INVESTIGATION OF NON-GENETIC FACTORS AFFECTING HAEMATOLOGICAL TRAITS IN DORPER SHEEP

by

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DECLARATION

I, LEDIMO FAITH MAKGOPA, declare that this dissertation hereby submitted to the University of Limpopo for the degree of Master of Science in Agriculture has not previously been submitted by me for a degree at this or any other university, that it is my own work in design and execution, and that all materials contained herein has been duly acknowledged.

Signature…________________ Date 21/02/2025

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DEDICATION

This dissertation is dedicated to my late father Mr Ramaja Lucas Makgopa may his soul rest in peace.

ABSTRACT

Haematological parameters may be affected by several internal and external factors making their interpretation more challenging. Non-genetic factors are known to have an influence on haematological parameters of sheep, therefore it is important to investigate the influence of non-genetic factors on haematological parameters, which could be useful in determining health, physiological changes, metabolic status, as well as disease diagnosis and prognosis. This study was aimed at establishing the effect of non-genetic factors such as sex, age, physiological status, and body condition score on haematological parameters of Dorper sheep at the University of Limpopo Experimental farm, South Africa. A total of thirty (n = 30) sheep (19 females and 11 males) were used as experimental animals. The blood samples were collected from each sheep via jugular venipuncture using 5 ml syringes and 21-gauge needles. The samples were analysed at Ampath Laboratories in Pretoria, South Africa, using Sysmex analyser (XE-2100). The haematological parameters including red blood cell count (RBC), white blood cell count (WBC), haemoglobin count (Hb), Normoblast count (NB), Platelet count (Plt), Haematocrit (Hct), Eosinophil count (Eos), monocyte count(Mn), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC), neutrophil count (NEU), absolute neutrophil count (ANC), absolute monocyte count (AMC), absolute lymphocyte count (ALC), Lymphocyte count (LYM), red blood cell distribution width (RDW), basophils (BASO) and absolute eosinophil count (AEC) were analysed. Non-genetic factors collected were body condition score (1 to 5 scale), physiological status (pregnant and non-pregnant), age (1 to 6 years) and sex (male and female). Pearson's correlation was used to determine the relationship between haematological parameters. General Linear Model procedure (GLM) was used to determine the effect of sex, age, body condition score and physiological parameters on haematological parameters. Correlation results indicated that RBC was positively high correlated ($p < 0.01$) with Hct, WBC, ALC, Eos, AEC, and negatively high correlated ($p < 0.01$) with MCV, Mn, and NB. However, RBC had no significant correlation ($p > 0.05$) with MCHC, RWD, NEU, ANC, AMC, BASO, ABC, and Plt. The results showed that sex had an influence ($p < 0.05$) on Hb and RWD, and high significant influence ($p < 0.01$) on LYM and NB. The findings indicated that physiological status had an effect ($p < 0.05$) on RDW. The findings also showed that body condition score and age had no significant effect ($p > 0.05$) on all the studied haematological parameters. The results suggest that sex and physiological status influenced haematological parameters of Dorper sheep. It was concluded that sex and physiological status should be considered when examining the health, nutritional, metabolic status to improve the productivity and management practiced of Dorper sheep.

Keywords: Haematological parameters, Dorper sheep, Sex, Age, Body condition score, Physiological status.

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LIST OF ABBREVIATION

PEO	Population, Exposure, Outcome
Hb	Haemoglobin
RBC	Red blood cell
Hct	Haematocrit
MCV	Mean corpuscular volume
MCH	Mean corpuscular haemoglobin
MCHC	Mean Corpuscular haemoglobin concentration
RDW	Red cell distribution width
WBC	White blood cell
NEU	Neutrophils
ANC	Absolute neutrophils
LYM	Lymphocytes
ALC	Absolute lymphocytes
Mn	Monocytes
AMC	Absolute monocytes
Eos	Eosinophils
AEC	Absolute eosinophils
BASO	Basophils
ABC	Absolute basophils
NB	Normoblasts
Plt	Platelet
SE	Standard error
SD	Standard deviation

CV %	Coefficient of variation
DMRT	Duncan Multiple Range Test

CHAPTER ONE

INTRODUCTION

1.1 Background

The Dorper sheep is a South African mixed breed, attained from cross-breeding the Black-headed Persian and the Dorset Horn (Cloete *et al*., 2000). Dorper sheep are renowned for their docility, prolificacy, excellent carcass characteristics, and ability to adapt to harsh environmental factors (Santo da Cruz *et al*., 2017). The sheep has become one of the most popular mutton breeds in South Africa and has since been exported to other countries (Solomon, 2013; Synman, 2014). According to Phaladi *et al*. (2024), Dorper is kept for its economic socio-cultural importance to the livelihoods of disadvantaged households in developing regions and agricultural potential. Haematological parameters are used to determine the health status, nutritional, metabolic conditions and productivity of sheep (Aicha *et al*., 2021), as well as disease diagnosis and prognosis (Etim, 2015). Haematological parameters are important parameters for evaluating the health and physiological status of animals (Ljubičić *et al*., 2022). Haemoglobin is an iron-rich protein found in RBC that is responsible for carrying oxygen throughout the body tissues and Carbon dioxide out of the body of the animal (Fanta *et al*., 2024). A reduction in RBC count implies that there are low levels of oxygen being transported to tissues and an increase in carbon dioxide levels in the animal's lungs (Etim *et al*., 2014). White blood cells, lymphocytes, monocytes, basophils, eosinophils, and neutrophils are responsible for fighting different infections in the body of the animal (Etim, 2015).

1.2 Problem statement

Haematological parameters can be affected by several internal and external factors which make their interpretation to be challenging in some instances (Carlos *et al*., 2015; Ljubičić *et al*., 2022). Factors that can affect haematological parameters of animals include sex, age, physiological status, and body condition score (Singh *et al.,* 2022). Since variations in haematological parameters may occur due to various factors, therefore, determining the effects of sex, age, body condition score, and physiological status on haematological parameters is important when establishing reference values in Dorper sheep, and for relevant interpretation of haematological results (AI-Thuwaini *et al*., 2019). Therefore, it is important to investigate the influence of non-genetic factors on haematological parameters to understand their relationship, which may be useful during the selection of animals that are genetically resistant to certain diseases and environmental conditions (Etim *et al.,* 2014).

1.3 Rationale

The haematological profile of an animal indicates the physiological responsiveness of the animal to its internal and external environments (Onasanya *et al*., 2015), such haematological parameters include white blood cell counts, lymphocyte counts, monocyte counts, granulocyte counts, red blood cell counts, haemoglobin concentration, haematocrit, and mean corpuscular volume (Etim, 2015). Ajayi *et al*. (2021) reported that breed, age and sex influenced haematological and serum parameters of Nigerian indigenous sheep. Torres-Chable *et al*. (2020) conducted a study on the relationship between haematological parameters, FAMACHA scores and body condition scores in Pelibuey ewes; and reported that there is a positive relationship between body condition score and red blood cell count, red blood cell distribution width standard duration, haematocrit, and red blood cell distribution with coefficient of variation. Winarsih *et al*. (2021) stated that sex, age, feed, and physiological status of animals should be considered when interpreting haematological profiles in Indonesian fat-tailed sheep. Soliman (2014) showed that physiological statuses of Ossimi ewes had significant influences on haematological and biochemical parameters as well as thyroid hormone concentrations. Non-genetic factors have been reported to have influence on haematological parameters of sheep; however, no studies investigated the influences of sex, age, physiological status and body condition scores on the haematological parameters of Dorper sheep. Findings from the current study will assist farmers to understand factors that affect haematological parameters of Dorper sheep.

1.4 Aim

The aim of this study was to establish the effect of non-genetic factors (sex, physiological status, body condition score, and age) on haematological parameters of Dorper sheep.

1.5 Objectives

The objectives of this study were to determine:

i. The phenotypic correlation between white blood cell counts, lymphocyte counts, monocyte counts, granulocyte counts, red blood cell counts, haemoglobin concentration, haematocrit, and mean corpuscular volume of Dorper sheep.
ii. The influence of sex, age, body condition score and physiological status on haematological parameters of Dorper sheep.

1.6 Hypotheses

i. There was no phenotypic correlation between white blood cell counts, lymphocyte counts, monocyte counts, granulocyte counts, red blood cell counts, haemoglobin concentration, haematocrit, and mean corpuscular volume of Dorper sheep.

ii. Sex, age, body condition score and physiological status had no influence on haematological parameters of Dorper sheep.

1.7 Dissertation organization

This mini-dissertation is presented in five stand-alone chapters containing an introduction to the dissertation (Chapter 1), followed by two stand-alone literature review chapters (chapter 2 and 3), one prepared as systematic review as a publication article, while the other is the traditional literature review, and one experimental chapter prepared as publication article (Chapters 4). The dissertation concluded with a general conclusion and recommendation (Chapter 5).

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CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The objectives of this chapter were: (i) to provide information on the Dorper sheep and its phenotypic characterization, and (ii) to provide information on the effect of non-genetic factors such as sex, age, and physiological status on hematological parameters of Dorper sheep. To achieve the objectives of this chapter, this literature review was structured as follows: (1) the origin of the Dorper sheep breed, (2) Phenotypic description of Dorper sheep, (3) Importance of haemotological parameters in sheep, (4) Effect of physiological status on hematological parameters of sheep, (5) Effect of sex on hematological parameters of sheep, and (6) conclusion.

2.2 The origin of Dorper sheep breed

The Dorper is a mutton producing sheep breed which originates from cross breeding Dorset Horn and Black headed Persian in the 1930s in South Africa (Ayichew, 2019; Tesema *et al*., 2021). It has become one of the most popular sheep breeds in the country and has since been exported to other countries (Solomon, 2013; Synman, 2014).

2.3 Phenotypic description of Dorper sheep

Dorper sheep is characterized by a black head, while other have all white body. The breed is known for its adaptability, high fertility, fast growth rate, hardiness, prolificacy, good mothering ability and it can survive in area of low rainfall (Tesema *et al*., 2021). The purebred lamb survival rate is around 94%, rams can weigh 50 to 55 kg at 8-9 months of age, while ewes can weigh 70 to 75 kg when they are around 2 years of age (Budai *et al*., 2013).

2.4 Importance of haematological parameters in sheep

The haematological parameters are important indicators that are used to evaluate and monitor the health, physiological changes, adaptability and metabolic conditions of sheep (Al-Thuwaini, 2021). Some of the haematological parameters that make up the haematological profile of an animal include red blood cell count, white blood cell count, mean corpuscular volume, mean corpuscular haemoglobin concentration, haematocrit, haemoglobin, platelet count and lymphocytes (Carlos *et al*., 2015; Abde-Lattif and Al-Mahja, 2021; Aksoy *et al*., 2021; Fanta *et al*., 2024). Red blood cells are made in the bone marrow and act as a carrier for a protein haemoglobin which is responsible for oxygen and carbon dioxide transportation in the body (Fanta *et al*., 2024). White blood cells alongside its components (basophils, neutrophils, and eosinophils) are responsible for fighting infections, and distribute antibodies to the immune system (Etim, 2015). Heamatocrit is the percentage of red blood cells in the blood (Etim *et al*., 2014). Platelets function in blood clotting which prevent and stop bleeding, and a low concentration of platelet may lead to excessive blood loss in the event of an injury. Mean corpuscular volume, mean corpuscular haemoglobin, mean corpuscular haemoglobin concentration measure average size of red blood cells, haemoglobin content, and concentration of haemoglobin in the blood (Etim, 2013). Haematocrit, mean corpuscular haemaglobin, and mean corpuscular hemoglobin are significant indicators for evaluating red blood cell in circulation, are vital in diagnosing anemia (Sitmo, 2018; Fanta *et al*., 2024), and act as valuable measure of the bone marrow's ability to generate red blood cell (Etim, 2015).

2.5 Effect of physiological status on hematological parameters of sheep

The physiological status of an animal is an important variable that influences blood parameters which are involved in modifying blood metabolic profile (Soliman, 2014; El-Malky *et al*., 2019). According to Sarmin *et al*. (2021) physiological status influenced red blood cell count, haemoglobin, and mean corpuscular haemoglobin of Indonesian fat-tailed sheep. Soliman (2014) reported that physiological status influenced haemaglobin, red blood cell count, haematocrit, white blood cell count, neutrophils, and monocytes but had no effect on eosinophils, basophils and lymphocytes in Ossimi sheep of Egypt. El-Malky *et al*. (2019) stated that physiological status influenced red blood cell count, haematocrit, and mean corpuscular haemoglobin. Yet, physiological status had no significant effect on white blood cell count, mean corpuscular volume, mean corpuscular haemoglobin concentration and haemoglobin in Egyptian Barki and Ossimi ewes (El-Malky *et al*., 2019).

2.6 Effect of sex on hematological parameters of sheep

Higher ranges of haemalotological parameters in males compared to females is due to testosterone which facilitates erythropoiesis production, while in females' estrogen inhibits erythropoiesis production (Ajayi *et al*., 2021). Carlos *et al*. (2015) showed that sex had no effect on red blood cell count, haematocrit, and mean corpuscular volume in Morada Nova sheep. Aicha *et al*. (2021) indicated that sex had no effect on white blood cell count, red blood cell count, lymphocytes count, haemoglobin, mean corpuscular haemoglobin concentration and monocytes in Ouled Djellal sheep of Northeastern Algeria. Al-Samarai and Aljbory. (2017) stated that sex did not influence white blood cell count and mean corpuscular haemoglobin concentration, however sex influenced mean corpuscular haemoglobin, mean corpuscular volume, red blood cell count, haemoglobin, and haemotocrit in Iraqi Awassi sheep. Oramari *et al*. (2014) reported that sex had no significant effect on haemoglobin and haematocrit. Ajayi *et* *al*. (2021) indicated that sex had a significant effect on the variation of haematocrit, haemoglobin, red blood cell count, neutrophil, lymphocyte, and eosinophil. On the other hand, sex did not influence platelet count, mean corpuscular volume, mean corpuscular haemoglobin concentration, and mean corpuscular haemoglobin in Nigerian indigenous sheep. Aksoy *et al*. (2021) reported that sex influenced red blood cell count, mean corpuscular volume, mean corpuscular haemoglobin, and platelet, on the other hand, sex did not have an effect on haemoglobin, white blood cell count, haematocrit, mean corpuscular haemoglobin concentration, and red blood cell distribution width Akkaraman sheep. Nafisat *et al*. (2021) indicated that sex has no significant effect on white blood cell count, haemoglobin, haematocrit, mean corpuscular volume, mean corpuscular haemoglobin, mean corpuscular haemoglobin concentration, platelet, and lymphocytes. The study also showed that sex had a significant effect on red blood cell count and red blood cell distribution of sheep in Nigeria.

2.7 Effect of age on haematological parameters of sheep

Animal age is an important factor that influences haematological parameters as the production of blood component is age dependent (Ljubičić *et al*., 2022). Carlos *et al*. (2015) reported that age had a significant effect on mean corpuscular volume, but age did not influence haematocrit and red blood cell count in Morada Nova sheep. Abdel-Lattif and Al-Muhja (2021) reported that age had no significant effect on red blood cell count, haematocrit, white blood cell count, neutrophils, basophils, monocytes, lymphocytes, however, age influenced haemoglobin and eosinophils in Nigerian sheep. Aicha *et al*. (2021) stated that age had no significant effect on white blood cell count, lymphocyte count, red blood cell count, haemoglobin, mean corpuscular haemoglobin concentration, and monocytes in Ouled Djellal sheep of Northeastern Algeria. Abdel-Lattif and Al-Muhja (2021) stated that age had no significant effect on white blood cell count, mean corpuscular haemoglobin concentration, mean corpuscular haemoglobin, mean corpuscular volume, red blood cell count, haemoglobin, and haemotocrit. Ajayi *et al*. (2021) indicated that age had a significant effect on haematocrit, haemoglobin, red blood cell count, and platelet count. The study also should that age had no significant effect on mean corpuscular haemoglobin, white blood cell count, neutrophil counts, lymphocyte counts, eosinophil counts, monocyte counts, mean corpuscular volume, and mean corpuscular haemoglobin concentration in Nigerian indigenous sheep. According to Oramari *et al*. (2014), age had significant effects on haemoglobin and haematocrit. Aksoy *et al*. (2021) reported that age had no effect on white blood cell count, haematocrit, mean corpuscular haemoglobin concentration, and red blood cell distribution width. The study further showed that age influenced red blood cell count, mean corpuscular volume, mean corpuscular haemoglobin, platelet, and haemoglobin of Akkaraman sheep. According to Nafisat *et al*. (2021), age had no significant effect on white blood cell count, red blood cell count, haemoglobin, haematocrit, mean corpuscular volume, and lymphocytes but the study also showed that age had significant effect on mean corpuscular haemoglobin, mean corpuscular haemoglobin concentration, and platelets of sheep in Nigeria.

2.8 Conclusion

This literature review concludes that Dorper sheep is originated in South Africa and survive in harsh environment. This literature review also revealed that sex, age, physiological status influenced the variation of some heamotological parameters in sheep, on the other hand, sex, age, and physiological status had no significant effect on certain haematological parameters of sheep. The variation in results might be due to breed, geographical location, and management practices. Furthermore, the literature also revealed the importance of studying the effect of non-genetic factors on haematological parameters of sheep, as this will help in estimating haematological profile of such breed which will become useful in the event of disease diagnosis.

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CHAPTER THREE

Systematic review of the effects of body condition score on maternal traits of sheep

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Abstract

Body condition scoring is a subjective tool used to assess the health and nutritional wellbeing of animals. This tool can be adopted by sheep farmers to improve production efficiency. Reproduction traits such as prolificacy, fecundity, lamb birth weight, and ewe fertility, can be affected by several genotypic and environmental factors. The objective of this paper is to systematically review literature published on effect of body condition score on maternal traits in sheep. Google scholar, PubMed, Web of science and ScienceDirect were systematically evaluated using combinations of the following keywords: Body condition score, maternal production traits, sheep. Ten articles that were published between 2008 and 2018 on studies conducted in Egypt, India, Iran, New Zealand and Turkey were found to be eligible for inclusion in the study. The results showed that out of 10 articles that studied the effects of body condition score on maternal traits; body condition score had an effect on prolificacy (n = 4), fertility (n = 3), fecundity (n = 3), conception rate (n = 4), and Lamb birth weight (n = 4). The results indicated that body condition score had an influenced on maternal production traits. The limitations of this systematic review are that 1) out of the 10 reviewed studies from only 5 countries investigated the effects of body condition score on maternal production traits, 2) No articles studied the same maternal production traits which limit conducting meta-analysis. The systematic literature review conclude that body condition score influences maternal production traits. Therefore, body condition might be used as a selection tool during breeding to improve production efficiency of sheep.

Keywords: Prolificacy, fertility, lamb birth weight, conception rate, fecundity

3.1. Introduction

Body condition scoring is a subjective tool used to assess the health and nutritional wellbeing of animals (Vatankhah *et al*., 2012). This tool can be adopted by sheep farmers to improve production efficiency (Sejian *et al*., 2010). Corner-Thomas *et al*. (2014) stated that reproductive capacity can be affected by body condition score of an animal at mating. Jalilian and Moeini (2013) and Sejian *et al*. (2015) emphasised the importance of maintaining optimal body condition scores in ewes during the different phases of their reproduction cycle. Reproduction efficiency influences profit margins of sheep farmers (Yilmaz *et al*., 2011). Reproduction traits such as prolificacy, fecundity, lamb birth weight, and ewe fertility, can be affected by several genotypic and environmental factors (Cam *et al*., 2018). Therefore, it is necessary to examine factors that can potentially influence the production efficiency of sheep so as to improve the management practices and increase profit potential of the sheep farm.

Based on the authors' knowledge, there is no systematic literature review on the effects of body condition score on maternal traits of sheep. Hence, the objective of this study was to systematically review literature published on effects of body condition score on maternal traits in sheep. The outcome of this systematic review will assist researchers in understanding the relationship between body condition score and maternal traits to improve the production efficiency of sheep herd.

3.2. Materials and Methods

3.2.1 Eligibility criteria

Identification of the Population, Exposure, and Outcomes (PEO) components of the research questions was conducted as explained by Bettany-Saltikov (2010) for this systematic review. "Sheep" were defined as the population of the study, with "body condition score" as exposure and "maternal traits" as outcomes. An initial search of PEO components on Web of Science was conducted, before deciding to perform the systematic review.

3.2.2 Search strategy

Three investigators (Ledimo Faith Makgopa, Thobela Louis Tyasi and Teedzai Chitura) conducted a search of articles on databases such as ScienceDirect, PubMed, Google Scholar, Web of Science, using the combinations of key terms such as "body condition score," "maternal production traits" and "sheep." The key terms were combined in various ways. All articles were collected, and only English articles were included in the study.

3.2.3 Inclusion criteria

Articles that appeared in more than one database were screened for eligibility. Articles that met the inclusion criteria were those that measured the relationship of body condition score and maternal traits in sheep, articles that were published in English, and articles that discussed production traits such as prolificacy (litter size), lamb birth weight, conception rate, and fertility.

3.2.4 Exclusion criteria

Articles that did not meet the requirements were excluded such as, duplicates, articles that did not discuss the effect of between body condition score on reproductive and productive performance of sheep, and articles that only had an abstract and not full text.

3.2.5 Data extraction

Ledimo Faith Makgopa, Thobela Louis Tyasi and Teedzai Chitura extracted the data of the current systematic review and reached a general agreement regarding all the materials. The articles that met the criteria had: author, year of publication, sample size, body condition score and maternal traits of sheep.

3.2.6 Ethical considerations

Plagiarism, misconduct, informed consent, data falsification, and fabrication were considered as unethical conducts by the authors when performing this systematic review.

3.3. Results

3.3.1 Search results

A flowchart of the identification and selection of studies for systematic review is represented in Figure 3.1. The findings showed that a total of seventy-three articles were retrieved in the initial search and sixteen (n = 16) of them were duplicates and hence were excluded from the study. The remaining articles (n = 57) were screened for titles and abstracts, 25 articles were removed since their titles did not have the required word combinations and abstracts did not have production traits and body condition score. A total of thirty-two articles were screened for full-text search and eligibility confirmation, leaving 10 articles for inclusion in this systematic review.

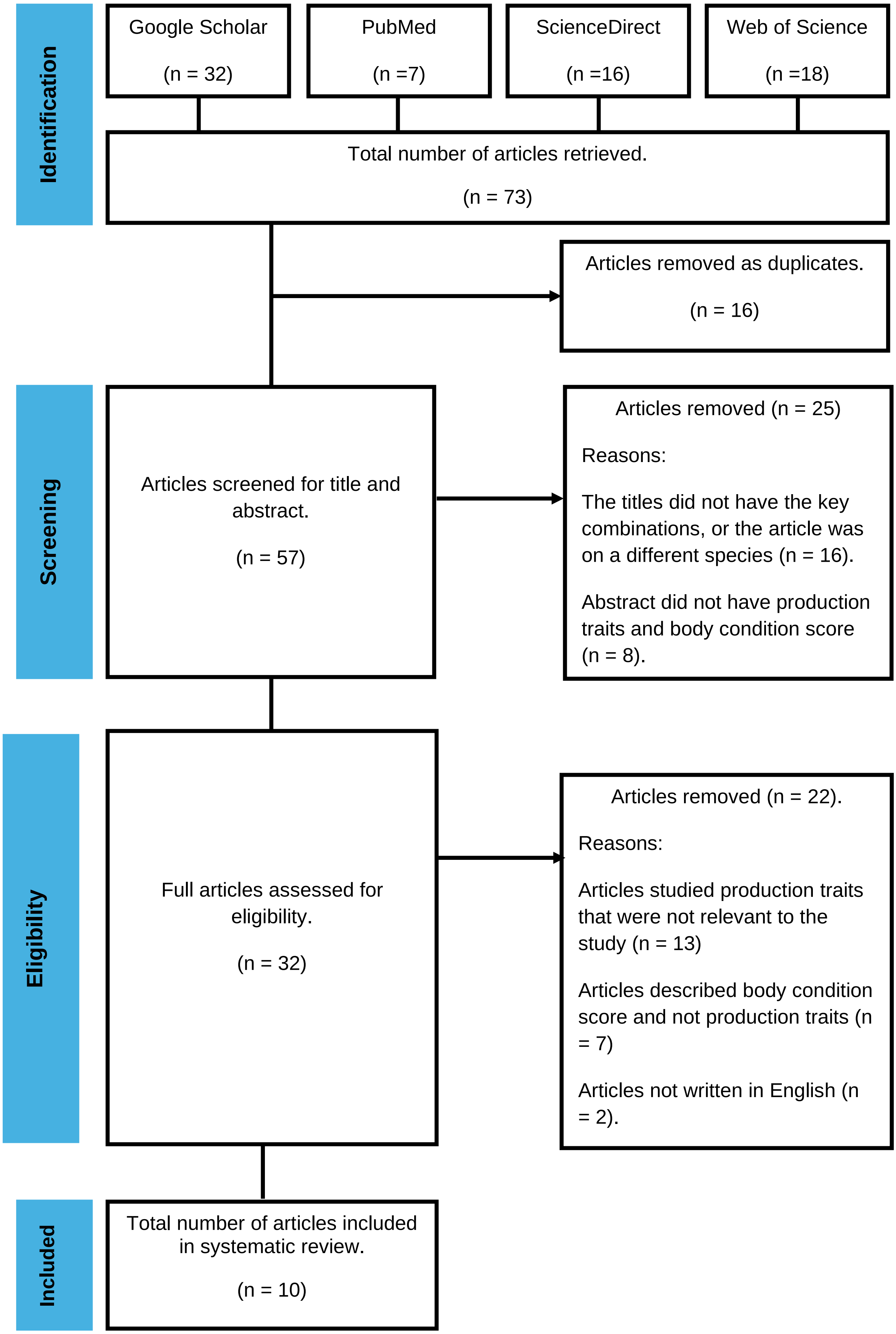

Figure 3.1: Flowchart of identification and selection of studies for systematic review

3.3.2 Characteristics of included studies

Ten articles were evaluated and selected as they met the inclusion criteria in the systematic review as indicated in Table 3.1. The results indicated that two articles (n = 2) were published by the same author in different years (Corner-Thomas *et al*., 2014; Corner-Thomas *et al*., 2015), and the sample size of the included articles ranged from 591 to 15510. The findings further indicated that one article (n = 1) had the highest variety of sheep breeds (Corner-Thomas *et al*., 2015). Upon closer inspection, it was noted that the article covered multiple study areas, with data collection conducted across 7 farms.

Table 3.1: Characterization of included studies

Authors	Year	Country	Sample size	Sheep breed
Corner-Thomas *et al*	2015	New Zealand	15510	Highlander composite (Romney, Texel, Finnish Landrace), Romney × Finnish Landrace to Coopworth × Finnish Landrace breed and Romney and Coopworth
Corner-Thomas *et al*	2014	New Zealand	591	Highlander composite (Romney, New Zealand Texel and Finn)
Mohammady and Hammam	2012	Egypt	541	Barki sheep
Sejian *et al*	2015	India	97	Garole and Malpura sheep
Cam *et al*	2018	Turkey	284	Karayaka sheep
Sejian *et al*	2008	India	30	Cyclic Malpura sheep breed
Abdel-Mageed	2011	Egypt	126	Rahmani, Barki, and Ossimi sheep
Yilmaz *et al*	2011	Turkey	240	Kivircik sheep
Vatankhah *et al*	2012	Iran	442	Lori-Bakhtiari
Jalilian and Moeini	2013	Iran	80	Sanjabi

3.3.3 Publications by year

Publications by year are represented in Figure 3.2. The results indicated that out of 10 reviewed articles, two articles (n = 2) each were published in the years 2011 (Abdel-Mageed, 2011; Yilmaz *et al*, 2011), 2012 (Mohammady and Hammam, 2012; Vataankhah *et al*., 2012), and 2015 (Corner-Thomas *et al*., 2015; Sejian *et al*., 2015). The findings further revealed that only one article (n = 1) was published in the years 2013 (Jalilian and Moeini, 2013), 2008 (Sejian *et al*., 2008), 2014 (Corner-Thomas *et al*., 2014), 2018 (Cam *et al*., 2018).

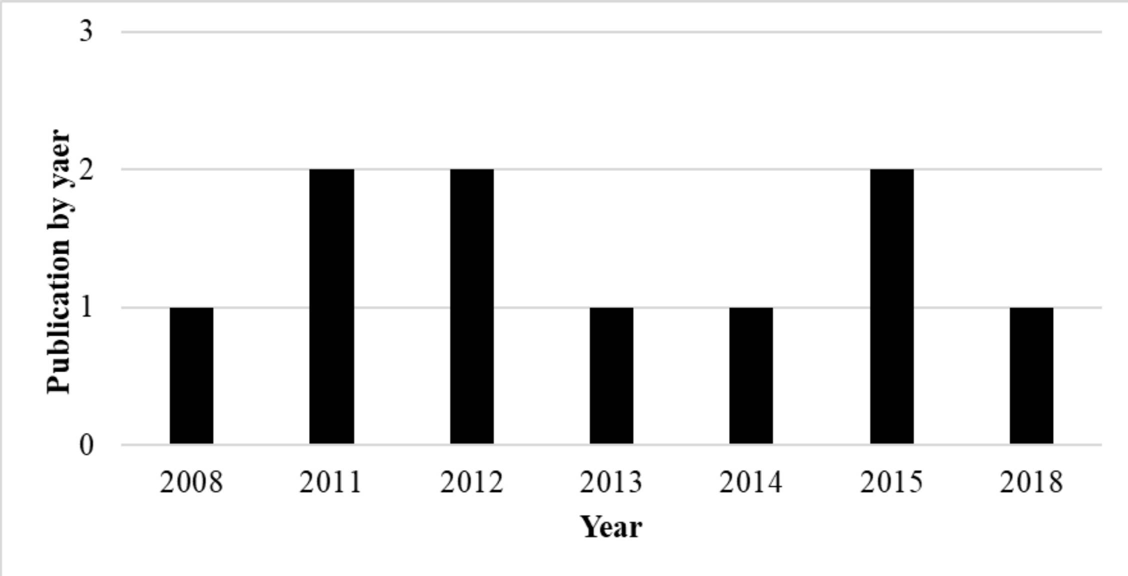

Figure 3.2: Publications by year

3.3.4 Publications by country

Figure 3.3 presents the publications by country for included articles in the systematic review. The results indicated that out of 10 articles included in the systematic review, studies from five countries namely Egypt (Abdel-Mageed, 2011; Mohammady and Hammam, 2012), India (Sejian *et al*., 2008; Sejian *et al*., 2015), Iran (Vatankhah *et al*., 2012, Jalilian and Moeini, 2013), New Zealand (Corner-Thomas *et al*., 2014; Corner-Thomas *et al*., 2015), and Turkey (Yilmaz *et al*., 2011; Cam *et al*., 2018) investigated the effects of body condition score on maternal production traits.

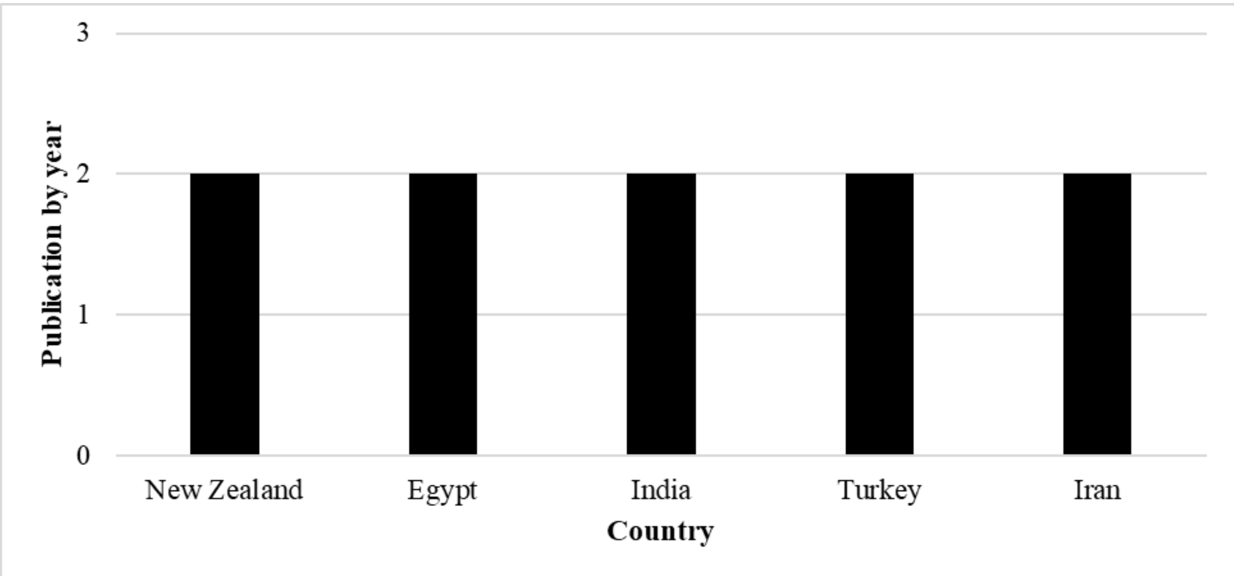

Figure 3.3: Publications by country

3.3.5 Effect of body condition score on prolificacy

Table 3.2 presents findings on the effect of body condition score on prolificacy as reported in the 10 articles included in the systematic review. The findings showed that out of 10 articles, seven (n = 7) articles studied the effect of body condition score on prolificacy. The results further indicated that out of 10 articles, three (n = 3) articles reported that prolificacy was highly affected by body condition score (Mohammady and Hammam, 2012; Vatankhah *et al*., 2012; Cam *et al*., 2018). The results also showed that out of 10 articles, three (n = 3) reported that body condition score had no significant effect on prolificacy (Sejian *et al*., 2010; Abdel-Mageed, 2011; Sejian *et al*., 2015).

Table 3.**2**: Effect of body condition score on prolificacy

Author and year	**Prolificacy** **Body condition score (Mean)**					**P value**
Cam *et al*., 2018	-	1.5-2.0(1.05)	2.5-3.0(1.11)	3.5-4.0(1.19)	4.5-5.0(1.29)	P < 0.01
Vatankhah *et al*., 2012	2(0.77)	2.5(0.95)	3(0.1.09)	3.5(1.19)	4(1.12)	P < 0.01
Mohammady and Hammam, 2012	1(1.00)	2(1.01)	3(1.01)	4(1.16)	5(1.00)	P < 0.01
Sejian *et al*., 2010	-	-	2.5(1.0)	3.0-3.5(1.25)	4.0(1.0)	P > 0.05
Sejian *et al*., 2015			2.5(1.82)	3.0(1.70)	3.5(1.74)	P > 0.05
Abdel-Mageed, 2011	-	-	-	-	-	P > 0.05
Jalilian and Moeini, 2013	-	2(133)	2.5(155)	3(177)	3.5(130)	P < 0.05

-, Not indicated

3.3.6 Effect of body condition score on fertility

Effect of body condition score on fertility is represented in Table 3.3. The results showed that out of 10 articles included in the systematic review, three (n = 3) articles studied the effect of body condition score on fertility. The results also indicated that out of three (n = 3) articles that studied the effect of body condition on fertility, one (n = 1) articles reported that body condition score had a high significant effect on fertility (Mohammady and Hammam, 2012).

Table 3.**3**: Effect of body condition score on fertility

Author and year	**Fertility (%)** **Body condition score (Mean)**	**P value**

Cam *et al*., 2018	1.5-2.0(81.42)	2.5-3.0(93.44)	3.5-4.0(94.44)	4.5-5.0(85.00)	-	P ≤ 0.023
Corner-Thomas *et al*., 2015	<2(78)	2.5(85)	3(88)	3.5(88)	>4(89)	P < 0.05
Mohammady and Hammam, 2012	1(69.61)	2(85.43)	3(87.72)	4(85.94)	5(60)	P < 0.01

-, Not indicated

3.3.7 Effect of body condition score on conception rate

The results indicated that out of 10 articles included in the systematic review, four (n =4) studied the effect of body condition score on conception rate (Table 3.4). The results showed that out of ten (n = 10) articles, three (n = 3) articles reported that body condition score had a high significant effect on conception rate (Vatankhah *et al*., 2012; Yilmaz *et al*., 2011; Abdel-Mageed, 2011).

Table 3.4: Effect of body condition score on conception rate

Author and year	**Conception rate** **Body condition score (Mean)**					**P value**
Sejian *et al*., 2010	-	2.5(40)	3.0-3.5(90)	4.0(40)		P < 0.05
Abdel-Mageed, 2011	-	-	-	-	-	P < 0.01
Vatankhah *et al*., 2012	2(0.76)	2.5(0.88)	3(0.96)	3.5(0.97)	4(0.97)	P < 0.01
Yilmaz *et al*., 2011	1.51-2.00(56.9)	2.01-2.50(73.0)	2.51-3.00(75.9)	3.01-3.50(70.5)	≥3.51(54.9)	P < 0.01

-, Not indicated

3.3.8 Effect of body condition score on fecundity/reproductive rates

Effect of body condition score on fecundity is represented in Table 3.5. The results indicated that out of 10 articles included in the systematic review, only three (n = 3) articles studied the effect of body condition scores on fecundity. The findings showed that out of 10 articles, two (n =2) articles reported that body condition scores had a significant effect on fecundity (Yilmaz *et al*., 2011; Corner-Thomas *et al*., 2015), while only one (n = 1) article reported that fecundity was significantly affected by body condition score (Cam *et al*., 2018).

Table 3.**5**: Effect of body condition score on fecundity

Author and year	Fecundity/ reproductive rate Body condition score (Mean)					P value
Yilmaz *et al*., 2011	1.51-2.00(0.81)	2.01-2.50(1.09)	2.51-3.00(1.11)	3.01-3.50(0.95)	≥3.51(0.72)	P < 0.05
Cam *et al*., 2018	-	1.5-2.0(0.86)	2.5-3.0(1.04)	3.5-4.0(1.13)	4.5-5.0(1.10)	P < 0.01
Corner-Thomas *et al*., 2015	<2(1.09)	2.5(1.22)	3(1.27)	3.5(1.27)	>4(1.31)	P < 0.05

-, Not indicated

3.3.9 Effect of body condition score on lamb birth weight

The results indicated that out of 10 articles included in the systematic review, six (n = 6) studied the effect of body condition scores on lamb birth weight (Table 3.6). The findings showed that out of 10 articles, two (n = 2) article reported that body condition score had no significant effect on lamb birth weight (Corner-Thomas *et al*., 2014; Cam *et al*., 2018). The results also indicated that out of 10 articles, three (n =3) articles reported that body condition score had significant effect on lamb birth weight (Sejian *et al*., 2010; Sejian *et al*., 2015; Jalilian and Moeini, 2013).

Table 3.6: Effect of body condition score on lamb birth weight

Author and year	Lamb birth weight Body condition score (Mean)				P value
Cam *et al*., 2018	1.5-2.0(3.70)	2.5-3.0(3.73)	3.5-4.0(3.68)	4.5-5.0(3.81)	P > 0.05
Corner-Thomas *et al*., 2014	≤2.5(5.2)	3(5.0)	3.5(5.1)	≥4(5.0)	P > 0.05
Sejian *et al*., 2010	-	2.5(2.96)	3.0-3.5(3.6)	4.0(4.4)	P < 0.05
Sejian *et al*., 2015	-	2.5(3.08)	3.0(3.12)	3.5(3.58)	P < 0.05
Abdel-Mageed, 2011	-	-	-	-	P < 0.01
Jalilian and Moeini, 2013	2(3.9)	2.5(5.3)	3(5.55)	3.5(4.18)	P < 0.05

-, Not indicated

3.4. Discussion

Body condition score is important in examining different traits of ewe reproductive performance and offers nutritional management guidelines during mating periods (Cam et al). The systematic review was conducted to collect information on the effects of body condition score on maternal traits in ewes. Understanding the influence of body condition score on maternal traits assist in determining the optimal body condition score to achieve before breeding (Sejian *et al*., 2010). A total of 10 articles were included in the systematic review with all the countries having equal number of articles and published from year 2008 to year 2018. Prolificacy, fertility, conception rate, fecundity and lamb birth weight were some of the maternal traits studied in the 10 articles included in the systematic review. The results indicated that out of the seven (n = 7) articles that studied the effect of body condition score on prolificacy, only one (n = 1) article reported that body condition score had no significant effect on prolificacy (Jalilian and Moeini, 2013). Sejian *et al*. (2010) stated that embryo donors with body condition score of 3.5 had high prolificacy compared to body condition score of 2.9. The findings showed that three (n = 3) articles reported that body condition score influenced fertility (Mohammandy and Hammam, 2012; Corner-Thomas *et al*., 2015; Cam *et al*., 2018). Body condition score during mating is associated with ovulation rate, and subsequently influencing fertility; low or high body condition score may result in poor fertility rate (Cam *et al*., 2018). The results further indicated that out of the four (n = 4) articles that studied the effect of body condition score on conception rate; one (n = 1) article reported that body condition score had a significant effect on conception rate, while three articles reported that body condition score had a highly significant effect on conception rate. Sejian *et al*. (2010) reported that poor conception rate may be due to low body condition score that results in poor production of reproductive hormones that influence the production oocytes, which affect fertilization and foetal development. The results also showed that out of six (n = 6) articles that studied the effect of body condition score on lamb birth weight, only two (n = 2) articles reported that body condition score had no significant effect on lamb birth weight. Lamb birth weight influences live weight at weaning, while low weaning weights are associated with late breeding in ewes (Corner-Thomas *et al*., 2014). Based on our knowledge, this is the first systematic review reporting on the effect of body condition score on maternal traits of sheep. Therefore, there is no comparisons of the systematic review results with others. The results of the study imply that body condition scores can be used during mating seasons to select ewes with high production efficiency. Sejian *et al*. (2015) suggested that ewes with optimal body condition scores during mating seasons have enough energy to sustain their reproductive performance, health, and productive efficiency. The strength of this review is that no prior systematic reviews were conducted to study the effect of body condition score on maternal traits in sheep. This study shows that body condition score might be used to evaluate the production efficiency of sheep. The limitations of this systematic review are that 1) out of the 10 included articles, studies from only 5 countries investigated the effect of body condition score on maternal production traits, 2) No articles investigated the same maternal production traits which makes it difficult conduct meta-analysis. It is concluded that body condition score influences maternal production traits. Therefore, body condition might be used as a selection tool during breeding to improve production efficiency of sheep.

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CHAPTER FOUR

Effects of sex, age, body condition score, and physiological status changes on haematological parameters of Dorper sheep

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Abstract

The Dorper is a South African sheep breed characterized by its fast growth and excellent body confirmation that is used for mutton production. Haematological profiling is useful in assessing the health, nutritional, and metabolic status of an animal and can be affected by non-genetic factors such as sex, age, season, body condition score, and physiological status of an animal. Hence, this study focused on the effect of aforementioned factors on the haematological parameters of Dorper sheep. Sex, age, physiological status, and body condition score for 30 (11 males and 19 females) Dorper sheep were recorded, and blood samples were collected from each sheep. Red blood cell count (RBC), white blood cell count (WBC), haemoglobin count (Hb), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC), absolute neutrophil count (ANC), absolute monocyte count (AMC), absolute lymphocyte count (ALC), lymphocyte count (LYM), normoblast count (NB), platelet count (PLT), haematocrit (Hct), eosinophils (Eos), monocytes (Mn), red blood cell distribution width (RDW), basophil count (BASO) and absolute eosinophil count(AEC) were determined. Pearson correlation analysis showed a correlation ($p<0.05$) between some of the haematological parameters in Dorper sheep. Pearson correlation analysis results indicated that RBC was positively highly ($p<0.01$) correlated with Hct, WBC, ALC, Eos, AEC, and negatively highly correlated ($p<0.01$) with MCV, Mn, and NB. However, RBC had no significant ($p>0.05$) correlation with MCHC, RWD, NEU, ANC, AMC, BASO, ABC, and Plt in Dorper sheep. Body condition score and age had no effects ($p>0.05$) on the haematological parameters ($p>0.05$), while physiological status affected only RDW. The results further showed that sex influenced ($p<0.05$) Hb, RDW, LYM, and NB. The findings of this study suggests that sex and physiological status can influence some of the haematological parameters of Dorper sheep. Therefore, it is important to consider factors such as sex and physiological status of an animal when evaluating the nutritional, physiological and health status to improve the management and productivity of Dorper sheep.

Keywords: Haematological parameters, Dorper sheep, Sex, Age, Body condition score, Physiological status

4.1 Introduction

The Dorper sheep was first introduced in South Africa in 1930 by crossing the Blackhead Persian and Dorset Horn (Molabe *et al*., 2024). Dorper sheep are renowned for their docility, prolificacy, excellent carcass characteristics, and ability to adapt to harsh environmental factors (Santo da Cruz *et al*., 2017). The sheep has become one of the most popular mutton breeds in South Africa and has since been exported to other countries (Solomon, 2013; Synman, 2014). According to Phaladi *et al*. (2024), Dorper is kept for its economic socio-cultural importance to the livelihoods of disadvantaged households in developing regions and agricultural potential.

Haematological profiling is applied for the assessment of health conditions as well as for the tracking of the nutritional and metabolic statuses of animals (Etim *et al*., 2014). When combined with clinical examination, haematological profiling can be useful in disease diagnosis as well as in determining disease prognosis (Aicha *et al*., 2021). However, the levels of haematological parameters are affected by different factors such as sex, age, body condition score, physiological status, and breed of the animal (Ljubičić *et al*., 2022). Therefore, for more precise interpretations of metabolic profiles, it is important to compare them with haematological reference values specific to the breed and population (Al-Samarai and Al-Jbory, 2017). Sarmin *et al*. (2021) reported that non-breed-specific haematological reference values are not reliable to use on local sheep as they have not been proven in such instances. Reference values of haematological profiles of animals in similar climatic regions are more applicable (Carlos *et al*., 2015). Hence, it is necessary to characterize haematological profiles for each breed and production region (Nafisat *et al*., 2021).

Matos *et al*. (2024) reported that the confinement environment influenced red blood cells and hemoglobin in Dorper sheep. Santo da Cruz *et al*. (2017) reported that age had an influence on several blood biochemical parameters of Dorper sheep between the ages of 15 to 121 days. Seixas *et al*. (2021) did a study on the physiological and hematological parameters of sheep in Brazil and concluded that physiological and hematological parameters should be considered for the correct interpretation of results as they are great indicators of animal physiological state. Santarosa *et al*. (2021), during the comparison of haematological parameters between single and twin pregnancies in Dorper sheep, found that gestation was a stressful period that led to the increase in WBC count with a bit of alteration in the erythrogram of Dorper sheep. According to Tadie *et al*. (2018), *Bovicola ovis* infection resulted in lower counts of RBC and high levels of WBC in the infected group of animals compared to the noninfected group. Al-Thuwaini (2021) stated that red blood cells, white blood cells, hematocrit, and hemoglobin are essential indicators of animal reproductive performance and health. Haemoglobin is an iron-rich protein found in RBC that is responsible for carrying oxygen throughout the body tissues and Carbon dioxide out of the body of the animal (Fanta *et al*., 2024). A reduction in RBC count implies that there are low levels of oxygen being transported to tissues and an increase in carbon dioxide levels in the animal's lungs (Etim *et al*., 2014). White blood cells, lymphocytes, monocytes, basophils, eosinophils, and neutrophils are responsible for fighting different infections in the body of the animal (Etim, 2015).

Several studies have been conducted to investigate the effects of sex, age, and physiological status on the haematological parameters of sheep (Soliman, 2014; Abdel-Lattif and Al-Muhja, 2021; Ajayi *et al*., 2021). However, based on our knowledge, there is no information in the literature on the haematological profile of Dorper sheep. Hence, the present study aimed to determine the effects of non-genetic factors such as sex, age, body condition score, and physiological status on the haematological parameters of healthy Dorper sheep. Haematological profiles guide farmers and sheep breeders to take proper measures to improve the health and productivity of their animals

. 4.2 Materials and Methods

4.21 Ethical Approval

The study received ethical clearance from the University of Limpopo Animal Research Ethics Committee (AREC). Project number AREC/04/2024: PG.

4.2.2 Study area

The study was conducted at the University of Limpopo Experimental Farm in Polokwane Local Municipality, Limpopo Province of South Africa. The area is located at 23°490 S longitudes and 29°410 E latitude, 1324 m above sea level (Phefadu and Kutu, 2016).

4.2.3 Experimental animals and management

The study used clinically healthy sheep of the Dorper breed for haematological evaluations. The animals were between the ages of one to six years. The animals were raised in a semi-intensive system, where the animals were allowed to graze during the day and housed at night.

4.2.4 Research design

A cross-sectional study was carried out using 30 animals (19 females and 11 males) that were selected using the census method of sampling. The sex, age, body condition score, and physiological status of each animal were recorded. Body condition score (1 to 5 scale) with 1 representing too thin, 2 representing thin, 3 representing moderate body condition score, and 4 representing heavy, physiological status (pregnant and non-pregnant), age (1 to 6 years) and sex (male and female) were used as non-genetic factors.

4.2.5 Collection of blood samples

Blood samples (n=30) were collected from each animal via jugular venipuncture using 5 mL syringes and 21-gauge needles. For haematological analysis, the blood was collected into sterile vacutainer tubes containing disodium salt ethylene diamine tetraacetic acid (EDTA) as an anticoagulant. The samples were transported immediately after collection in a portable refrigerator at 4°C to Ampath Laboratories in Polokwane, South Africa, where they were analyzed within 24 hours of collection.

4.2.6 Haematological profiling

Haematological parameters were determined using the Sysmex analyzer XE-2100 (TOA Medical Electonics, Kobe, Japan). The haematological parameters are red blood cell count (RBC), white blood cell count (WBC), haemoglobin count (Hb), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC), neutrophil count (NEU), absolute neutrophil count (ANC), absolute monocyte count (AMC), absolute lymphocyte count (ALC), Lymphocyte count (LYM), Normoblast count (NB), Platelet count (Plt), Haematocrit (Hct), Eosinophil count (Eos), monocyte count(Mn), red blood cell distribution width (RDW), basophils (BASO) and absolute eosinophil count (AEC) (Aicha *et al*., 2021; Ljubičić *et al*., 2022).

4.2.7 Statistical analysis

Data was analyzed using Statistical Package for Social Sciences (IBM SPSS, 2022) version 29.0. All the data was tested for Normality using the Kolmogorov-Smirnov test. Pearson correlation was used to determine the relationship between haematological parameters. The General Linear Model (GLM) procedure was used to determine the effect of sex, age, body condition score, and physiological status on haematological parameters. The following GLM was used:

$Y_{ijkl} = \mu + S_i + A_j + B_k + P_l + \varepsilon_{ijkl}$

Where: Y_{ijkl} = Observation on dependent variables (Haematological parameters); μ = Population mean; S_i = Effect of i^{th} sex; A_j = Effect of j^{th} age; B_k = Effect of k^{th} body condition score; P_l = Effect of l^{th} physiological status; $\varepsilon_{(ijkl}$ = Random error term. Significance was observed at $p < 0.05$. Significantly different means were compared using the Duncan Multiple Range Test (DMRT).

Correlation matrix between haematological parameters calculated using the following equation:

$$r = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \Sigma(y_i - \bar{y})^2}}$$

Where: r = correlation coefficient; $\boldsymbol{x_i}$ = values of the x-variable in sample; $\boldsymbol{x_i}$ = mean of the values of the x-variable; values of the y-variable in sample; $\bar{\boldsymbol{y}}$ =mean of the values of the y-variable.

4.3 Results

4.3.1 Descriptive statistics for haematological parameters

Table 4.1 shows the summary statistics of haematological parameters, along with reference values as indicated in (Schalm, 1965). The findings indicated that means for WBC and LYM were higher than the reference values, mean NEU was lower than the reference values while means for Hb, RBC, Hct, MCV, MCH, MCHC were within range. The results showed that coefficient of variation (CV) ranged from 3.6 % to 90.68%, where MCHC had the lowest CV and NB had the highest CV.

Table 4.1: Descriptive statistics for haematological parameters

Parameters	Minimum	Maximum	Mean ± SE	Reference	SD	CV %
Hb (g/dL)	6.50	12.70	9.69±0.30	8.00-16.00*	1.68	17.36
RBC (10^12/L)	6.15	13.21	9.79±0.35	8.00-16.00*	1.94	19.77
Hct (%)	21.60	41.90	31.02±1.00	24.0-50.00*	5.49	17.69
MCV (fL)	27.60	36.20	31.96±0.47	23.00-48.00*	2.60	8.14
MCH (pg)	8.60	11.60	10.00±0.15	9.00-12.00*	0.82	8.22
MCHC (g/dL)	29.90	33.40	31.29±0.21	31.00-38.00*	1.15	3.68
RDW (%)	20.40	33.30	25.38±0.52	-	2.84	11.21
WBC (10^9/L)	6.89	21.37	12.23±0.77	4.00–12.00*	4.23	34.63
NEU (%)	0.00	1.20	0.48±0.05	10.00-50.00*	0.29	61.76

ANC (10^9/L)	0.00	0.17	0.06±0.01	0.70-6.00*	0.05	83.87
LYM (%)	69.10	83.60	76.82±0.64	40.00-75.00*	3.53	4.60
ALC (10^9/L)	5.24	16.39	9.40±0.62	2.00-9.00*	3.29	34.94
Mn (%)	11.00	29.40	18.44±0.92	0.00-6.00*	5.03	27.29
AMC (10^9/L)	0.93	4.85	2.24±0.18	0.00-0.75*	1.00	44.72
Eos (%)	0.60	10.00	3.59±0.47	0.00-10.00*	2.59	72.12
AEC (10^9/L)	0.10	1.33	0.44±0.06	0.00-1.00*	0.35	78.92
BASO (%)	0.04	1.00	0.64±0.06	0.00-3.00*	0.30	47.10
ABC (10^9/L)	0.04	0.15	0.08±0.01	0.00-0.30*	0.03	42.90
NB (/100wcc)	0.00	0.40	0.13±0.02	-	0.12	90.68
Plt (10^9/L)	165.00	459.00	309.97±12.05	250.00-750.00*	66.01	21.30

Hb = Haemoglobin, RBC= Red blood cell count, Hct = Haematocrit, MCV= Mean corpuscular volume, MCH = Mean corpuscular haemoglobin, MCHC = Mean Corpuscular haemoglobin concentration, RDW = Red cell distribution width, WBC = White cell count, NEU = Neutrophils, ANC = Absolute neutrophils, LYM = Lymphocytes, ALC = Absolute lymphocytes, Mn = Monocytes, AMC = Absolute monocytes, Eos = Eosinophils, AEC = Absolute eosinophils, BASO = Basophils, ABC = Absolute basophils, NB = Normoblasts, Plt = Platelet, SE = Standard error, SD = Standard deviation, CV % = Coefficient of variation, - no reference value, * (Schalm, 1965).

4.3.2 Correlation matrix between haematological parameters

Table 4.2 shows the phenotypic correlation between haematological parameters. The findings indicated that some of the haematological parameters were significantly correlated (p<0.05) while others were not significantly correlated (p>0.05). The results showed that RBC was positively high correlated (p<0.01) to Hct (r=0.93), WBC (r=0.47), ALC (r=0.51), Eos (r=0.65), AEC (r=0.75), and negatively highly correlated (p<0.01) to MCV (r=-0.49), Mn (r=-0.64) and NB (r=-0.65). RBC was positively correlated to (p<0.05) LYM (r=0.43) and negatively correlated (p<0.05) MCH (r=-0.49). However, RBC had no significant correlation (p>0.05) with MCHC (r=0.01), RDW (r=0.09), NEU (r=0.09), ANC (r=0.33), AMC (r=0.00), BASO (r=0.19), ABC (r=0.20) and Plt (r=0.07). The results indicated that MCV was positively highly correlated (p<0.01) with MCH (r=0.90), and negatively highly correlated (p<0.01) with RDW (r=-0.54), Eos (r=-0.50), and positively correlated (p<0.05) with Mn (R=0.39) and negatively correlated (p<0.05) with AEC (r=-0.38). The findings showed that MCV was not significantly correlated (p>0.05) with MCHC (r=-0.20), WBC (r=-0.16), NEU (r=0.08), ANC (r=-0.01), LYM (r=-0.19), ALC (r=-0.18), AMC (r=0.04), BASO (r=-0.18), ABC (r=-0.19), NB (r=0.22), and Plt (r=-0.22).

Table 4.2: Correlation matrix between haematological parameters

	Hb	RBC	Hct	MCV	MCH	MCHC	RDW	WBC	NEU	ANC	LYM	ALC	Mn	AMC	Eos	AEC	BASO	ABC	NB	Plt
Hb																				
RBC	0.91**																			
Hct	0.97**	0.93**																		
MCV	-0.16^{ns}	-0.49**	-0.14^{ns}																	
MCH	-0.10^{ns}	-0.49*	-0.17^{ns}	0.90**																
MCHC	0.15^{ns}	-0.01^{ns}	-0.08^{ns}	-0.20^{ns}	0.24^{ns}															
RDW	-0.33^{ns}	-0.09^{ns}	-0.34^{ns}	-0.54**	-0.46**	0.18^{ns}														
WBC	0.40*	0.47**	0.49**	-0.16^{ns}	-0.32^{ns}	-0.38*	-0.28^{ns}													
NEU	0.05^{ns}	0.09^{ns}	0.12^{ns}	0.08^{ns}	-0.06^{ns}	-0.30^{ns}	0.24^{ns}	-0.07^{ns}												
ANC	0.26^{ns}	0.33^{ns}	0.37*	-0.01^{ns}	-0.22^{ns}	-0.46*	0.04^{ns}	0.53**	0.80**											
LYM	0.46*	0.43*	0.40*	-0.19^{ns}	-0.08^{ns}	0.24^{ns}	-0.10^{ns}	0.08^{ns}	-0.26^{ns}	-0.16^{ns}										
ALC	0.46*	0.51**	0.54**	-0.18^{ns}	-0.32^{ns}	-0.34^{ns}	-0.29^{ns}	0.99**	-0.09^{ns}	0.50**	0.23^{ns}									
Mn	-0.60**	-0.64**	-0.55**	0.39*	0.28^{ns}	-0.25^{ns}	-0.14^{ns}	-0.06^{ns}	-0.13^{ns}	-0.15^{ns}	-0.86**	-0.18^{ns}								

AMC	-0.04^{ns}	-0.00^{ns}	0.05^{ns}	0.04^{ns}	-0.14^{ns}	-0.41*	-0.26^{ns}	0.76**	-0.17^{ns}	0.29^{ns}	-0.50**	0.67**	0.59**							
Eos	0.53**	0.65**	0.51**	-0.50**	-0.42*	0.16^{ns}	0.39*	0.04^{ns}	0.53**	0.46*	0.33^{ns}	0.09^{ns}	-0.76**	-0.41*						
AEC	0.64**	0.75**	0.69**	-0.38*	-0.44*	-0.13^{ns}	0.11^{ns}	0.52**	0.52**	0.75**	0.34^{ns}	0.56**	-0.68**	-0.02^{ns}	0.84**					
BASO	0.23^{ns}	0.19^{ns}	0.17^{ns}	-0.18^{ns}	-0.04^{ns}	0.32^{ns}	-0.17^{ns}	-0.18^{ns}	-0.26^{ns}	-0.43*	0.15^{ns}	-0.16^{ns}	-0.07^{ns}	-0.15^{ns}	-0.13^{ns}	-0.25^{ns}				
ABC	0.17^{ns}	0.20^{ns}	0.18^{ns}	-0.19^{ns}	-0.18^{ns}	0.00^{ns}	-0.34^{ns}	0.36*	-0.56**	-0.36^{ns}	0.16^{ns}	0.38*	0.03^{ns}	0.34^{ns}	-0.29^{ns}	-0.15^{ns}	0.68**			
NB	-0.65**	-0.65**	-0.66**	0.22^{ns}	0.23^{ns}	0.03^{ns}	0.42*	-0.49**	-0.15^{ns}	-0.37*	-0.26^{ns}	-0.51**	0.35^{ns}	-0.18^{ns}	-0.29^{ns}	-0.52**	-0.36^{ns}	-0.25^{ns}		
Plt	-0.08^{ns}	0.07^{ns}	-0.00^{ns}	-0.22^{ns}	-0.36^{ns}	-0.32^{ns}	0.37*	0.53**	-0.16^{ns}	0.24^{ns}	-0.05^{ns}	0.51**	0.12^{ns}	0.52**	-0.11^{ns}	0.13^{ns}	-0.42*	-0.07^{ns}	0.07^{ns}	

Hb = Haemoglobin, RBC= Red blood cell count, Hct = Haematocrit, MCV= Mean corpuscular volume, MCH = Mean corpuscular haemoglobin, MCHC = Mean Corpuscular haemoglobin concentration, RDW = Red cell distribution width, WBC = White cell count, NEU = Neutrophils, ANC = Absolute neutrophils, LYM = Lymphocytes, ALC = Absolute lymphocytes, Mn = Monocytes, AMC = Absolute monocytes, Eos = Eosinophils, AEC = Absolute eosinophils, BASO = Basophils, ABC = Absolute basophils, NB = Normoblasts, Plt = Platelet, * significant ($p < 0.05$), **significant ($p < 0.01$), and ^{ns} no significance.

4.3.3 The effect of sex on haematological parameters

The effect of sex on haematological parameters is presented in Table 4.3. The results showed that sex had a significant effect ($p < 0.05$) on Hb and RDW, and high significant effect ($p < 0.01$) on LYM and NB. Males had the highest Hb and LYM, while females had the highest RDW and NB. However, sex had no significant influence ($p > 0.05$) on RBC, Hct, MVC, MCHC, WBC, NEU, ANC, ALC, Mn, AMC, Eos, AEC, BASO, ABC, NB, and Plt. The results further showed that females had the highest WBC and RBC counts compared to male Dorper sheep.

Table 4.3: Effect of sex on haematological parameters

Haematological Parameters	**Female (n=19)**	**Male (n=11)**	**P value**
Haematological parameters	**Mean ± SD**	**Mean ± SD**	**P value**
Hb (g/dL)	10.16^{a}±1.44	8.87^{b}±1.83	0.04
RBC (10^12/L)	10.21^{a}±1.74	9.05^{a}±2.11	0.11
Hct (%)	32.46^{a}±4.91	28.54^{a}±5.76	0.06
MCV (fL)	31.99^{a}±2.67	31.96^{a}±2.60	0.92
MCH (pg)	10.03^{a}±0.93	9.95^{a}±0.62	0.81
MCHC (g/dL)	31.33a±1.18	31.21^{a}±1.15	0.78
RDW (%)	24.49^{b}±1.39	26.91 ±3.99	0.02
WBC (10^12/L)	12.57^{a}±4.65	11.63^{a}±3.53	0.57
NEU (%)	0.44^{a}±0.30	0.54^{a}±0.28	0.41
ANC (10^12/L)	0.56^{a}±0.05	0.06^{a}±0.04	0.82
LYM (5)	78.10^{a}±2.89	74.60^{b} ±3.56	0.01
ALC (10^12/L)	9.84^{a}±3.64	8.65^{a}±2.55	0.35
Mn (%)	17.36^{a}±3.84	20.29^{a}±6.39	0.13
AMC (10^12/L)	2.14^{a}±0.84	2.42^{a}±1.26	0.48
Eos (%)	3.38^{a}±2.01	3.95^{a}±3.46	0.57
AEC (10^12/L)	0.45^{a}±0.33	0.44^{a}±0.40	0.92
BASO (%)	0.71^{a}±0.25	0.52^{a}±0.35	0.10
ABC (10^12/L)	0.08^{a}±0.03	0.08^{a}±0.04	0.78
NB(/100wcc)	0.08^{b}±0.05	0.22^{a}±0.15	0.00
Plt (10^12/L)	307.95^{a}±71.39	313.45^{a}±58.66	0.83

$^{a,\, b}$ means in the same row with different letter shows a significant difference ($p < 0.05$), Hb = Haemoglobin, RBC= Red blood cell count, Hct = Haematocrit, MCV= Mean corpuscular volume, MCH = Mean corpuscular haemoglobin, MCHC = Mean Corpuscular haemoglobin concentration, RDW = Red cell distribution width, WBC = White cell count, NEU = Neutrophils, ANC = Absolute neutrophils, LYM = Lymphocytes, ALC = Absolute lymphocytes, Mn = Monocytes, AMC = Absolute monocytes, Eos = Eosinophils, AEC = Absolute eosinophils, BASO = Basophils, ABC = Absolute basophils, NB = Normoblasts, Plt = Platelet, SD = Standard deviation.

4.3.4 The effect of body condition score on haematological parameters

Table 4.4 presents the effect of body condition score on haematological parameters. The results showed that body condition score had no significant effect ($p > 0.05$) on the haematological parameters. It was observed that the levels of RBC, MCV, ALC, AMC and WBC increased with an increase in body condition score. The results further indicated that thin animals had the lowest Hb, and Hct levels compared to the other body condition score categories. It was observed that heavy animal had the highest means for Hb, RBC, Hct, MCV, MCH, WBC, LYM, ALC, AMC, BASO and ABC compared to the other groups of body condition score.

Table 4.4: Effect of body condition score on haematological parameters

Haematological parameters	Too thin (n=6)	Thin (n=12)	Moderate (n=10)	Heavy (n=2)	P value
Haematological parameters	**(Mean ± SD)**	**(Mean ± SD)**	**(Mean ± SD)**	**(Mean ± SD)**	**P Value**
Hb (g/dL)	9.58^{a}±1.48	9.28^{a}±1.92	10.02^{a}±1.67	10.80^{a}±0.14	0.59
RBC (10^12/L)	9.42^{a}±0.99	9.44^{a}±2.21	10.29^{a}±2.21	10.43^{a}±0.85	0.71
Hct (%)	29.80^{a}±4.18	29.60^{a}±6.00	32.91^{a}±5.83	33.75^{a}±0.78	0.45
MCV (fL)	31.63^{a}±2.96	31.72^{a}±2.71	32.34^{a}±2.68	32.45^{a}±1.91	0.93
MCH (pg)	10.15^{a}±0.96	9.93^{a}±0.83	9.92^{a}±0.83	10.40^{a}±0.71	0.85
MCHC (g/dL)	32.12^{a}±1.11	31.27^{a}±1.30	30.67^{a}±0.72	32.00^{a}±0.28	0.07
RDW (%)	25.08^{a}±2.40	26.65^{a}±3.60	24.66^{a}±1.13	22.25^{a}±2.62	0.13
WBC (10^9/L)	10.57^{a}±2.62	11.34^{a}±3.40	13.84^{a}±5.74	14.46^{a}±0.09	0.34
NEU (%)	0.47^{a}±0.48	0.39^{a}±0.22	0.62^{a}±0.25	0.30^{a}±0.00	0.26
ANC (10^9/L)	0.48^{a}±0.06	0.04^{a}±0.02	0.09^{a}±0.06	0.04^{a}±0.00	0.09
LYM (5)	76.48^{a}±1.49	77.01^{a}±4.77	76.54^{a}±2.60	78.05^{a}±5.87	0.95
ALC (10^9/L)	8.11^{a}±2.18	8.71^{a}±2.53	10.64^{a}±4.49	11.28^{a}±0.78	0.33
Mn (%)	19.08^{a}±4.07	18.28^{a}±6.43	18.41^{a}±3.81	17.55^{a}±7.85	0.98
AMC (10^9/L)	1.96^{a}±0.46	2.15^{a}±1.26	2.46^{a}±0.94	2.54^{a}±1.15	0.78
Eos (%)	3.27^{a}±3.34	3.66^{a}±2.82	3.79^{a}±2.26	3.20^{a}±2.12	0.98
AEC (10^9/L)	0.38^{a}±0.47	0.36^{a}±0.23	0.58^{a}±0.41	0.47^{a}±0.30	0.54
BASO (%)	0.70^{a}±0.30	0.60^{a}±0.29	0.60^{a}±0.35	0.90^{a}±0.14	0.58
ABC (10^9/L)	0.07^{a}±0.03	0.08^{a}±0.04	0.08^{a}±0.03	0.14^{a}±0.03	0.10
NB(/100wcc)	0.08^{a}±0.04	0.19^{a}±0.13	0.09^{a}±0.12	0.10^{a}±0.00	0.13

Plt (10^9/L)	293.67[a]±35.76	330.67[a]±74.54	307.60[a]±69.11	246.50[a]±31.82	0.35

[a, b, c] means in the same row with different letter shows a significant difference ($p < 0.05$), Hb = Haemoglobin, RBC= Red blood cell count, Hct = Haematocrit, MCV= Mean corpuscular volume, MCH = Mean corpuscular haemoglobin, MCHC = Mean Corpuscular haemoglobin concentration, RDW = Red cell distribution width, WBC = White cell count, NEU = Neutrophils, ANC = Absolute neutrophils, LYM = Lymphocytes, ALC = Absolute lymphocytes, Mn = Monocytes, AMC = Absolute monocytes, Eos = Eosinophils, AEC = Absolute eosinophils, BASO = Basophils, ABC = Absolute basophils, NB = Normoblasts, Plt = Platelet, SD = Standard deviation. Too thin = 1 on the body condition score scale, Thin = 2 on the body condition score scale, Moderate = 3 on the body condition score scale, Heavy = 4 on the body condition score scale.

4.3.5 Effect of age on haematological parameters

Table 4.5 presents the effect of age on haematological parameters. The findings indicated that age had no significant influence ($p > 0.05$) on the haematological parameters. It was observed that three-year-olds and five-year-olds have the equal mean and standards error for NUE, on top of the this is the highest means compared to the other age groups. It was also observed that Hb, RBC, Hct, WBC, ANC, ALC, AMC, Eos, and Plt had the highest mean at the age of five. The value of Hct increasing from the one year to five-year-old Dorper sheep, however it decreased at the age of six. The results further indicated that the RBC and Hb were fluctuating between the ages going up and down.

Table 4.5: Effect of age on haematological parameters

Haematological parameters	One year old (n=6)	Two-year-old (n=12)	Three-year-old (n=1)	Four-year-old (n=8)	Five-year-old (n=5)	Six-year-old (n=6)	P value
Haematological parameters	**(Mean ± SD)**	**(Mean ± SD)**	**(Mean ± SD)**	**(Mean ± SD)**	**(Mean ± SD)**	**(Mean ± SD)**	**P Value**
Hb (g/dL)	8.53[a]±1.89	9.32[a]±1.78	9.30[a]±0.00	10.69[a]±1.29	11.40[a]±0.00	10.23[a]±2.16	0.17
RBC (10^12/L)	8.46[a]±1.93	9.64[a]±1.82	8.32[a]±0.00	10.95[a]±1.21	11.86[a]±0.00	9.69[a]±3.08	0.18
Hct (%)	27.30[a]±5.20	29.89[a]±4.99	30.10[a]±0.00	33.86[a]±4.51	38.00[a]±0.00	33.00[a]±7.86	0.19
MCV (fL)	32.58[a]±2.21	31.25±2.80	36.20[a]±0.00	30.92[a]±1.91	32.00[a]±0.00	34.60[a]±2.52	0.14
MCH (pg)	10.13[a]±0.64	9.81[a]±0.80	11.20[a]±0.00	9.78[a]±0.81	9.60[a]±0.00	10.80[a]±1.06	0.26

MCHC (g/dL)	31.12^{a}±1.30	31.36^{a}±1.09	30.90^{a}±0.00	31.58^{a}±1.38	30.00^{a}±0.00	31.13^{a}±0.97	0.86
RDW (%)	25.25^{a}±1.56	26.47^{a}±4.16	23.20^{a}±0.00	24.60^{a}±1.74	24.30^{a}±0.00	24.97^{a}±1.59	0.75
WBC (10^9/L)	11.70^{a}±2.39	11.60^{a}±3.65	7.12^{a}±0.00	13.65^{a}±5.33	21.37^{a}±0.00	10.42^{a}±2.96	0.15
NEU (%)	0.43^{a}±0.42	0.47^{a}±0.24	0.80^{a}±0.00	0.49^{a}±0.25	0.80^{a}±0.00	0.33^{a}±0.42	0.69
ANC (10^9/L)	0.05^{a}±0.06	0.05^{a}±0.02	0.06^{a}±0.00	0.07^{a}±0.06	0.17^{a}±0.00	0.03^{a}±0.03	0.15
LYM (5)	76.50^{a}±2.18	75.07^{a}±3.77	74.10^{a}±0.00	78.66^{a}±2.61	76.70^{a}±0.00	79.87^{a}±5.07	0.16
ALC (10^9/L)	9.00^{a}±2.08	8.68^{a}±2.64	5.28^{a}±0.00	10.72^{a}±4.08	16.39^{a}±0.00	8.42^{a}±2.82	0.19
Mn (%)	19.55^{a}±4.79	20.00^{a}±5.83	22.60^{a}±0.00	15.61^{a}±3.83	17.50^{a}±0.00	16.93^{a}±5.16	0.46
AMC (10^9/L)	2.22^{a}±0.42	2.40^{a}±1.29	1.61^{a}±0.00	2.15^{a}±1.05	3.74^{a}±0.00	1.66^{a}±0.09	0.58
Eos (%)	2.97^{a}±3.49	3.71^{a}±2.95	1.50^{a}±0.00	4.60^{a}±1.79	4.70^{a}±0.00	2.07^{a}±0.81	0.67
AEC (10^9/L)	0.37^{a}±0.48	0.39^{a}±0.29	0.11^{a}±0.00	0.63^{a}±0.31	1.00^{a}±0.00	0.23^{a}±0.14	0.19
BASO (%)	0.43^{a}±0.37	0.71^{a}±0.27	1.00^{a}±0.00	0.64^{a}±0.26	0.30^{a}±0.00	0.80^{a}±0.26	0.21
ABC (10^9/L)	0.07^{a}±0.04	0.09^{a}±0.04	0.07^{a}±0.00	0.08^{a}±0.00	0.08^{a}±0.03	0.06^{a}±0.00	0.88
NB(/100wcc)	0.18^{a}±0.17	0.16^{a}±0.12	0.10^{a}±0.00	0.06^{a}±0.05	0.00^{a}±0.00	0.13^{a}±0.05	0.31
Plt (10^9/L)	322.67^{a}±28.39	301.45^{a}±64.57	223.00^{a}±0.00	300.86^{a}±75.36	398.00±0.00	339.67^{a}±0.00	0.48

$^{a, b, c, d, e, f}$ means in the same row with different letter shows a significant difference ($p < 0.05$), Hb = Haemoglobin, RBC= Red blood cell count, Hct = Haematocrit, MCV= Mean corpuscular volume, MCH = Mean corpuscular haemoglobin, MCHC = Mean Corpuscular haemoglobin concentration, RDW = Red cell distribution width, WBC = White cell count, NEU = Neutrophils, ANC = Absolute neutrophils, LYM = Lymphocytes, ALC = Absolute lymphocytes, Mn = Monocytes, AMC = Absolute monocytes, Eos = Eosinophils, AEC = Absolute eosinophils, BASO = Basophils, ABC = Absolute basophils, NB = Normoblasts, Plt = Platelet, SD = Standard deviation.

4.3.6 Effect of physiological status on haematological parameters

Table 4.6 presents the effect of physiological status on haematological parameters. The findings showed that physiological status had no significant effect ($p > 0.05$) on studied haematological parameters except on RDW ($p > 0.05$). Non-pregnant females had the highest RDW while pregnant females had the lowest RDW. Pregnant animals had the highest mean value for RBC, Hct, MCV, MCH, MCHC, NEU, ANC, Mn, AMC, Eos, and AEC compared to the non-pregnant female Dorper sheep. Pregnant animals had the highest mean value for RBC, Hct, MCV, MCH, MCHC, NEU, ANC, Mn, AMC, Eos, and AEC compared to the non-pregnant female Dorper sheep. It was further observed that non-pregnant females had the highest mean values for WBC, LYM, ALC, BASO, ABC and NB compared to pregnant female Dorper sheep. On the other hand, ABC and NB had similar mean values for both pregnant and non-pregnant female Dorper sheep.

Table 4.6: Effect of physiological status on haematological parameters

Haematological Parameters	**Pregnant (n=10)**	**Non-pregnant (n=9)**	**P value**
Haematological parameters	**Mean ± SD**	**Mean ± SD**	**P Value**
Hb (g/dL)	10.49^{a}±1.15	9.79^{a}±1.69	0.30
RBC (10^12/L)	10.35^{a}±1.50	10.06^{a}±2.06	0.73
Hct (%)	33.22^{a} ± 3.75	31.61^{a}±6.08	0.49
MCV (fL)	32.34^{a}±2.47	31.61^{a}±2.97	0.57
MCH (pg)	10.21^{a}±0.90	9.83^{a}±0.98	0.40
MCHC (g/dL)	31.56^{a}±1.38	31.08^{a}±0.92	0.39
RDW (%)	23.89^{b}±0.94	25.17^{a}±1.54	0.04
WBC (10^12/L)	12.55^{a}±5.22	12.59^{a}±4.24	0.98
NEU (%)	0.49±0.31	0.39^{a}±0.30	0.48
ANC (10^12/L)	0.06^{a}±0.06	0.05^{a}±0.05	0.56
LYM (5)	77.32^{a}±2.62	78.97^{a}±3.07	0.24
ALC (10^12/L)	9.72^{a}±4.06	9.97^{a}±3.34	0.89
Mn (%)	17.81^{a}±4.21	16.87^{a}±3.57	0.61
AMC (10^12/L)	2.19^{a}±0.94	2.08^{a}±0.76	0.78
Eos (%)	3.71^{a}±2.14	3.02^{a}±1.91	0.47
AEC (10^12/L)	0.49^{a}±0.35	0.40^{a}±0.32	0.58
BASO (%)	0.67^{a}±0.27	0.76^{a}±0.24	0.48
ABC (10^12/L)	0.07^{a}±0.03	0.09^{a}±0.03	0.20
NB(/100wcc)	0.07^{a}±0.05	0.09^{a}±0.06	0.46
Plt (10^12/L)	290.00^{a}±74.53	327.89^{a}±66.09	0.26

$^{a,\ b}$ means in the same row with different letter shows a significant difference ($p < 0.05$), Hb = Haemoglobin, RBC= Red blood cell count, Hct = Haematocrit, MCV= Mean corpuscular volume, MCH = Mean corpuscular haemoglobin, MCHC = Mean Corpuscular haemoglobin concentration, RDW = Red cell distribution width, WBC = White cell count, NEU = Neutrophils, ANC = Absolute neutrophils, LYM = Lymphocytes, ALC = Absolute lymphocytes, Mn = Monocytes, AMC = Absolute monocytes, Eos = Eosinophils, AEC = Absolute eosinophils, BASO = Basophils, ABC = Absolute basophils, NB = Normoblasts, Plt = Platelet, SD = Standard deviation.

4.4 DISCUSSION

Haematological parameters are essential for the assessment of animal health, nutritional, metabolic and physiological status (Ljubičić *et al*., 2022). This study was conducted to investigate the influence of sex, age, body condition score and physiological status of animals on the haematological parameters of Dorper sheep. Dorper sheep is a South African indigenous sheep breed utilized for meat production (Cloete *et al*., 2000). This study first used Pearson's correlation to study the association between haematological parameters. The findings revealed that RBC was positively highly correlated with Hct, WBC, ALC, Eos, and AEC. On the other hand, RBC was not correlated with MCHC, RDW, NEU, ANC, AMC, BASO, ABC, and Plt. The results showed that RBC was negatively correlated to MCH. These results contradict Aicha *et al*. (2021) who reported a positive correlation between RBC, MHC and Plt in Ouled Djellal sheep of Northeastern Algeria. The current study agrees with Fanta *et al*. (2024), who reported that RBC had a negative high correlation with MCH, and MCHC and positively correlated with WBC and Hct in Doyogena sheep of Ethiopia. The inconsistent results may be due to differences in the breeds studied as well as different geographical areas in which the studies were undertaken. The relationship between Hct and RBC is that Hct measures the percentage blood made up of RBC (Etim *et al*., 2014). The studied haematological parameters were compared with the reference values and the results indicated that Hb, RBC, Hct, MCV, MCH, Plt, were within reference values given by Schalm (1965). Etim (2015) stated that Hb that is within range implies that the protein in the animal's diet is of high quality. Fanta *et al*. (2024) stated that animals with low levels of Hct may be more susceptible to macrocytic anemia due to folate deficiency. Furthermore, WBC and LYM were the exception as they were higher than the reference values, while NEU was lower than the reference value. The results are consistent with Ljubičić *et al*. (2022), who reported that the WBC count was higher compared to the reference values in (Kramer, 2000). High counts of WBC implies that the animal could produce antibodies and have higher ability to fight infections, meaning they are adaptable to their environment (Etim, 2015). On the other hand, Ljubičić *et al*. (2022) stated that the high WBC count might be due to underlying infectious, therefore it is rather alarming. Barsila *et al*. (2020) stated that NUE increases as age decreases owing to the immune response at older age. The current study contradicts Sarmin *et al*. (2021), who reported that Hct, Hb, and NEU were within the range, while RBC, MCH, and MCHC were below the range when compared to the reference values. According to Sitmo (2018) and Ljubičić *et al*. (2022), stress, management practices, and immune response to the environment may result in high levels of LYM and WBC. The variation in haematological parameters could be due to different factors such as sex, age, breed, and sampling techniques (Al-Samarai and Al-Jbory, 2017). The present study determined the effect of sex, age, body condition score and physiological status on haematological parameters of Dorper sheep. The results revealed that sex had a significant effect on LYM, NB, Hb, and RDW. The findings of the current study indicated that sex had no influence on RBC, Hct, MVC, MCHC, WBC, MCH, NEU, ANC, ALC, Mn, AMC, Eos, AEC, BASO, ABC, NB, and Plt in Dorper sheep. The results also reported higher values of WBC and RBC in female while male Dorper sheep had the lowest values. Ljubičić *et al*. (2022) found similar results where female Dalmatian Pramenka lambs had the highest WBC, Hb, and RBC compared to male lambs. In contrast, Sitmo (2018) reported a high WBC count in male compared to female Barbary sheep. These results are similar to those of Ajayi *et al*. (2021) and Nafisat *et al*. (2021), which showed that sex had an effect on LYM, Hb and RDW in sheep. However, our results contradict the report of Oramari *et al*. (2014), which showed that sex had no significant effect on Hb, and that of Nafisat *et al*. (2021), which indicated that sex had no significant effect on Hb and LYM. The results of the current study are similar to the findings of Carlos *et al*. (2015) in Morada Nova sheep, which indicated that sex did not affect MCV and RBC. In contrast, Ljubičić *et al*. (2022) indicated that sex had a significant effect on RBC, WBC, MCV, and Hb in Dalmatian Pramenka lambs. The results agree those of Oramari *et al*. (2014), who reported that sex had no significant influence on Hct and Rahman *et al*. (2018), who indicated that sex effect on Hct, Eos, and Mn in indigenous sheep of Bangladesh. The findings of Sitmo (2018), are not consistent with our results as they reported the influence of sex on RBC, MCH, Hct, MCHC, Mn, and MCV in Barbary sheep. The variation in haematological parameters between males and females may be due to physiological changes during pregnancy, lactation, parturition and milk production which lead to stress that can affect the levels of haematological parameters (Al-Samarai and Al-Jbory, 2017). Ljubičić *et al*. (2022) noted that the variation in RBC value may be due to stress, hormonal effect and environmental adaption. Due to hormonal difference between male and female Dorper sheep sex should be considered when interpreting heamatological parameter results. The present study reported that body condition scores did not influence the studied haematological parameters. The results also indicated that RBC, WBC, ALC, AMC, MCV increased with the increase in body condition score. It was also observed that thin animals had the lowest values of Hb and PVC compared to other categories of body condition score. The results contrast with

Carlos *et al*. (2015), who reported that body condition score had an influence on the variations in RBC, Hb, and MCV values in Morada Nova sheep. The results of the current study contrast with (Kumari *et al*., 2022), who indicate that body condition score had influence on Hct and Hb Marwari sheep. The same study also showed that body condition score had no significant influence on RBC count which agrees with the finding of the current study. In contrast Metodiev *et al*. (2021), reported that body condition score had significant influence on RBC, Hct, and Hb in IIe de France sheep. The same study further indicated that body condition score had no effect on MCHC, MCH, and MCV of IIe de France sheep, which is consistent with the finding of the current study. The findings of the current study are consistent with (Ferreira *et al*., 2021), who reported that body condition score had no influence on RBC and Hct in Morada Nova sheep. Kumari *et al*. (2022) explained that reduction in the values of PVC in thin animals could be due to decreased synthesis of RBC counts and Hb. Due to the nonstatistical significant effect body condition score had on haematological parameters it should not be considered when interpreting the haematological parameter results, rather other factors should be included. Age had no effect on haematological parameters in the current study. The results reported and increased in the value of Hct from one-year olds up to five years of age in Dorper sheep. Furthermore, they indicate that there was an up and down trend in the values of RBC and Hb. The results of the current study contrast Ljubičić *et al*. (2022), who reported a reduction in the value of RBC, Hb, and Hct values with an increase in age of Dalmatian Pramenka lambs. Indeed, Ljubičić *et al*. (2022) reported that age had a significant influence on RBC, Hct, MCV, MCHC, MCH, Plt, and Hb, excluding WBC and Ajayi *et al*. (2021) reported that age influenced the Hb, RBC, Plt. Ajayi *et al*. (2021) further showed that age had no significant influence on MCH, MCV, and MCHC, which agrees with the findings of the current study. The findings of this study are consistent with the findings of Nafisat *et al*. (2021), who reported that age did not affect WBC, RBC, Hct, MCV, LYM, NEU, and RDW. In contrast, Rahman *et al*. (2018) reported that age had an influence on Hb, Hct, and Eos in indigenous sheep of Bangladesh. The results contrast Sitmo (2018), who reported that age had significant influence on RBC, Hct, Hb, WBC, MCV, MCH, MCHC, Plt, and LYM of Barbary sheep. The results of the study agree with Abdel-Lattif and Al-Muhja (2021), who stated that age had no influence on RBC, Hct, NEU, BASO, Mn, LYM, and WBC in Awassi sheep. These findings agree with Al-Samarai and Al-Jbary (2017), who stated that WBC, MCHC, MCH, MCV, RBC, Hb, and Hct of Iraqi

Awassi sheep. The results of the current study imply that age does not affect the interpretation of haematological results. The study also investigated the effects of physiological status on haematological parameters and found that physiological status had no significant effect on haematological parameters except for RDW, with the highest value observed on non-pregnant animals compared to pregnant ones. The results were different from those of Soliman (2014), who reported that physiological status did not affect Hb, RBC, WBC, NEU, and Mn in Ossimi sheep, and Sarmin *et al*. (2021) on Indonesian fat-tailed sheep reported that physiological status effected RBC, HB, and MCH. The findings of the current study are consistent with those of David *et al*. (2020), who reported that pregnancy had an influence on RBC, Hct, Hb, MCV, MCH, Eos, LYM, Mn and MCHC of Santa Ines ewes. The results of the current study agreed with those of Soliman (2014), who stated that physiological status influenced Eos, BASO, and LYM, and Sarmin *et al*. (2021) reported that physiological status did not affect Hct, MCH, WBC, NUE, and LYM. In contrast Santarosa *et al*. (2021), reported that single and twin pregnancy at 140 days had an influence on RBC, Hb, MCV, and MCHC in Dorper ewes of Brazil. The difference in results could be that Santarosa *et al*. (2021), investigated different level of physiological status and found that they had an influence on RBC, Hb, Hct, MCV, MCHC, Mn, and Plt in both single and twin pregnancy in Dorper sheep, while in the present study only looked pregnant and non-pregnant physiological status of female Dorper sheep. The physiological status of an animal should be considered when interpreting haematological parameters of Dorper sheep.

4.5 Conclusion

This study examined the effect of sex, age, body condition score, and physiological status on haematological parameters of Dorper sheep raised introduction says semi-intensive. The study concludes that body condition score and age had no significant effect on the haematological parameters. Physiological status influenced the variation of one haematological parameter, namely red blood cell distribution width, while sex influenced some of the haematological parameters, such as haemoglobin, red blood cell distribution width, lymphocytes, and normoblasts of Dorper sheep. Therefore, based on the findings of the current study, sex, and physiological status should be considered when assessing the health, nutritional, and physiological status of Dorper sheep. The limitation of this study is that few animals were used for the study, which makes it difficult to make the conclusive effect of age, sex, body condition score, and physiological status on haematological parameters of Doper sheep. Further studies should be conducted to investigate the effect of these factors on Dorper sheep using a larger sample size.

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CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

Pearson's correlation was used to determine the phenotypic association between haematological parameters of Dorper sheep. The results revealed a correlation between some of the haematological parameters. The study also evaluated the influence of sex, age, body condition score, and physiological status on haematological parameters of Dorper sheep. The study concludes that physiological status had an influence on red blood distribution width, while sex had an influence on haemoglobin, red blood cell distribution width, lymphocytes, and normoblasts of Dorper sheep. Body condition score and age had no significant effect on haematological parameters. Based on the results of the study sex and physiological status should be considered when evaluation the health, physiological changes, nutritional status of Dorper sheep.

5.2 RECOMMENDATIONS

Based on the results of the current study, recommendations are:

The results revealed the influence of sex and physiological status on haematological parameters; therefore, it is recommended that the farmers to consider sex and physiological status when interpreting haematological profile of Dorper sheep.

Researchers need to investigate the effect of non-genetic factors using larger population size of Dorper sheep and different geographical areas.