

**PREVALENCE OF PARASITIC INFECTIONS IN ONE - HUMPED  
CAMEL (*Camelus dromedarius*) IN SELECTED LOCAL  
GOVERNMENT AREAS OF SOKOTO STATE, NIGERIA**

*BY*

**MUSA ABDULLAHI**

**DEPARTMENT OF VETERINARY MEDICINE  
FACULTY OF VETERINARY MEDICINE  
AHMADU BELLO UNIVERSITY ZARIA,  
NIGERIA**

**DECEMBER, 2018**

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GOVERNMENT AREAS OF SOKOTO STATE, NIGERIA**

*BY*

**Musa ABDULLAHI, D. V. M (UDUS) 2009  
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**DEPARTMENT OF VETERINARY MEDICINE  
FACULTY OF VETERINARY MEDICINE  
AHMADU BELLO UNIVERSITY ZARIA,  
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**DECEMBER, 2018**

## DECLARATION

I declare that, the work in this dissertation titled “**Prevalence of Parasitic Infections in One - Humped camel (*Camelus dromedarius*) in Selected Local Government Areas of Sokoto State, Nigeria**” has been carried out by me in the Department of Veterinary Medicine, Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria, Nigeria. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another degree or diploma at this or any other institution.

Musa ABDULLAHI  
Name of Student

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Date

## CERTIFICATION

This dissertation titled “**PREVALENCE OF PARASITIC INFECTIONS IN ONE-HUMPED CAMEL (*CAMELUS DROMEDARIUS*) IN SELECTED LOCAL GOVERNMENT AREAS OF SOKOTO STATE, NIGERIA**” by Musa ABDULLAHI meets the regulations governing the award of a Master degree in Food Animal Medicine of the Ahmadu Bello University, Zaria, Nigeria and is approved for its contribution to knowledge.

<u>Prof. A. K Mohammed</u> Chairman, supervisory committee	_____ Signature	_____ Date
<u>Prof. O. O Okubanjo</u> Member, supervisory committee	_____ Signature	_____ Date
<u>Prof. P. A Abdu</u> Head of Department Veterinary medicine	_____ Signature	_____ Date
<u>Prof. S. Z Abubakar</u> Dean, School of Postgraduate Studies.A.B.U Zaria	_____ Signature	_____ Date

## **DEDICATION**

This research work is dedicated with deepest gratitude to my parents Alhaji Abdullahi Salihu Musa and Hajia Aishatu Dahiru Musa for laying the foundation of my education. May ALLAH reward them abundantly.

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## ABSTRACT

This study was conducted with a broad objective of determining the prevalence of parasitic infections and their vectors in one-humped camel (*Camelus dromedarius*) in selected Local Government Areas of Sokoto State, Nigeria. A total of 208 camels made up of 116 (55.8%) males and 92 (44.2%) females of varying age groups (young, growers and adults) were sampled over a period of six months (October, 2016 to March, 2017). Blood, faeces and ectoparasites were collected for examination and identification. Out of the 19 hemoparasites identified, 15(7.2%) were *Trypanosoma evansi* while 4(1.9%) were *Anaplasma marginale*. Of the 61 eggs /oocysts of gastro intestinal parasites identified, 10(4.8) were *Coccidia* 25(12.0%) *Strongyle* 14(6.7%) *Oxyuris* and 12(5.8%) *Trichuris*. Ticks accounted for 67(32.2%) of the ectoparasites identified, with *Hyalomma dromedarii* leading with 49(23.6%), *Rhipicephalus sanguineus* 12(5.8%) and *Amblyomma variegatum* 8(3.8%). Biting fly, *Stomoxys calcitrans* accounted for 28(29.4%) of the ectoparasites. There were significant increases ( $P < 0.05$ ) in the values of WBC, neutrophils, lymphocytes, monocytes and eosinophils while PCV, Hb, MCV, MCH and MCHC decreased significantly ( $P < 0.05$ ) in camels infected with both *Trypanosoma evansi* and *Anaplasma marginale*. For the gastrointestinal parasites infected camels, there was significant decrease ( $P < 0.05$ ) in the value of haemoglobin and increase ( $P < 0.05$ ) in the value of eosinophils. In conclusion, this study establishes the overall prevalence of parasitic infections of camel and their possible vectors in Sokoto State. Further research on parasitic infections of camels in the study area is recommended.

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## LIST OF ABBREVIATIONS

%	Percent
<	Less than
>	Greater than
A	<i>Anaplasma</i>
ABU	Ahmadu Bello University
CAT	Card Agglutination Test
CCHFV	Crimean- Congo Haemorrhagic Fever Virus
CSA	Central Statistical Authority
DNA	Deoxyribonucleic Acid
DNPH	Dinitrophenylhydrazine
EDTA	Ethylene DiamineTetra- acetic Acid
ELISA	Enzyme- Linked immunosorbent assay
FAO	Food and Agricultural Organization
Fig	Figure
GIT	Gastrointestinal tract
Hb	Haemoglobin
HCL	Hydrogenchloride
HCO <sub>3</sub> <sup>+</sup>	Bicarbonate
LGA	Local Government Area
MAHFD	Ministry of Animal Health and Fishery Development

MCH	Mean Copuscular Haemoglobin
MCHC	Mean Copuscular Haemoglobin Concentration
MCV	Mean Copuscular Volume
n	Number
NWC	New World Camel
OWC	Old World Camel
PCR	Polymerase Chain Reaction
PCV	Packed cell volume
RBC	Red blood cell
<i>T.</i>	<i>Trypanosoma</i>
TTBD	Tick or tick born disease
UDUS	Usmanu Danfodiyo University, Sokoto
USD	US dollar
WBC	White blood cell
$X^2$	Chi- square

## **CHAPTER ONE**

### **1.0 INTRODUCTION**

#### **1.1 Study background**

Camels are important multipurpose animals in arid and semi-arid areas of the world. The original range of the camel's wild ancestors was probably south Asia and the Arabian Peninsula where they survive and reproduce in areas where survival of other animals was intricate (Khalid *et al.*, 2015). The present estimated world population of camels is 26,635,000 (Faye *et al.*, 2011). In Africa, the population of one-humped or dromedary camels (*Camelus dromedarius*) constitutes 60.1% of the world's camel population (Khalid *et al.*, 2015) where 84.0% occurs in Somalia, Ethiopia, Sudan, Djibouti, Niger and Kenya (Kneeland, 2011). In Nigeria, the estimated camel population is about 180,000 found mostly in Kebbi, Sokoto, Zamfara, Katsina, Kano, Yobe, and Borno States (Abdussamad *et al.*, 2015).

Although camels are usually depicted as disease resistant, they are nevertheless susceptible to a range of parasitic infections (Ashkan *et al.*, 2014). These parasitic infections are a major cause of economic losses (general debility, reduced growth rates and milk yields, abortion, inappetance and anaemia) (Mahanty *et al.*, 2011). In some cases, parasitic infections result in death of animal or the parasites play a significant role as zoonotic agents (Ayoub *et al.*, 2015). In Nigeria, movement of camels and other livestock across borders (Nigeria-Niger through Border States) contributes significantly to the introduction of parasites that might be of veterinary and public health

importance. These could be protozoan, arthropod and gastrointestinal parasites (Parsani and Momin, 2008).

Among the protozoan infections, trypanosomosis is an infection caused by *Trypanosoma evansi* and transmitted mechanically by blood sucking flies (*Tabanus*, *Stomoxys*, *Hippobosca*, and *Chrysops*) (Saleem *et al.*, 2011). Other protozoan infections that affect camel production include anaplasmosis, babesiosis and coccidiosis (Yahaya, 2008).

Mange due to ectoparasite (*Sarcoptes scabiei var. cameli*) is another infection on camels that is associated with great economic losses (Ashkan *et al.*, 2014). Other ectoparasites that infest camels are ticks (*Hyalomma dromedarii*, *H. anatolicum*, *H. marginatum*, *Rhipicephalus sanguineus* and *Amblyomma variegatum*) (Parsani and Momin, 2008).

Gastrointestinal parasites cause economic losses in camel production and the most common among them are nematodes (*Haemonchus longistipes*, *Trichostrongylus vitrinus*, *Ostertagia mongolica*, and *Camelo strongylus*), trematodes (*Fasciola hepatica* and *Echinococcus polymorphus*) and cestodes (*Moniezia expansa* and *Stilesia vittata*) (Yahaya, 2008).

## **1.1 Statement of Research Problem**

The presence of polyparasitism in camels is an indication that favorable environmental conditions for infection, survival and perpetuation exist in Sokoto State (Mahmuda *et al.*, 2014). Parasitic diseases are a major health problem that hinder optimum health and production of camels and make herders and other people vulnerable to zoonotic diseases (Mahmuda *et al.*, 2014). The diseases are playing a great role in causing production losses (meat, milk and hide) as well as reducing the great potentials of camels for traction which are known to be of greater efficiency than those of cattle and donkeys (Mohammed and Mansoor, 2013). Movement of camels across borders contributes significantly to the introduction of parasites that might be of veterinary and public health significance (Yahaya, 2008).

## **1.2 Justification of the Study**

Animals such as sheep, which are known to serve as reservoir hosts for some camel parasites like *Haemonchus longistipes*, are often herded with camels leading to inter-species transmission (Yahaya, 2008). Camels are known to transmit zoonotic parasitic infections to humans (Parsani and Momin, 2008). Camel meat consumption is currently on the increase in many parts of the world and Sokoto, Nigeria (where an average of five camels are slaughtered daily) (Khalid *et al.*, 2015). Camel herders are dependent on meat, milk and hide production for source of income (Khalid *et al.*, 2015). Currently, there is an increase in the use of camels as draught animals due to their greater tractive efficiency when compared with work bulls and donkeys (Mohammed

and Mansoor, 2013). There is also an increase in demand for camel milk and urine as source of food and medication (Abdussamad *et al.*, 2015). In Nigeria, due to the importance attached to camel, a research programme has been established with a mandate to conduct research on all aspects of camel production, health inclusive at the National Animal Production Research Institute, Ahmadu Bello University, Shika, Zaria. These showed the importance of camel to human health and survival which made it necessary to investigate its parasitic infections to ensure production of wholesome meat, prevention of zoonoses, and generation of information for the researchers and improving the economy of camel keepers.

#### **1.4 Aim of the Study**

The aim of the study was to determine the prevalence of camel parasitic infections in selected Local Government Areas of Sokoto State, Nigeria.

#### **1.5 Objectives of the Study**

The objectives of the study were to:

- i. Determine the parasites that affect camels in selected Local Government Areas of Sokoto State, Nigeria.
- ii. Determine the prevalence of parasitic infections affecting camels in selected Local Government Areas of Sokoto State, Nigeria.
- iii. Determine possible vectors of identified parasitic infections in camels in selected Local Government Areas of Sokoto State, Nigeria.

## **1.6 Research Questions**

- (i) What are the parasites that affect camels in selected Local Government Areas of Sokoto State, Nigeria?
- (ii) What is the prevalence of parasitic infections affecting camels in selected Local Government Areas of Sokoto State, Nigeria?
- (iii) What are the possible vectors of identified parasitic infections in camels in selected Local Government Areas of Sokoto State, Nigeria?

## CHAPTER TWO

### 2.0 LITERATURE REVIEW

#### 2.1 The Camel

##### 2.1.1 Taxonomy and evolution

The camel belongs to the taxonomic order *Artiodactyla* (even-toed ungulates), suborder *Tylopoda* (pad-footed mammals) and family *Camelidae*. Camelids evolved in North America and migrated to northeast Asia about five million years ago over a land bridge, known as the Bering Strait (Faye *et al.*, 2011). The Old World camels (OWC) of today evolved from these early camels, spreading westwards across Asia. They were most widespread during the Pleistocene era, which began around two million years ago, when they reached as far as Eastern Europe, North and East Africa and East Asia (Faye *et al.*, 2011). During the great Ice Ages, they later died out in some of the areas of their range. When the OWC migrated eastwards after crossing the Bering Strait, the ancestors of the humpless New World camels (NWC) migrated south over the newly formed Panamanian land bridge and found their niche in the cool, dry mountain areas (altiplano) of South America (Faye *et al.*, 2011).

##### 2.1.2 Camel species and breeds

The *Camelidae* family is comparatively small, and contains only two genera; the *Camelus* (old world) camels and the *Illama* (new world camels). The genus *Camelus* consists of *Camelus dromedarius*, also called the dromedary, one-humped or Arabian camel and the *Camelus bactrianus*, also called the Bactrian or two humped camel

(Abdussamad *et al.*, 2015). Today, the common camel species are the one - humped camel (*Camelus dromedarius*) and the two - humped camel (*Camelus bactrianus*). The one-humped camel is mostly found in the tropical countries especially in Africa and Arabian countries and hence called Arabian camel, while the latter is commonly found in the temperate countries, especially the Asian continent. Generally, breeds of camels are not as differentiated and classified as breeds of other domestic animal species. In most camel rearing societies, breed classifications are based on names of the ethnic group, clan as well as on the geographical localities where these camels are raised, rather than upon phenotypic characteristics. However, attempts have been made to phenotypically characterize them into; sand-brown, grey-white, dark-brown, and pied ecotypes (Abdussamad *et al.*, 2015).

### **2.1.3 Economic and food potentials of camel**

#### *2.1.3.1 Camel milk*

The dromedary camel has fabulous potential for producing high quantity and quality milk, producing first milk at the age of 4 - 5 years. The high concentration of niacin and vitamin C, the high water content, especially during the hot summer months and the low fat content of camel milk are remarkable (Yagil, 2000). Lactating camels, therefore, will guarantee ample food with the desired content for their offspring and humans alike. Economically, camels can produce four times more milk in the desert environment than domestic cattle and hence contributing significantly to the economy of their keepers through income generation (Yagil, 2000).

#### 2.1.3.2 *Camel meat*

Camel meat production is on the decrease due to the length of the animal's reproductive cycle, but the quality of the meat from camels of less than four years old is similar to that of beef, with various dietic advantages of very little fat (Trabelsi *et al.*, 2012). Camel meat is also characterized by high quality protein content to the consumers (Trabelsi *et al.*, 2012). The camel meat represents 0.13% of the total meat consumed in the world and 0.45% of the herbivorous meat only. The camel meat production was increased by 2.90 between 1961 and 2011 corresponding to an annual growth of 3.5 % (Trabelsi *et al.*, 2012).

#### 2.1.3.3 *Camel hide*

Hair production of grown-up camel goes yearly between 1 to 3 kg and is utilized for making ropes, sacks, floor coverings and covers and is often sufficient for local demand and is sold to tourists as well as traded on the international market and hence a potential source of income (Faye *et al.*, 2011). The camel hides are very strong with a tensile strength five times greater than that of cattle. Camel leather is being crafted for fashion garments such as wallets, handbags, purses and shoes (Faye *et al.*, 2011).

#### 2.1.3.4 *Transport, draught and agriculture*

Despite the end of trans-saharan camel trains, dromedaries are still used to carry salt, fuel wood, rural agricultural produce and family unit products as well as pulling carts for the transportation of agricultural products and people (Faye *et al.*, 2012). A stuff camel carries stacks of up to 300 Kg to far off spots at a rate of 30 Km/day. The camel

is also a cheap source of power for drawing water from wells, ploughing farm land, grinding wheat, leveling of area and for oil extraction. It has been generally reported that all products of camel are useful (Faye *et al.*, 2012). Camel faeces are of great value as they are utilized as natural fertilizer and fuel. Camel racing is a major traditional heritage sport in the Arabian Gulf region where good race camels can fetch high prices (Ayoub *et al.*, 2015).

#### *2.1.3.5 Medicinal potentials of camel products*

Camel milk has been reported to be of greater health benefit than cattle milk. It has been reported to contain 25-30 times more elevated amounts of lactoferrin and lysozyme than cattle milk (Yagil, 2000). The iron holding protein lactoferrin has been demonstrated to have antiviral, antibacterial, antifungal, pain relieving and against cancer-causing impacts. Camel milk is hypoallergenic (it does not contain beta-lactoglobulin, which causes allergies). It also has a hypoglycemic effect for use by diabetic patients (Faye *et al.*, 2012). Milk allergy and lactose intolerance, which are very common in the western world, are unknown diseases where camel milk is commonly consumed (or part of the daily food) (Yagil, 2000). Camel milk is used as an aphrodisiac, particularly during dry hot periods (Faye *et al.*, 2012). Camel urine has also been reported to be locally medicinal against gastric ulcer and diabetes (Yagil, 2000). Camel hide and bones have also been reported to be medicinal against hypertension and epilepsy respectively and due to the properties of the camel products, their prices in the market are generally high (Yosef *et al.*, 2013).

#### **2.1.4 The camel in Africa**

In Africa, the one-humped camel (*Camelus dromedarius*) is a highly appreciated and valued animal and represents an important genetic resource. It occupies regions, notably the Sahara Desert inhabiting the dry, hot regions of North Africa and Ethiopia, (Wardeh, 2004). All African camels are dromedaries, of which 84% occur in Somalia, Ethiopia, Sudan, Djibouti, Niger and Kenya (Kneeland, 2011) which constitutes 60.1% of the world's camel population (Khalid *et al.*, 2015).

#### **2.1.5 The camel in Nigeria**

In Nigeria, the estimated camel population is about 180,000, mostly found in the Sudan and Sahel Savanna areas of Kebbi, Sokoto, Zamfara, Katsina, Kano, Jigawa, Yobe, and Borno (Abdussamad *et al.*, 2015). They have been traditionally used for haulage and currently there is an increase in camel use for farm work with greater tractive efficiency than work bulls and donkeys. Camel is used as a good source of milk, meat and hides. Camel is also used as a source of power for drawing water from wells, oil extraction, grinding of wheat and corn, sugarcane crushing, and its dung is used for making fires (Abdussamad *et al.*, 2015).

#### **2.1.6 Camel phenotypes in Nigeria**

Base on coat colour, four major camel types were identified in Yobe State (North-eastern Nigeria) as: sand-brown, grey-white, dark-brown, and pied ecotypes (Abdussamad *et al.*, 2015). In addition, white, brown-black and black phenotypes in the Nigeria-Niger corridor were reported (Abdussamad *et al.*, 2015).The dark-brown (*Ja*)

is the favorite for camel pastoralists in the Nigeria-Niger corridor. Indeed, dark-brown camels, as well as the pied-coloured (*Bule*) and grey-white dromedaries, are associated with high milk production during the rainy season. The brown-black (*Kurri*) breed is described as hardy to the dry season, while grey-white camels are considered as strong and beautiful but poor performing during the dry season. Overall, most breeders prefer to keep an assortment of phenotypes in their herds as a possible survival strategy that supports pastoral life in a fragile ecosystem (Abdussamad *et al.*, 2015).

## **2.2 Parasitic Infections of Camels**

The sustainability of camel benefits to human survival is dependent on the health constraints. Although camels are usually depicted as extremely disease resistant animals, they are nevertheless often subjected to severe stress conditions which make them susceptible to a range of parasitic infections with high risk of trans-boundary transmission (Faye *et al.*, 2012; Ashkan *et al.*, 2014). The infections are associated with great economic losses in camels due to morbidity and mortality (Bekele, 2010). These infections in severe cases are associated with great economic loss to farmers (meat, milk, hide and draught power) as well as sources of zoonosis worldwide (Swai *et al.*, 2011). These economic losses are due to mortality, decrease in reproductive and growth rates, weight loss and increased cost of production due to cost of veterinary drugs and feeds (Khan *et al.*, 2010). The predisposing factors and patterns of infection include poor husbandry and management practices, abundance of vectors, trans- boundary movements as well as climatic changes (Khan *et al.*, 2010).

The causative agents of the parasitic infections of camels may be grouped under the following categories:

### **2.2.1 Protozoan parasites**

The protozoans are unicellular organisms in which the various activities of metabolism and locomotion are carried out by organelles of the cell (Saleem *et al.*, 2011). There are many protozoan parasites that are known to occur in camels but most of them have little or no economic impact on the productivity of camels with the exception of *Trypanosoma species* (Bekele, 2010). This probably explains the scanty work that has been done on the occurrence of most of these protozoan parasites in camels. Other protozoan infections reported in camels include coccidiosis, anaplasmosis, babesiosis, and theileriosis (Yahaya, 2008).

#### *2.2.1.1 Trypanosomosis*

*Trypanosoma evansi* is the causative agent for Trypanosomosis (surra) and is reported as the most important and serious pathogenic protozoal infection of camels throughout tropical and sub-tropical regions of the world (Yahaya, 2008). Although other species of trypanosoma such as *T. vivax*, *T. simiae* and *T. congolense* have been reported to infect camels, they are not as common and as important as *T. evansi* (Swai *et al.*, 2011).

#### 2.2.1.2 Coccidiosis

*Eimeria cameli*, *E. dromedarii*, and *E. pellerdyi* have been reported to cause coccidiosis in dromedary camel but with little or no clinical significance (Wilson, 1998).

#### 2.2.1.3 Anaplasmosis

*Anaplasma marginale* has been reported to cause anaplasmosis in dromedary camel but there is dearth of information regarding its health implications to camel. However, it is an infectious, non-contagious and tick-borne disease of domesticated and wild ruminants that also affects the dromedary (Rabana *et al.*, 2011). The infection is caused by other species of the genus *Anaplasma* (Rickettsiales: *Anaplasmataceae*) (Sudan *et al.*, 2015). However, *Anaplasma marginale* is the most virulent (Ghafar and Mohammed, 2014).

#### 2.2.1.4 Babesiosis and Theileriosis

*Babesia caballi* and *Theileria equi* have been reported to cause camel piroplasmiasis, which is a tick-borne haemoprotozoan infection caused by these intra-erythrocytic protozoan parasites and the same aetiology of such diseases in horses, donkeys, mules, zebras and dogs (Qablan *et al.*, 2013).

#### 2.2.1.5 Epidemiology of protozoal infections of camel

There may be variation in rates of infection with protozoan parasites between regions due to abundance of vectors, climatic variation, the diverse farming systems and lack of proper health care (Parsani *et al.*, 2008). The infection is mostly common in younger

camels (Yahaya, 2008). An overall prevalence rate of 3.50%, 3.95% and 9.22% for *Trypanosoma evansi* were respectively reported from Zamfara, Katsina and Kano states (Yahaya, 2008). Prevalence rates of 21.5% and 31.5% were reported from Borno and Kebbi States (Argungu *et al.*, 2014). Prevalences of 33.0% and 10.0% were reported from Jordan and Iran (Zarif-fard and Hashemi- Fasherki, 2001). Prevalence rate of 20.24% was reported from Egypt (El-naga *et al.*, 2016).

*Anaplasma marginale* were reported as blood parasites that affect camels in Nigeria where prevalence rate of 95.5% was reported from Maiduguri (Rabana *et al.*, 2011). An overall prevalence of 47.4% belonging to *A. marginale* and *A. centrale* were reported from Saudi Arabia (Ghafar and Mohammed, 2014).

*Babesia caballi* was identified as a common hemoparasite seen in camels where a 1.8% prevalence rate was reported from Sokoto Nigeria (Chafe *et al.*, 2008), 11.8% and 18.43% were reported from Egypt (El- Naga *et al.*, 2016). A study from Saudi Arabia recorded an infection rate of 13.2% in camels (Beck *et al.*, 2009).

#### 2.2.1.6 Vectors and mode of transmission

The transmission of protozoan infections in camel occurs by different ways depending on the type of infection. In the case of camel trypanosomosis, transmission takes place mechanically worldwide by biting flies such as *Stomoxys calcitrans*, *Tabanus taeniola*, *Haematopota coronate*, and *Hippobosca species* (Ayoub *et al.*, 2015).

In coccidiosis, transmission occurs by ingestion of fresh grasses already contaminated with coccidia oocysts especially when such grasses are fertilized with contaminated manure (Aktar *et al.*, 2011).

Anaplasmosis is transmitted by a number of ticks but *Hyalomma dromedarri* and *Boophilus species* are more commonly reported (Abdelrahim *et al.*, 2009). The transmission of anaplasmosis can also be due to biting flies such as *Stomoxys*, *Tabanus* or *Hippobosca species* as well as by hard ticks (Chaudry *et al.*, 2010). The practice of herding camels together with other livestock especially cattle increases the risk of occurrences of infections (Khamesipour *et al.*, 2015). *B. caballi* is transmitted by several tick species belonging to the genera *Hyalomma*, *Rhipicephalus* and *Dermacentor* (Ayoub *et al.*, 2015).

#### *2.2.1.7 Clinical signs of protozoal infections of camel*

Trypanosomosis due to *T. evansi* is characterized by signs including fever, progressive anaemia, petechiation of mucous membranes, lymphadenopathy and development of oedema in the pendulous parts of the body, abortion and poor general condition (Ayoub *et al.*, 2015).

Coccidial infections mostly present as sub clinical cases while the chronic form may be characterized by anaemia, poor growth and low productivity (Wilson, 1998). Coccidiosis in young camels is characterized by diarrhea, dysentery, dehydration, rough hair coat and anaemia.

The clinical signs for anaplasmosis include anemia, digestive disturbances, emaciation, dullness and rough hair coat (Alkhatib *et al.*, 2012).

Babesiosis manifests signs including fever, anaemia, haemoglobinuria, icterus, weakness, depression, and gastrointestinal stasis (Swelum *et al.*, 2014).

#### *2.2.1.8 Diagnosis of protozoal infections of camel*

The common methods used in the field and laboratory for the diagnosis of camel trypanosomosis are thin and thick blood smears while thin blood smear is used for anaplasmosis and babesiosis. However, other methods such as wet blood film, is used for diagnosing trypanosomiasis (Charles, 2002). Others are serological tests which include; complement fixation test (CFT), card agglutination test for trypanosomiasis (CATT), antibody detection ELISAs (Ab-ELISAs), antigen detection ELISAs (Ag-ELISAs) and use of Polymerase chain reaction (PCR) (Luqueti, 2004). Serological techniques are not specific for any *Babesia* spp. due to cross-reactivity and therefore, cannot be relied on (D'Oliveira *et al.*, 1997). Scrapings of the small and large intestinal mucosae may be examined for the developmental stages of coccidia parasites at postmortem (Soulsby, 1986).

#### *2.2.1.9 Prevention and control of protozoal infections of camel*

The prevention of protozoan infections of camel depend on effective control of vectors; biting flies in the case of trypanosomosis; ticks in the case of anaplasmosis and babesiosis and proper herd hygiene in the case of coccidiosis. However, prompt

isolation and treatment of infected camels is also very important in any case (Akhtar *et al.*, 2011).

### **2.2.2 Helminth parasites**

The helminthes organisms are gastrointestinal (GI) and tissue parasites which affect camel and other ruminants (Getaw *et al.*, 2010). Though due to its typical browsing habit, camel is less prone to helminthic infections, yet several helminthes parasites have been reported to affect camel (Rewatkar *et al.*, 2009). Some of these helminthes are camelids specific, but some are also common to other hosts, especially domestic ruminants and wild animals (Mohammad and Mansoor, 2013). Among domestic animals, camel is known to tolerate a lot of helminthes infections (Al Haj and Al Kanhai, 2010). Concurrent infections with two, three or four parasites have been reported (Swai *et al.*, 2011). The helminthes parasites can be categorized into cestodes, nematodes and trematodes (Bulto *et al.*, 2013).

#### *2.2.2.1 Cestodes*

These are parasitic flatworms of the class cestoda which comprises tapeworms that are dorso-ventrally flattened and segmented. They are devoid of cilia and digestive tract and typically consist of differentiated scolex and a set of proglottids each including a set of reproductive organs (Bulto *et al.*, 2013). They belong to the family *Anoplocephalidae*, that have been identified in the small intestine of camels and other ruminants and which are transmitted by the ingestion of mites carrying *cysticerci* (Mehlhorn, 2008; Mahanty *et al.*, 2011). The major cestodes that have been reported

from camel are *Moniezia expansa*, *M. benendeni*, *Stilesia vittata*, *Stilesia globipunctata*, *Stilesia centripunctata*, *Stilesia hepatica* and *Avitellina spp.* (Parsani and Momin, 2008).

#### 2.2.2.2 Nematodes

These are un-segmented round worms of the class nematoda having an elongated and cylindrical body with an outer cuticle. They may be free- living or disease causing in nature (Rewatkar *et al.*, 2009). Gastrointestinal nematodiasis generally occurs in subclinical form in camels. The common gastro-intestinal nematodes of camel are; *Haemonchus longistipes*, *Trichostrongylus probolurus*, *Camelostrongylus species*, *Stroglyoides*, *Ostertagia circumcincta*, *Marshallagia marshalli*, *Cooperia pectinata*, *Trichuris globulosa*, and *Nematodirus species* (Parsani and Momin, 2008). *Haemonchus* species are the main causative agents of gastrointestinal disorder in camels.

#### 2.2.2.3 Trematodes

These are parasitic platyhelminthes (tape worms) of the class *trematoda* especially flukes having external hooks or suckers. They have outer cuticle which together with suckers are used for attachment to host tissues leading to severe damage. The trematodes may be internal (as in *fasciola*) or external (as in schistosomes) (Weilsenberg and Parlada, 2013). The trematodes of major importance in camels are; *Fasciola gigantica*, *F. hepatica* and *Schistosoma spp.* (Wakelin, 1984). *Fasciola*

*hepatica* is one of the trematodes that is most frequently encountered in camels in Africa (Weilsenberg and Parlada, 2013).

#### 2.2.2.4 Epidemiology of helminthic infections of camels

Gastrointestinal parasites have been reported to affect camel health and production in many camel rearing regions of the world. This is despite the unfavorable climatic conditions for the propagation of parasitic helminthes as a consequence of the long dry season in most camel breeding areas (Elnaga *et al.*, 2016). The prevalence of GIT parasite eggs/oocysts infection can be influenced by a number of factors including the host age whereby eggs/oocysts were more frequently reported in age categories >3-10 years than <3 years and >10 years camels (Bathia *et al.*, 2010). The occurrence of helminthosis in camels at the age range of less than 3 years may suggest a possibility of early introduction of young camels to grazing fields and subsequent increase in larval uptake (Mahmuda *et al.*, 2014).

Female camels have been reported to significantly harbor more GIT parasites eggs than camel bulls while treated camels were reported to remain carriers (Swai *et al.*, 2011). The level of endoparasitism may be related to the number of adult parasites established in the GIT, level of host immunity, stage of parasite infection and lack of improvement in animal health management programmes by camel owners (Swai *et al.*, 2011). Therefore, these gastrointestinal parasites may assume much more significant role in camel husbandry because helminthes not only reduce the productivity and performance of camels but also predispose them to other infectious diseases (Saleem *et al.*, 2011).

In Nigeria, Prevalence rates of gastrointestinal parasites reported from Katsina, Zamfara and Kano States were 45.34%, 36.70% and 59.14% respectively (Yahaya, 2008). While 41% was reported in Maiduguri (Jalaludeen *et al.*, 2011). Another study reported helminthosis to be one of the most prevalent health problems of camels in Zaria with a prevalence rate of 31.8% during the rainy season (Mohammed *et al.*, 2007).

#### *2.2.2.5 Life-cycle and mode of transmission*

Gastrointestinal parasites infection results from the ingestion of infective larvae which develop in the camel environment. Most of the economically important gastrointestinal parasites of camel have a direct life cycle as follows: adult parasites living within the camel lay eggs which are excreted in the faeces; larvae develop within the eggs and are hatched when environmental conditions are favorable, after which they grow and moult until they reach infective third stage (L<sub>3</sub>) larvae. The most suitable climatic conditions for the transformation of eggs into larvae in the majority of helminth parasites are provided by warm, wet weather under which larvae can remain alive for 6- 8 weeks (Swai *et al.*, 2011).

#### *2.2.2.6 Clinical signs of helminthosis*

Camels generally undergo multiple parasitisms with infestation by many species of gastro-intestinal helminthes. With the exception of acute haemonchosis, it is practically impossible to distinguish the signs produced by different helminths. Hence the clinical

picture of these helminthoses is a combination of symptoms induced by various species (Bulto *et al.*, 2013).

In the case of haemonchosis, the clinical picture is more of general illness that is manifested by anaemia, with ingestion of considerable amounts of sand, general weakness and decreased milk production in lactating camels and oedema of the hollow above the eye and sides of the sternal cushion (resulting in a characteristic and well-recognised swelling), and sometimes between the jaws. Others include progressive wasting, abortion (rare) and death, which may occur after several weeks of illness (Salimabadi *et al.*, 2010).

The general clinical and pathological features of helminthosis other than haemonchosis have been described collectively (Fowler, 2010).

#### *2.2.2.7 Light Infestation*

This is manifested almost exclusively by signs of diminished productivity such as decreased growth rate, wasting and decrease in milk production in lactating camels (Mahanty *et al.*, 2011).

#### *2.2.2.8 Massive Infestation*

This is accompanied by variable clinical signs that include apathy, capricious and diminished appetite, progressive wasting, characterized by atrophy of the hump(s) and diminution of abdominal volume (the flank fold fails to fill after the animal has drunk)

(Lahma *et al.*, 2004). Others are anorexia, alternation of constipation and diarrhoea, or the passing of soft faeces and more or less prominent anaemia, loss of body weight, loss of body condition, rough hair coat and oedematous swellings of lower body parts and pica (Kebede *et al.*, 2009). Others include difficulty to eat easily, which accentuates the wasting, difficulty to move and death may occur after a few weeks or a few months in the absence of treatment (Ibrahim *et al.*, 1998). In the case of fasciolosis, hepatic infestations are subclinical in camels, with the exception of heavy infestations which are manifested solely by vague digestive symptoms (Ekizaed and Yalcintan, 2013).

#### *2.2.2.9 Diagnosis of helminthosis*

Diagnosis by examining faeces (sedimentation and flotation techniques) provides useful information (Bulto *et al.*, 2013). An egg count above 600 eggs per gram (epg) of faeces indicates a number of helminths sufficient to cause physiological disorders (Alkhatib *et al.*, 2012). Camels are considered severely affected if the egg count is greater than 1,000. However, many factors are responsible for producing variation in the worm egg count, regardless of the number of helminths present, including the phenomenon of hypobiosis and also nutritional and immunological factors (Biu and Konto, 2012).

#### *2.2.2.10 General treatment of helminthoses*

Most of the broad spectrum anthelmintics such as fenbendazole, levamisole, tetramisole hydrochloride, morantel tartarate and ivermectin that are used in cattle and sheep for the treatment of digestive tract helminthoses can also be used in camels (Parsani and Momin, 2008.). This is because; most of these drugs are capable of eliminating the

various species of helminths present in the digestive tract (with a few exceptions) (Keiser and Utzinger, 2007).

In the case of fascioliasis, treatment can be applied only in those rare instances when fascioliasis is diagnosed. Several fasciolicidal drugs are currently available and may be used, although few publications refer to their use in camels. Nitroxylinil at 10 mg/kg injected subcutaneously, and rafoxanide at 7.5 mg/kg by mouth have been found to be effective (Swelun *et al.*, 2014). Albendazole, already mentioned for treating gastrointestinal helminthoses, is also effective against *Fasciola spp.* at a dose rate of 10 mg/kg (Mahanty *et al.*, 2011).

#### *2.2.2.11 General prevention of helminthosis*

This can be effectively achieved by ensuring of routine deworming, rotational grazing and regular evacuating and cleaning of faeces from herds as well as maintaining the herd dry. Since the use of herbivore manure as fertilizer is a common practice preceeding infection, thorough cleaning and cooking of vegetables is required for prevention of infection to humans (Gracia, 2007).

### **2.2.3 Ectoparasites**

Camels are exposed to and are affected by different types of external parasites. Ectoparasites (arthrophods) are metamerically segmented animals possessing chitinus exoskeleton. Many species belonging to the class *Insecta* and *Arachnida* are important parasites/ vectors of medical and veterinary importance (Roger *et al.*, 2001). The camel

ectoparasites and their capacity to cause/transmit infections are important constraints to productivity and performance of camels worldwide (Megarsa *et al.*, 2012). Ticks and flies are reported to serve as vectors of other important protozoan diseases of camel such as babesiosis, anaplasmosis and trypanosomosis (Salimabadi *et al.*, 2010). Other effects of ticks include tick paralysis, metabolic debilitation, tick toxicosis and secondary infections (Salimabadi *et al.*, 2010). The negative effects of these ectoparasites in camels are slow reproduction cycle, high calf mortality and general health problems and occasional mortalities in untreated and young animals (Ayoub *et al.*, 2015). Ectoparasites are associated with great economic losses to camel production due to cost of medications and loss of vitality of skin which later became encrusted and decreased hide quality (Fowler, 2010).

The ectoparasites of camels include:

#### 2.2.3.1 Mites

The common and important flea of camel is *Sarcoptes scabiei var. cameli* and has been reported to cause sarcoptic mange which is a serious problem in camels and is ranked as the second most important parasitic disease of camels after trypanosomiasis (Fowler, 2010).

#### 2.2.3.2 Ticks

The most commonly reported ticks on camels are *Hyalomma dromedarii*, (two- host tick) *H. anatolicum*, *H. marginatum isaaci*, *Rhipicephalus spp* (two host tick),

*Ornithodoros spp* and *Amblyomma variegatum* (three- host tick) which have been associated with disease transmission (Parsani and Momin, 2008).

#### 2.2.3.3 Biting Flies

There are various types of flies that have been reported to be widespread and associated with physical irritation and transmission of certain diseases in camels (Bekele, 2010). These flies include the genera of *Stomoxys*, *Tabanus*, *Hematopinus*, *Hippobosca*, *Musca* and *Cephalopina* (Bebe, 2001). Larvae of *Cephalopina titillator* known as the camel nasal fly can cause brain compression and nervous disorders, which can prove fatal (Bekele, 2010).

#### 2.2.3.4 Epidemiology of ectoparasitic infestation of camels

The permanent presence of camels in the deserts with constant feed scarcity in camel rearing regions, in addition to lack of adequate health care (which favor close contact of these animals at available communal watering and grazing sites “Contact points” ) may result in favoring the establishment and spread of camel ectoparasitic infestations (Taddese *et al.*, 2013).

Sarcoptic mange is the commonest and most widespread ectoparasitosis of camels (Megersa *et al.*, 2012) that causes a serious problem in camels and ranks second to trypanosomosis in terms of importance whose incidence and pattern depends upon seasonal conditions and vary from region to region (Parsani and Momin, 2008). The maximum incidence is observed during the dry season particularly from December

(dry-cold) to April (dry-hot) months, while the predisposing factors include poor management practices, age, nutritional status, overcrowding and debilitating condition due to other diseases like trypanosomosis and worm burden (Parsani and Momin, 2008).

In Nigeria, prevalence rate of camel mange was reported from Sokoto and Zaria as 3.54% and 4.7% respectively (Lawal *et al.*, 2007). A prevalence rate of 10.68% was reported from Ethiopia (Dinka *et al.*, 2010). Another prevalence of 31.60% was also reported from Sudan (Agab and Abbas, 1992).

The most common tick species of camel are *Hyalomma dromedarii*, *Rhipicephalus sanguineus*, *R. pulchellu*, *Amblyomma gemma* and *Amblyomma variegatum* (Ashkan *et al.*, 2014). Tick infestation is higher during rainy season when the immature stages (larvae and nymph) of ticks are mainly found in the pasture while the adults stage are found on the camel's body (Abdelrahman *et al.*, 2001). However, the smallest number of ticks per camel has been reported to be during the driest month (Zelege and Bekele, 2004). There may be a high difference in prevalences between different regions which could be attributed to the variation in the management practice provided to these animals by their owners particularly with regards to ectoparasite control (regular use of acaricides) and also due to lack of veterinary services by owners in some areas (Bulto *et al.*, 2013). Tick paralysis is due to the heavy tick infestation in camels that have been reported to cause 59% morbidity and 34.3% mortality in Sudan where it is locally called "Abu Eggal" (Musa *et al.*, 1989). In Africa, an overall prevalence of 61.46% of

tick infestation was reported on camel from Ethiopia, as *Hyalomma dromedarii* (15.36%), *Rhipicephalus pulchellus* (27.86%) (Dinka *et al.*, 2010).

In Nigeria, *Hyalomma*, *Boophilus*, *Amblyomma* and *Rhipicephalus* had been reported as the tick species that infest camels with *Hyalomma* predominating as reported from Sokoto where prevalence rate of 91.28% was recorded (Lawal *et al.*, 2007). The same species were also found to be common to camels in Maiduguri (Biu and Konto, 2012).

There are various types of flies that have been reported to be widespread and associated with physical irritation and transmission of certain infections in camels (Bekele, 2010). These disease may be zoonotic and of economic constraints to productivity and performance of camels (Lawal *et al.*, 2007). These flies include species of *Stomoxys*, *Tabanus*, *Hematopinus*, *Hippobosca* and *Musca* as well as *Cephalopina titillator* (Bebe, 2001).

The genus *Stomoxys* (Stable flies, or “dog flies”), are considered to be a serious economic pest of livestock, being ectoparasites that suck blood from their hosts and occasionally transmitting various pathogenic organisms (Taylor *et al.*, 2010). *Stomoxys calcitrans* (Diptera: *Muscidae*), is the most widely distributed and associated with transmission of *Trypanosome evansi* in camels (Kneeland, 2011).

The larval stage of *Cephalopina titillator* (the camel nasal fly) is an obligate parasite and the cause of nasal myiasis in camels. It can also cause brain compression and

nervous disorders, which can prove fatal. It has been reported that both sexes and different ages of camels are susceptible to infestation with the fly (Ayoub *et al.*, 2015).

#### *2.2.3.5 Mode of ectoparasitic infections of camels*

The transmission of camel mange occurs either directly or indirectly. The direct transmission takes place by body contact when larvae, nymphs or adults are transferred from an infested camel to a healthy one which may spread within an entire herd (Dinka *et al.*, 2010). Contact during suckling is another important way of transmission of mange to calves (Bebe, 2001). The indirect transmission on the other hand occurs when healthy camel comes in contact with contaminated objects such as harnesses, tents, tree trunks, blankets, baggage and soil (Megersa *et al.*, 2012).

#### *2.2.3.6 Clinical signs of camel ectoparasitic infestations*

For the mange, the signs start with appearance of skin lesions at areas of thin skin: on the face, base of the neck, abdominal region including prepuce, flank and mammary gland (Nesibu *et al.*, 2014). This is followed by erythema, pruritus, Alopecia and anxiety (Dinka *et al.*, 2010). The skin will later become dry and hard, with scab formation, keratinization, and proliferation of connective tissues as well as thickening and corrugation (wrinkling or fissuring) of skin (Getau *et al.*, 2010).

Tick infestation in camels is characterized by the presence of either adult or nymph stages of ticks on the same predilection sites with mange (Elghali and Hassan, 2009). These ticks result in swellings and small wounds in the skin from the bites, the tick

feeds on blood and infections result in loss of blood, weight loss and weakening of the animal (Elghali and Hassan, 2009).

Nasal miasis is characterized by nasal discharge, restlessness, frequent sneezing and snoring on inspiration. The nasal cavity become congested and has dark mucus in which some larvae are entangled (Ashkan *et al.*, 2014).

#### *2.2.3.7 Diagnosis of camel ectoparasitic diseases*

These include collection and examination of skin scraping for mange, appearance of ticks on camel's body as well as capturing flies using biconical traps (Biu and Konto, 2012).

#### *2.2.3.8 Treatment and control of camel ectoparasitic diseases*

The treatment of mange could be achieved using ivermectin therapy at a dose rate of 200 µg/kg body weight subcutaneously at the base of the neck at fortnightly intervals (Veer *et al.*, 2001). However, the use of diazinon, amitraz, deltamethrin, and fenvalerat sprays were reported to be 100% effective after three applications (Parsani Momin, 2008).

For the control, prompt isolation and treatment of infected camels are important. Routine tick control measures need to be employed and pour-on method for acaricide application is suggested because this method is fast, easy and suitable for use by camel owners in deserts (Mullen and Durden, 2009). Control measures against *S. calcitrans*

could be achieved through routine sanitary measures within camel herds by ensuring regular cleaning and burning of dungs after drying (Tamarit *et al.*, 2010).

## **CHAPTER THREE**

### **3.0 MATERIALS AND METHODS**

#### **3.1 Description of the Study Area**

Sokoto State is located at the extreme north-western, semi-arid part of Nigeria between latitudes 12<sup>0</sup>N and 13<sup>0</sup>N and longitudes 4<sup>0</sup>E and 4<sup>0</sup>E. It covers a total land area of 28,232 km<sup>2</sup>. The State has two seasons; rainy season from June to October with annual rainfall of 700 to 800 mm having its high peak in August and September and the dry season from October to May with humidity of less than 20% (Mu'azu, 2009). The state has a population of 3.6 million people and is bounded by Zamfara State to the east, Kebbi State to the South-west and two international borders with Niger Republic and Benin Republic to the north and south-west respectively (Figure 1).

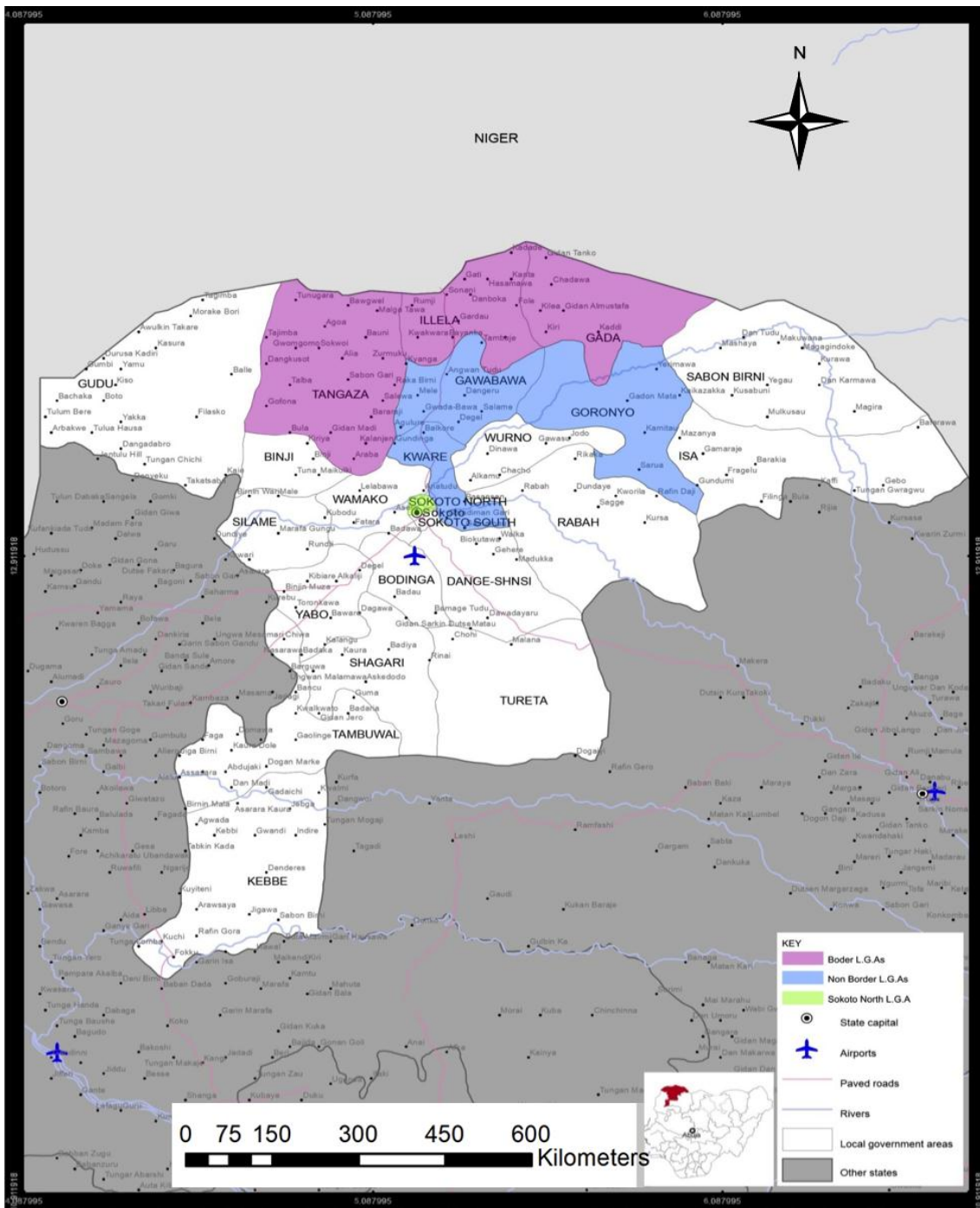
The livestock population in Sokoto State is; 66,058 camels, 2,577,512 cattle, 58,642 horses, 103,390 donkeys, 15,199, 11 goats, 14,485, 27 sheep and 39,621,92 poultry (MAFD Sokoto, 2009) (Figure 2).

Sokoto State was used in this study due to safety, high camel population and shearing border with Niger Republic through which mutual trans-border migration of camels occurs.

#### **3.2 Study locations**

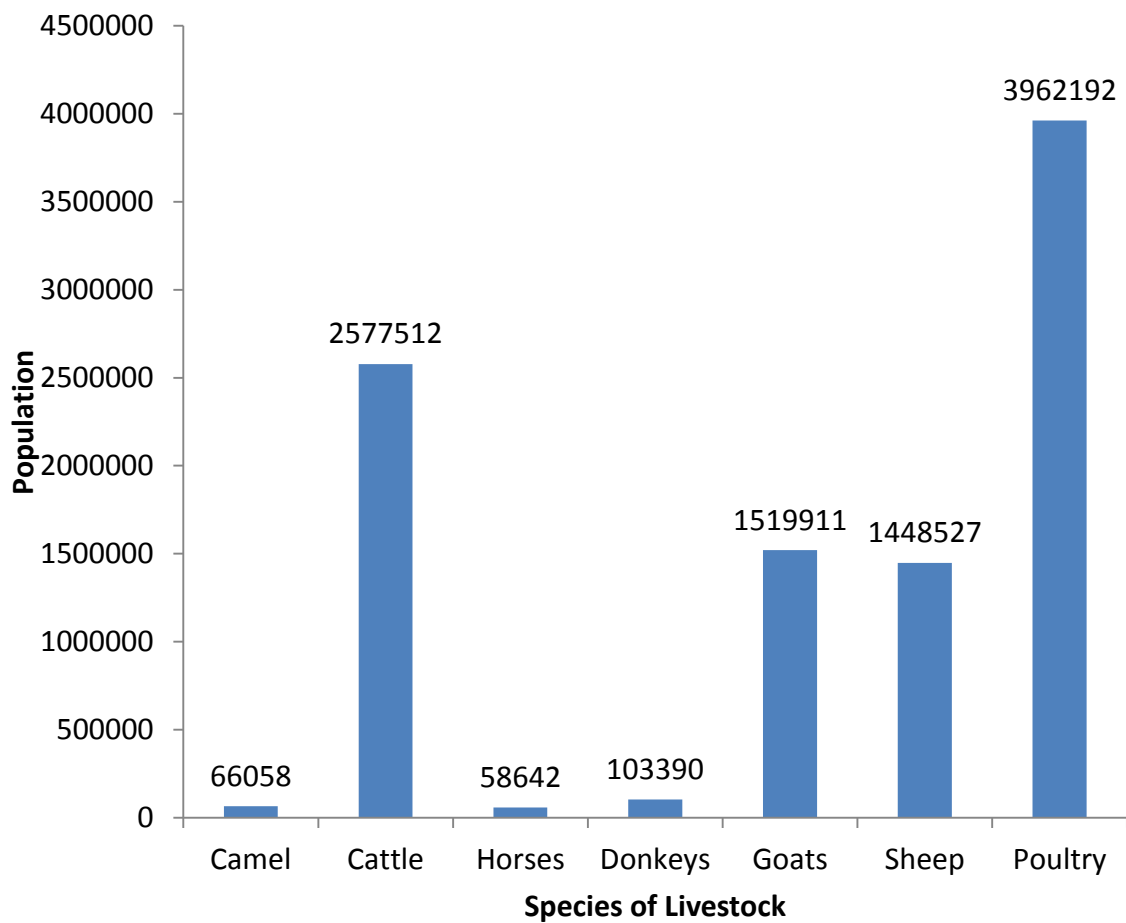
Six Local Government Areas with high camel population were selected for sampling out of the twenty three Local Government Areas in the State. Three of the selected Local Government Areas (Illela, Gada and Tangaza) share borders with Niger

Republic. The other three were non- border LGAs; Gwadabawa, Kware and Goronyo. Samples were taken at the Sokoto metropolitan abattoir which is located in Sokoto North Local Government Area. The sampled LGAs were further categorized into fields and abattoir.



**Figure 1: Map of Sokoto State showing the sampled Local Government Areas**

**Source: Sokoto State Reference Map (2016).<https://www.humanitarianresponse.info/en/op>**



**Figure 2: Livestock population in Sokoto State, Nigeria**

**Source: Ministry of Animal Health and Fisheries Development Sokoto State – Nigeria, 2009**

### **3.3 Sampling**

#### **3.3.1 Study animals**

Camels of all sexes and age groups belonging to camel herders and those brought to the abattoir for slaughter were sampled in this study using purposive sampling technique (Ayoub *et al.*, 2015). The age groups were categorized into three: young were less than five years, growers were five years and adults were greater than five years. The reason for classification was to be able to have age categories as variables while ageing was based on information of the camels obtained from the camel herders.

#### **3.3.2 Sample size**

This was based on availability and owners consent. This is due to the fact that purposive sampling technique is a non- probability sampling technique (the subjects of the population have not equal chances of being selected) in which sample subjects are usually scarce (as in the case of camels) and hence selection is purposely based on availability and owners consent rather than calculating sample size.

A total of 208 camels were sampled, out of this, 32(15.3%) were from Gada and Tangaza respectively, 30(14.5%) from Illela, 20(9.7%) from Gwadabawa, 19(9.1%) from Goronyo, 16(7.7%) from Kware and 59(28.4%) from Sokoto metropolitan abattoir. 116(55.7%) camels were males while 92(44.3%) were females. A total of 90(43.2%) were young, 25(12.1%) growers while 93(44.7%) were adults.

### **3.3.3 Sampling period**

The sampling period was from October, 2016 to March, 2017.

## **3.4 Sample Collection and Processing**

Blood, faeces and ectoparasites were collected from camels at the various sampling locations, transported on ice pack and processed at the Parasitology Laboratory, Department of Veterinary Parasitology and Entomology, Faculty of Veterinary Medicine, Usmanu Danfodio University, Sokoto.

### **3.4.1 Camel restraint**

This was achieved by restraining each camel in crouching position and resting on sternal recumbency with the use of ropes.

### **3.4.2 Collection of blood samples**

Ten milliliters (10 ml) of blood were aseptically collected from the jugular vein using a 18 gauge needle on a 10 ml syringe. 5 ml each were placed into two separate bijoux bottles containing disodium salt of ethylene diamine tetra-acetic acid (EDTA) as anticoagulant for haematological and parasitological analyses respectively. The samples were transported to the laboratory on ice pack.

#### *3.4.2.1 Examination of blood samples*

The following investigations were carried out: red blood cell count which includes total red blood cell (RBC), determination of packed cell volume (PCV), hemoglobin (Hb) measurement and erythrocytic indices which include mean corpuscular volume (MCV), the mean corpuscular hemoglobin (MCH) and the mean corpuscular hemoglobin concentration (MCHC), as described by (Mosby and Margi, 1995). Also examined were white cell counts which include total WBC, neutrophils, eosinophils, lymphocytes, monocytes and basophils as described by Mosby and Margi (1995).

#### *3.4.2.2 Examination and identification of haemoparasites*

Thin and thick blood smears were made and stained using the method described by Charles (2002) for the examination of hemoparasites.

#### **3.4.3 Collection of faecal samples for gastrointestinal parasites**

About five grams (5 g) of faeces were collected in the morning by 7: 00 am achieved by inserting a hand into a new set of polythene bag and evacuating the rectum, withdrawing the hand, inverting and tying the bag. The collected faeces was immediately transferred into a labeled polythene bag, tightened and transported in ice pack to the laboratory.

#### *3.4.3.1 Examination of faecal samples*

Fecal floatation (for cestodes and nematodes) and sedimentation (for trematodes) techniques as described by Charles (2002) were used to examine for eggs and oocysts in all the fecal samples collected.

#### **3.4.4 Collection of ectoparasites and identification**

Camels were physically examined carefully and ticks seen were pulled out gently using forceps. All ticks collected were identified and preserved in 70% alcohol in the laboratory.

Biconical traps were set around selected camel herds (Plate I) for two weeks during each month of study. A collection of trapped flies was done on weekly basis, and the flies were preserved in 70% alcohol and transported to the laboratory for identification. Two collections were made from each herd and mean of the collections were calculated and recorded.

### **3.5 Data Analyses**

Data obtained were expressed as frequency and percentages and presented as tables and plates.

Number of flies collected were expressed as means.

Statistical package for Social Science (SPSS IBM, 2011) version 20.0 was used for the following:

*Prevalence:*

$$P = \frac{\text{Number of positive samples}}{\text{Total sample analyzed}} \times 100$$

**Chi square test:** This was carried out to test for association between variables (camel sex, age and month of study) and infections/infestations.

**T- test:** This was carried out to compare the haematological values between parasitized and non-parasitized camels with haemo and gastro-intestinal parasites.

Probability values of less than 0.05 ( $P < 0.05$ ) were considered statistically significant.



**Plate I: Example of biconical trap set around camel herds in Sokoto State, Nigeria.**

## CHAPTER FOUR

### 4.0 RESULTS

#### **4.1 Prevalence of Parasitic Infections in One-humped camel (*Camelus dromedarius*) from the Selected Local Government Areas in Sokoto State, Nigeria.**

The hemoparasites encountered were *Trypanosoma evansi* (Plate II) and *Anaplasma marginale* (Plate III) with a prevalence of 7.2% and 1.9% respectively while the month of November had the highest prevalence (15.6%) (Table 4.1).

The highest prevalence (21.1%) for haemoparasitic infection was recorded in Goronyo Local Government Area (Table 4.2).

There was no significant association ( $P > 0.05$ ) for haemoparasitic infection between study locations (Table 4.3).

There was no significant association ( $P > 0.05$ ) for haemoparasitic infection between camel sexes (Table 4.4).

There was no significant association ( $P > 0.05$ ) for haemoparasitic infection between camel age groups. However, the adult camels had the highest prevalence (14%) (Table 4.5).

There was significant association ( $P < 0.05$ ) for erythrocytic parameters (PCV and Hb) and indices (MCV, MCH and MCHC) except for RBC ( $P > 0.05$ ) between infected and non infected camels with *Trypanosoma evansi* (Table 4.6).

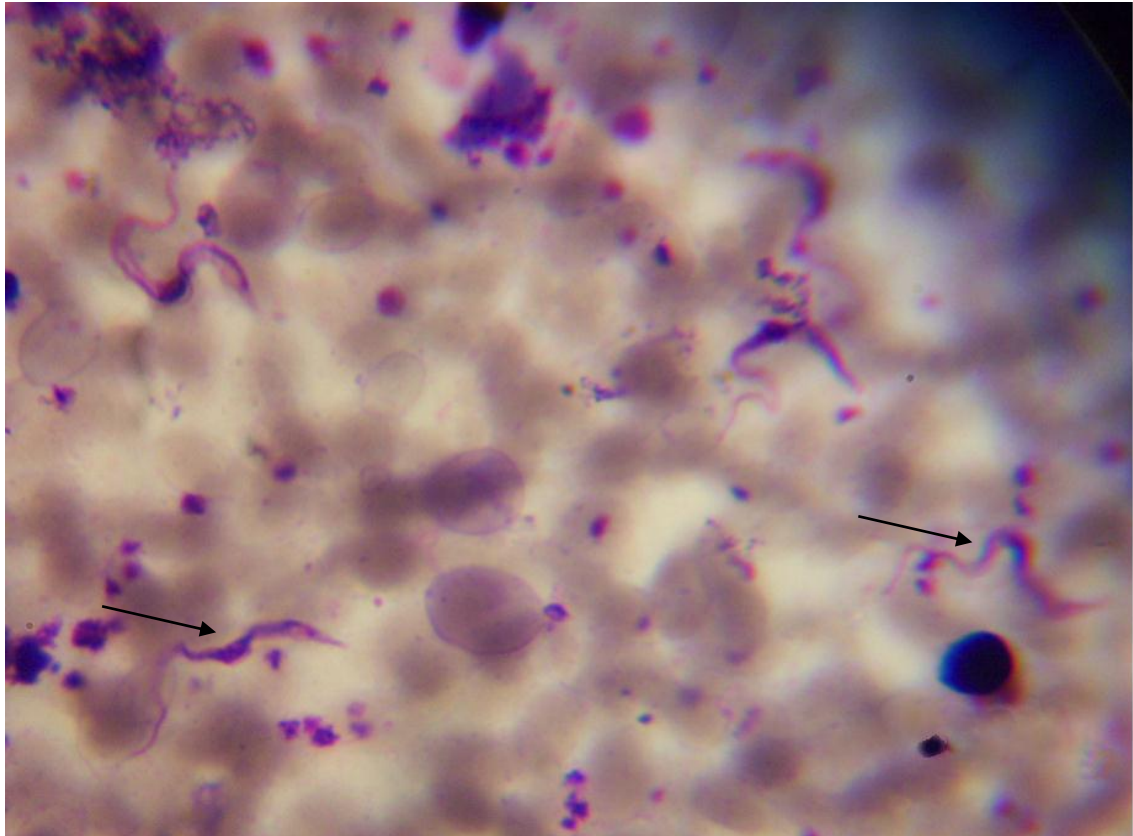
There was significant association ( $P < 0.05$ ) for total differential white blood cells (WBC, Neutrophils, lymphocytes, monocytes and eosinophils) except for basophils ( $P > 0.05$ ) between infected and non infected camels with *Trypanosoma evansi* (Table 4.7).

There was significant association ( $P < 0.05$ ) for erythrocytic parameters (PCV, Hb and RBC) and indices (MCV, MCH and MCHC) between infected and non infected camels with *Anaplasma marginale* (Table 4.8).

There was significant association ( $P < 0.05$ ) for total differential white blood cells (WBC, Neutrophils, lymphocytes, monocytes, eosinophils and basophils) between infected and non infected camels with *Anaplasma marginale* (Table 4.9).

Table 4.1: Overall prevalence of haemoparasites of camels in relation to study periods (2016- 2017) in Sokoto State, Nigeria

Month of year	Total No. of camels examined	No. of parasites observed (%)	Haemoparasites n(%)	
			<i>A. marginale</i>	<i>T. evansi</i>
October	25	2 (8.0)	0(0.0)	2(100)
November	45	7(15.6)	0(0.0)	7(100)
December	38	5(13.2)	3(60.0)	2(40)
January	32	2(6.3)	0(0.0)	2(100)
February	37	3(8.1)	1(33.3)	2(66.7)
March	31	0(0.0)	0(0.0)	0(0.0)
<b>Total</b>	<b>208</b>	<b>19(9.1)</b>	<b>4(1.9)</b>	<b>15(7.2)</b>



**Plate II: *Trypanosoma evansi* (arrowed) from blood sample of a young male camel in Sokoto State, Nigeria at  $\times 1000$  magnification**



**Plate III: *Anaplasma marginale* (arrowed) from blood sample of a young male camel in Sokoto State, Nigeria at  $\times 1000$  magnification**

Table 4.2: Overall prevalence of haemoparasites of camels in study areas in Sokoto State, Nigeria

Study area	Total No. of camels examined	No. of parasites observed (%)	Haemoparasites n(%)	
			<i>A. marginale</i>	<i>T. evansi</i>
Gada	32	1(3.1)	0(0.0)	1(100)
Illela	30	3(10.0)	0(0.0)	3(100)
Tangaza	32	4(12.5)	0(0.0)	4(100)
Goronyo	19	4(21.1)	0(0.0)	3(100)
Kware	16	2(12.5)	1(50)	1(100)
Gwadabawa	20	1(5.0)	1(100)	0(0.0)
Sokoto Abbtair	59	4(6.8)	2(40)	3(60.0)
<b>Total</b>	<b>208</b>	<b>19(9.1)</b>	<b>4(1.9)</b>	<b>15(7.2)</b>

Table 4.3: Overall prevalence of haemoparasites according to locations in Sokoto State, Nigeria

Type of study area	Total no. of camels examined	Positive n (%)	$\chi^2$	P-value
Field	120	11(9.2)	0	0.925
Sokoto Abattoir	88	8(9.1)		
<b>Total</b>	<b>208</b>	<b>19(9.1)</b>		

Not significant at  $P > 0.05$

Table 4.4: Overall prevalence of hemoparasites in relation to sex of camels in study areas in Sokoto State, Nigeria

<b>Variable</b>	<b>Total no. of camels examined</b>	<b>No. of parasites observed n(%)</b>	<b>X<sup>2</sup></b>	<b>P-value</b>
<b>Sex</b>				
Male	116	11(9.5)	0.038	0.845
Female	92	8(8.7)		
<b>Total</b>	<b>208</b>	<b>19 (9.1)</b>		

Not significant at P> 0.05

Table 4.5: Overall prevalence of hemoparasites in relation to age of camels in study areas in Sokoto State, Nigeria

<b>Variable</b>	<b>Total no. of camels examined</b>	<b>No. of parasites observed n(%)</b>	<b>X<sup>2</sup></b>	<b>P-value</b>
<b>Age</b>				
<5years	90	5(5.6)	4.812	0.09
5years	25	1(4.0)		
>5years	93	13(14)		
<b>Total</b>	<b>208</b>	<b>19 (9.1)</b>		

Not significant at P> 0.05

Table 4.6: Mean erythrocytic parameters and indices in *Trypanosoma evansi*-infected and non- infected camels study areas in Sokoto State, Nigeria

<b>Parameter</b>	<b>Infected Mean± SEM</b>	<b>Non infected Mean± SEM</b>	<b>P- value</b>	<b>Significance</b>
PCV(%)	21.333 ± 0.333	28.881 ± 0.295	0.0000	S
Hb(g/dl)	5.933 ± 0.228	11.706 ± 0.402	0.0000	S
RBC ( $\times 10^6 / \text{mm}^3$ )	6.066 ± 1.857	7.868 ± 0.333	0.3550	NS
MCV(fl)	13.066±1.452	41.782 ± 0.438	0.0000	S
MCH(pg)	13.866 ± 0.767	19.041 ± 0.161	0.0000	S
MCHC(g/dl)	21.666 ± 0.622	33.673 ± 0.555	0.0000	S

Significant at P< 0.05

Table 4.7: Mean total differential white blood cells in *Trypanosoma evansi*-infected and non - infected camels in study areas in Sokoto State, Nigeria

<b>Parameter</b>	<b>Infected Mean± SEM</b>	<b>Non infected Mean± SEM</b>	<b>P- value</b>	<b>Significance</b>
WBC ( $\times 10^6 / \text{mm}^3$ )	20.866 ± 2.159	13.803 ± 0.153	0.0060	S
Neutrophils ( $\times 10^9$ )	10.627 ± 1.062	4.411 ± 0.614	0.0000	S
Lymphocytes ( $\times 10^9$ )	11.559 ± 3.353	6.453 ± 0.452	0.0330	S
Monocytes ( $\times 10^9$ )	2.309 ± 0.686	0.769 ± 0.175	0.0000	S
Eosinophils ( $\times 10^9$ )	2.742 ± 0.824	0.898 ± 0.321	0.0000	S
Basophils ( $\times 10^9$ )	0.347 ± 0.303	0.152 ± 0.081	0.0920	NS

Significant at  $P < 0.05$

Table 4.8: Mean erythrocytic parameters and indices in *Anaplasma marginale*-infected and non- infected camels in study areas in Sokoto State, Nigeria

<b>Parameter</b>	<b>Infected Mean± SEM</b>	<b>Non infected Mean± SEM</b>	<b>P- value</b>	<b>Significance</b>
PCV(%)	22.500 ± 0.500	28.451 ± 0.307	0.0000	S
Hb(g/dl)	6.250 ± 0.250	11.389 ± 0.392	0.0000	S
RBC ( $\times 10^6 / \text{mm}^3$ )	4.250 ± 0.478	7.806 ± 0.341	0.0010	S
MCV(fl)	31.000±1.080	41.205 ± 0.459	0.0010	S
MCH(pg)	13.250 ± 0.478	8.774 ± 0.179	0.0000	S
MCHC(g/dl)	21.750 ± 0.478	33.024 ± 0.560	0.0000	S

Significant at P< 0.05

Table 4.9: Mean total differential white blood cells in *Anaplasma marginale*-infected and non - infected camels in study areas in Sokoto State, Nigeria

<b>Parameter</b>	<b>Infected Mean± SEM</b>	<b>Non infected Mean± SEM</b>	<b>P- value</b>	<b>Significance</b>
WBC( $\times 10^6 / \text{mm}^3$ )	18.500 ± 1.040	14.230 ± 0.244	0.0230	S
Neutrophils ( $\times 10^9$ )	9.435 ± 1.870	4.693 ± 0.658	0.0010	S
Lymphocytes ( $\times 10^9$ )	10.730 ± 0.912	6.799 ± 0.501	0.0000	S
Monocytes ( $\times 10^9$ )	2.457 ± 2.629	0.828 ± 0.179	0.0610	S
Eosinophils ( $\times 10^9$ )	2.497 ± 2.101	0.971 ± 0.324	0.0490	S
Basophils ( $\times 10^9$ )	0.786 ± 0.946	0.154 ± 0.724	0.0440	S

Significant at P < 0.05

The gastrointestinal parasites identified were *coccidia* (Plate III), *strongyles* (Plate IV), *trichuris* (Plate V) and *oxyuris* with prevalences of 4.8%, 12.0%, 5.8% and 6.7% respectively while the month of December had the highest prevalence (44.7%) (Table 4.10).

The highest prevalence (37.2%) for gastrointestinal parasitic infection was recorded in abattoir (Table 4.11).

There was significant association ( $P < 0.05$ ) for gastrointestinal parasitic infection between study locations. However, the abattoir had the highest prevalence (39.8%) (Table 4.12).

There was no significant association ( $P > 0.05$ ) for gastrointestinal parasitic infection between camel sexes (Table 4.13).

There was no significant association ( $P > 0.05$ ) for gastrointestinal parasitic infection between camel age groups. However, the adult camels had the highest prevalence (32.3%) (Table 4.14).

There was no significant association ( $P > 0.05$ ) for erythrocytic parameters (PCV and RBC) and indices (MCV, MCH and MCHC) except for Hb ( $P < 0.05$ ) between infected and non infected camels with gastrointestinal parasites (Table 4.15).

There was no significant association ( $P > 0.05$ ) for total differential white blood cells (WBC, Neutrophils, lymphocytes, monocytes and basophils) except for eosinophils ( $P < 0.05$ ) between infected and non infected camels with gastrointestinal parasites (Table 4.16).

Table 4.10: Overall prevalence of gastrointestinal parasites in relation to study periods (2016-2017 in Sokoto State, Nigeria)

Month	Total No. of camels Examined	No. of parasites observed (%)	Gastrointestinal parasites n(%)			
			<i>Coccidia</i>	<i>Stronglyle</i>	<i>Trichuris</i>	<i>Oxyuris</i>
October	25	9(36.0)	2(22.2)	4(44.4)	3(33.3)	0(0.0)
November	45	15(33.3)	4(26.7)	8(53.3)	3(20.0)	0(0.0)
December	38	17(44.7)	3(17.6)	6(17.64)	3(17.6)	5(29.4)
January	32	11(34.4)	0(0.0)	4(36.4)	1(9.1)	6(54.5)
February	37	5(13.5)	0(0.0)	1(20.0)	1(20.0)	3(60.0)
March	31	4(12.9)	1(25.0)	2(50.0)	1(25.0)	0(0.0.0)
<b>Total</b>	<b>208</b>	<b>61(29.3)</b>	<b>10(4.8)</b>	<b>25(12.0)</b>	<b>12(5.8)</b>	<b>14(6.7)</b>



**Plate IV: *Coccidia* oocysts (arrowed) from faecal sample of a young female camel in Sokoto State, Nigeria at  $\times 400$  magnification**



**Plate V: *Strongyle* egg (arrowed) from faecal sample of an adult female camel in Sokoto State, Nigeria at  $\times 400$  magnification**



**Plate VI: *Trichuris* Egg (arrowed) from faecal sample of an adult male camel in Sokoto State, Nigeria at  $\times 400$  magnification**

Table 4.11: Overall prevalence of gastrointestinal parasites in study areas in Sokoto State, Nigeria

Location	Total number of camels examined	No. of parasites Observed	Types of Gastro Intestinal parasites n (%)			
			<i>Coccidia</i>	<i>Strongyle</i>	<i>Trichuris</i>	<i>Oxyuris</i>
Gada	32	11(34.3)	0(0.0)	8(72.7)	3(27.3)	0(0.0)
Illela	30	6(20.0)	1(6.7)	1(16.7)	1(16.7)	3(5.0)
Tangaza	32	8(25.0)	2(25)	4(50.0)	0(0.0)	2(25.0)
Goronyo	19	7(36.8)	2(28)	2(14.3)	1(14.3)	2(28.6)
Kware	16	5(31.25)	0(0.0)	3(60.0)	2(40.0)	0(0.0)
Gwdbwa	20	2(10.0)	1(50.0)	0(0.0)	0(0.0)	1(50.0)
Sokoto Abattoir	59	22(37.2)	4(18.2)	7(31.8)	5(22.7)	6(27.3)
<b>Total</b>	<b>208</b>	<b>61(29.3)</b>	<b>10(4.8)</b>	<b>25(12.0)</b>	<b>12(5.8)</b>	<b>14(6.7)</b>

Table 4.12: Overall prevalence of gastrointestinal parasites according to locations in Sokoto State, Nigeria

<b>Type of study area</b>	<b>Total number of camels examined</b>	<b>Positive n (%)</b>	<b><math>\chi^2</math></b>	<b>P-value</b>
Field	120	26 (21.7)	8.03	0.005
Sokoto Abattoir	88	35(39.8)		
<b>Total</b>	<b>208</b>			

Significant at  $P < 0.05$

Table 4.13: Overall prevalence of gastrointestinal parasites in relation to sex of camels in study areas in Sokoto State, Nigeria

<b>Variable</b>	<b>Total number of camels examined</b>	<b>Positive n(%)</b>	<b><math>\chi^2</math></b>	<b>P-value</b>
<b>Sex</b>				
Male	116	34(29.3)	0	0.995
Female	92	27(29.3)		
<b>Total</b>	<b>208</b>			

Not significant at  $P > 0.05$

Table 4.14: Overall prevalence of gastrointestinal parasites in relation to age of camels in study areas in Sokoto State, Nigeria

<b>Variable</b>	<b>Total number of camels examined</b>	<b>Positive n(%)</b>	<b>X<sup>2</sup></b>	<b>P-value</b>
<b>Age</b>				
<5 years	90	24(26.7)	0.714	0.700
5 years	25	7(28.0)		
>5 years	93	30(32.3)		
<b>Total</b>	<b>208</b>			
Not significant at P> 0.05				

Table 4.15: Mean erythrocytic parameters and indices in gastrointestinal parasites-infected and non- infected camels in study areas in Sokoto State, Nigeria

<b>Parameter</b>	<b>Infected Mean± SEM</b>	<b>Non infected Mean± SEM</b>	<b>P- value</b>	<b>Significance</b>
PCV (%)	27.459 ± 0.513	28.701 ± 0.375	0.0530	NS
Hb(g/dl)	11.880 ± 1.193	11.045 ± 0.240	0.0496	S
RBC ( $\times 10^6 / \text{mm}^3$ )	7.126 ± 0.200	7.992 ± 0.468	0.0910	NS
MCV(fl)	40.950 ± 0.891	41.034 ± 0.539	0.9370	NS
MCH(pg)	18.459 ± 0.383	18.755 ± 0.207	0.4980	NS
MCHC(g/dl)	31.590 ± 0.929	33.312 ± 0.689	0.1390	NS

Significant at P<0.05

Table 4.16: Mean total differential white blood cells in gastrointestinal parasites-  
 Infected and non - infected camels in study areas in Sokoto State, Nigeria

<b>Parameter</b>	<b>Infected Mean± SEM</b>	<b>Non infected Mean± SEM</b>	<b>P- value</b>	<b>Significance</b>
WBC( $\times 10^6$ /mm <sup>3</sup> )	14.278 ± 0.337	14.326 ± 0.315	0.9180	NS
Neutrophils ( $\times 10^9$ )	4.789 ± 1.286	4.761 ± 0.784	0.8390	NS
Lymphocytes ( $\times 10^9$ )	7.035± 0.698	6.796 ± 0.644	0.0550	NS
Monocytes ( $\times 10^9$ )	0.872 ± 0.472	0.846 ± 0.197	0.6920	NS
Eosinophils ( $\times 10^9$ )	1.703 ± 0.387	0.698 ± 0.295	0.0000	S
Basophils ( $\times 10^9$ )	0.149 ± 0.160	0.169 ± 0.895	0.4670	NS

Significant at P<0.05

The tick species encountered were *Hylomma dromedarii* (Plate VI), *Rhipicephalus sanguineus* (Plate VII) and *Amblyomma variegatum* ((Plate VIII) with prevalences of 23.6%, 5.80%, and 3.80% respectively while the month of October had the highest prevalence (96%) (Table 4.17).

The highest prevalence (50%) for tick infestation on camels was recorded in Gwadabawa Local Government Area (Tables 4.18).

There was no significant association ( $P > 0.05$ ) for tick infestation on camels between study locations. However, the field had the highest prevalence (35%) (Table 4.19).

There was no significant association ( $P > 0.05$ ) for tick infestation on camels between camel sexes (Table 4.20).

There was no significant association ( $P > 0.05$ ) for tick infestation on camels between camel age groups. However, the young camels had the highest prevalence (40.0%) (Table 4.21).

The haematophagous fly identified was *Stomoxys calcitrans* (Plate IX) with mean collection of  $4.7 \pm 1.86$  and prevalence of 13.46% while the month of December had the highest collection (10.0) (Table 4.22).

Table 4. 17: Overall monthly (2016-2017) prevalence of tick infestation on camels in Sokoto State, Nigeria

Month of year	Total no. of camels examined	No. of ticks Observed	Types of ticks n (%)		
			<i>A.varriegatum</i>	<i>H.dromedarri</i>	<i>R.sanguineus</i>
October	25	24(96)	2(8.3)	21(87.5)	1(4.2)
November	45	34(75.6)	5(14.7)	21(61.8)	8(23.5)
December	38	8(21.1)	1(12.5)	5(62.5)	3(37.5)
January	32	1(3.1)	0(0.0)	1(100)	0(0.0)
February	37	0(0.0)	0(0.0)	1(100)	0(0.0)
March	31	0(0.0)	0(0.0)	0(0.0)	0(0.0)
<b>Total</b>	<b>208</b>	<b>67(32.2)</b>	<b>8(3.80)</b>	<b>49(23.6)</b>	<b>12(5.80)</b>



**Plate VII: *Amblyomma variegatum* isolated from an adult male camel in Sokoto State, Nigeria ( $\times 0.8$  of Nikon dissecting microscope)**



**Plate VIII:** *Hyalomma dromedarri* isolated from an adult female camel in Sokoto State, Nigeria ( $\times 0.8$  of Nikon dissecting microscope)



**Plate IX: *Rhipicephalus sanguineus*. isolated from an adult male camel in Sokoto State, Nigeria ( $\times 0.8$  of Nikon dissecting microscope)**

Table 4.18: Overall prevalence of Tick infestation in camel in study areas in Sokoto State, Nigeria

Location	Total no. of camels examined	No. of ticks observed	Type of ticks n (%)		
			<i>A.varriegatum</i>	<i>H.dromedarri</i>	<i>R.sanguineus</i>
Gada	32	6(18.8)	0(0)	4(66.7)	2(33.3)
Illela	30	9(30)	2(22.2)	5(55.6)	2(22.2)
Tangaza	32	11(34.4)	1(9.1)	7(63.6)	3(27.3)
Gornyo	19	5(26.3)	0(0.0)	5(100)	0(0.00)
Kware	16	7(43.8)	1(14.3)	6(85.7)	0(0.00)
Gwadabawa	20	10(50)	0(0.0)	7(70.0)	3(30.0)
Sokoto Abattoir	59	19(32.2)	4(19.0)	15(70.0)	2(9.5)
<b>Total</b>	<b>208</b>	<b>67(32.2)</b>	<b>8(3.80)</b>	<b>49(23.6)</b>	<b>12(5.80)</b>

Table 4.19: Overall prevalence of tick infestations in camels according to sampling locations in Sokoto State, Nigeria

<b>Types of study areas</b>	<b>Total no. of camels examined</b>	<b>Infested n(%)</b>	<b>X<sup>2</sup></b>	<b>P-value</b>
Field	120	42(35)	1.01	0.315
Sokoto Abattoir	88	25(28.4)		
<b>Total</b>	<b>208</b>	<b>67(32.2)</b>		

Not significant at P> 0.05

Table 4.20: Overall prevalence of tick infestation in relation to sex of camels in study areas in Sokoto State, Nigeria

<b>Variable</b>	<b>Total no. examined</b>	<b>No. Observed n (%)</b>	<b><math>\chi^2</math></b>	<b>P-value</b>
<b>Sex</b>				
Male	116	38 (32.8)	0.036	0.85
Female	92	29 (31.5)		
<b>Total</b>	<b>208</b>	<b>67 (32.2)</b>		

Not significant at  $P > 0.05$

Table 4.21: Overall prevalence of tick infestation in relation to age of camels in study areas in Sokoto State, Nigeria

<b>Variable</b>	<b>Total no. examined</b>	<b>No. Observed n (%)</b>	<b><math>\chi^2</math></b>	<b>P-value</b>
<b>Age</b>				
<5 years	90	29 (32.2)	0.209	0.901
5 years	25	10 (40)		
>5 years	93	28 (30.1)		
<b>Total</b>	<b>208</b>	<b>67 (32.2)</b>		
Not significant at $P > 0.05$				

Table 4.22: Monthly (2016-2017) means for haematophagous flies in study areas in Sokoto State, Nigeria

<b>Month of year</b>	<b><i>S. calcitrans</i></b>
October	2
November	9
December	10
January	0
February	0
March	7
<b>Total</b>	<b>28</b>
<b>Mean</b>	<b>4.7 ± 1.86</b>



**Plate X: A *Stomoxys calcitrans* captured using biconical trap set around camel herds in Sokoto State, Nigeria ( $\times 0.8$  of Nikon dissecting microscope)**

## CHAPTER FIVE

### 5.0 DISCUSSION

The higher prevalence observed in the month of November for the distribution of haemoparasites could be due to the fact that, November was the second month with highest collection of *Stomoxys calcitrans* (possible vector of *Trypanosome evansi*) and also during the periods of November to January, trans- border movement of camels occurs from Niger to Nigeria involving Sokoto State which can leads to introduction and transmission of hemoparasites (Chandrawathani *et al.*, 2002).

The finding of slightly higher prevalence of haemoparasites in this study for male could be attributed to the fact that, they are more in used than female camels as draught animals and transportation which may all expose them to various stress conditions and increase their chances of encountering possible disease vectors and contracting haemoparasitic infections. This disagrees with the report of Parsani and Momin (2008), who reported infection to be more in females due to pregnancy stress which may possibly overwhelm the immune system.

The observed higher prevalence in adult camels could be due to the fact that, adult male camels are more used than young as draught animals and transportation. Adult female camels are more exposed to stress than young females due to pregnancy which may possibly overwhelm the immune system. Therefore, adult camels are more likely to contract hemoparasitic infections due to their higher chances of encountering possible diseases vectors and haemoparasites. This disagrees with the finding of Elnaga *et al*

(2016), who reported that hemoparasites can infect all age groups but higher prevalence is observed more in growing camels shortly after weaning which could be due to immune system strong enough to counteract the infection.

The findings of significant association between infected and non-infected camels for *Trypanosoma evansi* in erythrocytic parameters, indices and total differential white blood cells could be due to haemolysis of red blood cell caused by *Trypanosoma evansi* as well as increase in antibodies in response to the infection; that is a natural defense mechanism against parasites. These agrees with the reports of Alsa'ad (2009); Sattar and Mirza (2009); Arugungu *et al* (2014), Fatihu *et al* (2014) and Ayoub *et al* (2015).

The findings of significant association between infected and non-infected camels for *Anaplasma marginale* in erythrocytic parameters, indices and total differential white blood cells could be due to haemolysis of red blood cell caused by *Anaplasma marginale* as well as increase in antibodies in response to the infection; that is a natural defense mechanism against parasites. These agreed with the reports of Alsa' ad *et al* (2009); Njiru *et al* (2012); Ngaira *et al* (2014) and Argungu *et al* (2014).

The higher prevalence observed in December for the distribution of gastrointestinal parasites could be explained by the fact that climatic changes, sub-optimal feeding of camels as well as poor husbandry and management practices (deworming) may determine the occurrence of helminthic infections in camels (Bekele, 2010; Khan *et al.*, 2010). However, the finding of Strongyl as the most prevalent GIT parasite between sampling

units in this study was agreed with the report of Rewatkar *et al* (2009) who reported *Strongylus spp* and *Trichostrongylus spp* as the most incriminated helminthes in camels.

The significant association in prevalence of gastrointestinal parasites observed between types of study areas in this study, with abattoir having the highest prevalence could be due to the fact that camels gathered for slaughter at abattoir are transported and brought to abattoir from different regions with different management and husbandry practices in which case they might have been exposed to and contracted the infection from their original locations.

The finding of non association between prevalence of camel sexes for gastrointestinal parasites in this study was not agreed with the report of Swai *et al* (2011), who reported that female camels significantly harbor more GIT parasite eggs than male camels.

The finding of slightly higher prevalence of camel GIT parasites in adult camels in this study is agreed with the report of Bathia *et al* (2010). However, the occurrence of helminthosis in camels at the age range of less than 3 years may suggest a possibility of early introduction of young camels to grazing fields and subsequent increase in larval uptake (Mahmuda *et al.*, 2014).

The findings of non significant association between infected and non-infected camels for gastrointestinal parasites in erythrocytic parameters, indices and total differential white blood cells except for haemoglobin and eosinophils could be due to interference of gastrointestinal parasites with camel nutrition or increase in antibodies in response to the infection respectively; that is a natural defense mechanism against parasites for eosinophils (Ekizaed and Yalcintan, 2013).

The finding of higher prevalence of tick infestation during the month of October which is part of the rainy season in Sokoto State could be due to the fact that, rainy season provides a favorable environment for the tick's life cycle and increases their rate of infestation (host -vector contact) during browsing on green pasture and in addition rainfall, temperature and relative humidity are considered as the major determining factors (Biu and Konto, 2012). This agreed with the report of Abdelrahman *et al* (2001). However, the smallest number of ticks per camel observed during the driest months of this study agreed with the report of Zeleke and Bekele (2004). During rainy season the immature stages (nymph) of ticks are mainly found in pasture while the Adults stages are found on the camel's body. However, the finding of *Hyalomma dromedarri* with highest prevalence from the sampling units (Local Government Areas) during the study period agreed with the finding of Salem *et al* (2011).

The prevalence of 23.6% for *Hylomma dromaderii* encountered in this study was however lower than earlier reports of 91.28% by Lawal *et al* (2007) from the same study area and 88.1% reported from Borno (Biu and Konto, 2012). However, it was

higher than 15.36% reported from Euthopia (Dinka *et al.*, 2010) and 20.44% (Bebe, 2001). Though, *Rhipicephalus sanguineus* (a dog specific tick) was found on camels in this study, it could be attributed to close association between camels and dogs as the former was used as guard animals.

The finding of non- significant difference in the prevalence of tick infestation between the study areas (field and abattoir)with field having the highest prevalence could be attributed to the fact that, lack of adequate health care (hand de- ticking or regular use of acaricides) and with enhanced close contact of these animals at available communal watering and grazing sites “Contact points” may result in the establishment and spread of camel ectoparasites including ticks (Taddese *et al.*, 2013). Furthermore, the Spread of ticks in a particular region may occur as a result of transboundry movements of camels from other regions (Yahaya *et al.*, 2015).

The finding of growing camels (5 years) with highest prevalence could be attributed possibility of early introduction of young camels to grazing fields (Dinka *et al.*, 2010). However, low prevalence in adult camels may suggest development of acquired immunity in older animals with effects ranging from interference to feeding, inhibition of egg lying, decreased viability of eggs and death of the tick on the host (Akhtar *et al.*, 2011). This agreed with the reports of Van and Jongejan (2000) and Bui and Konton (2012).

The presence of *Stomoxys calcitrans* around camel herds could be attributed to the fact that, the fly follows camel for blood feeding while camel has been reported to produce an estimate of 58kg methane annually which is responsible for maintenance of the *Stomoxys* (responsible for transmission of surra) population within the camel environment than cattle and horses with an annual methane production of estimate of 45kg and 18kg, respectively (Müller *et al.*, 2011)..

## CHAPTER SIX

### 6.0 CONCLUSIONS AND RECOMMENDATION

#### 6.1 Conclusions

1. The parasites that affect camels in Sokoto State were Hemoparasites (*Trypanosoma evansi* and *Anaplasma marginale*), gastro intestinal parasites ( *coccidian*, *Strongyle*, *Oxyuris* and *Trichuris*) and Ectoparasites: Ticks (*Hyalomma dromedarri*, *Rhipicephalus sanguineus* and *Amblyomma varriegatum*) and Haematophagous Flies: *Stomoxys calcitrans*.
2. The overall prevalence of parasitic infections in this study was 84.1% (hemoparasites; 9.1%, gastrointestinal parasites; 29.3% and ectoparasites; 45.7%).
  - a. Hemoparasites : *Trypanosoma evansi* 15 (78.1%) and *Anaplasma marginale* 4(21.1%).
  - b. Gastro intestinal parasites: *coccidia* 10 (16.4%) *Strongyle* 24 (39.3%), *Oxyuris*14 (23.0%), *Trichuris*12 (19.7%) and *Ostertagia* 1(1.60%).
  - c. Ectoparasites:
    - i. Ticks of three different species namely *Hyalomma dromedarri* 49 (71.0%), *Rhipicephalus sanguineus* 12 (17.4%) and *Amblyomma spp.* 8 (11.6%).
    - ii. Haematophagous Flies: *Stomoxys calcitrans* 28 (6.90%).

3. The possible vectors of identified parasitic infections of camels in Sokoto State, Nigeria are: *Stomoxys calcitrans*, *Hyalomma dromedarii* and *Amblyomma variegatum*.

## **6.2 Recommendation**

Other basic research on parasitic infections of camels in the study area is recommended

### **6.3 Limitations of the Study**

This study had the following limitation:

The exhibited lack of patience by camel owners to allow for taking of vital parameters and skin scrapings during sampling

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## APPENDICES

### Appendix I: Mean ( $\pm$ SD) Haematological parameters, indices and differential leucocyte counts of the adult/ young dromedary camels in study areas of Sokoto State

Parameter	Mean	S/Deviation
PCV(%)	28.337	4.429
HB(g/dl)	11.290	5.600
RBC( $\times 10^6/\text{mm}^3$ )	7.738	4.860
MCV(fl)	41.009	6.652
MCH(pg)	18.668	2.657
MCHC(g/dl)	32.809	8.077
WBC( $\times 10^6/\text{mm}^3$ )	14.312	3.510
Neutrophils(%)	33.326	9.645
Lymphocytes(%)	47.981	7.236
Monocytes(%)	5.971	2.826
Eosinophils(%)	6.956	4.692
Basophils(%)	1.144	1.137

**Appendix II: Monthly mean ( $\pm$ SD) of haematological parameters and indices of the adult/ young dromedary camels in study areas of Sokoto State, Nigeria**

Month	Mean $\pm$ Standard deviation					
	PCV(%)	HB(g/dl)	RBC( $\times 10^6/\text{mm}^3$ )	MCV(fl)	MCH(pg)	MCHC(g/dl)
October	27.440 $\pm$ 3.969	11.100 $\pm$ 2.812	9.600 $\pm$ 12.655	42.360 $\pm$ 7.465	18.920 $\pm$ 3.121	33.160 $\pm$ 8.928
November	27.068 $\pm$ 5.571	10.888 $\pm$ 3.248	7.6844 $\pm$ 3.959	37.622 $\pm$ 5.175	18.377 $\pm$ 2.790	27.466 $\pm$ 3.564
December	28.868 $\pm$ 4.325	10.736 $\pm$ 3.227	7.092 $\pm$ 1.618	41.657 $\pm$ 7.048	18.368 $\pm$ 3.017	32.973 $\pm$ 7.820
January	28.656 $\pm$ 3.882	10.950 $\pm$ 2.625	7.309 $\pm$ 1.270	42.250 $\pm$ 6.744	18.937 $\pm$ 2.354	36.781 $\pm$ 9.132
February	28.567 $\pm$ 4.213	10.891 $\pm$ 2.769	7.502 $\pm$ 1.399	41.648 $\pm$ 6.101	18.675 $\pm$ 2.495	35.027 $\pm$ 8.684
March	29.645 $\pm$ 3.450	13.548 $\pm$ 12.617	7.832 $\pm$ 0.973	42.000 $\pm$ 5.932	18.967 $\pm$ 2.152	33.322 $\pm$ 7.035
Total	28.337 $\pm$ 4.429	11.290 $\pm$ 5.600	7.738 $\pm$ 4.860	41.009 $\pm$ 6.652	18.668 $\pm$ 2.657	32.807 $\pm$ 8.077

**Appendix III: Monthly mean ( $\pm$ SD) of differential leucocyte values of the adult/ young dromedary camels in study areas of Sokoto State, Nigeria.**

Month	Mean $\pm$ Standard deviation					
	WBC( $\times 10^6/\text{mm}^3$ )	Neutrophils(%)	Lymphocytes(%)	Monocytes(%)	Eosinophils(%)	Basophils(%)
October	14.240 $\pm$ 3.031	33.120 $\pm$ 9.942	49.240 $\pm$ 5.418	5.920 $\pm$ 2.628	7.200 $\pm$ 5.236	1.400 $\pm$ 1.118
November	14.977 $\pm$ 5.967	30.215 $\pm$ 11.532	47.682 $\pm$ 8.017	6.000 $\pm$ 2.513	7.795 $\pm$ 5.346	1.466 $\pm$ 0.504
December	13.921 $\pm$ 2.222	33.763 $\pm$ 9.982	49.473 $\pm$ 4.880	6.236 $\pm$ 4.174	8.368 $\pm$ 5.132	1.157 $\pm$ 1.568
January	13.781 $\pm$ 2.210	35.187 $\pm$ 7.676	46.750 $\pm$ 9.249	5.937 $\pm$ 2.198	7.062 $\pm$ 4.369	0.750 $\pm$ 0.342
February	14.351 $\pm$ 2.530	33.718 $\pm$ 9.193	48.456 $\pm$ 5.144	5.937 $\pm$ 2.198	5.945 $\pm$ 3.635	1.162 $\pm$ 1.190
March	14.387 $\pm$ 2.333	35.087 $\pm$ 7.795	46.274 $\pm$ 9.212	5.937 $\pm$ 2.198	4.935 $\pm$ 3.336	0.838 $\pm$ 1.267
Total	14.312 $\pm$ 3.510	33.326 $\pm$ 9.695	47.981 $\pm$ 7.236	5.937 $\pm$ 2.198	6.956 $\pm$ 4.692	1.144 $\pm$ 1.137

