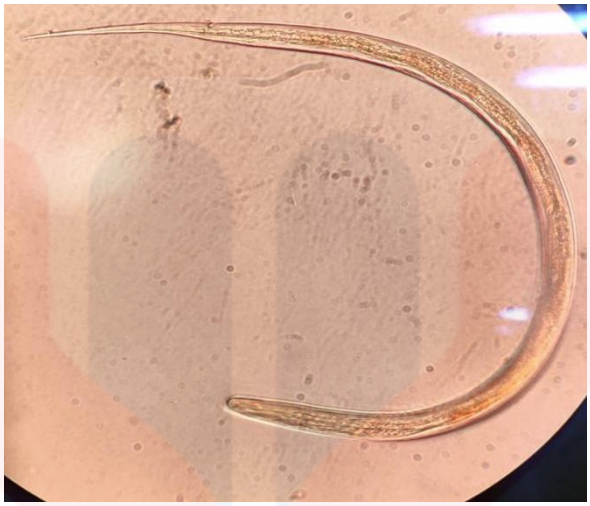

Figure 10. *Haemonchus* L3 at 40x magnification (host: caprine)

Figure 11. *Trichostrongylus* L3 at 10x magnification (host: bovine)

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