EPIDEMIOLOGICAL STUDIES OF OVINE COCCIDIAL INFECTIONS IN SELECTED FARMS IN BAUCHI STATE, NIGERIA

BY

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A THESIS SUBMITTED TO THE POSTGRADUATE SCHOOL IN PARTIAL FULFILLMENT OF THE REQUIMENTS FOR THE AWARD OF MASTER OF SCIENCE IN VETERINARY PARASITOLOGY

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SEPTEMBER, 2007

DECLARATION

I declare that the work in the thesis entitled 'EPIDEMIOLOGICAL STUDIES OF OVINE COCCIDIAL INFECTIONS IN SELECTED FARMS IN BAUCHI STATE, NIGERIA' has been performed by me in the Department of Veterinary Parasitology and Entomology under the supervision of Dr. I. A. Lawal, Professors L. B. Tekdek and J.O Ajanusi.

The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at any university.

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CERTIFICATION

This thesis entitled 'EPIDEMIOLOGICAL STUDIES OF OVINE COCCIDIAL INFECTIONS IN SELECTED FARMS IN BAUCHI STATE, NIGERIA' by Biallah, Markus Bukar meets to regulations governing the award of the degree of Master of Science of Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This work is dedicated to:

a. My children (Mathias and Pamela) for making it worthwhile

b. The memory of my parents and sisters for the immeasurable roles they played in my life

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ABSTRACT

A cross-sectional survey of coccidiosis in sheep was carried out between June, 2005 and July, 2006 in order to study the epidemiology of the infection in Bauchi state. Eight hundred and sixty six (866) faecal samples were collected four times from farms in three locations (Bauchi, Misau and Azare). Faecal samples were obtained directly from the rectum in August, 2005; November, 2005; February, 2006 and May, 2006; coinciding with the late rainy, early dry, late dry and early rainy seasons, respectively. Coccidial infections were relatively common with 78.3% of all the animals positive for the infection. There was almost identical prevalence in all the three locations. Misau had the highest prevalence of 79.2%, followed by Bauchi (78.9%) and Azare (76.6%) but the differences were not statistically significant ($p > 0.05$). There were also no significant differences between the prevalence in relation to breed and sex. Significantly ($p < 0.05$) higher prevalence was observed in the late rainy season compared with the other seasons. Adults significantly ($p < 0.05$) showed high prevalence than the immature and young. Oocyts counts were not significantly ($p > 0.05$) influenced by sex, breed and systems of management. The young and immature sheep were significantly ($p < 0.05$) excreting higher number of oocysts than the adults. Eight *Eimeria* species were identified in this study. The most prevalent were *E. bakuensis*, found in 80% of the adult animals, *E.*

ovinoidalis (62.7%), *E. parva* (60.0%) and *E. ahsata* (52.0%). The other species were *E. faurei, E. granulosa, E. pallida*, and *E. intricata*, present in 40%, 36%, 16% and 12% of the samples, respectively. There was a negative correlation between oocyst counts and body condition score. It was concluded that there was potential for clinical coccidiosis in sheep in Bauchi state especially during the late rainy seasons when conditions are suitable for sporulation of the pathogenic species of *Eimeria* (*E. ovinoidalis* and *E. bakuensis*). It is hereby suggested that detailed studies on the economic importance of coccidiosis in Bauchi state be conducted to ascertain losses due to the disease in sheep industry in the state.

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ABBREVIATIONS

%	-	percent
g	-	gram
g	-	gravity
opg	-	oocyst per gram
fig	-	figure
^{o}C	-	degree centigrade
mm	-	millimetre
w/v	-	weight by volume
ml	-	millilitre
min	-	minutes
m	-	metre

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background information

The population of sheep in Nigeria has been estimated at 22.1 million (FDLPCS, 1992; Bourn *et al.*, 1994). They are found across the various ecological zones of the country with most breeds located in the Guinea and Sudan savannah zones (Fig.1).

Sheep constitute an important source of meat and they are crucial in the socio-economic and even religious life of most of the people. They account for over 11.0% of total meat supply in Nigeria (Adu and Ngere, 1979). The rams play an important role in the religious festivities of the Muslims as they are slaughtered in large numbers for religious rites and entertainment.

In spite of the importance of sheep in Nigeria, their productivity is low (David–West, 1983). Parasitism has been reported by many researchers as one of the important factors limiting the productivity of small ruminants including sheep in Nigeria (Akerejola, 1980; Umoh *et al.*, 1982; Ademosun, 1985).

Coccidial infection is one of the most important parasitic infections that prevail in different parts of the world and in different animal species. Most, if not all, domestic ruminants are infected during their lives (Taylor and Catchpole, 1994). In livestock, it leads to economic loss from both clinical and sub-clinical infections due to mortality, low growth performance, decrease in productivity and veterinary cost (Fitzgerald, 1980; Abo–Shehada and Abo–Farieha, 2003; Daugschies and Najdrowski, 2005).

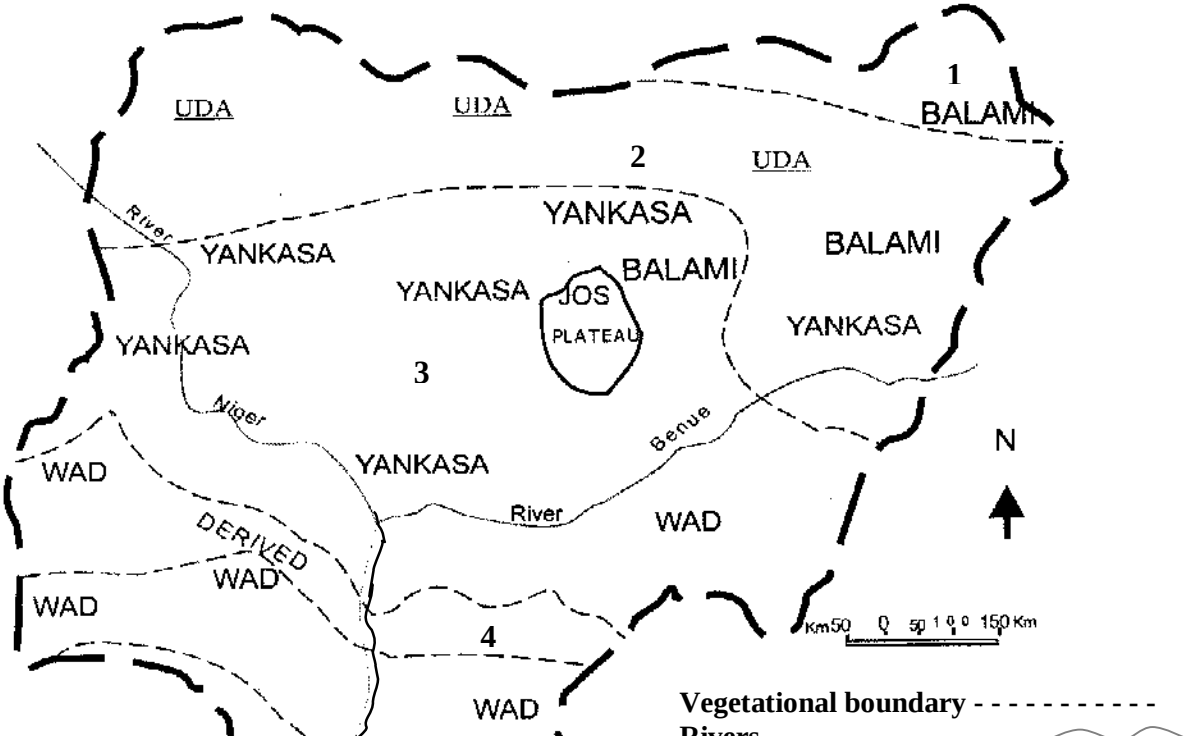
Ovine coccidiosis has become an increasingly important problem in recent years most probably due to fundamental changes in sheep management systems, such as the intensification of sheep farming, higher birth/twinning rate, higher stocking densities and limited opportunities for pasture rotation (Alzieu *et al.*, 1999). A survey in the USA (Anon, 1996 cited by Alzieu *et al.*, 1999), showed that the most important health and productivity factors affecting sheep was coccidiosis which was regarded as being of moderate to serious concern by the farmers.

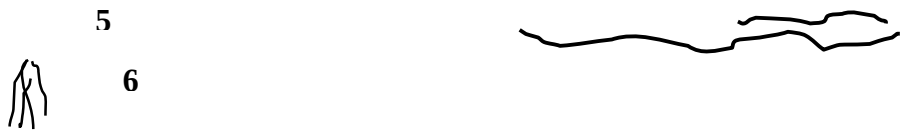
The world wide annual cost due to coccidiosis has been estimated at 140 million US dollars (Fitzgerald, 1980).impaired performance, mortality and veterinary cost result in considerable economic losses (Fitzgerald, 1980).

1.2 Justification of the study

Sheep production has become important in many tropical countries. This is due to their comparative biological efficiency in meat, fibre and milk production as well as their inherent suitability for small-scale production (Jasiorowski, 1986). The population of sheep in the north-eastern part of Nigeria in, which Bauchi state is located, is 7.1 million (Osinowo, 1999). They are highly concentrated in the state, especially in the northern part (Fig.2).

There have been some studies on ovine coccidial infections in Nigeria (Akerejola *et al.*, 1979; Fabiyi, 1980; Adefolabi and Chiejina, 1987; Adewuyi *et al.*, 1989), but there are no known reports from Bauchi state. This study is therefore needed to provide information on ovine coccidiosis in Bauchi state, Nigeria.





Key to vegetational zones

1- Sahel savannah

2- Sudan savannah

3- Northern Guinea savannah

4- Southern Guinea savannah

5- Derived savannah

6- Forest vegetation

The present study was aimed at identifying species of coccidia currently occurring in sheep flocks in Bauchi state to study patterns of infection

according to age, management system, season and sex, and relate these findings to clinical signs.

1.3 Objectives of the study

1. To determine the field prevalence and spectrum of coccidial infections among sheep in Bauchi State.
2. To evaluate the influence of management systems, age, sex, breed and season on ovine coccidiosis.
3. To determine the correlations between oocyst excretion rate and clinical signs associated with the infection.

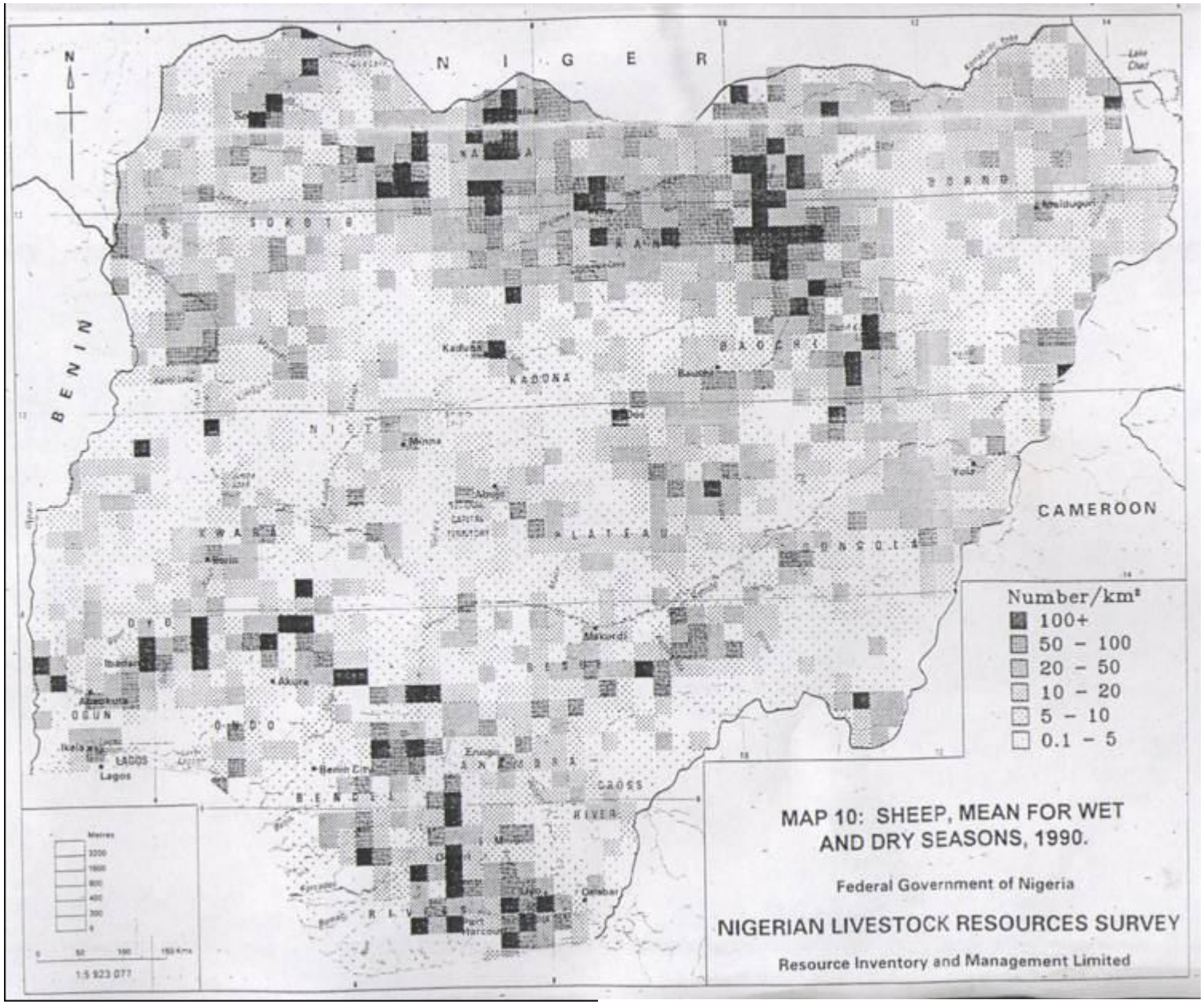


Figure 2: Concentration of sheep in Nigeria
(Source: FLDPCS ,1992)

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

Ovine coccidiosis is a common disease of sheep caused by different *Eimeria* species (Yvore and Esnault, 1987). It can be a serious clinical problem of lamb rearing, particularly in pre-weaned and recently weaned lambs (Alzieu *et al.,* 1999), causing diarrhoea and reduced growth (Gregory *et al.,* 1980; Berriatua *et al.,* 1994), and mortality of up to 10% (Soulsby, 1986). Its greater economic importance, however, lies in the unthriftiness and lowered productivity that it causes (Radostits *et al.,* 2000; Taylor, 1995)

Different species of coccidia have been detected in sheep. The clinically most important species are *Eimeria ovinoidalis*, *E. ovina* (*E. bakuensis),* and *E. ahsata* (Pellerdy, 1974; Gregory *et al.,* 1980; Gregory, 1990; Lindsay and Todd, 1990; Kaufmann, 1996; Rommel, 2000).

The current review is intended to summarise the present knowledge on ovine coccidiosis particularly in Nigeria.

2.2 Economic impact

The prevalence of *Eimeria* infection in sheep is generally high and can reach up to 100% (Arslan *et al.*, 1999). Lambs of age 4-8 weeks old are particularly susceptible to clinical coccidiosis (Taylor and Catchpole, 1994). It is most probable that sheep kept under conventional management are unavoidably exposed to infection with coccidia (Radostits *et al.*, 2000). Although infected lambs may suffer from diarrhoea, sometimes with lethal outcome. When clinical disease is not associated with infection, the infection pressure may be low, the respective *Eimeria* spp is not pathogenic, or the animals have developed immunity due to previous infection (Taylor and Catchpole, 1994). Impaired performance, mortality and costs for treatment result in considerable economic losses (Fitzgerald, 1980). Assumedly, the monetary losses due to subclinical disease even exceed those resulting from clinical coccidiosis (Fitzgerald, 1980) because the former occurs more frequently and may impair intestinal physiology, feed conversion and growth of animals (Fox 1985; Matjila and Penzorn, 2002).

According to Fitzgerald (1980), the world wide annual cost due to coccidiosis in sheep is approximately 140 million US dollars. Animals that have survived severe coccidiosis show retarded growth and it has been suspected that they never become profitable (Fox, 1985).

2.3 The Parasite

The intestinal coccidia known to induce enteritis in sheep belong to the genus *Eimeria* of the family Eimeriidae. The taxonomic classification of the parasite is given in Appendix 1.

Seventeen *Eimeria* species are known to infect sheep (Levine and Ivens, 1986) and 11 species have been closely studied. These include *Eimeria faurei, E. crandallis, E. ninakohlyakimovae* (*E. ovinoidalis*), *E. parva, E. ahsata, E. punctata and E. ovina (E.bakuensis)* (Thompson and Hall, 1931; Fabiyi, 1980; Fayer, 1980; Vercruysse, 1982).

The identification of species of *Eimeria* in sheep is based on the morphological characteristics of the unsporulated and sporulated occysts such as colour, shape, size, and presence or absence of micropyle and micropylar cap (Eckert *et al.,* 1985; Gardiner *et al.,* 1988; Levine, 1985; Levine and Ivens, 1986). Other criteria include prepatent period and sporulation time (Shah, 1963; Pout, 1965; Catchpole *et al.,* 1975). The detailed description of these species is summarized in Appendix 2.

A determining characteristic of the coccidia is the development of resistant occysts that are shed with faeces. In sheep the occyst is unsporulated and non-infectious when excreted; it contains a single, undifferentiated cytoplasmic mass and is essentially the zygote stage of the parasite surrounded by a protective wall. At appropriate temperatures and humidity, sporulation occurs by meiotic division (Canning and Anwar, 1968; Del Cacho *et al.,* 2005). During this process the cytoplasm divides into a characteristic number of sub-masses (secondary sporoblasts), which develop resistant wall and are termed sporocysts. Within the sporocysts, the infectious stages (sporozoites) are formed. The structure of the sporulated oocysts determines the genus of the parasite; *Eimeria* species have four sporocysts, each containing two sporozoites.

The oocyst wall is vital for parasite survival in the environment. It is important to the parasite as the exoskeleton is to the insects or the cuticle is to nematodes. Surprisingly, the characterization of this structure in coccidia has received little attention (Belli *et al.,* 2003 cited by Belli *et al*., 2006). Although the development and formation of the oocyst have been reported at the ultrastructural level in a number of coccidia (Pittilo and Ball, 1980), charactersization at the molecular level has focused on a limited number of reports based on *Eimeria* spp (Belli *et al.*,2003 cited by Belli *et al*.,2006).

This is due largely to limitations in obtaining large numbers of coccidian oocysts from which to isolate walls and the inherent nature of the wall, which has made characterization of wall proteins extremely difficult.

2.4 Parasite Biology

All *Eimeria* spp. share a similar monoxenous life cycle with an internal (parasitic) and external (environmental) phase (Fig. 3). They are strictly host-specific and develop within cells at certain sites of the intestinal mucosa.

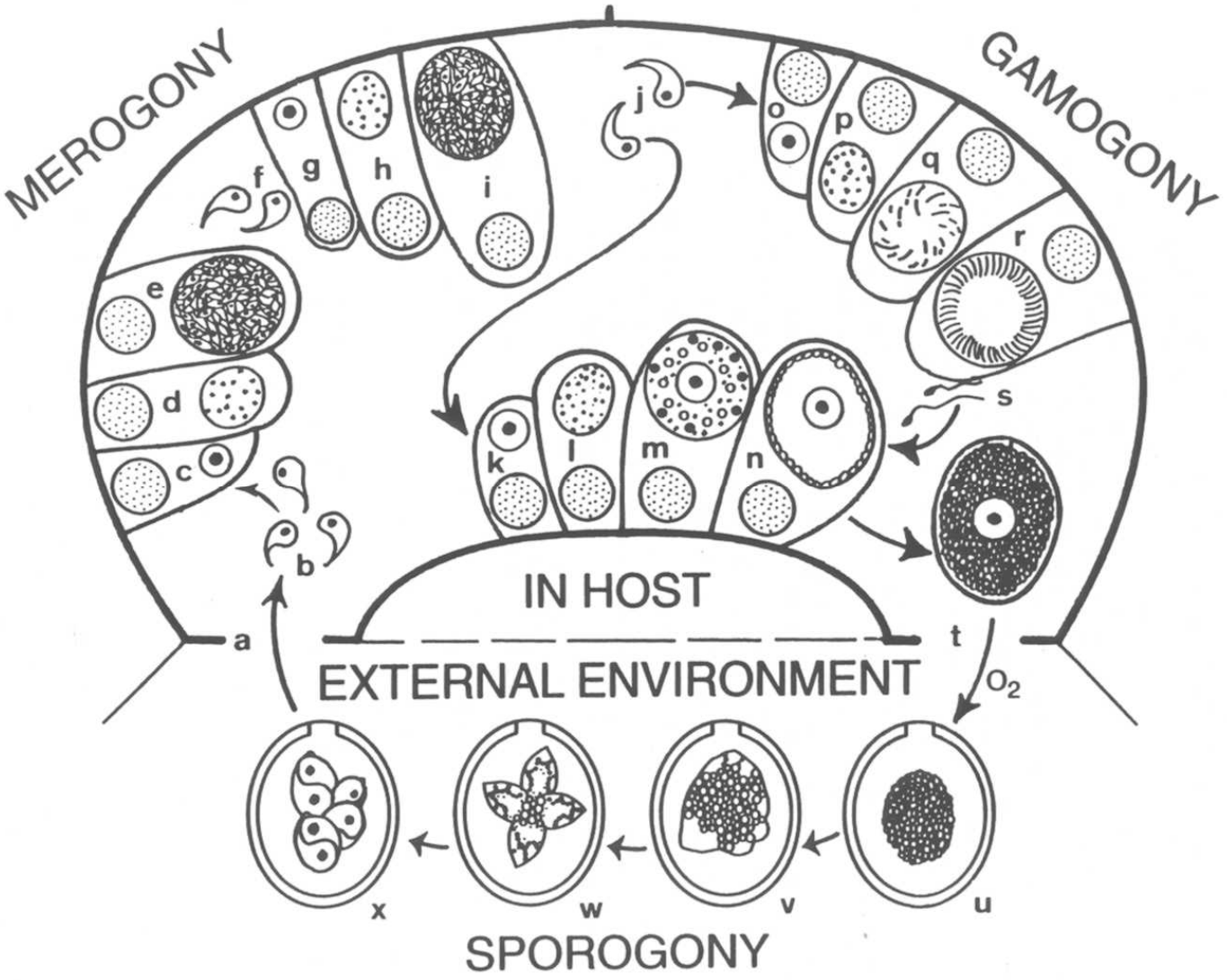


Fig 3: Life cycle of *Eimeria*
(Source: http://biology.unm.edu/biology/coccidia/eimeriabiol.html)

The parasitic phase of the life cycle of the coccidia is initiated when the infective oocyst is ingested by the appropriate host. Excystation releases the contained sporozoites. Two separate stimuli are necessary for excystation (Jackson, 1962; Nyberg *et al.*, 1968), the first is provided by CO_2 and the second by trypsin and bile. Using sheep coccidia, Jackson (1962) found that exposure to at least 15% CO_2 in the gas phase was necessary to prepare oocysts for the second stimulus.

The second stage of the excystation is pH-dependent and effects the escape of the sporozoites. Bile facilitates the entry of trypsin through the altered micropyle, which then digest the sporocystic plug permitting escape of the motile sporozoites.

Liberated sporozoites in the natural host traverse mucosal cells without considerable alterations and finally invade the endothelial cells of the central lymph capillaries of the ileal villi (Behrendt *et al.*, 2004). The penetration process is quick and completed within a few seconds (Hammond, 1973). Invasion of the host cells is accompanied by release of antigens from organelles located in the anterior region of the sporozoites (micronemes and rhoptries) that play significant role in host cell recognition, penetration

through host cell membrane and formation of the parasitophorous vacuole (Heisse *et al.,* 1999 a, b).

2.4.1 Schizogony or Merogony

Schizogony is initiated when the sporozoites within the parasitophorous vacuole become rounded up and transformed to trophozoites (Daugschies and Najdrowski, 2005). Within a few days, the nucleus of the trophozoites divide by schizogony to become first generation schizonts (meronts). In most ruminants, it is very large (100-200 μm) and may be visible to the naked eye as pin point white spots on the mucosa. More than 10^5 merozoites are formed is each of the schizonts by asexual multiplication. When the schizonts are mature, the parasitized cell ruptures and releases the slender merozoites which are mobile and invade neighbouring mucosal cells where they initiate the development of the much smaller second generation schizonts in the large intestine.

2.4.2 Gametogony

The merozoites released from the second generation schizont differentiate into male (microgamonts) and female (macrogamonts). Following fertilization of the macrogamont by one of the numerous microgametes developing from each microgamont, the wall–forming bodies of the former

macrogamont build a wall around the zygote and the resulting oocysts are shed with the faeces. Generally, patency lasts for several days but may continue for 2 weeks or more.

2.4.3. Sporogony

Once outside, the oocyst sporulate i.e they undergo two divisions and produce four sporocysts each containing two sporozoites.

The time required for sporulation to the infective stage is a specific feature of each species of coccidia and is used as a characteristic for identification (Soulsby, 1986). Temperature also has an important influence on sporulation. Long (1980) reported that sporulation process takes place at temperatures between 12-39^{o}C, the optimum temperatures being between 29-31^{o}C.

If ingested by a susceptible host, the sporozoites emerge and start the cycle again. The source of infection is the faeces of clinically affected or carrier animals, and infection is acquired by ingestion of contaminated feed, water or by licking the hair coat contaminated with infected faeces (Radostits *et al.,* 2000).

2.4.4. Factors affecting survival and infectivity of oocysts

Three factors known to affect the infectivity and survival time of coccidial oocysts are humidity, temperature and oxygenation. Studies on survival of oocysts under natural conditions by Fayer (1980), showed that oocysts in the soil exposed to direct sunlight survived for up to 18 weeks. Those in the soil of wooded range were viable for up to 18 months. In general, the oocysts remain infective longer in shade than in direct sunlight. Coccidial oocysts survive in aerobic conditions. Sporulated oocysts are highly susceptible to dry conditions also especially under prolonged sunlight (Foreyt, 1986), but the oocysts may survive for up to 2 years under favourable conditions (Radostits *et al.*, 2000). Low temperatures apparently are not detrimental because oocysts are still highly infective after the lower winter temperatures (Fayer, 1980).

2.5. Epidemiology

2.5.1 Occurrence

Coccidial infections in sheep have been observed in almost all sheep-rearing countries (Pellerdy, 1974), but is of most importance where animals are housed or confined in small areas which are contaminated with oocysts (Radostits *et al.,* 2000). Coccidiosis in sheep occurs mainly in lambs 4-8 weeks and stressed animals (Pout *et al.*, 1965; Harper and Penzorn, 1999).

The epidemiology of coccidial infections in housed lambs have been extensively studied in Great Britain by Gregory *et al.(* 1980, 1983, 1989), in Germany (Gauly *et al.* 2004; Reeg *et al.,* 2005) and in France (Alzieu *et al*., 1999).

Coccidiosis can be a serious problem of lamb rearing, particularly in pre-weaned and recently weaned lambs (Alzieu *et al*., 1999). The main clinical signs are diarrhoea and reduced growth (Gregory *et al.,* 1980; Berriatua *et al.,* 1994). The rate of coccidiosis is extremely high, especially when lambs are moved from an oocysts-free into a contaminated environment (Gregory *et al.,* 1989). Acute coccidiosis in intensively grazed lambs in Britain occurs at about 6 weeks of age when the oocysts output is very high in healthy as well as in clinically affected lambs (Gregory *et al.,* 1983). Infection also occurs commonly in lambs following their introduction into a feedlot situation where overcrowding and other stressors are operative (Foreyt,

1990; Gregory, 1990). Often such lambs come directly off range and have very little if any exposure to coccidia, making them highly susceptible to infection and outbreaks of clinical disease (Radostits *et al.*, 2000).

2.5.2 Host factors

Acute coccidiosis may occur in animals of any age when their resistance is affected by concurrent infections with other disease producing agents such as helminths, bacteria and viruses (Taylor and Catchpole, 1994). Interactions between *Nematodirus battus* and coccidia have been reported to have damaging effects on lambs (Catchpole and Harris, 1989).

All ages of sheep are susceptible to infection but the younger animals are more likely to develop clinical disease (Taylor and Catchpole, 1994). During the first few months of life the majority of young sheep will probably have been infected and may or may not show signs of disease. Those that reach adulthood are highly resistant to the pathogenic effect of the parasites but may continue to harbour small numbers of parasites throughout their lives. Occasionally acute coccidiosis occurs in adult animals with impaired cellular immunity or in those which have been subjected to stress (Taylor and Catchpole, 1994).

An animal's resistance to coccidial infection can be reduced by adverse conditions such as dietary changes, prolonged travel, extremes of temperature and weather conditions; changes in environment or severe concurrent infections (Gregory, 1990). Nutritional status, mineral and vitamin deficiency can also influence resistance to infection. Well nourished animals may simply be able to fight off infection more readily (Taylor and Catchpole, 1994). Ewes excrete large numbers of oocysts, particularly around the periparturient period when the ewes immune status is lowered (Coop and Wright, 2000).

2.5.3 Parasite factor

Multiple infections comprising more than a single species of coccidia are the rule in natural infections (Radostits *et al.,* 2000). In a sheep flock there may be as many as 10 species of *Eimeria* (Silva and Miller, 1991; Arslan *et al.,* 1999; Gauly *et al.,* 2001; Reeg *et al.,* 2005). A single species of coccidia may be the major pathogen while others contribute to the disease (Radostits *et al.,* 2000). *Eimeria ovinoidalis, E. ovina, E. ahsata and E. parva* are considered highly pathogenic, whereas *E. faurei, E. intricata, E. crandallis and E. weybridgensis* are only moderately pathogenic (O'Callagan *et al.,* 1987). In an experimental infection with *E. ovinoidalis,* Mahmoud *et al.*

(2001) observed reduced appetite, bouts of bloody diarrhea, straining and weakness in infected untreated Najdi lambs in Saudi Arabia.

Faecal oocyst outputs showed high variation among different *Eimeria* species and ages of the animals (Gregory *et al.,* 1983). *Eimeria bakuensis, E. ovinoidalis, E. crandallis and E. weybridgensis* infect the highest proportion of animals in a flock and produce highest oocyst counts. The other species are mostly dominant for short periods only (Gregory *et al.,* 1983; Gregory and Catchpole, 1987; Gauly *et al.,* 2004).

2.5.4 Environmental and Management Factors

The general condition of animal husbandry considerably contributes to the risk of coccidiosis outbreaks (Gauly *et al.,* 2004; Daugschies and Najdrowski, 2005). Straw bedding and high stocking density predispose to a heavy contamination of an environment which is ideal for oocyst survival and rapid sporulation due to suitable temperature and moisture (Berriatua *et al.,* 1994).

The frequency of cleaning the pen is reported to affect the live weight of sheep. Sheep were found to be significantly heavier when the pens are cleaned once a week compared to once a month (Richkowski *et al.,* 2005).

The process of separation at weaning can induce some stress for lambs thereby predisposing them to clinical coccidiosis (Orgeur, 1998). According to Yvore *et al.* (1980), the disease appears mostly under stressful conditions, particularly after weaning.

2.5.5 Transmission

The source of infection is the faeces of clinically affected or carrier animals. Infection is acquired by ingestion of contaminated feed and water or by licking the hair coat infected with faeces (Radostits *et al.,* 2000). Dirty oocysts-contaminated udders of the ewes may also serve as source of infection for lambs within the first days of life (Catchpole and Devonshire, 1989).

Ingestion of sporulated oocysts results in infection but very large numbers must be taken before clinical disease results (Radostits *et al.,* 2000). This level of ingestion usually comes about by continual re-infection and building up the degree of environmental contamination. Ewes play an important role in the transmission of the disease in lambs since they contaminate their environment with oocysts. The increased output of oocysts during the periparturient period enhances environmental contamination (Soulsby, 1986)

thereby, precipitating coccidiosis (Schillhorn van Veen, 1986). Good hygiene reduces the transmission of infection and the prevalence of disease (Foreyt, 1990).

2.6 Pathogenesis

The pathogenesis of coccidiosis is related to the massive invasion and the endogenous development of the coccidian parasites, which usually takes place within specific sites and cells of the gastrointestinal tracts of the host (Taylor and Catchpole, 1994).

Some species are more pathogenic than others (Levine, 1985; Taylor and Catchpole, 1994); therefore, pathological changes will vary with the species of *Eimeria* and section of the intestine infected. Coccidia that invade the large intestine are more likely to cause pathological changes because the rate of cellular turnover is much less than in the small intestine (Taylor and Catchpole, 1994).

Damage to the host cell is primarily that of cell disruption caused by stages of the parasites invading and destroying cells (Foreyt, 1990). The second generation schizogony and gametogony are the stages of the life cycle which

cause functional and structural lesions in the large intestine (Radostits *et al.*, 2000).

As the second generation schizonts and gamonts mature, the cells containing them slough from the basement membrane and cause haemorrage and destruction of the caecum, colon and distal parts of the ileum resulting in diarrhoea (Lotze, 1952; 1953). When sudden epithelial loss does occur, exudate, electrolytes and proteins pour into the lumen from the denuded areas. Coagulation of these proteins sometimes forms pipe-like casts which are passed in the faeces (Taylor and Catchpole, 1994).

2.7 Clinical coccidiosis

In the majority of hosts the parasite co-exists causing minimal damage. Clinical eimeriosis occurs if the host is subjected to heavy infection or if its resistance is lowered (Taylor, 1995). All age groups are susceptible to infection, but disease outbreaks are usually restricted to younger animals (Taylor and Catchpole, 1994).

Gregory and Catchpole (1989) showed that susceptibility of lambs to *E. ovinoidalis* and *E. crandallis* increases progressively up to at least 4 weeks of age. Depending on the rearing conditions, lambs are mostly affected with

clinical eimeriosis around 6 weeks of age or when animals are moved to feed lot (Foreyt, 1990, Gregory, 1990). According to Yvore *et al.* (1980), the disease appears mostly under stressful conditions particularly after weaning. Clinically affected animals show diarrhoea, abdominal pain and anorexia (Gregory and Catchpole, 1990). Other signs include lassitude, loss of weight, blanching of skin and subnormal temperatures before death (Mahrt and Sherrick 1965; Pout, 1974). Mortality is variable and may reach 10% (Soulsby, 1986)

In groups of lambs raised and fed under intensive management system the major clinical findings may be low growth rate, gradual onset of weakness, inappetence, recumbency, emaciation and death with a course of 1-3 weeks. The diarrhoea may escape cursory examination of the animals, but clinical examination of the affected lambs reveals a perineum smudged with faeces, and soft faeces in the rectum.

2.8 Diagnosis

Intestinal coccidiosis can be diagnosed in live animals based on history, observation of clinical signs and demonstration of oocysts of the pathogenic species by an experienced diagnostician in diarrhoeic faeces (Levine, 1985;

Foreyt, 1990). Coccidial oocysts are very commonly found in livestock and only large numbers (5,000-10,000 per gram of faeces) in association with relevant signs have diagnostic value (Barriga, 1997).

Oocysts counts on their own are not reliable because healthy animals can pass large numbers of oocysts per gram (opg) of faeces; animals can die of coccidiosis before any oocysts are shed; oocysts output can be transient, so an animal that is dying of coccidiosis may shed very few oocysts (Taylor and Catchpole, 1994).

Direct faecal smear may be used for detection of oocysts in faeces. This is done by mixing a small quantity of faeces, about the size of a match stick head, with a few drops of tap water or normal saline using an applicator on a clean glass slide until a transparent homogenous mixture is formed, and cover-slipped. The slide is mounted on a light microscope and observed under low objectives. However, the reliable methods for oocysts detection are concentration/floatation techniques using saturated sugar, sodium chloride and magnesium sulphate solution (Foreyt, 2001).

At necropsy, observed gross changes (congestion, haemorrhagic enteritis and thickening of the mucosa), mucosal scrapings and histopathological

sections of the affected regions of the intestine are very valuable aids in diagnosis of intestinal coccidiosis (Levine, 1985; Foreyt, 1990; Radostits *et al.*,2000) where facilities exist. Confirmatory diagnosis of coccidiosis usually depends on microscopic examination of gut section collected during post mortem examination of recently deceased animal (Sargison, 2004). The pathological changes vary with the species concerned (Soulsby, 1986). A descriptive pathology caused by endogenous stages of *E.crandallis* was reported by Gregory and Catchpole (1989), Gregory *et al*. (1987). Gregory *et al.* (1987) described macroscopic patches of intestinal mucosa parasitized by gamonts and oocysts of *Eimeria* spp., which were frequently present in lambs at post- mortem examinations. These discrete lesions were attributed to naturally acquired infections of *E. bakuensis* (syn. *E. ovina*). The lesions were categorized into three: flat oocyst patches, raised oocyst patches and polyps. All three types contained high concentrations of gamonts and oocysts within enterocytes.

An unusual case of ileoileal intussusception associated with coccidiosis has been reported in three year old Iranian ram (Tafti, 1999).

Recently, modern molecular tools such as polymerase chain reaction (PCR) and random applied polymorphic DNA (RAPD) have been employed to

detect and identify coccidia which are important in veterinary and human parasitology (Duzynski and Upton, 2001). These methods may in the near future replace the old traditional methods of identification and diagnosis of coccidia and coccidiosis.

2.9 Immunity

Immunity to coccidiosis in ruminants has been extensively studied in the calves (Daugschies *et al.*,1986; Sevensson *et al.*,1996). Immunity against intestinal coccidiosis appears to have both cellular and humoral components. The degree of immunity depends on the quantity of oocysts picked up during the primary infection; exposure to few or moderate number of oocysts may not deliver the antigenic stimulus necessary to trigger the immune response sufficient to prevent subsequent infection and disease (Conlogue *et al.*, 1984; Burger *et al.*, 1995).

Very young lambs are relatively resistant to infection with a mixture of pathogenic species but susceptibility increases progressively up to at least 4

weeks of age (Gregory and Catchpole, 1989). Lambs inoculated at 4-6 weeks of age develop severe diarrhoea, whereas the same inoculum given at one day of age causes no clinical disease. Early subclincial infection improves the resistance of lambs to later challenge. When lambs receive a relatively heavy inoculation of oocysts during their first week of life they are relatively resistant to pathogenic effect of some coccidia and are able to respond immunologically and are protected from subsequent challenge (Gregory and Catchpole, 1989). This suggests that a challenge with coccidia, before the lamb becomes susceptible to their pathogenic effects, may help to reduce the incidence and severity of clinical coccidiosis later in life (Gregory *et al.,* 1989).

Protective immunity is only of a cellular type, species specific and can break under high infection pressure (Fiege *et al.,* 1992; Hooshmand-Rad *et al.,* 1994). It has been assumed that $CD4^+$ T cells and other lymphoid cells are particularly important in this respect and may be transferred via colostrum to the newborn (Faber *et al.,* 2002). Although activated T cells are not capable of abrogating the parasite life cycle in primary infections the T-cell response may interact with the level and duration of oocysts excretion and may also be related to immunological control of further infections (Hermosilla *et al.,*1999)

Although it is possible to immunize sheep artificially using live unattenuated or precocious strains (as in poultry), the development of commercial vaccine appears difficult. Thus vaccination program is not available as an alternative for treatment currently (Taylor and Catchpole, 1994).

2.10 Control

Sheep live in perpetual contaminated environment, thus exposing young lambs to infection. Control will include the following:

2.10.1 Control through management

Successful economical control will depend on avoiding the overcrowding of animals while they develop immunity to the coccidial species in the environment (Radostits *et al.,* 2000). Lambing pens should be kept dry and bedding disposed of so that oocysts do not have time to sporulate and become infective. All measures which minimize the amount of faecal contamination of the hair coat should be practiced regularly. Feed and water troughs should be high enough to avoid heavy faecal contamination.

In groups of lambs at pasture, the frequent rotation of pasture for parasite control will also assist in the controls of coccidial infection (Radostits *et al.*, 2000).

The control of coccidiosis in lambs brought into a feedlot will again depend on management practice. Management procedures which include establishing optimum stocking density to avoid overcrowding should be practiced; when animals are overcrowded they usually become dirty, there is excessive competition for feed and growth rate is affected (Radostits *et al.* ,2000).

2.10.2 Chemotherapeutic control

Anticoccidial drugs are often used to prevent or minimize effects of clinical disease where managemental manipulations are impracticable or ineffective (Foreyt, 1990; Taylor and Catchpole, 1994).

Many chemotherapeutics have been examined for the control of both experimental and naturally occurring coccidiosis in lambs (Radostits *et al.*, 2000).

To be effective, coccidiostats must be given early in the life cycle of coccidia before any severe damage to the intestinal mucosa occurs (Taylor *et al.*, 2003).

Routine prophylactic medication of the feed and water supplies of lambs with the most economical coccidiostat will usually control the disease and allow the development of effective immunity (Radostits *et al.*, 2000).

Chemotherapeutic agents used in control and prevention of coccidiosis in animals include sulphonamides (sulphanilanide derivatives), monensin and lasalocid (ionophorous antibiotics), amprolium (a thiamine analogue); toltrazuril (a symmetrical triazinone) and diclarzuril (a benzene–acetonitrile) (Foreyt, 1990, Radostits *et al.*, 2000).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study area

The study was carried out in Bauchi state (Figure 4). Bauchi state lies between latitudes $10^{\circ}10^{1}$ to $10^{\circ}\ 33^{1}$N and longitude $9^{\circ}40^{1}$ to $10^{\circ}13^{1}$ E. It has an estimated land area of about 49, 24832 square kilometers with a population figure of about 3, 290, 422.5 (NPC,1996).

Data on major weather elements shows that the state has five months of rainy season (May to September) and seven months of dry season (October to April). BSADP (2003) gave the total annual rainfall as 700-900 mm for Northern Zone, 969-1031 mm for Central Zone and 900-1300 mm for Western Zone. The temperature ranges from 19.15 to 39˚C, the hottest months being March and April while the coolest are February and August. Similarly, August records the highest relative humidity (99%) and February has the lowest (57%) (Anon, 1999).

and east), the vegetation has been reduced to Acacia shrubs due to effect at cultivation and bush burning. Grasses in such deforested areas often reach a height of 3 m or more (Akwuchi, 1990).

Soils in most parts of the state are generally rich in nutrients. In west and southeastern parts of the state the soils are sandy clay and loamy (Inah, 1991)

3.2 Study design

The working hypothesis was that age, management systems, sex, breeds and seasons had no influence on the prevalence of ovine coccidiosis in Bauchi state, Nigeria and that the infection would be randomly distributed. The prevalence of coccidial infection was not well known in the study area, so the sample size was estimated using 90% prevalence rate reported by Fabiyi, (1980) in neighboring Plateau State with a 95% confidence interval (CI) and precision level of 5%:

$n = \frac{z^2(pq)}{d^2}$ where:

n is the sample size, z is the critical value of the standard normal distribution at the 5% level (1.96), p is the coccidial prevalence estimate, q=1-p, and d is the precision level (2%).

The calculated sample size was 866 samples.

3.3 Study population and sample collection

The study, which involved 866 sheep, was carried out in four cross-sectional surveys undertaken in August, 2005; November, 2005; February, 2006 and May, 2006 corresponding to late rainy season, early dry season, late dry season, and early rainy season in the state, respectively. Fresh faecal samples were obtained directly from the rectum using a polythene gloved hand from three institutional farms, which included School of Agriculture, Bauchi; Government Sheep Farm, Misau; and College of Education Farm, Azare; and three other randomly selected private flocks in each of the three towns. Age, sex, breeds, faecal consistency, body conditions and management system were recorded for each animal during the sampling occasions. The animals were divided into three age-groups, namely young (less than 6 months old), immature (6-12 months old), and adult (over 12 months old) sheep as described by Arslan *et al.*, 1999. Ages of the sampled sheep were estimated by their dentition (Aiello and Mays, 1998) as age records were not available. Faecal consistency was scored (1: pellets, 2: semi-pellets 3: soft 4: watery, 5: with blood or mucus) as described by Platzer *et al.,* 2005. The breeds identified were Yankasa, Balami, Uda and their crosses.

Body conditions were scored as follows: (1: very poor, 2: poor, 3: good, 4: fatty, 5: grossly fatty) as described by Thompson and Mayer (1994). Three

management systems were recognized: extensive, semi-intensive and intensive.

3.4. Faecal examinations

The samples were conveyed on ice blocks to the Helminthology Research Laboratory of the Department of Veterinary Parasitology and Entomology, Ahmadu Bello University, Zaria, for processing. Samples were refrigerated at 4^{o}C until examined (generally within 2 weeks) to maintain the integrity of the oocysts (Duszynski and Wilber, 1997).

The presence and number of faecal oocysts were determined using the modified McMaster technique (Taylor *et al*., 1995) with saturated sodium chloride solution (400 NaCl, 1000 ml distilled water; specific gravity 1.18 – 1.2) as the floatation fluid.

A 2 g portion of faecal material was mixed thoroughly with 30 ml of water in a universal bottle and centrifuged at 500 *g* for 10 min. The supernatant was discarded and the sediment resuspended in 12 ml of the floatation medium and mixed thoroughly. The suspension was then centrifuged at 500 *g* for 5-10 min. The supernatant was decanted into another bottle and stored

at 4^{o}C. To determine the number of oocysts per gram (opg), a small amount of the sample was aliquoted into the chambers of a McMaster slide and examined under the microscope at 400 x magnification. The number obtained from both chambers was multiplied by a factor of 20 to obtain the opg.

Speciation of oocysts

Samples with 2000 opg were thoroughly mixed with at least 20x their volume of an aqueous potassium dichromate (2.5% w/v) solution, placed in thin layers in Petri dishes to allow aeration of the oocysts and allowed to sporulate for 7-10 days at room temperature (24^{o}C to 33^{o}C) as described by Adefolabi and Chiejina, 1987; Harper and Penzorn, 1999).

Samples were stored at 4^{o}C to maintain the integrity of the oocysts, but were usually examined within 1-2 weeks (Duszynski and Wilber, 1997).

To retrieve and concentrate oocysts, the dichromate solution was centrifuged at 300 *g* for 10 min and the supernatant discarded (Harper and Penzorn, 1999). The sediment was placed into faecalyzer tube which was filled with modified Sheather's sugar solution (sp. gravity 1.2) until a positive meniscus has formed. A cover slip was placed on the faecalyzer tube, allowing 10

min for oocysts to float unto the cover slip. The cover slip was removed carefully in a vertical manner, placed on a microscope slide and the edges sealed with clear nail polish (Harper and Penzorn, 1999). The slide was scanned in parallel sweeps and the first 100 oocysts seen (all if less were present) were identified. Measurements were made with an ocular eyepiece, calibrated with a micrometer, under a 40 x objective (magnification factor x 3.75). Species identification was based on descriptions and illustrations by MAFF (1986). .

3.6 **Data analysis**

Along with descriptive statistics, chi-square test and Fisher's exact test were performed to compare prevalence and intensities of coccidial oocysts excretion with age, breed, sex, and management system as variables. Spearman's rank correlation test was used to determine correlations between oocyst excretion intensity and clinical parameters. All data were entered into a Microsoft Access database and statistical valuations were computed by using SPSS version 10.0 program (SPSS Inc. Chicago, IL, USA). A p value < 0.05 was considered statistically significant.

CHAPTER FOUR

4.0 RESULTS

4.1 Prevalence of coccidial infections

4.1.1 Prevalence of ovine coccidial infection by location in Bauchi state

The prevalence of coccidial infection among sheep in Bauchi, Misau and Azare are presented in Table 1.

. Of the 851 animals examined, 78.3% were positive for coccidial infections. Misau had the highest rate of 79.2%, followed by Bauchi 78.9% and Azare (76.6%)

4.1.2 Prevalence of coccidial infections in four breeds of sheep in Bauchi state

Prevalence of oocysts in the four breeds of sheep identified in Bauchi state is presented in Table 2. There was no significant difference ($p>0.05$) in the prevalence of coccidial infections among the various breeds of sheep studied.

Table 1: Prevalence of coccidial infection in sheep in three locations in

Bauchi State

Location	No. of animals sampled	No. of positive samples	% of positive samples
Misau	312	247	79.2
Bauchi	265	209	78.9
Azare	274	210	76.6
Total	851	666	78.3

4.1.3 Prevalence of coccidial infection in sheep in Bauchi state by sex

There was no significant difference in the sex distribution of coccidial infection in the sampled population (Table 3).

4.1.4 Prevalence of coccidial infections in sheep in Bauchi state by age

The prevalence of coccidial infection among the various age groups is depicted in Figure 5. The adult and the immature sheep were significantly more infected by the young ones.

4.1.5 Prevalence of coccidial infections in sheep by management systems.

The prevalence of coccidial infections in the sheep by management system is shown in Table 4. The extensive management system has the highest prevalence rate of 81.4% followed by semi intensive management system. The differences were not statistically significant ($p > 0.05$).

4.1.6 Prevalence of ovine *Eimeria* species in Bauchi State

One hundred and eight faecal samples which had more than 2000 oocysts per gram (opg) were sporulated for speciation. Eight species of *Eimeria* were identified in this study. Their prevalences in the various age groups of sheep are presented in Table 5.

Table 2: Prevalence of coccidial infections in sheep in Bauchi state by breed

Breeds	No. of animals sampled	No. of positive samples	% of positive samples
Cross	135	112	83.0
Yankasa	514	405	78.8
Balami	165	123	74.5
Uda	37	26	70.3
Total	851	666	78.3

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Table 3: Prevalence of coccidial infections in sheep in Bauchi state by sex.

Sex	No. of animals	No. of positive	% of positive

	sampled	samples	samples
Male	370	301	81.4
Female	481	365	75.9
Total	851	666	78.3

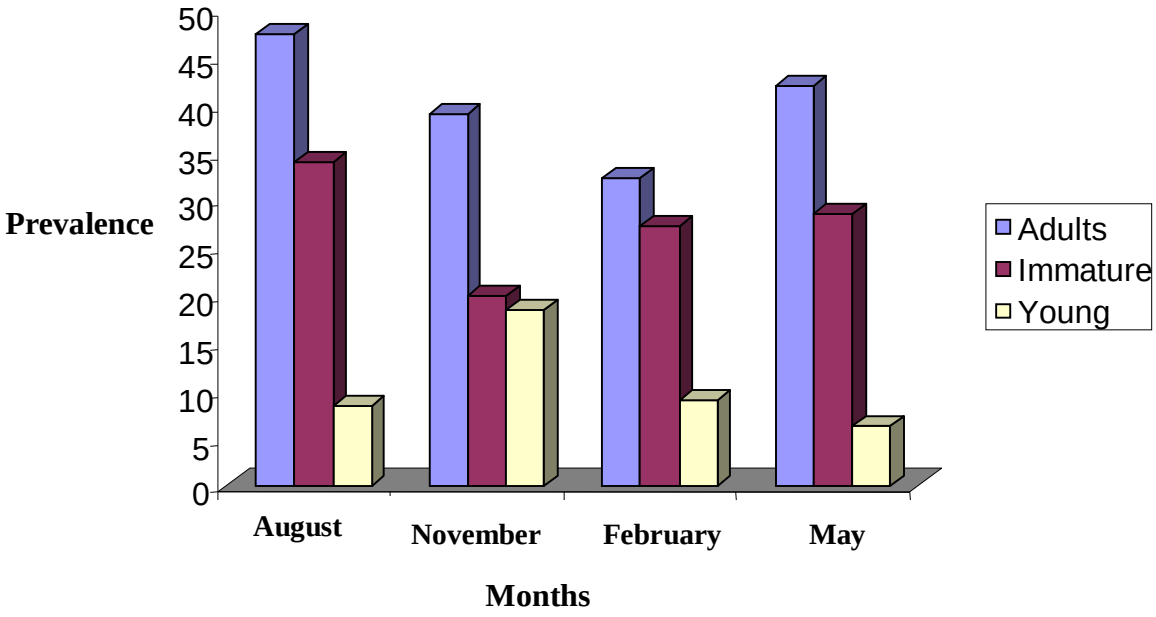

Fig. 5: Prevalence of coccidial infections in sheep in Bauchi state by age.

Table 4: Prevalence rate of coccidial infections in sheep in Bauchi state by management systems

Management Systems	No. of animals sampled	No. of animals positive	% of animals positive
Extensive	86	70	81.4
Semi intensive	528	418	79.2
Intensive	237	178	75.1
Total	851	666	78.3

Table 5: Frequency of occurrence of *Eimeria* species in sheep in Bauchi State

Species of *Eimeria*	Young n (%)	Immature n (%)	Adults n (%)	Total n (%)
Eimeria ovinoidalis	22 (64.7)	36 (73.5)	20 (80.0)	78 (72.22)
E. bakuensis	18 (52.9)	30 (61.2)	16 (62.7)	64 (59.25)
E. parva	12 (35.3)	28 (57.1)	15 (60.0)	55 (50.93)
E. ahsata	8 (23.5)	19 (38.7)	13 (52.0)	40 (37.03)
E. faurei	7 (20.6)	14 (28.6)	10 (40.0)	40 (37.03)
E. granulosa	7 (20.6)	9 (18.4)	9 (36.0)	25 (23.15)
E. pallida	2 (5.8)	6 (12.2)	4 (16.0)	12 (11.11)
E. intricata	2 (5.8)	6 (12.2)	3 (12.0)	11 (10.19)

n = number of positive sporulated samples examined.

4.2 The effect of age, sex, breed, and management system on the rate oocysts excretion in sheep

4.2.1 The distribution of ovine coccidial oocyst excretion rate by age

The oocyst burden according to age is presented in Table 6. More young stock were excreting a higher number of oocysts compared to adults.

4.2.2 The distribution of ovine coccidial oocyst excretion rate by sex

The frequency distribution of oocyst per gramme of faeces is presented in Table 7. More females (3%) were shedding oocysts > 5000 than males (2%) although the difference was not statistically significant ($p > 0.05$).

4.2.3 Distribution of oocysts excretion rate by season

Higher oocysts excretion rate was recorded for rainy season than the dry season. Oocysts burden > 5000 opg were detected in 4.4% of animals in the rainy season compared with 0.6% for dry season, as presented in Table 8.

Table 6: Variations of opg in various age groups of sheep in Bauchi state

	Age group					
Range of oocyst	Young		Immature		Adults	
per gram	No.	%	No.	%	No.	%
Up to 1000	26	3.9	138	20.7	260	42.0
1001-2000	31	4.7	51	7.7	38	5.7
2001-3000	16	3.4	23	3.5	14	2.1
3001-4000	3	0.5	3	0.5	1	0.2
4001-5000	3	0.5	6	0.9	0	0
> 5000	10	1.5	13	2.0	10	1.5

Table 7: Variations in oocysts excretion rate in relation to sex in sheep.

Range of oocyst	Male	Female	Total

per gram	n	%	n	%	n	%
Up to 1000	190	28.5	254	38.1	444	66.7
1001-2000	59	8.9	61	9.2	120	18.0
2001-3000	29	4.4	24	3.6	53	8.0
3001-4000	4	0.6	3	0.5	7	1.1
4001-5000	6	0.9	3	0.5	9	1.4
> 5000	13	2.0	20	3.0	33	5.0

Table 8: Opg variations in relation to season in sheep in Bauchi state.

	Season of year	
Range of oocyst per gram	Rainy season %	Dry season %
Up to 1000	33.8	32.9
1001-2000	9.8	8.3
2001-3000	5.3	2.7
3001-4000	0.8	0.4
4001-5000	0.9	0.5
> 5000	4.4	0.6

4.2.4 The distribution of ovine coccidial occysts excretion rate by management systems

Considering the distribution of opg by management systems, majority of sheep shedded less than 2000 opg in all the management systems. Oocyst distributions were 2.1%, 1.5%, and 1.4% in semi-intensive, intensive and extensive management systems, respectively (Table 9). However, the differences were not statistically significant ($p > 0.05$).

4.3 Correlation between oocyst counts and clinical parameters

Significant correlation was found between faecal oocyst count and faecal consistency score but oocyst count and body condition score showed significantly negative correlation ($rs = -0.152$ $p < 0.05$) as presented in Table 10.

Table 9: The distribution of ovine coccidial opg in Bauchi state by management systems

Range of oocyst per gram	Management systems					
	Extensive		Intensive		Semi-intensive	
	n	%	n	%	n	%
Up to 1000	39	5.9	115	17.3	290	43.5
1001-2000	15	2.3	30	4.5	75	11.3
2001-3000	5	0.8	19	2.9	29	4.4
3001-4000	1	0.2	3	0.5	3	0.5
4001-5000	1	0.2	1	0.2	7	1.1
>5000	9	1.0	10	1.5	14	2.1

Table 10: Correlation between oocyst counts and clinical parameters

Parameter	rs
Facal consistency score	0.182**

Body condition score	-0.152**

rs = Spearman’s rank correlation coefficient

CHAPTER FIVE

5.0 DISCUSSION

Coccidial infection is widespread and common among sheep in Bauchi state as revealed by the high prevalence obtained in this study. This observation is in accordance with other studies in Nigeria (Fabiyi, 1980; Chiejina and Adefolabi 1987; Adewuyi *et al*., 1989).

The almost identical prevalence for all the three locations where samples were obtained may be explained by the similarity of the climatic conditions that are experienced in these towns as well as in management systems. All the breeds identified in the study had similar prevalence .This may suggest that all breeds of sheep encountered in this study, are equally susceptible to coccidial infection. The prevalence was almost identical in both male and female possibly as a result of similarity in exposure rate and susceptibility.

Although all age-groups were infected, the adults had the highest prevalence. Similar findings had been reported by Chiejina and Adefolabi (1987) in Southeastern Nigeria, and in Europe (Platzer *et al*., 2005). The pre-weaned animals had the least prevalence rate contrary to the findings of Arslan *et al*. (1999) in Turkey. Unweaned lambs are generally much less exposed to infectious oocysts since teats of ewes, the only source of

infection before weaning, are less liable to contamination by sporulated oocysts than the pasture grazed by the immature after weaning. The immature are moderately infected because they are spared of the stress of early weaning as practiced in the developed countries. Furthermore, weaned lambs are not usually crowded in feedlots as the case elsewhere (Adewuyi *et al*., 1989).

In contrast to the findings of Adewuyi *et al*. (1989) the prevalence was highest in the extensive system of management than in the intensive and semi-intensive systems. A possible explanation to this is that in the extensive system, grazing is not supplemented making the animals poorly nourished. Well nourished animals fight infection readily than the poorly nourished ones (Taylor and Catchpole, 1994).

In the present study, 8 ovine *Eimeria* spp were identified in Bauchi state which corresponds to the findings in Jos, Plateau State (Fabiyi 1980), except that *Eimeria crandallis* was not encountered in this study.

The identification of species of *Eimeria* based upon oocyst characteristics is difficult. Some difficulties were encountered in differentiating the oocysts due to overlap in sizes and shapes of some species especially dislodgement

of micropylar cap and distortion in the course of the study. Similar observations were earlier made by Duszynski and Wilber (1997).

The measurements and descriptions of the *Eimeria* spp. identified in this study agreed with those previously reported studies (Majaro and Dipeolu, 1981).

Since two known pathogenic species which affect sheep have been identified in this investigation, infected sheep can be potential carriers and sources of infection to susceptible sheep.

The high output of coccidial oocysts in the young and immature concurs with the findings of Arslan *et al*. (1999). The young and the immature sheep might not have developed immunity to infection and the stress of weaning makes the animals more susceptible to infection which in turn, results in high oocysts output. Although male and female animals had broadly similar faecal oocysts output, available evidence suggest that under field conditions breeding females are epidemiologically more important than the males (Gregory et al., 1980). Nuvor *et al*. (1988) observed higher occysts output in ewes than gimmers. Higher oocysts burden was detected more in the rainy season than in the dry season. During the rainy season, the high

environmental temperature and high relative humidity and of precipitation provide adequate conditions for effective sporulation of oocysts. In the presence of oxygen, adequate moisture and optimum temperature, sporulation would occur (Nuvor *et al.,* 1988), hence high faecal oocysts count is likely to occur in the rainy season. In the dry season, relatively few coccidial oocysts were excreted. In addition, continuous increase in the temperature, low the relative humidity and little precipitation. Usually inhibit sporulation and deaths of oocysts (Soulsby, 1986).

There was almost identical oocyst output for all the systems. The generally low and variable rates of exposure to infection associated with extensive systems of management such as nomadic and some other traditional methods of sheep husbandry might also have contributed to the low oocysts output. This may be due to the dissemination of oocysts which could occur over a large territory under such systems of management, resulting in relatively low infection pressure. Overcrowding is a predisposing factor in animals to coccidiosis (Radostits *et al*., 2000). No breed susceptibility to Coccidial has been established in sheep although heritability study on resistance to infection in Rhon lambs indicated some degree of resistance to coccidial infections (Gauly *et al*., 2001).

The negative correlation between body condition score and oocysts output that was observed means coccidiosis is a cause of poor body condition in sheep. Poor growth rate and low production are signs of coccidiosis in sheep (Radostits *et al*, 2000).

CHAPTER SIX

6.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

Eight hundred and sixty six (866) faecal samples were collected in four cross sectional surveys in twelve selected farms in Bauchi, Misau, and Azare

towns in Bauchi state. The sampling period coincided with late rainy season, early dry season, late dry season, and early rainy season of 2005 and 2006.

The feacal samples were processed by the modified McMaster technique to determine the presence and number of faecal cocysts. Samples with more than 2000 opg were sporulated for specification of the *Eimeria* parasites.

Coccidial infections were relatively common with 78. 3% of all the animals positive for the infection. Significantly ($p< 0.05$) higher prevalence was observed in the rainy season than the dry season. Adults significantly ($p< 0.05$) showed high prevalence than the young and immature sheep. There were no significant ($p> 0.05$) differences between the prevalence in relation to location, breed and sex.

Occyst counts were not significantly ($p>0.05$) influenced by sex, breed and management systems. The young and immature sheep were significantly ($p<0.05$) excreting higher number of oocysts than the adults.

Eight *Eimeria* species were identified in this study. The most prevalent were *E. bakuensis* found in 80% of the adult animals, *E ovinoidalis* (62.7%), *E. parva* (60%), and *E. ahsata.* (52.0%). The other species were *E. faurei, E*

granulosa, E. pallida, and E intricata, found in 40%, 36%, 16% and 12% of the samples, respectively.

There was a significantly negative correlation ($rs = -0.152$, $p < 0.05$) between oocyst counts and body condition score.

6.2 Conclusions

This study indicated that there is high prevalence of coccidial infections among sheep in Bauchi state. The presence of pathogenic *Eimeria* spp affecting sheep has been identified in this study. It signifies that infected sheep can be potential carriers and a source of infection to susceptible animals. In addition, the high rate of coccidial oocysts output observed in some instances may negatively influence the weight gain of sheep especially when poor management, poor feeding and unhygienic conditions prevail as observed in some farms during collection of samples.

6.3 Recommendations

From this study, the following recommendations are prescribed:

1. Advanced tools for *Eimeria* differentiation such as molecular methods which are not yet available for routine diagnosis should be developed.

2. Sheep intended for research should be treated against coccidiosis before commencement of study.
3. Special attention should be given to sheep lambed during the rainy seasons as severe infections occur during this period.

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APPENDIX 1: Classification of *Eimeria*

Phylum: APICOMPLEXA Levine, 1970

Class: CONOIDASIDA Levine, 1988

Subclass: COCCIDIOSINA Leukart, 1879

Order: EUCOCCIDORIDA Leger and Duboscq, 1910

Suborder: EIMERIORINA Leger, 1911

Family: EIMERIIDAE, Minchin, 1903

Genus: *Eimeria* Schneider, 1875

(Source: Soulsby, 1986; Duszynsky and Upton, 2001).

APPENDIX 2: Morphological characteristic of ovine coccidial oocysts

Species	Average oocyst dimension (microns)	Characters of oocyst
E. ahsata	39x25	Ellipsoidal, with prominent polar cap Yellowish-brown.
E. ovina	31x 20	Ellipsoidal, with polar cap. Pale yellowish-brown.
E. crandallis	24x 17	Broadly ellipsoidal to subspherical, with or broad, Average. 11 x7 microns.
E. faurei	29x21	Ovoidal, distinct mircopyle at narrow end. Pale yellowish-brown.
E. granulosa	29x 21	Pear-shaped with large polar cap on broad end; yellowish-brown.
E. intricata	47x32	Elliposoidal. Thick brown wall, transversely striated; polar cap.
E. ovinoidalis	23x18	Ellipsoidal; micropylle barely perceptible; thin walled; colourless.
E. pallida	14x10	Ellipsoidal; very thin-walled. Pale yellow.
E. parva	16x14	Spherical to subspherical. Colourless; characteristics crystalline appearance.
E. marsica	19x13	Ellipsoidal with inconspicuous polar cap; colourless ord pale yellow.
E. weybridgensis	24x17	Broadly ellipsoidal to subspherical, with or without a shallow polar ca. sporocysts elongate, Average. 14 x7 microns.

(Source: MAFF, 1986)