THE EFFECT OF *BERCHEMIA DISCOLOR* LEAF MEAL (MUNI TREE) ON GASTROINTESTINAL NEMATODE INFECTIONS AND HAEMATOLOGICAL PROPERTIES OF NON-DESCRIPT GOATS

BY

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A RESEARCH MINI-DISSERTATION

Submitted in fulfilment of the requirements for the degree of

MASTER OF SCIENCE IN AGRICULTURE

in

ANIMAL PRODUCTION

in the

FACULTY OF SCIENCE AND AGRICULTURE

(School of Agricultural and Environmental Sciences)

at the

UNIVERSITY OF LIMPOPO, SOUTH AFRICA

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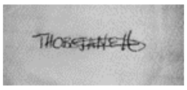
11 MARCH 2025

DECLARATION

I declare that this research report, hereby submitted to the University of Limpopo for the Master of Science in Agriculture (Animal Production) degree, has not been submitted for a degree at this university or any other university. This is my work in design, execution and all materials contained here have been duly acknowledged.

Signature:  Date: 11 March 2025

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ACKNOWLEDGEMENTS

I would like to acknowledge and give my warmest thanks to my supervisor Prof B Gunya and co-supervisor Prof TG Manyelo who made this work possible. Their guidance and advice carried me through all the stages of writing my research project.

I would also like to give special thanks to my family, my mother Thobejane Tlopele Thelma, my father Thobejane Malegodi Gibson for their deep consideration for the finances, continuous support and understanding when undertaking my research and writing my project. Your prayer for me was what sustained me this far.

Finally, I would like to thank Almighty God for his enduring grace, guidance and protection that he has bestowed upon me during this research project.

DEDICATION

I dedicate this work to myself and my family, whose unwavering support and encouragement have been my constant strength throughout this journey. To my parents, who instilled in me a love for learning and the courage to pursue my dreams. Finally, I dedicate this work to all the individuals committed to advancing knowledge and making a difference in the world. Thank you for inspiring me every day.

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LIST OF SYMBOLS

%	Percentage
^{o}C	Degree Celsius
g	Grams
kg	kilograms
m	metre
mg	milli grams

LIST OF ABBREVIATIONS

ANOVA=	ONE-WAY ANALYSIS OF VARIANCE
BA =	BASOPHILS
B.D =	*BERCHEMIA DISCOLOR*
COWP =	COPPER OXIDE WIRE PARTICLES
CRD =	COMPLETE RANDOMIZED DESIGN
DM =	DRY MATTER
EDTA =	ETHYLENE DIAMINE TETRA ACETIC ACID
EO =	EOSOPHILS
FEC=	FAECAL EGG COUNTS
FOC =	FAECAL OOCYSTS COUNT
GIN =	GASTROINTESTINAL NEMATODE INFECTIONS
GNI =	GASTROINTESTINAL NEMATODE INFECTIONS
HB =	HAEMOGLOBIN
LSD =	LEAST SIGNIFICANT DIFFERENCE
LY =	LYMPHOCYTES
L2 =	SECOND STAGE LARVAE
L3 =	THIRD STAGE LARVAE
MCH =	MEAN CELL HAEMOGLOBIN
MCHC =	MEAN CELL HAEMOGLOBIN CONSOLIDATION
MCV =	MEAN CELL VOLUME
MO =	MONOCYTES
MUC =	*MUCUNA PRURINS*
NE =	NEUTROPHILS

PCV= HAEMATOCRIT

RBCS = RED BLOOD CELLS

SEM = STANDARD ERROR OF THE MEAN

SPSS = STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES

TGDP = TOTAL GROSS DOMESTIC PRODUCT

ULAREC = ANIMAL RESEARCH AND ETHICS COMMITTEE OF THE UNIVERSITY OF LIMPOPO

WBCS = WHITE BLOOD CELLS

CHAPTER ONE

INTRODUCTION

1.1. Background

Goats play a crucial role in improving livelihoods and food security in Africa. Despite the importance of goat production for the supply of meat and milk in developing countries (Mataveia and Garrine, 2019). Goat production is widespread in the tropics is susceptible to gastrointestinal nematode infections (Mataveia and Garrine, 2019). The use of medicinal herbs containing plant secondary metabolites with bioactive properties is an alternative strategy to control nematode populations. Medicinal herbs can affect a population of parasites at various stages of their life cycle (Waller and Thamsborg, 2004).

1.2. Problem statement

The cost of feeding goat enterprise to produce meat or milk is expensive. Goats grown for meat consistently need high-quality feed and a perfect merger of various nutrients to widen their chance of success (Schoenian, 2003). Goats are fed mostly on grass and browsers, which are naturally low in nutrients and contain lower digestibility during the wet season consequently leading to overgrazing, where there is excessive removal of vegetation, reducing the availability of nutrient-rich plants (Makkar, 2003). As a result, the animals are more susceptible to parasites (Mabbott, 2018). For instance, *Haemonchus contortus* infection in goats has been linked to anaemia, hypoproteinemia, and parasite gastroenteritis (Pathak, 2011), all of which lower the goats' ability for production.

According to Egbu and Ubachukwu, (2013) parasitic infections in goats also have a negative impact on serum enzyme levels and haematological parameters, which lowers goat productivity in many ways, including stunted growth, poor skin traits, significant mortality, starved animals, and decreased milk and meat output. Additionally, parasitic illnesses such as cryptosporidiosis and strongyloidiasis result in significant economic loss (Echevaria *et al.,* 2007).

Berchemia discolor leaf meal can satisfy the nutritional needs of goats. The effect of *Berchemia discolor* (Muni tree) on gastrointestinal nematode infestation is unknown. Therefore, the purpose of this study is to ascertain how *Berchemia discolor* (Muni tree) affects gastrointestinal nematode infections and haematological properties.

1.3. Motivation

In Africa, goats enhance people's livelihoods and food security. They are valuable because they provide meat, skins, and fibre and can be milked for household use. Goats are utilized for ceremonial, religious, and festive purposes in addition to socioeconomic ones (Peacock, 2015). They are therefore commonly referred to as the "village bank." In Southern Africa, most goats are grown in communal areas using small-scale convectional elongation systems. They are kept in smallholder and community systems (Lamy *et al.,* 2011). They depend on natural veld and do not receive any additional feed (Kemboi *et al.,* 2017) and these natural veldts are characterised by serious feed shortages due to the dry season and periods of drought.

One of the possible alternatives for feed shortage for goats is the utilization of drought-tolerant traditional tree forages like *Berchemia discolor* that grow through the tropics. *Berchemia discolor* is drought resistant and can be used as a browse for feeding goats because it has high nutritive value such as carbohydrates, crude protein, and crude lipid (Kemboi *et al.,* 2017).

Several researchers have studied the effect of indigenous trees on gastrointestinal nematode infections (GIN) and haematological properties of goats. There have been several reports documenting reduced infection levels in sheep and goats grazing condensed tannin (CT) - containing forages, including sulla (*Hedysarum coronarium* L.), birdsfoot trefoil (*Lotus corniculatus* L.), big trefoil (*Lotus uliginosis Schkuhr.),* and sericea lespedeza [SL; *Lespedeza cuneata* (Dum-Cours.) G. Don.] (Niezen *et al.,* 2002; Min and Hart, 2003; Min *et al.,* 2004; Shaik *et al.,* 2006; Terrill *et al.,* 2009). However, they have neglected the use of *Berchemia discolor* in goat production. Such information will help farmers and researchers assimilate the significance of using *Berchemia discolor* for ruminant nutrition and goat health. Therefore, the objective of this study is to determine the effect of *Berchemia discolor* leaf (Muni tree) on gastrointestinal nematode infections and haematological properties of non-descript goats.

1.4. Aim

To investigate the effect of *Berchemia discolor* (Muni tree) leaf meal on gastrointestinal nematode infestation and haematological properties of non-descript goats.

1.5. Objective

The objective of the study was:

I. To determine the effect of *Berchemia discolor* leaf meal (Muni tree) on gastrointestinal nematode infections of non-descript goats.
II. To determine the effect of *Berchemia discolor* leaf meal (Muni tree) l on haematological properties of non-descript goats.

1.6. Hypotheses

The null hypothesis of the study was:

I. The *Berchemia discolor* leaf meal (Muni tree) has no effect on gastrointestinal nematode infections of non-descript goats.
II. The *Berchemia discolor* leaf meal (Muni tree) has no effect on haematological properties of non-descript goats.

CHAPTER TWO

LITERATURE REVIEW

2.1. Introduction

Goat production contributes significantly to improving the livelihoods of resource-limited farmers under communal production systems, as they provide milk, meat, skin, hides and generate income (Idamokoro *et al.,* 2016). Despite the contributions of indigenous goat farming to resource-limited farmers, their productivity is retarded by the high prevalence of gastrointestinal nematodes (GIN) and diseases, poor quality and quantity of forage (Mpofu *et al.,* 2020). Therefore, to improve indigenous goat productivity, it is essential to determine loads and control methods of gastrointestinal nematode in goats foraging in Savanna biome as goats are more browsers.

The fecundity of goats maintained in resource-poor environments are usually low due to seasonal variations in the supply and quality of animal feeds. This can be defeated by using locally available natural resources such as the different local browse species (Aregawi *et al.,* 2008). *Berchemia discolor* (*B. discolor*) is one of the potential tree forages can be used as a supplement goat as goat consume it. It has been reported that *B. discolor* is widely rich in protein and minerals and can be used during the dry season to supplement poor-quality natural pasture or fibrous crop surplus to enhance animal performance (Devendra *et al.,* 1990).

Shrubs are acquiring immense attention as potential livestock feeds in arid regions and several studies have shown that the different local browse species are rich in nutrients and improve the performance of animals, particularly that of small ruminants (Melaku *et al.,* 2004). Fodder from browses is often available throughout the year, especially in the dry periods when pastures and crops remaining are depleted (Aregawi *et al.,* 2008). It is possible and most appropriate to supplement grazing with local shrubs such as *Grewia hostii*, *Balanites aegyptiaca, Acacia brevispica*, *Berchemia discolor* and *Maerua angolensis* to make up for the deficiency of some nutritional components and to improve performance. Therefore, the objective of this review is to highlight the use of *B. discolor* leaf meal (Muni tree) as goat feed and its effect on gastrointestinal nematode infections (GIN) and haematological properties of South African non-descript goats.

2.2. Importance of shrubs

Shrubs, herbs, and tree forage play a significant role in providing fodder for ruminants worldwide. Trees and shrub forage are of importance in animal production because they do not compete with human for food. Supplementation with browse to low-quality roughage diets has been shown to increase dry matter (DM) intake and improve animal performance (Hassan *et al.,* 2003). The browse is well fermented in the rumen and improves the rumen environment in the ruminants, especially the goats. The fodder is generally rich in protein and minerals and can be used in the dry season to subsidize poor-quality natural pasture or fibrous crop residue. The existence of tannins and other phenolic compounds in many shrubs and tree leaves hampers their utilization as animal feeds.

Browse species are acquiring rising attention as potential livestock fodder are more importantly in arid regions. Several studies have shown that the various shrubs are rich in nutrient and improve the performance of animals, particularly that of small ruminants (Melaku *et al.,* 2004). Shrubs are adapted to grow in arid and semi-arid areas and usually stays green throughout the year. Trees and shrubs are increasingly sighted as important components of animal feeding, especially as suppliers of protein and their contribution is acceptable in difficult environmental conditions, where the available grazing is not sufficient to meet the maintenance requirements of the animal. They are easily utilised by browsers and consist of high levels of digestibility, minerals and crude protein that improve animal performance especially during the dry period of the year.

2.3. Description of *Berchemia discolor*

Berchemia discolor is a widespread tree (Figure 2.1) or shrub species found in eastern and southern Africa, from Sudan to South Africa (Janick and Paull, 2008). It is an indigenous African fruit tree species (Figure 2.2) with potential in terms of commercialisation and domestication which has a date-like taste, and the seeds taste like walnuts. *B. discolor* grows in dry open woodland, semi-arid bushland and along riverbanks from sea level to 1900 m. However, harvesting its fruits for human use overlap with livestock as it is also preferred especially by camels and goats. This shrub or tree is 3–20 m tall with a dense, round crown. The trunk has a rough, dark grey bark that flakes longitudinally. The alternate, simple, opposite to sub-opposite leaves are elliptic to ovate, 2–9 x 2–5 cm and are entire, shiny above and dull below. The small, greenish yellow, solitary flowers are 4–5 mm in diameter. The fruit is shaped like a date, up to 20 x 8 mm in size, and with 1–2 flat seeds enclosed in sweet, edible flesh.

The skin turns yellow during ripening (Janick and Paull, 2008). The species is drought tolerant and can survive in areas receiving rainfall in 4 out of 5 years. The tree is not resistant to frost or cold wind. It prefers areas with a mean annual temperature from 17°C to 28°C and a mean annual rainfall from 250 to 1270 mm. It grows well on a variety of soil types, though it does best on well-drained soils. Flowering normally occurs at the onset of the rains. The fruits take 4–5 months from anthesis to maturity, ripening towards the end of the rainy season. In South Africa, flowering occurs from October to January and fruiting from January to July (Janick and Paull, 2008).

Figure 2.1: *Berchemia discolor* tree.

Figure 2.2: *Berchemia discolor* fruits.

2.4. Importance of *Berchemia discolor*

Berchemia discolor species play a role in the socio-economic well-being of small-scale farmers and rural communities (Lusepani, 1999). The *Berchemia discolor* dry pulp (Figure 2.3) is rich in carbohydrates, calcium, sodium, iron, magnesium, and potassium (Debela and Njoka, 2012). Trade for the fruit is important for generating income, which is used to acquire other goods and services by the rural people.

Humans find the sweet, date like taste of the fruit quite pleasant. The sugar content of the pulp is as high as 30%, and seeds taste like walnuts. The vitamin C content of the fruit is 65 mg/100 g (Debela and Njoka, 2012). A beverage like tea is made from the leaves. The wood is excellent for making furniture such as tables, chairs and benches and is also used in making poles, pestles, and hair combs. The heartwood produces a resin (Asfaw and Nyangito, 2012). Black dye, popular with basket makers, is produced from powdered heartwood and roots. A strong alcoholic drink is distilled from the fruit. The roots have various medicinal uses and products such as whitewash produced from the ash is used for painting houses. The spreading branches and heavy, rounded crown make *B. discolor* an effective shade tree, it can also act as a windbreak (Njoka, 2012).

Figure 2.3: Dry pulp.

2.5. Health management of goats

One of the main health issues in goats is (gastrointestinal nematode infections) GIN which negatively affect goat production, economic effectiveness and can lead to high mortality in goats when the infection is not treated on time (Saurez *et al.,* 2013). Mdladla *et al.* (2017) reported that in most communal areas of the developing countries, parasitic infections play a significant role. A proper diet for animals is required throughout growth and reproduction stages to minimises the prevalence of GIN. The most productive and parasite-resistant animals should be selected and kept in the herd, and cull those that require constant deworming or that permanently present high parasitic loads. (Burke and Miller, 2006) reported that goat breeds such as St. Croix and Katahdin were found to have a higher tolerance to parasitism and, despite their parasite load, grow and reproduce properly. Culling older animals which suffer from teeth problems that can affect their intake and compromise their immunity should be considered, as they result in making them more susceptible to nematodes.

2.6. The effect of *Berchemia discolor* on prevalence of gastrointestinal nematode infections.

Berchemia discolor is a medium to large, deciduous, or evergreen tree and is considered an important source of feed for livestock (Scholtz and Bester, 2010). Grazing lands in most communal areas are characterized by being poorly managed, which contributes greatly on the prevalence and loads of GIN infection. An increase in the spread of parasitic diseases and worm burden in goats can be associated with grassland vegetation types since goats can re-infect on contaminated pastures. The lower infestation rate in the forestland vegetation could be that goats had access to various trees and shrubs such as *Berchemia discolor* which can reduce worm burden in livestock (Doe and Smith, 2020). Infections may be lower in goats foraging in the forestland vegetation type due to their browsing behaviour, which minimizes chances of ingesting the larvae which is found on plants closer to the group (Doe and Smith, 2020).

Lower infestation in the forestland vegetation types can also be explained by the presence of tannin-rich plants found in forestlands that can reduce worm burden and improve goat performance (Scholtz and Bester, 2010). *Berchemia discolor* has been found to be rich in tannins which assist in the use medicines for various ailments such as can reduce worm burden in livestock (Abbiw, 1990). Spread of parasitic diseases in extensive farming is aggravated by uncontrolled and free grazing systems practiced in many developing countries (Sanhokwe *et al.,* 2016). Goats kept under poorly managed vegetation are characterized by poor performance, high GIN infection and mortality, and lower reproductive rate (Risso *et al.,* 2015).

Seó *et al.* (2015) reported that goats fed in areas suppressed of various trees and shrubs carry less GIN relative to those grazing in the grassland vegetation types. Effective control of GIN in goats entails an integrated control strategy that should be based on vegetation type on each environment.

2.7. Prevalence of gastrointestinal nematode infection

Gastrointestinal nematode infection (GIN) is a prime limiting factor of goat farming globally, more precisely in tropical and sub-tropical regions (Mpofu *et al.,* 2020). Poor livestock management, quality and quantity of forage intensify the GIN challenge in goats of resource-limited farmers. Moreover, goat kids are more susceptible to GIN than older goats due to immunity that is low and there is a tendency to decrease of worm burdens with the increase in goat age (Zvinorova *et al.,* 2016).

Amran *et al.* (2018) indicated that, however higher prevalence of GIN in older goats than younger goats. Infection with GIN is closely related to great economic losses in goat farming through lowered productivity and the cost of treatment and mortality (Jiménez-Colmenero *et al.,* 2001; Marume *et al.,* 2012). The most common GIN infecting goats include *Haemonchus contortus, Teladorsagia circumcincta, Trichostrongylus spp., nematodirus spp., Strongyloides papilosus, Oesophagostomum spp., Trichuris spp., Cooperia spp., and Dictyocaulus filarial* (Mpofu *et al.,* 2020). *Trichuris spp.* (whipworms) and *Strongyloides* (often referred to as threadworms, while hookworms belong to the Ancylostomatidae family) are extensively studied in goats and other livestock due to their significant impact on animal health and agricultural productivity. Infections by these gastrointestinal parasites can lead to malnutrition, reduced growth rates, decreased fertility, and even mortality in severe cases, thereby causing substantial economic losses in the livestock industry (Mpofu *et al.,* 2020).

Haemonchus spp. has a direct life cycle. It is granted reclining through grazing on natural pasturelands by third stage (L3) larvae. It has a two-phase life cycle, a free-living and a parasitic within the abomasum of the host (Zvinorava *et al.,* 2016). The eggs reach the ground through the faeces of the parasitised ruminants, thus vitiating herbage. Then, the eggs evolve into first stage larvae (L1), continuing to second stage larvae (L2) (Mpofu *et al.,* 2020). The third stage larvae (L3), which is the infective form of this parasite, is the next evolutionary stage. After L3 larvae are taken up by a ruminant, they migrate to the predilection site, i.e., the abomasum, where they become adult nematode parasites, compelling their blood-sucking activity (Amran *et al.,* 2018). *H. contortus* infection leads to anaemia, primarily due to the blood-sucking activity, and consequently, potentially unusual death of the infected animals.

The primary consequence of the infection is the momentous reduction in the production of infected animals, which includes a decrease in the growth of young animals, a decrease in milk production of lactating animals and in fibre production. In the end, all these result in relentless economic losses for farmers (Marume *et al.,* 2012).

2.8. Effect of feeding system on prevalence of gastrointestinal nematodes

There are various feeding systems which farmers use for managing livestock such as tethered grazing (staking the animals), herding and free-range based on different seasons. These feeding systems provide animals with sufficient outdoor access as required by the organic livestock standards (IFOAM, 2000). Although tethering and free-range systems provide outdoor access, a requirement in the organic standards and desirable practices in organic animal husbandry, it increases the risk of animals encountering a broad range of environmental pathogens which might comprise animal health (Kijlstra and Eijck, 2006).

Goat tethering means that the goat is tied to a line that runs along another line called run line, the run line is either staked along the ground or strung on posts over the goat's head. Nsereko *et al.* (2015) reported that goat tethering is associated with low growth performance and higher loads of GIN infestation as goats graze more nematode larvae from infested pasture compared to those goats that are browsing. Tethered goats have higher faecal egg counts (FEC) compared to those free grazing goats reported by Nsereko *et al.* (2015). Goats that are allowed to roam freely can graze on a variety of plants, some of which are rich in crude protein and condensed tannins, which improve the goats' nutrition and immunity to disease. Benefits of protein supplementation is one of the ways to control parasites Marume *et al.* (2012) reported. According to research by Kumar *et al.* (2013) goats given low-protein fodder is also more vulnerable to infection because they release fewer immunoglobin IgA. Thus, veld management is crucial for the efficient control of gastrointestinal nematode infection.

To reduce pasture contamination and increase vegetation type productivity, rotational grazing and resting are used as GIN control measures. These strategies minimise the host-parasite contact. Uncontrolled grazing system means that animals will eat down the most nutritious grasses till there is nothing left. Not only will their nutritional value decrease but they will be less able to handle harsh conditions like low rains while rotational grazing system when goats graze in one camp, the other camp is rested with a specific goal for pastures to regrow (Hawkins, 2017).

2.9. Factors influencing gastrointestinal nematode infection in goats.

2.9.1. Climate

Gastrointestinal nematodes and other diseases are fundamentally altered by temperature, rainfall, and humidity (Menkir *et al.,* 2006). These climatic variables persuade the parasite reproduction, development, survival, and population dynamics in divergent stages of their life cycle. Temperature is one of the most important climatic variables that influence the survival and expansion of larvae (Pfukenyi and Mukaratirwa, 2013). Once the eggs pass out of the host, they hatch into first-stage larvae (L1) and moult into second-stage larvae (L2), and they obligate appropriate conditions of temperature and humidity. For eggs to undergo these development processes, they require warm temperatures greater than 25 ºC and moist conditions (Kim *et al.,* 2012). The endemic L3 larva can survive for months on pasture depending on the environmental conditions. Moisture and relative humidity maintain reckoning pressure until they are ready for the next stage in their life cycle. However, parasite activities are arrested in temperatures below 10 ºC. During the rainy season, rainfall and temperature expedite the rate of development of GIN (Menkir *et al.,* 2006). Pfukenyi and Mukaratirwa, (2013) revealed that GIN and parasitic diseases reach their peak prevalence in warm and rainy seasons and become less abundant during dry seasons. Gastrointestinal parasites are more prevailing during the hot-wet season than cool-dry season (Zvinorova *et al.,* 2016; Mpofu *et al.,* 2020).

2.9.2. Impact of gastrointestinal nematode infection in goat production

Gastrointestinal nematode infections are the main prevalent parasitic diseases affecting goats. The most prevalent nematode species that affect goats are *Haemonchus contortus*, *trichostrongylus colubriformis* and *Teladorsagia circumcincta* (Bishop and Morris, 2007; Zvinorova *et al.,* 2016). Infection with GIN is companioned with great economic losses and a huge impact on livestock productivity through stirring body weight loss of between 6 and 12 kg per animal per year (Hassan *et al.,* 2019), fertility, meat quality, and milk production and lead to mortality (Zvinorova *et al.,* 2016).

Mortality rates cognate by GIN may exceed 40 % in goat flocks (Hassan *et al.,* 2019). Goats highly infested with GIN are characterized by having weakness, diarrhoea, signs of hypo-proteinaemia, submandibular oedema (bottle jaw), loss of appetite, and weight. These parasites margin to anaemia since they can discard erythrocytes as well as protein (Zvinorova *et al.,* 2016; Mpofu *et al.,* 2020). Conventional drugs to restrict parasites are expensive for many resource-limited farmers.

2.9.3. The effect *Berchemia discolor* leaf meal on haematological properties of non-descripts goats.

Blood is an important medium in assessing the health status of animals. The physiological and the pathological conditions of animals can be assessed by haematological and biochemical analyses of the blood (Khan *et al.,* 2012). *Berchemia discolor* is used as a dye, fodder, ornamental tree, and herbal medicine to treat several human and animal diseases and ailments (Balemie and Kebebew, 2006). *Berchemia discolor* can be used as a traditional medicine to treat blood-related diseases e.g., bleeding gums.

Oyawoye and Ogunkunle, (2004) reported that, red blood cells, white blood cells, or leucocytes, mean corpuscular volume, mean corpuscular haemoglobin, and mean corpuscular haemoglobin concentration are examples of haematological components that are useful in monitoring feed toxicity, particularly when feed ingredients have an impact on farm animals' blood and general health.

Plant tannins have an impact on gas production rates by reducing the microbial adhesion to feed particles (Miller *et al.,* 2007). Fibrobacter succinogenes detaches from condensed tannins significantly. According to Terrill *et al.* (1994), since hydrolysable tannins have been shown to harm organs including the liver, kidney, and spleen, it is unlikely that condensed tannins, which are not absorbed into the bloodstream will harm these tissues under normal physiological settings. However, condensed tannins may be absorbed into the bloodstream and produce organ damage comparable to hydrolysable tannins in cases of intestinal injury brought on by heavy tannin consumption or other intestinal membrane irritants (Terrill *et al.,* 1994).

According to Gramb *et al.* (2011), the amount and quality of diet have an impact on haematological components. Goat blood parameters can be affected by climatic conditions and low nutritional level of grass pasture (Turner *et al.,* 2005). Red and white blood cell characteristics are therefore employed as a starting point to achieve the initial steps in nutritional study. Anaemia, haemolysis, or leukaemia are symptoms of severe deficiency or toxic principles. Traditional blood biochemistry and trace element analysis are required for a more precise and trustworthy diagnosis (Singh *et al.,* 2002). Due to limited green vegetation availability, especially in the dry season, efforts ought to concentrate on making use of the copious amounts of unconventional greenery that goats consume. Most of these materials are accessible year-round.

2.10. Conclusion

Berchemia discolor can be used during the dry season to supplement poor-quality natural pasture or fibrous crop surplus to enhance animal performance. Goat GIN prevalence and control are greatly influenced by the type of vegetation and management techniques used. The most sustainable method of increasing goat production in resource-constrained communities may involve upgrading livestock management systems and husbandry techniques, as well as taking vegetation type into account to prevent GIN infestations. Furthermore, the creation of an all-encompassing and long-lasting plan for GIN control in goats housed in various vegetation types depends mostly on epidemiological understanding. Goat blood parameters can be affected by climatic conditions and low nutritional level of grass pasture.

CHAPTER THREE

EFFECT OF *BERCHEMIA DISCOLOR* LEAF MEAL MUNI TREE ON GASTROINTESTINAL NEMATODE INFECTIONS OF NON-DESCRIPT GOAT

3.1. Introduction

Parasites restrict goat production, which raises the mortality rate, causes skin irritation and blood sucking, and lowers fertility (Molefe *et al.,* 2012). Main health problems in small ruminants are gastrointestinal parasites such as *Haemonchus contortus and Fasciola hepatica* (Vatta and Lindberg, 2006). Exogenous parasites like ticks, lice, and mites have been identified in goats. The high incidence of parasites in poor nations was caused by inadequate veterinary care and disproportionate housing (Mungube *et al.,* 2006). Commercial medications are one way to manage parasites, but developing farmers rarely have access to them due to their high cost. According to Clark *et al.* (1996), a small number of these parasites have developed resistance to these medications, which, as noted by (Cawley *et al.,* 1996) leads to environmental pollution.

The use of medicinal plants is the alternative measure to treat and control livestock parasites which is adopted by farmers. Natural products are user friendly and congenial with organic system (Erasto *et al.,* 2007). *Berchemia discolor* is a forage species which beneficial for health of the goats. The availability of tannin-rich plants in forestlands, which can lower worm burden and enhance goat performance, can also account for lower infestation in the forestland vegetation types (Scholtz and Bester, 2010). It has been discovered that *Berchemia discolor* has a lot of tannins, which help with the use of medications for a variety of conditions, including lowering the worm burden in cattle (Tinkler, 2020). However, the information on the effect of *Berchemia discolor* leaf (Muni tree) on gastrointestinal nematode South African non-descripts goat is limited. Therefore, this study aims to investigate the effect of *Berchemia discolor* leaf meal on gastrointestinal nematode infestation of South African goats.

3.2. Materials and Methods

3.2.1. Study site

The study was conducted at University of Limpopo's Animal farm in South Africa (1282 altitude, 27.55°S latitude and 29.41°E longitudinal). The study area experiences summer temperatures between 20 and 36 °C and winter temperatures between 10 and 25 °C. It averages lower than 400 mm of precipitation annually (Kutu and Asiwe, 2010).

3.2.2. Ethical statement

The study was approved for ethical consideration by the Animal Research and Ethics Committee of the University of Limpopo (AREC) with the AREC number: AREC/26/24: PG.

3.2.3. Acquisition of materials and goats

A total of 16 yearling intact males of South African non-descript goats were acquired from the University of Limpopo Animal Farm, South Africa. *Berchemia discolor* leaf material was manually harvested from Hamakuya village Thohoyandou (Latitude -22.64°E and longitude 30.84°S). The leaves from the branches were then shaded-dried and kept indoors for 16 days before being chopped. The samples were cut and kept in sealed bags until it was required for analysis and feeding.

3.2.4. Preparation of experimental procedures, dietary treatments, and house

3.2.4.1. Experimental house procedure

The experimental individual metabolic cages (Figure 3.1) were carefully cleaned with water and sterile (ViruKill) and then left vacant for 7 days to allow for adequate drying and the death of disease-causing microorganisms. The metabolic cage was separated into three equal-sized floors, with fresh sawdust spread out to a 7cm depth. Feeders and drinkers were used during the experiment and were washed and sanitized.

Figure 3.1: Individual metabolic cage

3.2.4.2. Experimental goats and feeding management

Yearling intact males of non-descript goats were housed in a 1.5 m×0.8 m in individual pen size dimension and acclimated to the trial food for 14 days. There was a total of 16 pens. The feeding trial was for 37 days, with 7 days adaptation period. 600 g of supplements was given to goats two times a day (10:00 AM and 4:00 PM). Goats were fed individually and water troughs with a basic meal and unlimited access to water were provided.

3.2.4.3. Experimental design and treatments

A total of 16 goats were used and were assigned to four dietary treatments in the Complete Randomized Design (CRD). Each treatment was replicated eight times and each goat served as an experimental unit. The dietary treatments were as follows: Control 0kg, 1.5kg, 2.0kg, and 3.0kg (BFL_o, BFL_1.5, $BFL_{2.o}$, and $BFL_{3.o}$) as shown in Table 3.1.

Table 3.1: The dietary treatments of *Berchemia discolor* leaf meal

Treatment code	**Treatment description**
BFL_o	Male yearling that are intact and unremarkable are fed an unlimited diet without *Berchemia discolor* leaf meal.
BFL_1.5	Male yearling goats that are intact and unremarkable are fed an unlimited diet that contains 1.5 kg *Berchemia discolor* leaf meal.
$BFL_{2.o}$	Male yearling goats that are unremarkable and intact are fed an unlimited diet that includes 2.0 kg *Berchemia discolor* leaf meal.
$BFL_{3.o}$	Yearling intact male non-descript goats fed *ad libitum* diet containing 3.0 kg *Berchemia discolor*

3.2.5. Management

A total of 16 yearling intact male non-descript were acclimated to an experimental diet for 14 days in an individual pen with 1.5 m long × 0.8 m wide dimension to allow some levels of interaction between animals to avoid stress associated with the isolation. Random sampling was carried out from the yearling intact South African non-descripts during blood and faeces samples collection to avoid disturbing their normal routine. Goats were gently guided following animal handling procedures (Jadhao *et al.,* 2020) to minimize stress and discomfort and to decrease the risk to animal health. Health assessment and monitoring of the goats was carried out by a veterinarian. Loud noise, sudden movements, or crowded conditions that could make the goat anxious were avoided. At the end of the study, goats were returned to the University farm.

3.2.6. Faeces collection

Faecal samples were collected at the end of the feed trial. They were freshly collected (uncontaminated by soil or bedding) directly from the rectum using a modified McMaster process, transported them on ice, and promptly analysed them for faecal egg count (FEC) and faecal oocyst counts (FOC) (Figure 3.2). The dietary BFLs were as follows: control 0kg, 1.5kg, 2.0kg, and 3.0kg (BFL_{o}, BFL_{1}.5, $BFL_{2.o}$, and $BFL_{3.o}$). The control BFL_{o}, was given no inclusion level of *Berchemia discolor* leaf meal. The collection container was labelled with the number of the animal and the date of collection. Faeces samples were refrigerated to avoid eggs from hatching within 12-24 hours, since once hatched, they cannot be counted. Faeces samples were collected on the last day of experiment. Faecal egg count was used to measure how many parasites egg a goat is passing in each gram, while faecal oocyst counts measured the number of protozoan oocysts in each gram of faeces.

Figure 3.2: Picture showing how faecal samples were collected

3.2.7. Statistical Analysis

The data for faeces samples was analysed with a one-way Analysis of variance (ANOVA) using a statistical software programme Statistical Package for the Social Sciences (SPSS), version 29.0. The statistical significance differences between group means were compared by Duncan's post hoc test. The data was conferred as the mean ± standard error of the mean (MSE). The results of statistical analysis were considered significant at $P < 0.05$.

The following statistical model was used for analysing the data obtained:

$Y_{ij} = \mu + T_i + e_{ij}$

Where: Y_{ij} =variable response in faeces samples

μ=overall mean,

T_i= fixed effect level of *Berchemia discolor* leaf meal

e_{ij}= random error.

The following quadratic equation was used to estimate the optimal South African non-descript goat in the analysis of data related to the effect of *Berchemia discolor* leaf meal on gastrointestinal nematodes infections.

Optimal responses in non-descript goat nematode infections to the level of *Berchemia discolor* expansion was designed using the subsequent quadratic equation:

$Y = a + b_1X + b_2X^2 + e$

Y= the response variable (faeces samples).

a = intercept; b_1 and b_2 = application of the quadratic equation.

x = constant *Berchemia discolor* supplementation.

e = random error and $–b_1/2b_2$ is the x value for optimal response.

The linear quadratic exemplary was used because it is the most used tool for quantitative predictions of dose dependencies.

3.3. RESULTS

Table 3.3.1 shows the impact of *B. discoloration* on gastrointestinal nematode infection. Supplementing non-descript goats with *Berchemia discolor* influenced *Strongyloides* ($P<0.05$). Despite significantly different ($P<0.05$), the greatest value for *Strongyloides* was found on goats in $BFL_{3.o}$, followed by $BFL_1.5$. *Strongyloides* were not identified for goats in $BFL_{2.o}$ or BFL_o.

Berchemia discolor supplementation had an influence ($P<0.05$) on *Trichuris sp*. The highest value was observed on BFL_o, followed by $BFL_{2.o}$, followed by $BFL_{3.o}$, and least value was observed on $BFL_{1.5}$ no difference between BFL_o. and $BFL_1.5$, BFL_o and $BFL_{3.o}$, $BFL_{1.5}$ and $BFL_{2.o}$, $BFL_{3.o}$ and $BFL_{2.o}$. However, there was no significant difference between BFL_o and $BFL_{2.o}$, $BFL_1.5$ and $BFL_{3.o}$.

Berchemia discolor had an influence ($P<0.05$) on oocyst of the non-descript goats among the dietary BFLs. The highest oocyst value was observed on $BFL_1.5$, followed by BFL_o, followed by $BFL_{3.o}$ and the smallest values were recorded on $BFL_{2.o}$.

Table 3.2: Faecal Samples Analysis for Nematode Egg Count and Oocyst Counts

Treatment	*Strongyloides*	*Trichuris sp.*	Oocyst	p-value
BFL_o	0.00 ± 0.0^a	1210.0 ± 11.55^b	3427.5 ± 3.75^c	< 0.05
$BFL_1.5$	302.5 ± 2.88^b	650.0 ± 57.74^a	10850.0 ± 57.74^d	< 0.05
$BFL_{2.o}$	0.0 ± 0.00^a	1125.0 ± 28.87^b	594.0 ± 51.96^a	< 0.05
$BFL_{3.o}$	305.0 ± 5.77^b	930.0 ± 25.55^a	2610.0 ± 11.55^b	< 0.05

BFL = *Berchemia discolor* feed level

$_{o,\ 1.5,\ 2.0,\ 3.0}$: different levels of *Berchemia discolor* feed level

Means with different superscripts within a column differ significantly at p < 0.05.

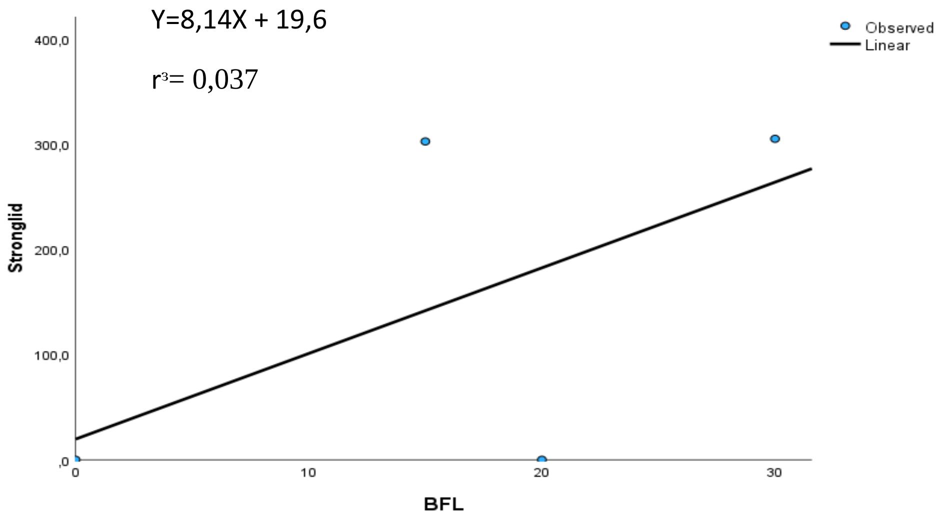
Positive relationship was observed between *Berchemia discolor* leaf meal and *Strongyloides* (r^3=0,337) of non-descript goats (Figure 3.3). However negative relationships were observed between *Berchemia discolor* leaf meal and *Trichuris sp.* (r^3=0,139) and oocyst (r^3=0,33) of non-descript goats (Figure 3.4 and Figure 3.5).

Table 3.3: Relationship between *Berchemia discolor* leaf meal and FEC (*Strongyloides* and *Trichuris sp.*) and FOC (oocyst).

Variable	**Formula**	**r^3**	**Probability**
Strongyloides	Y=8,14X + 19,6	r^3= 0,037	0,042
Trichuris sp.	Y=-7,44x + 1099	r^3= 0,139	0,628
Oocyst	Y= 63,80x + 5489,65	r^3= 0,33	0,818

Y linear regression formula

r^3 correlation coefficient



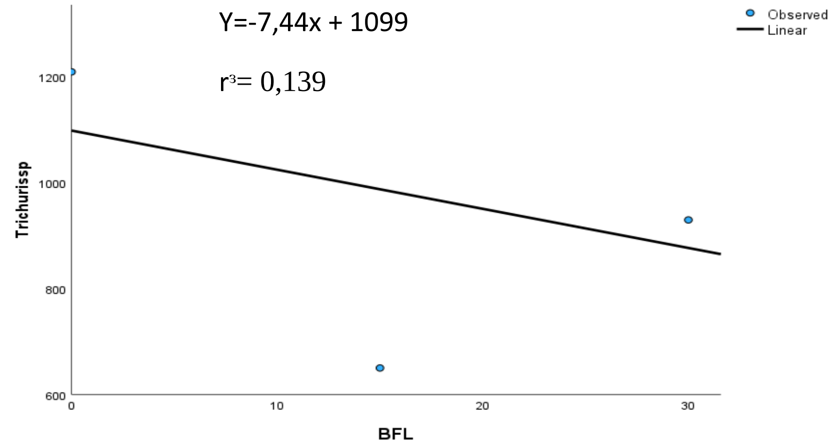
BFL = *Berchemia discolor* feed level

o, 1•5, 2•0, 3•0: different levels of *Berchemia discolor* feed level

Y =linear regression formula

r^3 =correlation coefficient

Figure 3.3: The effect of *Berchemia discolor* on *Strongyloides*



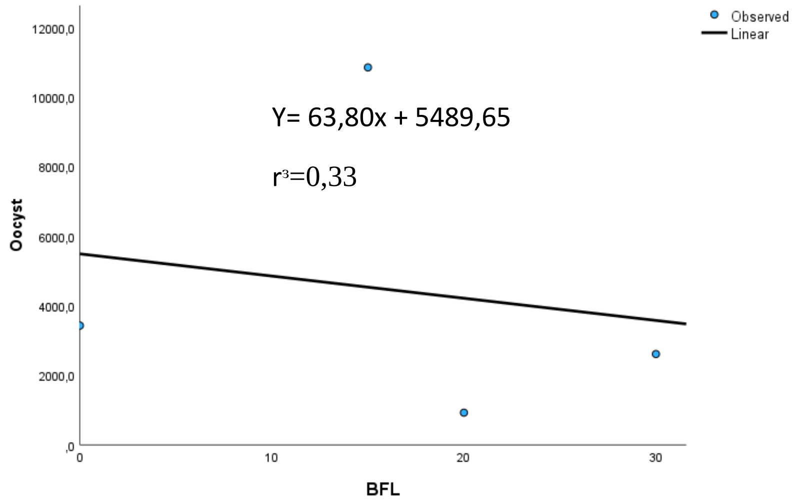
BFL = *Berchemia discolor* feed level

0, 1.5, 2.0, 3.0: different levels of *Berchemia discolor* feed level

Y = linear regression formula

r^3 = correlation coefficient

Figure 3.4: The effect of *Berchemia discolor* on *Trichuris sp.*



BFL = *Berchemia discolor* feed level

0, 1.5, 2.0, 3.0: different levels of *Berchemia discolor* feed level

Y = linear regression formula

r^3 =correlation coefficient

Figure 3.5: The effect of *Berchemia discolor* on oocyst

3.4. Discussion

One of the primary factors limiting ruminant output that impacts animal performance is infestation by internal parasites, gastrointestinal nematodes become more resilient and resistant when the amount of digestible protein increases (Holmes, 1993). Supplementation with *B. discolor* had a slight effect on FEC and worm burdens. This is in line with findings by Kabasa *et al.* (2000); Paolini *et al. (*2003a) and Min *et al.* (2004) who reported lower effects on parasite-infested sheep or goats that were offered tanniniferous fodder.

In this study before goats were fed *B. discolor* had high FEC, to ascertain that, goats in BFL_o were not given *B. discolor,* and all the BFLs that were given *B. discolor* had lower infestation compared to BFL_o. According to Max *et al.* (2005), the provision quebracho tannins as a drench to sheep had caused a significant reduction in their worm burden, these findings are similar to this study's findings, plant leaf meal had an effect on worm reduction.

B. discolor influenced FEC and significantly reduced their worm burden. This contradicts the finding by Athanasiadou *et al.* (2001) who reported that there was no significant effect observed on *Quebracho tannins* against the FEC. This deviation might be because of the use of different leaf meals. In the current study we used *B. discolor* and Athanasiadou *et al.* (2001) used *Quebracho tannins.*

The faecal egg count of goats supplemented with *B. discolor was* significantly low as compared to goats in control. This might be because *B. discolor* supplementation influenced faecal egg production, potentially reducing egg hatchability and larval development, which could have contributed to lower infestation levels, as goats that did not receive supplementation exhibited higher infestation. The These findings are consistent with previous research by Hegazi *et al. (*2018), which demonstrated the ovicidal action of *M. oleifera* leaf extracts, both alcoholic and aqueous, against Fasciola eggs in vitro. Results from this study differs from the finding by Ramirez *et al.* (2004) who reported that worm fecundity was negatively impacted by acacia supplements. This deviation might be because of the use of different leaf meals. In the current study, we used *B. discolor* and (Ramirez *et al.*, 2004) used acacia supplements.

In this study, *B. discolor* influenced the FOC. Coccidia was present in every goat used in this investigation. These findings are in agreement with the findings by Chikagwa *et al.* (2009) who reported that *Mucuna pruriens (*MUC) did not reduce FEC or FOC. In this study, *Berchemia discolor* leaf meal did not reduce oocyst values. These findings are in contrast with Min *et al.* (2003) who reported that although *G. sepium* leaves can lessen moderate to low worm infestation levels, they are not as successful at eliminating worms as chemical medications like albendazole. Leaves from *G. sepium* can be used to manage worm infestations in the sense that sheep that have a severe worm infestation need to be dewormed at the right time. The differentiation between these might be due to that different plant meals were used which are *B. discolour* and *G. sepium*.

According to this study goats on BFL_o were not fed *B. discolor* and other remaining BFLs were fed *B. discolor* and had high FOC compared to BFL_o. This contradicts with Lin *et al. (*2003) reported that FOC in goats was reduced by feeding leucaena (*Leucaena leucocephala*). This deviation could be because two distinct plant meals were used, *B. discolor* and *G. sepium.* In this research study BFL_o was the only BFL that was not fed *B. discolour* and as a result, had lower FOC values.

3.5. Conclusion and Recommendations

The study indicates that *Berchemia discolor* supplementation significantly influenced gastrointestinal nematode infections of non-descript goats. Strongly infections were notably affected, with the highest prevalence observed in goats supplemented with $BFL_{3.o}$, followed by $BFL_1.5$, while no *strongyloides* infections were recorded in $BFL_{2.o}$ and BFL_o groups. For Trichuris sp., supplementation with *Berchemia discolor* also showed a significant impact, with the highest infection rate in the BFL_o group and the least in $BFL_1.5$. However, several pairwise comparisons among BFLs revealed no significant differences. Regarding oocysts, the highest values were recorded in goats fed $BFL_1.5$, while the lowest was found in the $BFL_{2.o}$ group, demonstrating a significant dietary influence ($P<0.05$). These findings highlight the differential effects of *Berchemia discolor* supplementation on gastrointestinal parasites, suggesting its potential utility in managing specific infections based on the supplementation level.

Recommendations

Optimize the inclusion level of *Berchemia discolor* in goat diets to balance parasite control and overall health, focusing on levels like $BFL_{2.0}$ for the most beneficial outcomes. Further research should investigate the mechanisms behind the variation in parasite response across different supplementation levels. Long-term studies should evaluate the effects of *Berchemia discolor* on goat productivity, health, and economic viability in varying environmental conditions. Promote the use of *Berchemia discolor* as part of an integrated parasite management strategy for sustainable goat farming practices.

CHAPTER FOUR

EFFECT OF *BERCHEMIA DISCOLOR* LEAF MEAL MUNI TREE ON HAEMATOLOGICAL PROPERTIES OF SOUTH AFRICAN NON-DESCRIPT GOATS

4.1. Introduction

An assessment of an animal's blood profile may reveal some possibilities for a dietary intervention to address the animal's metabolic requirements (Church *et al.,* 1984), dietary elements have quantifiable effects on blood constituents, and substantial variations in their values can be used to infer the nutritional value of the feeds given to the animals. Ikhimoya and Imasuen, (2007), reported that most of the data on the haematological characteristics of goats in the humid tropics is derived from disease prognosis. The separate and combined actions of blood's constituents, the biochemical and haematological components, enable the blood's many functions.

Both the biochemical and haematological blood components are often affected by the amount and quality of feed as well as the amount of anti-nutritional elements or factors, such as toxicity, that are present in the feed (Akinmutimi, 2004). They can also be used to monitor the feeds' protein quality. Blood's haematological components are also useful for tracking feed toxicity, particularly when it comes to feed ingredients that influence blood formation (Oyawoye and Ogunkunle, 1998). Abu *et al.,* (1988) noted that low levels of haemoglobin (Hb) in treatment diets may indicate that the dietary proteins were of low quality. Poor oxygen transfer from the respiratory organs to the peripheral tissues is typically the result of diets with low protein content (Roberts *et al.,* 2000).

A high WBC count is typically linked to a microbial infection, a foreign body, or an antigen in the bloodstream. According to (Madubuike and Ekenyem, 2006), the haematological traits of animals indicate their physiological propensity to the plane of nutrition. *Berchemia discolor* is widely used for animal feed because it is a cheaper source of protein and has the potential to be cultivated under diverse environmental and soil conditions (Ashour *et al.,* 2020). *Berchemia discolor* is a drought resistance and it is the best promoting the synthesis of the microbial protein in the rumen and has high levels of naturally useful components such as minerals, vitamin (Ashour *et al.,* 2020). Deficiency of natural deterioration can be evaded by using *Berchemia discolor* restoration of concentrate feed in arid areas to meet animal’s requirements for growth and production (Abdelnour *et al.,* 2019). Goats kept under arid conditions where they are fed *Berchemia discolor* at different levels positively impact growth performance, blood haematology, serum metabolites, and blood minerals. Therefore, determine the effect of *Berchemia discolor* leaf meal (Muni tree) I on haematological properties of South African non-descript goats.

4.2. Material and Method

4.2.1. Study site

The study design is as described in Chapter 3, section 3.2.1.

4.2.2. Ethical statement

The study was approved for ethical consideration by the Animal Research and Ethics Committee of the University of Limpopo (AREC) with the AREC number: AREC/26/24:PG

4.2.2. Acquisition of materials and goats

Acquisition of materials is as described in Chapter 3, section 3.2.2.

4.2.3. Preparation of experimental procedures, dietary treatments, and house

Preparation of experimental procedures, dietary treatments, and house is as described in Chapter 3, section 3.2.3.

4.2.4. Management

Management is as described in Chapter 3, section 3.2.4.

4.2.5. Blood collection

Blood collection was done on the first and last day of the experiment from sixteen goats. Goat was restrained with the head elevated and jugular vein. Goat was set on its on its rump with its back against the handler's legs (Hawk *et al.,* 2005). Goat was held on the head about a 30° angle to the side to extend neck and expose jugular (Figure 4.1). Two handlers were needed, one to restrain and one to collect blood. With goat set between handler's legs, tuck head under arm, and access jugular from above, a small area was clipped over the jugular groove and swiped with antiseptic gauze to remove superficial dirt and debris. Occlude jugular vein applied pressure at the base of the jugular groove and visualize raised vein. With bevel up, needle was inserted through skin (Figure 4.2) and into vein at 20° angle using vacutainer once needle inserted, needle was stabilized and pushed the vacutainer tube into hub. Vein was hit to allow free flow into tube. Multiple tubes were filled by removing filled tube and replacing with fresh tube. If vein was missed, needle was carefully repositioned until vessel penetration. Vessel may be deep and roll away from needle. Typically, no more than two to three attempts were made at a time to minimize distress to the animal and potential damage to the vein. Once blood collection was completed, pressure was released to the vein and applied over injection site with gauze, needle was removed. Needles were disposed in a sharp container (Donovan and Brown, 1993).

At ARC, the haematological characteristics of goats were analysed. A pair of scissors were used to shear the goats for better exposure and access to the jugular vein and to have a clean area to minimize the chance of introducing dirt or bacteria into the vein with a needle. Blood was drawn from jugular veins of the animals using vacutainer needle and draw blood directly into a 5mL blue top (3.8% Na citrate) vacutainer tube (MDS-USA, 2008). A vacutainer needle, 5-cm-long needle was introduced into the mid-way along the jugular vein against the flow of blood. A total volume of 15 mL/kg of blood (approximately 450 mL) was drawn (Hunt and Moore 1990) within 10 min into the sterile bags. During the blood collection, the goats head was tilted at a 30-degree angle to the side by holding the animal under its jaw to allow for easy access to the vein. The jugular groove on the left side of the neck was shaved and disinfected. Therefore, pressure was applied with a thumb on the neck to locate the vein. The samples were divided into two batches for biochemical and haematological analyses (Dacie and Lewis, 1991). Five millilitres of the blood sample was collected (Figure 4.3) from each sample in a labelled sterile universal bottle containing ethylene diamine tetra acetic acid (EDTA) and used for haematological analysis. Another 5 ml was collected over the anticoagulant free bottle and used for serum biochemical determination. Within an hour of compilation, the sterile test tubes containing EDTA as an anticoagulant was delivered to the laboratory for resolution of the haematological framework (Figure 4.4). Without the use of an anticoagulant, blood tubes were allowed to harden before being diverged at 3000 rpm for 10 minutes at 21°C and stored at 20°C for chemical analysis.

The haematological assessment was neutrophil (NE), lymphocytes (LY%), monocytes (mo%), eosinophil (EO%), basophilia (BA%). For serum, biochemical determination, an additional of 5 millilitres was collected over the anticoagulant free container for serum biochemical determination. Using Bayer DCA 2000+ HbA1c analyser and the Beckman Coulter Ac-T10 laboratory Haematology Blood Analyzer suitable, appropriately serum biochemistry and haematological parameters were evaluated. Calculations were made for mean cell haemoglobin (MCH), mean cell volume (MCV), and mean cell haemoglobin consolidation (MCHC) (Hansen and Perry, 1994).

Figure 4.1: Goat held a 30° angle to the side to extend neck and expose jugular

Figure 4.2: Needle was inserted through skin of the goat

Figure 4.3: Five millilitres of the blood sample

Figure 4.4: Resolution of the haematological framework.

4.2.6. Statistical Analysis

Blood samples were analysed with a one-way Analysis of variance (ANOVA) using a statistical software programme Statistical Package for the Social Sciences (SPSS), version 29.0. The statistical significance differences between group means were compared by Duncan's post hoc test. The data was conferred as the mean ± standard error of the mean (MSE). Results of statistical analysis was considered significant at $P < 0.05$.

The following statistical model was used for analysing the data obtained:

$Yij = \mu + Ti + eij$

Where: Y_{ij} =variable response in blood samples

μ=overall mean,

T_i= fixed effect level of *Berchemia discolor* leaf meal

e_{ij}= random error.

The following quadratic equation was used to estimate the optimal South African non-descript goat in the analysis of data related to the effect of *Berchemia discolor* leaf meal on haematological properties.

Optimal responses in non-descript goat blood haematology to the level of *Berchemia discolor* expansion was designed using the subsequent quadratic equation:

$Y = a + b_1X + b_2X^2 + e$

Y= the response variable (blood samples).

a = intercept; b_1 and b_2 = application of the quadratic equation.

x = constant *Berchemia discolour* supplementation.

e = random error and $-b_1/2b_2$ is the x value for optimal response.

The linear quadratic exemplary was used because it is the most used tool for quantitative predictions of dose dependencies.

4.3. Results

4.3.1: The effect of *Berchemia discolor* on haematological properties of South African non-descript goats

Table 4.1 shows the effect of *Berchemia discolor* on the haematological properties of South African non-descript goats. Changes in different white blood cells were evaluated across four BFLs (BFL_o, $BFL_{1.5}$, $BFL_{2.o}$, and $BFL_{3.o}$). There were no significant differences among Neutrophil (NE) percentages on BFLs for both the first and last days ($P = 0.289$ and $P = 0.705$, respectively). Lymphocyte (LY) percentages were also not significantly different between BFLs on either day (P = 0.077 and P = 0.284). Monocyte (MO) percentages showed a significant difference on the first day (P = 0.046) but not on the last day (P = 0.310). Eosinophil (EO) and Basophil (BA) percentages exhibited no significant differences across BFLs at both time points. Furthermore, *Berchemia discolor* did not cause significant changes in the haematological parameters.

Table 4.1: The effect of *Berchemia discolor* on haematological properties of South African non-descript goats

		BFL$_{0}$	**BFL$_{1.5}$**	**BFL$_{2.0}$**	**BFL$_{3.0}$**	**P-value**
NE (%)	1st day	$12,0\pm2,58^{a}$	$11,0\pm2,16^{a}$	$14,8\pm3,86^{a}$	$13,8\pm2,50^{a}$	0,289
	Last day	$15,0\pm2,45^{a}$	$11,0\pm3,65^{a}$	$12,5\pm2,08^{a}$	$11,5\pm2,08^{a}$	0,705
LY (%)	1st day	$80,5\pm4,12^{a}$	$82,8\pm4,27^{a}$	$75,0\pm3,74^{a}$	$76,8\pm4,27^{a}$	0,077
	Last day	$79,5\pm3,40^{a}$	$83,2\pm4,72^{a}$	$79,8\pm1,50^{a}$	$81,8\pm1,50^{a}$	0,284
MO (%)	1st day	$4,6\pm0,96^{a}$	$4,6\pm0,96^{a}$	$5,8\pm1,50^{a}$	$5,5\pm1,91^{a}$	0,046
	Last day	$5,0\pm0,82^{b}$	$3,5\pm1,29^{a}$	$5,0\pm0,82^{b}$	$3,5\pm0,58^{a}$	0,310
EO (%)	1st day	$2,3\pm0.50^{a}$	$2,0\pm0,82^{a}$	$4,0\pm0,82^{a}$	$2,8\pm0,96^{a}$	0,17
	Last day	$2,3\pm0,50^{a}$	$2,0\pm0,82^{a}$	$4,0\pm0,82^{a}$	$2,5\pm0,58^{a}$	0,529
BA (%)	1st day	$0,5\pm0,58^{a}$	$0,5\pm0,58^{a}$	$0,5\pm0,58^{a}$	$1.0\pm0,82^{a}$	0,627
	Last day	$0,8\pm0,50^{a}$	$0,0\pm0,00^{a}$	$0,3\pm0,50^{a}$	$0,8\pm0,50^{a}$	0,073

BFL = *Berchemia discolor* feed level

%= percentage

NE = Neutrophil; Ly= Lymphocytes; Mo= Monocyt, EO= Eosophil, Ba Basophil,

$_{0, 1.5, 2.0, 3.0}$: different levels of *Berchemia discolor* feed level

Means with different superscripts within row show significant difference at $p < 0.05$.

4.3.1. The effect of *Berchemia discolor* on NE% (1st and last day) of goats

Neutrophil Percentage (NE%): The analysis showed no statistically significant effect (Figure 4.5) on the NE% amongst the different BFLs for both first day and last day of blood collection. This indicates that the inclusion of *Berchemia discolour* in the diet did not significantly affect the neutrophil counts of the goats. The data shows that for BFL_0, the NE% increased significantly from the first day to the last day. For $BFL_{1.5}$, and $BFL_{3.0}$, there is minimal change between the two days, suggesting relatively stable NE%. In contrast, $BFL_{2.0}$ starts with the highest NE% on the first day but decreases by the last day. This variation indicates differing trends across categories, possibly influenced by unique factors related to each BFL condition.

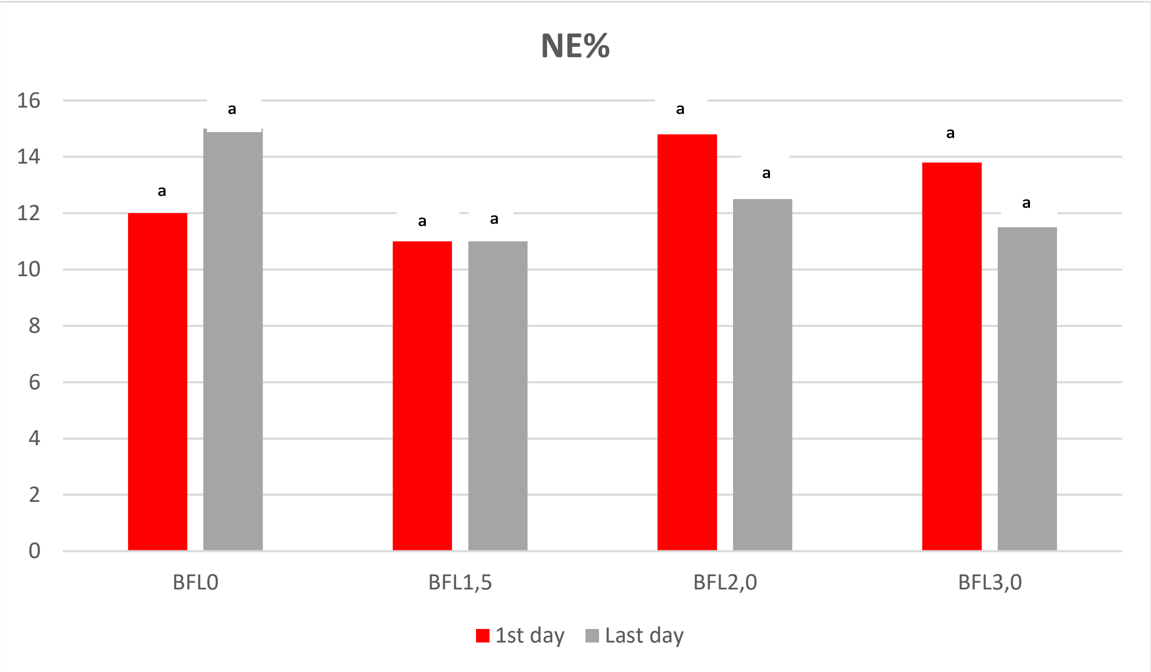


Figure 4.5: The effect of *Berchemia discolor* on NE% (1st and last day) of goats

NE %   = NEUTROPHILS PERCENTAGE

BFL   = *Berchemia discolor* feed level

$_{0, 1.5, 2.0, 3.0}$: different levels of *Berchemia discolor* feed level

Means with different superscripts within treatment differ significantly at ($p < 0.05$).

Lymphocyte Percentage (LY%): The LY (%) did not show significance difference (Figure 4.6) among the four BFLs (p>0.05) both for the first day and last day, this implies that $BFL_{1.5}$ exhibits the highest performance for both the 1st and Last day, with only a slight increase between them. Conversely, $BFL_{2.0}$ and $BFL_{3.0}$ show significant improvement from the 1st to the last day. BFL_0 demonstrates minimal change, indicating relative consistency over time. Overall, the graph highlights varying trends, with some BFLs showing stability while others experience noticeable growth.

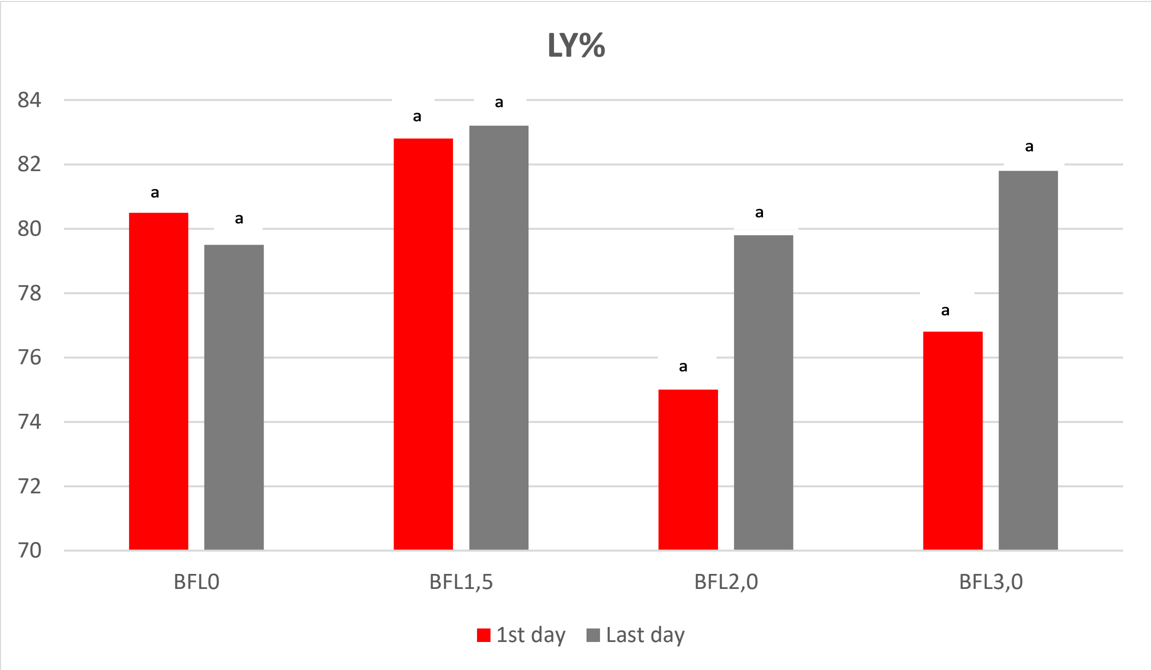


Figure 4.6: The effect of *Berchemia discolor* on LY% (1^{st} and last day) of goats

LY % = Lymphocytes Percentage

BFL = *Berchemia discolor* feed level

$_{0,\ 1.5,\ 2.0,\ 3.0}$: different levels of *Berchemia discolor* feed level

Means with different superscripts within treatment differ significantly at ($p < 0.05$).

4.3.3. The effect of *Berchemia discolor* on MO% (1^{st} and last day) of goats

Monocyte Percentage (MO%): MO (%) there was a significant difference (P<0.05) among the four BFLs on the last day of blood collection although on the first day, there was no significant difference among the 4 BFLs, with BFL_0 and $BFL_{3.0}$ having same results and it is shown (Figure 4.9,4.10 &4.11). This indicates that the *Berchemia discolor* leaf meal had an influence on monocyte since on the first day goats were not on diet that was given to them during the trial. The lowest MO (%) was observed in $BFL_{3.0}$ compared to $BFL_{2.0}$, $BFL_{1.5}$, and BFL_0. There was significant difference ($P<0.05$), between $BFL_{3.0}$ and BFL_0, $BFL_{1.5}$ and $BFL_{2.0}$, $BFL_{2.0}$ and $BFL_{3.0}$. The highest MO (%) was observed according to BFL_0 and $BFL_{2.0}$ with the same results followed by $BFL_{1.5}$ and lowest values were observed in $BFL_{3.0}$. It is evident that the highest monocyte percentages on both the first and last days were observed in $BFL_{2.0}$, while $BFL_{1.5}$ and $BFL_{3.0}$ exhibited lower values, with BFL_0 showing intermediate results. Notably, the monocyte percentages decreased slightly over time for most BFLs, indicating some level of change due to the dietary intervention.

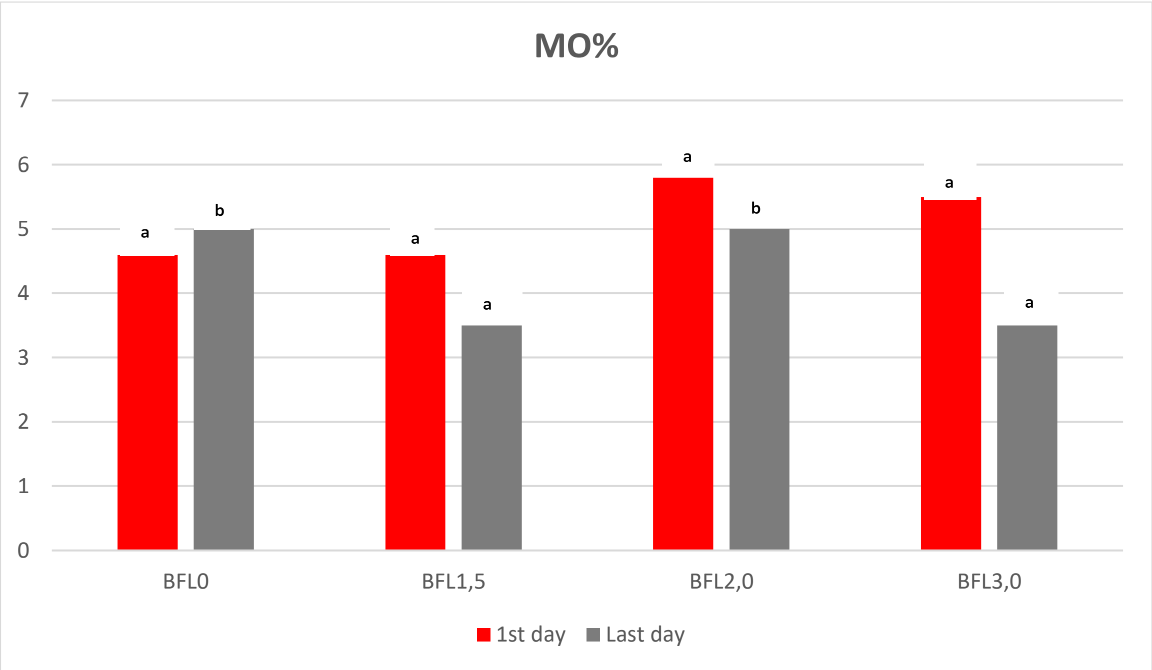


Figure 4.7: The effect of *Berchemia discolor* on MO% (1^{st} and last day) of goats

MO % = Monocytes Percentage

BFL = *Berchemia discolor* feed level

$_{0, 1.5, 2.0, 3.0}$: different levels of *Berchemia discolor* feed level

Means with different superscripts within treatment differ significantly at ($p < 0.05$).

A positive relationship was observed between *Berchemia discolor* leaf meal and MO% on the 1^{st} day of data collection (r^3=0,728) of non-descript goats (Figure 4.7). However negative relationships were observed between *Berchemia discolor* leaf meal and MO% on the last day of data collection (r^3= 0,333) of the non-descript goats (Figure 4.3.3.3).

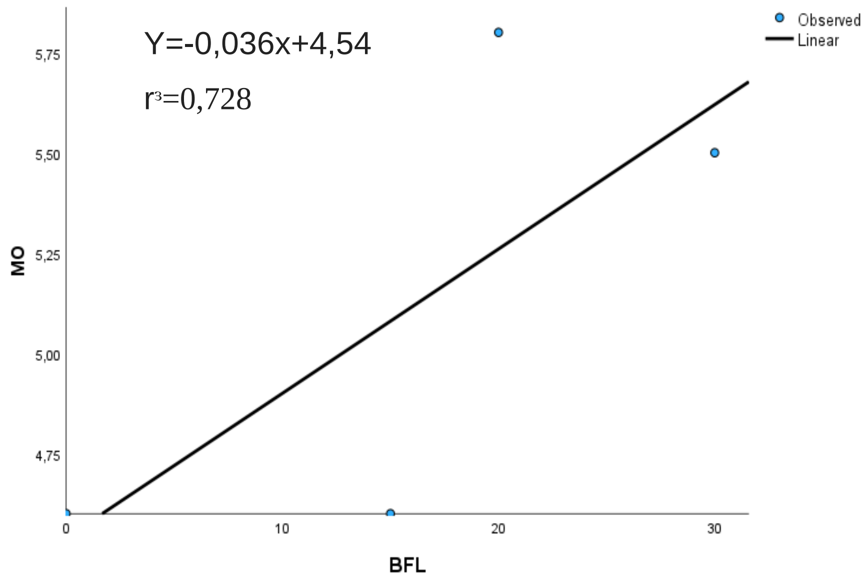
Table 4.2: Relationship between *Berchemia discolor* leaf meal and MO% (for the 1st and last day of data collection)

Variable	Day of data collection	Formula	r^3	Probability
MO	1st day	Y=8,14X + 19,6	r^3= 0,728	0,272
	Last day	Y=-7,44x + 1099	r^3= 0,333	0,423

MO =Monocyte

Y =linear regression coefficient

r^3 =correlation coefficient



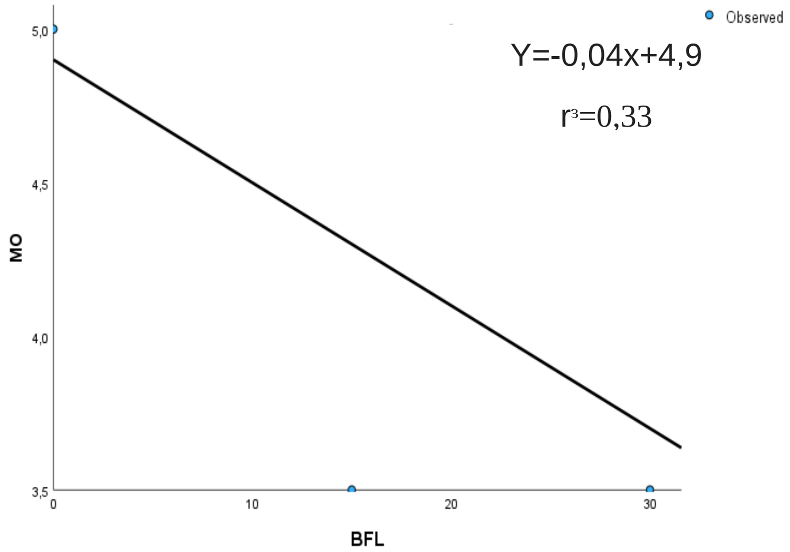
BFL = *Berchemia discolor* feed level

0, 1.5, 2.0, 3.0: different levels of *Berchemia discolor* feed level

Y = linear regression formula

r^3 = correlation coefficient

Figure 4.8: The effect of *Berchemia discolor* on MO% for the 1st day



BFL = *Berchemia discolor* feed level

0, 1.5, 2.0, 3.0: different levels of *Berchemia discolor* feed level

Y = linear regression formula

r³ = correlation coefficient

Figure 4.9: The effect of *Berchemia discolor* on MO% for last day

4.3.4. The effect of *Berchemia discolor* on EO% (1st and last day) of goats

Eosinophil Percentage (EO%): There was no significant difference (p>0.05) on eosinophil levels amongst all BFLs, blood samples for EO (%) results were the same (Figure 4.10), implying that the dietary BFLs did not alter eosinophil counts, which are typically associated with parasitic infections or allergic reactions. For BFL_0 and $BFL_{1.5}$, the EO% shows little variation between the first and last days. However, for $BFL_{2.0}$, there is a marked increase in EO% compared to the other BFLs, with both days having similar, high values. Conversely, $BFL_{3.0}$ exhibits a slight decrease in EO% from the first to the last day. The data indicates variability in trends across the different BFLs, particularly the pronounced peak at $BFL_{2.0}$.

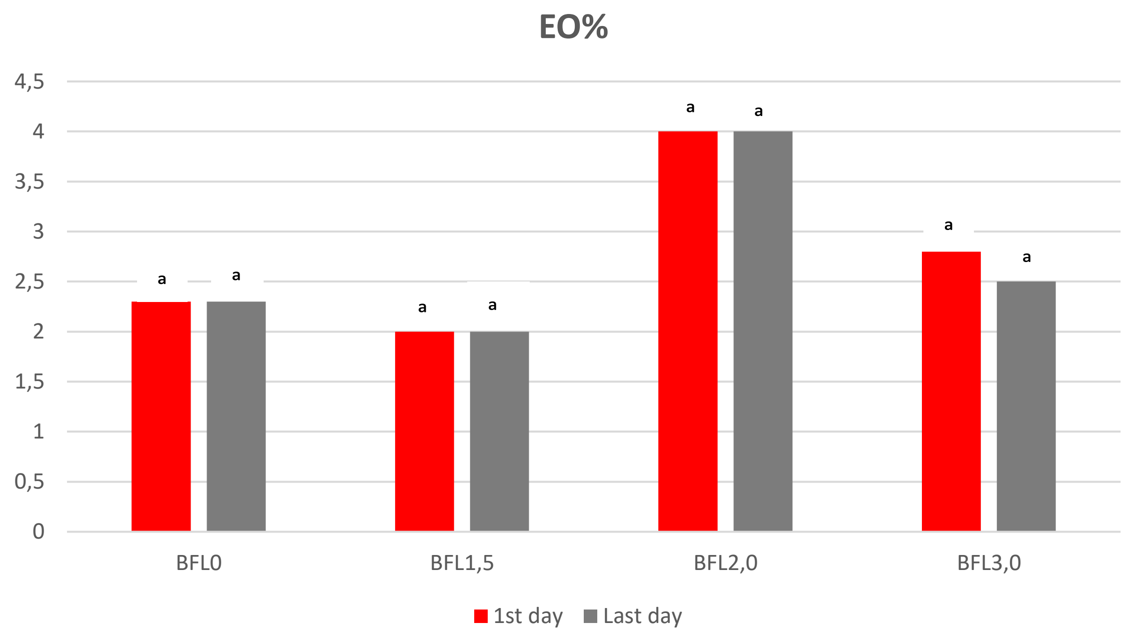


Figure 4.10: The effect of *Berchemia discolor* on EO% (1st and last day) of goats

OE % = EOSINOPHILPERCENTAGE

BFL = *Berchemia discolor* feed level

o, 1.5, 2.0, 3.0: different levels of *Berchemia discolor* feed level

Means with different superscripts in a treatment differ significantly at $p < 0.05$.

4.3.5. The effect of *Berchemia discolor* on BA% (1st and last day) of goats

Basophilia Percentage (BA%): *Berchemia discolor* had no significant difference (P>0.05) among the 4 BFLs both on first day and last day, this implies that Basophilia levels remained stable despite the dietary changes. In $BFL_{1.5}$, BA% remained relatively stable, indicating minimal variation over time. For $BFL_{2.0}$, BA% decreased slightly from the first to the last day, while in $BFL_{3.0}$. BA% showed a high value on the first day but remained consistent by the last day (Figure 4.11).

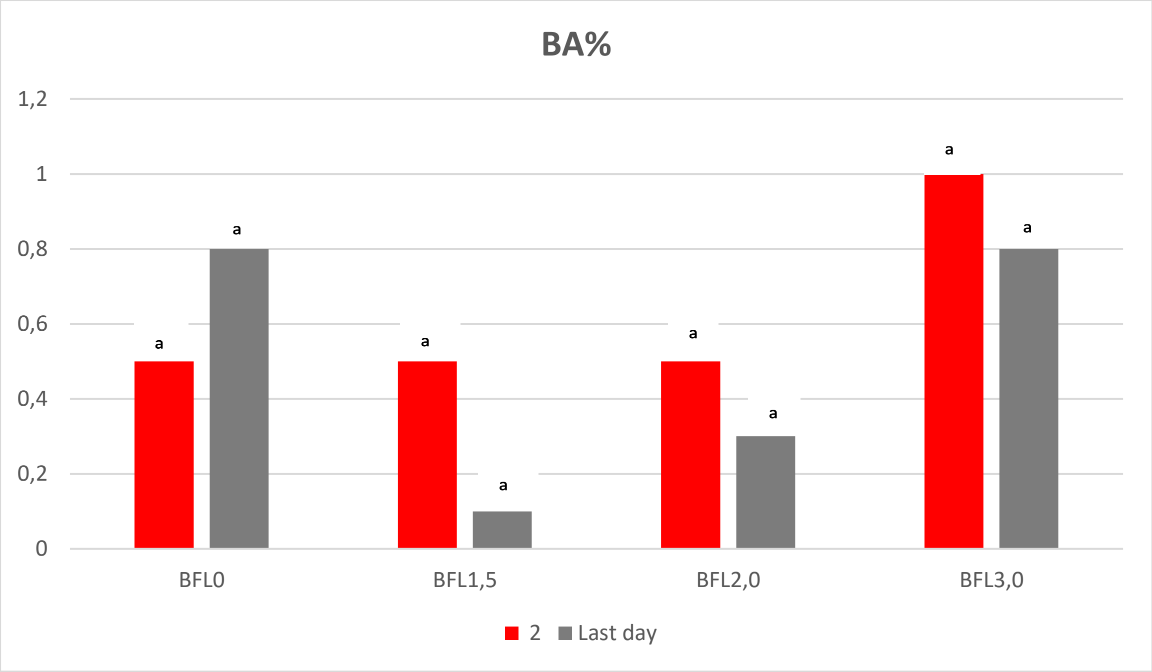


Figure 4.11: The effect of *Berchemia discolor* on BA% (1st and last day)

BA % = BASOPHILIA

BFL = *Berchemia discolor* feed level

0, 1.5, 2.0, 3.0: different levels of *Berchemia discolor* feed level

. Means with different superscripts in treatment differ significantly at $p < 0.05$.

4.4. Discussion

Goats fed *Berchemia discolor* leaves and showed improved daily weight gain as leaves contains efficient protein utilization. In this present study there was significant differences among MO% BFLs which showed that *Berchemia discolor* had an effect MO%. The notable difference in the WBC counts of goats fed treated diets may be partially explained by the diets increased nutritional utilization and digestibility. These findings agree with the findings by Makkar, (1993), (Odenyo *et al.,* 1997), and Oyawoye and Ogunkunle, (2004). Makkar, (1993), who observed that goats fed more leave meal of *V. karro*o had improved daily weight gain. Clinical indicators of disease or tannin poisoning, such as head pressing, generalized depression, teeth grinding, foaming at the mouth, and twitching and jerking, were not displayed by the experimental goats in the current investigation (Odenyo *et al.,* 1997). According to Oyawoye and Ogunkunle, (2004), haematological components such as white blood cells, or leucocytes, are helpful in assessing feed toxicity, especially when feed ingredients affect the blood and overall health of farm animals.

In this study only monocytes were significant. Lymphocyte, neutrophils, eosinophils and basophils were not significantly different among all BFLs. These findings are like Opara *et al.,* (2010), who reported that white blood cell differential, lymphocyte, neutrophils, monocyte, eosinophils and basophils were not significantly different among all groups when goats were fed *Moringa oleifera* leaves.

In this current study, lymphocyte levels remained stable in all the BFLs, despite the dietary changes. This study is in contrary with (Amirghofran *et al.,* 2009) who reported that, extracts of *Linum persicum* resulted in a significant decrease in lymphocyte proliferation in humans. The differentiation between these results, might be due to that different plant meals were used which are *B. discolour* and *Linum persicum*. However, my findings are similar to Jiwuba *et al.,* (2017) who reported the response observed for MO extract. Moringa supplementation resulted in increased WBC count but had no effect on lymphocyte count in West African Dwarf goats.

In this study, there were insignificant RBC values obtained. This might have happened of the *Berchemia discolor* leaf meal was used. This is in agrees with Solaiman *et al.,* (2010) findings, which reported no differences in RBC numbers when Kiko crossbred male kids were fed a *Sericea lespedeza* diet containing varying levels of CT. The blood's ability to carry oxygen is indicated by the concentration of haemoglobin. According to (Olafadehan *et al.,* 2014) findings goats fed *tanniniferous Ficus polita* had similar Hb concentration values. The Hb values in the present study also indicate the absence of microcytic hypochromic anaemia owing to iron deficiency (Olafadehan *et al.,* 2014). According to (Daramola *et al.,* 2005) the absolute lymphocyte counts for goats in groups values fell within the range of 47–82% reported for clinically, healthy goats. These findings are in contrast with findings of this study as lymphocyte counts for goats in groups values 74-89% reported for clinically, healthy goats.

Haematocrit (HCT), also known as packed cell volume, is a measurement of the blood's ability to carry oxygen since it represents the proportion of blood volume that is made up of erythrocytes. In this current study, dietary BFLs had no effect on haematocrit. These finding are in line with findings by Solaiman *et al.* (2010) who reported that goats fed different amounts of tannin-rich *Sericea lespedeza* diets showed no change in HCT values. This suggests that there was no cell loss or degradation, and that RBC production was sufficient.

4.5. Conclusion

The inclusion of *Berchemia discolor* leaf meal in the diet of goats demonstrated a significant effect on monocyte percentages, particularly on the last day of the trial, suggesting a potential role in modulating immune responses. However, there were no significant effects on other haematological indicators, including neutrophil, lymphocyte, eosinophil, and basophilia percentages, implying that the dietary intervention did not adversely affect these parameters. These findings indicate that *Berchemia discolor* leaf meal may selectively influence certain immune-related parameters without disrupting overall haematological stability in goats.

Recommendations: Further research should be conducted to explore the specific mechanisms through which *Berchemia discolor* affects monocyte levels and its implications for immune function in goats. Additionally, studies on long-term feeding and its effects on productivity and health outcomes in various environmental conditions are recommended. Incorporating *Berchemia discolor* leaf meal in controlled proportions could be considered in goat diets to potentially enhance immune modulation while maintaining haematological balance.

CHAPTER FIVE

GENERAL DISCUSSION AND CONCLUSIONS

5.1 General discussion

Goats play a vital role in enhancing livelihoods and food security in Africa, contributing to milk, meat, skins, cashmere, and mohair production while also holding cultural significance. *Berchemia discolor* is a versatile medium to large tree, reaching heights of up to 20 meters. It can be deciduous or evergreen, with a pale green stem marked by brown lenticels when young, and mature bark that is dark grey and fissured. Rich in protein and minerals, this tree serves as an important resource during the dry season, offering a nutritional supplement to poor-quality natural pastures or fibrous crop residues, thereby improving animal performance.

Non-descript goats, valued for their heat and drought tolerance and disease resistance, often subsist on poor-quality feed within agropastoral systems. However, their productivity is hindered by the high prevalence of gastrointestinal nematode infections, particularly in grassland and forestland vegetation types. To address this challenge, it is essential to assess nematode loads and control measures. Blood analyses, including haematological and biochemical parameters, serve as critical tools for evaluating animal health, as they reflect the impact of diet, climatic conditions, and pasture quality on goats' physiological status and overall productivity.

Chapter 3, the study evaluated the impact of *Berchemia discolor* supplementation on non-descript goats and revealed significant ($P<0.05$) effects on parameters such as strong lids, *Trichuris* sp., and oocyst counts across dietary BFL. While the highest strong lid values were observed in goats on $BFL_{3.0}$, followed by $BFL_{1.5}$, no strong lids were identified in $BFL_{2.0}$ and BFL_{0}. *Berchemia discolor* had more effect on BFL_{0} and $BFL_{2.0}$ for strong lids since it was not diagnosed on these dietary BFL. *Trichuris* sp. counts were highest in BFL_{0}, followed by $BFL_{2.0}$ and $BFL_{3.0}$, with the least value in $BFL_{1.5}$, though some pairwise differences were not significant ($P>0.05$). *Berchemia discolor* had no effect on *Trichuris* sp. for all the dietary BFL. Oocyst counts varied significantly, with the highest value in $BFL_{1.5}$, followed by BFL_{0} and $BFL_{3.0}$, and the lowest in $BFL_{2.0}$. *Berchemia discolor* had effect on oocyst for all dietary BFL. These findings indicate that *Berchemia discolor* supplementation influences gastrointestinal health parameters in goats, suggesting its potential as a dietary intervention, though effects are dependent on the supplementation levels.

Chapter 4, focused on the inclusion of *Berchemia discolor* leaf meal in the diet of goats had minimal effects on their haematological parameters. Neutrophil (NE%) and lymphocyte (LY%) counts remained stable across all BFLs, indicating no significant impact of the dietary intervention on these immune cells. Eosinophil (EO%) and basophil levels were also unaffected, suggesting that the dietary BFLs did not influence factors associated with parasitic or allergic responses. However, monocyte (MO%) levels showed significant differences ($P<0.05$) on the last day of the trial, with the lowest levels observed in $BFL_{3.0}$ and the highest in BFL_{0}, and $BFL_{2.0}$. This suggests that *Berchemia discolor* may influence monocyte activity depending on dietary composition and duration. Overall, while *Berchemia discolor* had a limited impact on most blood parameters, its potential effect on monocyte counts warrants further investigation.

CHAPTER SIX

REFERENCES

REFERENCES

Abbiw, D.K. (1990). Useful Plants of Ghana. International Technology Publications.

Abdelnour, S.A., Abd El-Hack, M.E., Khafaga, A.F., Arif, M., Taha, A.E., Noreldin, A.E., (2019).Stress biomarkers and proteomics alteration to thermal stress in ruminants: A review. *Journal Thermal Biology.*, *79*, 120–134.

Abu, O.A., Rabo, J.S., Onifade, A.A., and Danny, C.B. (1988). Blood composition and histological changes in the gastrointestinal tract of rabbits fed untreated rice husk based diets. Proceedings of Annual Conference of Nigerian Society for Animal Production, 23: 144-147.

Adejoro, F., and Hassen, A. (2018). In vitro methane production of eragrostis hay treated with graded levels of urea or nitrate. JAPS, *Journal of Animal and Plant Sciences*. .28(3): 679-685.

Adiwimarta, K., Daryatmo, J., Orskov, E. R., Mayes, R.W., Hartadi, H. (2010). Utilisation of cassava leaf and Carica papaya leaf as feeds and anthelmintics for goats. *Advanced Animal Bioscience,*1:114.

Akinmutimi, A.H. (2004). Evaluation of sword bean (Canavalia gladiata) as an alternative feed resource for broiler chickens. Ph.D. Thesis, Department of Non-ruminant Animal Production, Michael Okpara University of Agriculture, Umudike, Nigeria.

Amirghofran, Z., Bahmani, M., Azadmehr, A., Javidnia, K., Miri, R. (2009). Immunomodulatory activities of various medicinal plant extracts: Effects on human lymphocytes apoptosis. *Immunol. Investigation*, *38*: 181–192.

Amran, M.A., Yadav, S.K., Akter, F., Sarkar, S., Hossain, M.A., Joy, S.M., and Samrat A.A.K. (2018). Prevalence of gastrointestinal parasitic infections in different existing goat breeds in different districts of Bangladesh. *The Journal of Advances in Parasitology,* 5:11-21.

Aniagu, S.O., Binda, L.G., Nwinyi, F.C., Orisadipe, A., Wambebe, C., and Gamanie,K. (2005). Anti-diarrhoeal and ulcer-protective effects of the aqueous root extract of Guiera senegalensis in rodents. *Journal Ethnopharmacol.* 97(3): 549-554.

Anjorin, T.S., Ikokoh, P., and Okolo, S. (2010). Mineral composition of Moringa oleifera leaves, pods and seeds from two regions in Abuja, Nigeria. *International Journal of Agriculture and Biology*, 12: 431–434.

Aregawi, T., Melaku S. and Nigatu L. (2008). Management and utilization of browse species as livestock feed in semi-arid district of North Ethiopia. Livestock Research for Rural Development. 20(86).

Arzani, H., Sadeghimanesh, M.R., Azarniv, H., Asadian, G.H., Shahriyari, E. (2008). Study of phonological stages effect values of twelve species in Hamadan rangelands. *Iranian Journal of Agricultural Research* 16: 86–95.

Athanasiadou, S., Kyriazakis, I., Jackson, F., and Coop, R.L.(2001). Direct anthelmintic effects of condensed tannins towards different gastrointestinal nematodes of sheep: in vitro and in vivo studies. *Veterinary Parasitology*. 99: 205 – 219.

Ashour, E.A., El-Kholy, M.S., Alagawany, M., Abd El-Hack, M.E., Mohamed, E.; Mohamed, L.A., Taha, A.E., Sheikh A.I., Laudadio, V., Tufarelli, V., (2020). Effect of dietary supplementation with *Moringa oleifera* leaves and/or seeds powder on production, egg characteristics, hatchability and blood chemistry of laying Japanese quails. *Sustainability,* 12: 2463.

Attia, N.E. (2016). Physiological, haematological, and biochemical alterations in heat stressed goats. *Benha Veterinary Medical Journal*, 31(2): 56-62.

Azaizeh, H., Mrenya, R., Markovics, A., Muklada, H., Glazerd, I., and Landau S.Y. (2015). Seasonal variation in the effects of Mediterranean plant extracts on the exsheathment kinetics of goat gastrointestinal nematode larvae. *Small Ruminant Research*, 131, 130–135.

Azas, N., Laurencin, N., Delmas, F., Di Giorgio, C., Gasquet, M., Laget, M., and Timon David P. (2002). Synergistic in vitro antimalarial activity of plant extracts used as traditional herbal remedies in Mali. *Parasitology Researc*h. 88(2): 165-171.

Balemie, K., Kebebew, K. (2006). Ethnobotanical study of wild edible plants in Derashe and Kucha Districts, *South Ethiopia Journal Ethnobiology Ethnomed*, 2: 53-53.

Belewu, M.A., and Ojo-Alokomaro, K.O. (2007). Haematological indices of West African dwarf goat fed leaf meal-based diets. *Journal Agriculture Science*, 13: 601-606.

Bishop, S., and Morris, C. (2007). Genetics of disease resistance in sheep and goats. *Small Ruminant Research*, 70:48-59.

Blackie, S. (2014). A Review of the Epidemiology of gastrointestinal nematodes infections in sheep and goats in Ghana. *Journal of Agricultural Science*, 6: 1916-9760.

Church, J.P., Judd, J.T., Young, C.W., Kebay, J.L., and Kin WW (1984). Relationships among dietary constituents and specific serum clinical components of subjects eating self-selected diet. *American Journal of Clinical Nutrition*, 40: 1338-1344.

Chikagwa, S.K., Adesogan, A.T., Szabo, N.J.(2009). Nutritional characterization of Mucuna pruriens: 3. Effect of replacing soybean meal with Mucuna on intake, digestibility, N balance and microbial protein synthesis in sheep. *Animal Feed Science Technology*,148:107–23.

Chin, Y,W., Kinghorn, A,D.(2006). The role of pharmacognosy in modern medicine and pharmacy. *Curr Drug Targets*,7: 247 – 264.

Clark, A.M., Stephen, F.B., and Cawley, G.D. (1996). Resistance of the sheep scab mites against Psoroptes ovis to propetamphas. *Veterinary Record*, 139(18): 151.

Dacie, J.V. and Lewis, S.M. (1991). Practical Haematology. 7th Edition, Churchil Livingstone, Edinburgh, 54-79.

Daramola, J.O., Adeloye, A.A., Fatoba, T.A., Soladoye, A.O.(2005). Haematological and Biochemical parameters of WAD goats. *Livestock Research for Rural Developmen*t, 17.

Darcan, N.K., and Silanikove, N. (2018). The advantages of goats for future adaptation to climate change: A conceptual overview. *Small Ruminant Research*,163: 34-38.

Debela, H.F., Njoka, J.T., Asfaw, Z., and Nyangito, M.M. (2012). Nutritional Value of *Berchemia discolour*: A Potential to Food and Nutrition Security of Households. *Journal of Biological Sciences, 12: 263-271.*

Del Valle, M., Ibarra, J.T., Hörmann, P.A., Hernández, R., and Riveros, F.J.L. (2019). Local Knowledge for Addressing Food Insecurity: The Use of a Goat Meat Drying Technique in a Rural Famine Context in Southern Africa. Animals. 9: 808.

Devendra, C., (1990). Fibrous crop residues: strategies for the efficient use and development of feeding systems. Feeding of Ruminants on Fibrous Crop Residues, p.8.

Dixit, S.P., Verma, N.K., Aggarwal, R. A. K., Kumar, S., Chander, R., Vyas, M.K., and Singh, K.P. (2017). Genetic structure and differentiation of three Indian goat breeds. Asian-Austral Asian *Journal Animal Science,* 22: 1234-1240.

Doe, J., & Smith, A. (2020). The impact of browsing behavior on parasite infestation in goats. *Journal of Animal Science Research*, 45(3), 123-135. https://doi.org/xxxx

Donovan, J., and Brown, P. (1993). Removal of blood from laboratory mammals and birds: First report of the BVA/FRAME/RSPCA/UFAW Joint working group on refinement. *Animal Laboratory* 27, 1-22.

Dykes, G.S., Terrill, T.H., Shaik, S.A., Miller, J.E., Kouakou, B., Kannan, G., Burke, J.M., Kaplan R.M., Mosjidis J.A. (2006). Effect of sericea lespedeza hay on gastrointestinal nematode infection in goats,245–249.

Echevaria, F.A., Amour, J., Borba, M.F., and Duncal, L. (2007). Response to ivermectin treatment of parasitic stages of *Haemonchus conturtus* resistance or susceptible to ivermectin. *Journal Parasitology.*78(5): 894–898.

Egbu, F. M., Ubachukwu, I., Patience, O., and Okoye, I. C. (2013). Haematological changes due to bovine fascioliasis. *African Journal of Biotechnology*, 12:1828-1835.

Erasto, P., Grierson, D.S., and Afolayan, A.J., (2007). Antioxidant constituents in Vermonia amygdalina leaves. *Pharmaceutical Biology*, 45 (3):195-199,35.

FAO. (2011). World Livestock 2011—Livestock in Food Security; FAO: Rome, Italy, 2011.

FAO. (2016). The State of Food and Agriculture Climate Change, Agriculture and Food Security 2016, Livestock in food Security; FAO: Rome, Italy.

Feyssa, D.H., Njoka, J.T., Asfaw, Z. and Nyangito, M.M. (2011). Wild edible fruits of importance for human nutrition in semiarid parts of east Shewa zone, Ethiopia: Associated indigenous knowledge and implications to food security. *Paper Journal Nutrition*, 10: 40-50.

Fthenakis, G.C., Papadopoulos E. (2018). Impact of parasitism in goat productions. *Small Ruminant Research*. 163, 21–23.

Gramb, M., Uchechi, I.J., Kehinde, A.N., Bala, A.S. and Onimisi, R.A. (2011). Haematological and serum biochemical indices of growing rabbits fed camel blood rumen content mixture. *Journal Research Opinion in Animal and Veterinary Sciences*. 1(1): 44-47.

Gutteridge, R.C., and Shelton, H.M. (1993). Forage tree Legumes in Tropical Agriculture published by the Tropical Grassland Society of Australia Inc. 79–81.

Hansen, J., and perry, B. (1994). The Epidemiology, Diagnosis, and Control of Helminth Parasites of Ruminants. 4th Edition, International Laboratory for Research on Animal Diseases, Nairobi, 74.

Hassan, Y. I., Lahaye, L., Gong, M. M., Peng, J., Gong, J., & Yang, C. (2023). The roles of phytogenic feed additives, trees, shrubs, and forages on the rumen microbiome and methane emissions: A review. *Frontiers in Veterinary Science*, 11, 1475322. https://doi.org/10.3389/fvets.2023.1475322

Hassan, N.M.F., Farag, T.K., Ebu, E.l., Ezz, N.M.T., and Abou-Zeina H.A.A. (2019). Prevalence assessment of gastrointestinal parasitic infections among goats in Giza Governorate, Egypt. *Bulletin of the National Research Centre*, 43:127.

Hawk, C.T., Leary, S.T., and Morris, T.H. (2005). Formulary for Laboratory Animals (3rd ed.). Blackwell Publishing.

Hawkins, H.J. (2017). A global assessment of holistic planned grazing compared with season long; continuous grazing meta-analysis. *Findings African Journal Range : Forage Science,* 34: 65-75.

Hegazi, A.G., Megeed, K.N.A., Hassan, S.E., Abdelazi, M. (2018). Veterinary World.;11:215. doi: 10.14202/vetworld.215-220. [DOI] [PMC free article] [PubMed] [Google Scholar].

Henkin, N., Ungar, E.D., Dvash, L., Perevolotsky, A., Yehuda, Y., Sternbergs, M., Voet, H., Landau, S.Y. (2011). Effects of cattle grazing on herbage quality in a herbaceous Mediterranean rangeland. *Grass and Forage Science*, 66: 516–525.

Holmes, P.H. (1993). Interactions between parasites and animal nutrition: the veterinary consequences. *Proceedings of the Nutrition Society*, 52: 113-120.

Hunt, E., Moore, J.S. (1990). Use of blood and blood products. *Veterinary Clinic North America,* 6:133–147.

Idamokoro, E.M., Masika, P.J., and Muchenje, V. (2016). *Acacia karroo* leaf meal: A promising non-conventional feed resource for improving goat production in low-input farming systems of southern Africa. *African Journal of Range and Forage Science*, 33: 1727- 66 9380.

IFOAM.(2000). Basic standard for organic production and processing. In: International Federation of Organic Agriculture Movement GA (Ed.), Basel.

Ikhimioya, I., and Imasuen, J.A. (2007). Blood profile of West African dwarf goats fed Panicum maximum supplemented with Afzelia africana and Newbouldia laevis. *Pakistan Journal of Nutrition*, 6: 79-84.

Jadhao, U.A., Lagad, C.E., and Ingole, R.K. (2022). Laboratory animal handling techniques, basic facilities and care: A review. *World Journal of Biology Pharmacy and Health Sciences,* 12(3), pp.170-182.

Janick, J., Paull, R. E.(2008). CABI. xviii + 954 pp. http://www.cabi.org/cabebooks/ebook/20113366221.

Jiménez-Colmenero, F., Carballo, J., and Cofrades, S. (2001). Healthier meat and meat products: their role as functional foods. *Meat Science,* 59:5-13.

Jiwuba, P.C., Ahamefule, F.O., Ogbuewu, I.P., Ikwunze, K. (2017). Blood chemistry and haematology of West African Dwarf goats fed *Moringa oleifera* leaf meal (MOLM) in their diet. *Composition Clinical Pathology. 26*, 621–624.

Kabasa, J.D., Opuda-Abiso, J., and Ter-Meulen, U. (2000). The effect of oral administration of polyethylene glycol on FEC in pregnant goats grazed on browse containing condensed tannins. *Tropical Animal Health Production*\, 32: 73–86.

Kahiya, C., Mukaratirwa, S., Thamsborg, S.M.(2003). Effects ofAcacia nilotica and Acacia karoo diets on Haemonchus contortus infection in goats. *Veterinary Parasitology*, 115, 265–274.

Kahn, L., and Woodgate, R. (2012). Integrated parasite management: Products for adoption by the Australian sheep industry. *Veterinary Parasitology*, 186: 58–64.

Kaplan, R.M., Burke, J.M., Terrill, T.H., Mille,r J.E., Getz W.R., Mobini, S., Valencia, E., Williams, M., Williamson, L.H., Larsen, M., and Vatta, A.F .(2004).Validation of the FAMACHA© eye colour chart for detecting clinical anaemia on sheep and goat farms in the southern United States. *Veterinary Parasitology*, 123(1-2): 105–120

Kawas, J.R., Andrade-Montemayor, H., Lu C.D. (2010). Strategic nutrient supplementation of free-range goats. *Small Ruminant Researc*h 89: 234–243.

Kemboi, F., Ondiek, J. O., Onjoro, P. A. (2017). 29Article 118. http://www.lrrd.org/lrrd29/6/kemb29118.html

Kerharo, J., Bouquet, A., and Heintz, R. (1948). Le Wilinwiga des Mossi (Guiera senegalensis), ses usages thérapeutiques indigènes et son application au traitement des diarrhées cholériformes. *Acta. Tropical*. 5: 345-351.

Kerharo, J., and Adam, J.G. (1974). La Pharmacopée Sénégalaise Traditionnelle. Plantes Médicinales et Toxiques. Vigot.

Kijlstra, A., and Eijck, I.A.J.M. (2006). Animal health in organic livestock production systems: a review. *NJAS-Wageningen Journal of Life Sciences*, 54(1):77-94.

Kim, M.K., Pyo, K.H., and Hwang, Y.S. (2012). Effect of temperature on embryonation of Ascaris suum eggs in an environmental chamber. *Korean Journal of Parasitology*, 50:239-242.

Kumar, N., Rao, T.K.S., Varghese, A., and Rathor, V.S., 2013. Internal parasite management in grazing livestock. *Journal of Parasitic Diseases*, 37:151-157.

Kutu, F.R., and Asiwe, J.N. (2010). Assessment of maize and dry bean productivity under different intercrop systems and fertilization regimes. *African Journal of Agricultural Research*. 5(13): 1627-1631.

Lamy, E., Costa G., Santos, R., Silva, F.C., Potes, J., Pereira, A., Coelho, A.V. and Baptista, E.S. (2011). Effect of condensed tannin ingestion in sheep and goat parotid saliva proteome. *Journal Animal Physiology Animal Nutrition*, 95: 304–312.

Lange, K., Olcott,D.D., Miller J.E., Mosjidis, J.A., Terrill, T.H., Burke, J.M., Kearney, M.T. (2006). Effect of *sericea lespedeza* (Lespedeza cuneata) fed as hay, on natural and experimental *Haemonchus contortus* infections in lambs. *Veterinary Parasitology*. 141, 273–278.

Lin, N.K., Preston T., Van Binh D., Ly N.D. (2003) Effects of tree foliages compared with grasses on growth and intestinal nematode infestation in confined goats. *Livestock Research Rural Development.*;15(41).

Lusepani, N.E. (1999). Reproductive biology and utilisation of Berchemia discolor (Klotzsch) Hemsley (Rhamnaceae) (Doctoral dissertation, Stellenbosch: Stellenbosch University).

Mabbott, N.A. (2018). The influence of parasite infections on host immunity to co-infection with other pathogens. *Frontiers in Immunology,* 9, .2579.

Madubike, F.N., and Ekenyem, B.U. (2006). Haematology and Serum Biochemistry Characteristics of Broiler Chicks fed varying Dietary Levels of Ipomoea Asarifolia leaf meal. *International Journal Poultry Science*. 5: 9-12.

Makkar, H.P.S. (2003). Effects and fate of tannins in ruminant animals, adaptation to tannins, and strategies to overcome detrimental effects of feeding tannin-rich feeds. *Small Ruminant Research* 49, 241-256.

Makkar, H.P.S., Bluemmel, M., Borowy, N.K., and Becker, K., (1993). Gravimetric determination of tannins and their correlations with chemical and protein precipitation methods, *Journal Science Food Agriculture.* 61: 161–165.

Mapiye, C., Chimonyo, M., Dzama, K., Raats JG, Mapekula, M. (2009a). Opportunities for improving Nguni cattle production in the smallholder farming systems of South Africa. *Livestock Science* 124: 196–204.

Marume, U., Chimonyo, M., and Dzama, K.(2012). Influence of dietary supplementation with Acacia karroo on experimental haemonchosis in indigenous Xhosa lop-eared goats of South Africa. *Livestock Journal of Science,* 144:132-139.

Masika, P.J., Mafu, J.V. 2004. Aspects of goat farming in the communal farming systems of the central Eastern Cape, South Africa. *Small Ruminant Research,* 52: 161–164.

Mataveia, G., Garrine, C.M.L.P., Pondja, A., Hassen, A., and Visser, C. (2019). Impact of supplementation of Moringa oleifera and Leucaena leucacephala tree fodder on the production performance of indigenous goats in Mozambique. *Black Sea Journal of Agriculture*, 2(2): 93-100.

Max, R.A., Kimambo, A.E., Kassuku, A.A., Mtenga, L.A., and Buttery, P.J. (2005). The effect of wattle tannin drench or an acacia meal supplement on faecal egg counts and total worm burdens of tropical sheep with an experimental nematode infection. In Smith, T., Godfrey, S.H., Buttery, P.J., Ssewannyana, E. and Owen, E. (ed.). Small stock in development Proceedings of a workshop on enhancing the contribution of small livestock to the livelihoods of resource-poor communities. Hotel Brovad, Masaka, Uganda, 15-19 November 2004. Natural Resources Ltd., Aylesford, Kent.

Melaku, S., Peters, K.J., and Tegegne, A. (2004). Effects of supplementation with foliages of selected multipurpose trees, their mixtures or wheat bran on feed intake, plasma enzyme activities, live weight and scrotal circumference gains of Menz sheep. *Livestock Production Science*, 89, 253–264.

Menkir, M.S., Uggla, A., and Waller, P.J. (2006). Epidemiology and seasonal dynamics of gastrointestinal nematode infections of sheep in a semi-arid region of eastern Ethiopia. *Veterinary Parasitology* 143: 311-321.

Mdladla, M., Dzomba, E.F., and Muchadeyi, F.C. (2017). Characteristics of the village goat production systems in the rural communities of the Eastern Cape, KwaZulu-Natal, Limpopo and Northwest Provinces of South Africa. T*ropical Animal Health and Production,* 49:515-527.

MSD-USA. (2008). *Techinque for collection of ech-Molecular Diagnostic services.* [Online]. Available at http://www.mds-usa.com/citrateanti.html [Accessed March 2024]

Min, B., Barry, T., Attwood, G., Mcnabb, W. (2003;b). The effect of condensed tannins on the nutrition and health of ruminants fed fresh temperate forages: a review. *Animal Feed Science Technology*, 106:3-19.

Min, B.R., Hart, S.P. (2003). Tannins for suppression of internal parasites. *Journal Animal Science*. 81 (E. Supplementation). 2: 102–109.

Min, B.R., Pomroy, W.E., Hart, S.P., and Sahlu, T. (2004). The effect of short-term consumption of a forage containing condensed tannins on gastro-intestinal nematode parasite infections in grazing weather goats. Small Ruminant. Research. 51, 279–283.

Mlambo, V., Mapiye, C. (2015). Towards household food and nutrition security in semi-arid areas: what role for condensed tannin-rich ruminant feedstuff*s. Food Research International,* 76: 953–961.

Mlambo, V., Sikosana J.L.N., Mould, F.L., Smith T., Owen E., MuellerHarvey, I. (2007). The effectiveness of adapted rumen fluid versus PEG to ferment tannin-containing substrates in vitro. *Animal Feed Science and Technology*, 136: 128–136.

Molefe, N.I., Tsotetsi, A.M., Ashafa, A.O.T., Thekisoe O.M.M. (2012). In vitro anthelmintic effects of *Artemisia afra* and *Mentha longifolia* against parasitic gastro-intestinal nematodes of livestock. *Bangladesh Journal Pharmacology* 7(3):157–163.

Mpofu, T.J., Nephawe, K.A., and Mtileni, B. (2020). Prevalence of gastrointestinal parasites in communal goats from different agro-ecological zones of South Africa. *Veterinary World*, 13:26-32.

Mungube, E.O., Bauni, S.M., Tenhagen, B.A., Wamae, L.W., Nginyi, J.M., and Mugambi, J.M. (2006). ‘The prevalence and economic significance of Fasciola gigantica and Stilesia hepatica in slaughtered animals in the semi-arid coastal Kenya’, *Tropical Animal Health and Production,* 38(6): 475–483.

Niezen, J.H., Charleston, W.A.G., Robertson, H.A., Shelton, D., Waghorn, G.C., Green, R. (2002). The effect of feeding sulla (Hedysarum coronarium) or Lucerne (Medicago sativa) on lamb parasite burdens and development of immunity to gastrointestinal nematodes. *Veterinary Parasitology*. 105: 229–245.

Norton, B.W.(2018). Methods for dietary fibre, neutral detergent fibre and non-starch polysaccharides in relation to animal nutrition.163: 34-38.

Nsereko, G., Emudong, P., Mulindwa, H., & Okwee-Acai, J. (2015). Prevalence of common gastro-intestinal nematode infections in commercial goat farms in Central Uganda. *Uganda Journal of Agricultural Sciences*, 16(1); 99-106.

Odenyo, A.A., Osuji, P.O., Karanfil, O., and Adinew, K. (1997). Microbiological evaluation of Acacia angustissima as a protein supplement for sheep. *Animal Feed Science Technology*. 65: 99-112.

Olafadehan, O.A., Adewumi, M.K., and Okunade, S.A. (2014). Effects of feeding tannin-containing forage in varying proportion with concentrate on the voluntary intake, haematological and biochemical indices of goats. *Trakia Journal of Science* 1: 73-81.

Omotosho, B., Bemji, M., Bamisile, K., Ozoje, M., Wheto, M., and Lawal, A. (2020). Comparative study of growth patterns of Kalahari Red goats and West African dwarf goats reared in Southwest Nigeria. *Nigerian Journal of Animal Production*.47(5): 213-226.

Opara, M.N., Udevi, N., and Okoli, I.C. (2010). Haematological parameters and blood chemistry of apparently-healthy West African Dwarf (WAD) goats in Owerri, South Eastern Nigeria. NY. *Science Journal* 3: 68-72.

Oyawoye, E.O., and Ogunkunle, M. (1998). Physiological and biochemical effects of raw jack beans on broilers. *Proceedings of annual Conference of Nigerian Society of Animal Production*, 23: 141-142.

Paolini, V., Dorchies, P., Hoste, H. (2003). Effects of sainfoin hay on gastrointestinal infection with nematodes in goats. Veterinary Record, 152: 600–601.

Paolini, V., Frayssines, A., De-La Farge, F., Dorchies, P., and Hoste, H. (2003a). Effects of condensed tannins on established populations and on incoming larvae of Trichostrongylus colubriformis and Teladorsagia circumcincta in goats. Veterinary. Research, 34: 331–339.

Parrotta, J.A. (2005). Moringa oleifera (monograph 111-114 in the enzyclopeadia de Holzgewachse (encyclopedia of wood plants) Ecomed valag Germany.

Pathak, A.K. (2011). Nutritional status and performance of ruminants as influenced by gastrointestinal nematodes – An overview. N. E. *Veterinary*, (3):20–26.

.K., Dutta, N., Pawaiya, R.V.S., Sharma, K. (2014). The influence of condensed tannins containing leaf meal mixture on histopathological changes in Haemonchous contortus infected sheep. *Indian Journal of Veterinary Pathology*. 38:231-234.

Peacock, C. (2015). A pathway out of poverty. *Small Ruminant Research.* 60: 79-186.

Pfukenyi, D.M., and Mukaratirwa, S. (2013). A review of the epidemiology and control of gastrointestinal nematode infections in cattle in Zimbabwe. *Onderstepoort Journal of Veterinary Research*, 80:1-12.

Pratt, P.W. (1985). Laboratory procedure for animal health technicians, 1st edition. American Veterinary Publication Inc, California, 39–60.

Ramirez, C.A., Barry, T.N., Lopez-Villalobos, N., Kemp, P.D., and McNabb, W.C. (2004). Use of L. corniculatus containing CT to increase lamb and wool production under commercial dryland farming conditions without the use of anthelmintics. *Animal Feed Science Technology*, 117: 85–105.

Reed, J.D., Soller,H., and Woodward, A. (1990). Fodder tree and straw diets for sheep. Intake, growth and digestibility and the effects of phenolics on nitrogen utilization. *Animal Feed Science and Technology,* 30: 39-50.

Risso, A., Kessler, J.D., Soriano, V.S., Nunes, M.L.A., Machado, G., Langaro, A., Rossetto, R., Zuffo, T., Dallago, M., Castro, P. (2015). Influence of pathological conditions caused by gastrointestinal parasites infection on pregnant ewe's behavior. *Acta Science Veterinar*y, 43, 1283.

Roberts, K.M., Daryl, K.G., Peter, A.M., and Victor, W.R. (2000). Mayer's Biochemistry, 25th edition, McGraw Hill, New York, 25: 763-765.

Sanhokwe, M., Mupangwa, J., Masika, P., Maphosa, V., and Muchenje, V. (2016). Medicinal plants used to control internal and external parasites in goats. Onderstepoort *Journal of Veterinary Research*, 83:1-7.

Suarez, V.H., Rossanigo, C.E., and Descarga, C. (2013). Epidemiology and productive impact of nematodes in the Central Pampas of Argentina. Parasitic diseases of clinical and productive importance in ruminants. Epidemiological foundations for its diagnosis and control. Eds. Fiel, 100, pp.59-88.

Sawe, J.J. (2018). Evaluation of common tree leaves or pods as supplements for goats on range area of Kenya. *Small Ruminant Research*. 30: 81–93.

Seó, H.L.S., Pinheiro Machado Filho, L.C., Honorato, L.A., da Silva, B.F., do Amarante, A.F.T., & Bricarello, P.A. (2015). The Effect of Gastrointestinal Nematode Infection Level on Grazing Distance from Dung. *PLoS ONE*, 10(6), e0126340.

Schoenian, S. (2003). An Introduction to Feeding Small Ruminants. Maryland Cooperative Extension. Maryland Small Ruminant Page. Available at: http://www. Sheep and goat.com

Scholtz, M.M., and Bester, J. (2010). Off-take and production statistics in the different South African cattle sectors: Results of a structured survey. *Applied Animal Husbandry and Rural Development*, 3:19-23.

Shaik, S.A., Terrill, T.H., Miller, J.E., Kouakou, B., Kannan, G., Kallu, R.K., Mosjidis, J.A. (2004). Effects of feeding sericea lespedeza hay to goats infected with Haemonchus contortus. *South African Journal Animal Science,* 34: 234–236.

Shaik, S.A., Terrill, T.H., Miller, J.E., Kouakou, B., Kannan, G., Kaplan, R.M., Burke, J.M., Mosjidis ,J. (2006). Sericea lespedeza hay as a natural deworming agent against gastrointestinal nematode infection in goats. *Veterinary Parasitology,* 139, 150–157.

Singh, A.S., Pal, D.T., Mandal, B.C., Singh, P., and Pathak, N.N. (2002). Studies on changes in some of blood constituents of adult crossbreed cattle fed different levels of extracted rice.

Silanikove, N. (2020). The physiological basis of adaptation in goats to harsh environments. *Small Ruminants Research*, 35:181–193.

Singh, A.S., Pal, D.T., Mandal B.C., Singh P., and Pathak N.N. (2002). Studies on changes in some of blood constituents of adult crossbreed cattle fed different levels of extracted rice.

Sissay, M.M. (2007). Helminth parasites of sheep and goats in eastern Ethiopia: Epidemiology, and anthelmintic resistance and its management. Doctoral thesis, *Swedish University of Agricultural Sciences*, Uppsala, Sweden.

Solaiman, S., Thomas, J., Dupre, Y., Min, B.R., Gurung, N., Terrill, T.H., and Haenlein, G.F.W. (2010). Effect of feeding sericea lespedeza (Lespedeza cuneata) on growth performance, blood metabolites, and carcass characteristics of Kiko crossbred male kids. *Small Ruminant Research,* 93: 149–156.

Tessema, Z.K., De Boer, W.F., Baars, R.M.T., Prins, H.H.T. (2011). Changes in soil nutrients, vegetation structure and herbaceous biomass in response to grazing in a semi-arid savanna of Ethiopia. *Journal of Arid Environment,* 75: 662–670.

Terrill, T.H., Mosjidis, J.A., Moore, D.A., Shaik, S.A., Miller, J.E., Burke, J.M., Muir, J.P., Wolfe, R. (2007). Effect of pelleting on efficacy of sericea lespedeza hay as a natural dewormer in goats. *Veterinary Parasitology*, 146, 117–122.

Terrill, T.H., Dykes, G.S., Shaik, S.A., Miller, J.E., Kouakou, B., Kannan, G., Burke, J.M., Mosjidis, J.A. (2009). Efficacy of sericea lespedeza hay as a natural dewormer in goats: dose titration study. *Veterinary Parasitology*. 163, 52–56.

Terrill, T.H., Waghorn, G.C., Woolley, D.J., McNabb, W.C., and Barry, T.N. (1994). *Breeding Journal* 72:467–477.

Tinkler, S. H. (2020). Preventive chemotherapy and anthelmintic resistance of soil-transmitted helminths—Can we learn nothing from veterinary medicine. *One health* 9, 100106.

Tshabalala, P.A., Strydom, P.E., Webb, E.C., and De Kock, H.L. (2003). Meat quality of designated South African Indigenous goat and sheep breeds. Meat Science.65, 563–570.

Turner, K.E., Wildeus, S., and Collins, J.R. (2005). Intake, performance and blood parameters in young goats offered high forage diets of lespedeza or alfalfa hay. *Small Ruminant Research*. 59, 15-23.

Van Barrel-Chested, E. and Visser, C. (2016). 'Challenges to the Development of a Rural Goat Industry in South Africa'. Sustainable Goat Breeding and Goat Farming in the Central and Eastern European Countries.1(8):5–23. Available at www.researchgate.net. 1(8): 5–23.

Van Wyk, A.E., Van den Berg, E., Coates Palgrave, M. and Jordaan, M. (2011). Dictionary of names for southern African trees: scientific names of indigenous trees, shrubs, 2`and climbers with common names from 30 languages, Publications, Pretoria. 11 (1&2): 53–102.

Vatta, A.F., Lindberg, A.L.E.(2006). ‘Managing anthemintic resistance in small ruminant livestock of resource poor farmers in South Africa’, *Journal of the South African Veterinary Association,* 77(1): 2.

Vatta, A., Waller, P., Githiori, J., & Medley, G. (2012). Persistence of the efficacy of copper oxide wire particles against *Haemonchuscontortus* in grazing South African goats. *Veterinary Parasitology*, 190, 159–166.

Waller, P.J. and Thamsborg, S.M. (2004). Nematode control in ‘green’ ruminant production systems. TRENDS in Parasitology. 20: 494-97.

Zaher, H.A., Alawaash, S.A., Tolba, A.M., Swelum, A.A., Abd El-Hack, M.E., and Taha, A.E. (2020). Impacts of moringa oleifera foliage substituted for concentrate feed on growth, nutrient digestibility, haematological attributes, and Blood Minerals of Growing Goats under Abu Dhabi Conditions. *Sustainability*, *12*(15), 6096.

Zvinorova, P.I., Halimani, T.E., Muchadeyi, F.C., Matika, O., Riggio, V., and Dzama, K. (2016). Prevalence and risk factors of gastrointestinal parasitic infections in goats in low input, low output farming systems in Zimbabwe. *Small Ruminant Research*, 143:75-83.

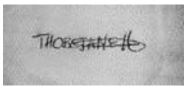
Appendix A: Consent form

CONSENT FORM

I……………………………………………hereby voluntarily consent to participate in the following project titled, “The effect of *Berchemia discolour* leaf meal (Muni tree) on gastrointestinal nematode infections and haematological properties of non-descript goats” and I realise that:

1. The aim of the study is to investigate the effect of *Berchemia discolour* (Muni tree) leaf meal on gastrointestinal nematode infestation and haematological properties of non-descript goats.
2. The researcher is a master’s student in the Department of Agricultural Economics and Animal Production at the University of Limpopo.
3. The researcher will make efforts to safeguard and adhere to the confidentiality of the information provided by the respondents and anonymity is guaranteed.
4. I may withdraw from the study at any time I feel like.
5. I am aware that it is anticipated that my participation in this study will enhance my understanding of nutritional qualities of goats supplementary feeds, the study will provide information on the health effects of gastrointestinal infections in goats. This information will assist in developing health monitoring protocols to improve animal welfare and to also curb losses associated with internal parasite infections in goats.
6. I have every right to ask questions at the end of the interview.
7. I have every right to be interviewed in a private space if I want to.
8. If I have any question or problems regarding the study, I will contact the University Research Office (the University of Limpopo, Private Bag X1106, Sovenga, 0727, Tel: 015 268 2401)
9. My signature below indicates that I have given my informed consent to participate in the abovementioned study.

Signature of respondent: ………… Date: ……………………

Signature of the researcher:  Date: …19/11.2024………………

Appendix B: Ethical Certificate Clearance.

University of Limpopo

Department of Research Administration and Development

Private Bag X1106, Sovenga, 0727, South Africa

Tel: (015) 268 3935/2401 Fax: (015) 268 2306, Email: Tukiso.Sewapa@ul.ac.za

ANIMAL RESEARCH ETHICS COMMITTEE **CLEARANCE CERTIFICATE**

MEETING:22 May 2024

PROJECT NUMBER: AREC/ 26/2024: PG

PROJECT:

Title:	The effect of B*erchemia discolour* leaf meal (muni tree) on gastrointestinal nematode infections and haematological properties of South African non-descript goats
Researcher:	H Thobejane
Supervisor:	Prof B Gunya
Co-Supervisor/s:	Dr TG Manyelo
School:	Agricultural and Environmental Sciences
Degree:	Master of Science (Animal Production)

PROF LJC ERASMUS

CHAIRPERSON: ANIMAL RESEARCH ETHICS COMMITTEE

The Animal Research Ethics Committee (AREC) is registered with the National Health Research Ethics Council, Registration Number**: AREC-290914-017**

Note: **i)** Should any departure be contemplated from the research procedure as approved, the researcher(s) must re-submit the protocol to the committee. **ii)** The budget for the research will be considered separately from the protocol. **iii)** Please note that this clearance certificate is valid for a period of 12 months from date of issue. **iv)** **PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES.**