PREVALENCE OF COCCIDIAL INFECTIONS AMONG SHEEP FLOCKS IN ZARIA AND OBSERVATIONS ON RAISING COCCIDIA-FREE LAMBS

BY

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A thesis submitted to the Ahmadu Bello University, Zaria, in partial fulfilment of the requirement for the degree of Master of Science.

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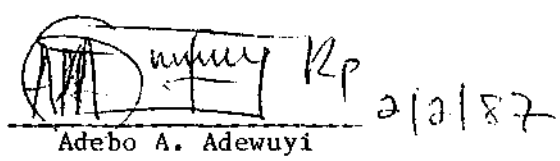
DECLARATION

The work presented in this thesis is original and was carried out by me under the supervision of Dr. A. Sannusi, Dr. (Mrs) E. K. Kyewalabye and Prof. O. O. Akerejola in the Laboratories of the Department of Veterinary Parasitoloty and Entomology and National Animal Production Research Institute, Ahmadu Bello University, Zaria.

Reference is made to the work of other investigators and duely acknowledged. No part of this thesis has previously been submitted for a degree or diploma.



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CERTIFICATION

This thesis entitled *Prevalence of coccidial infections among sheep flocks in Zaria and observations on raising coccidia-free lambs* by Adebo A. Adewuyi meets the regulations governing the award of the degree of Master of Science of Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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ABSTRACT

A survey of ovine faecal coccidia was carried out in four farms in Zaria area in order to assess the seasonal and age distributions of coccidial infections under the prevailing husbandry practices. Twenty per cent of the sheep population in each farm were sampled twice during the pre-rainy (April - June), rainy (July - September), pre-dry (October - December) and dry (January - March) seasons. The same animals were sampled throughout the study period. The faecal examinations revealed that varying percentages of sheep in the flocks were shedding coccidia oocysts during the seasons. However, high prevalence of coccidia oocysts was recorded during the rainy and pre-dry seasons. Differences in prevalence of coccidia were found for different age groups. The highest prevalence figure was recorded in the seven to fifteen months old age group. The findings of this study indicate that coccidial infections are important in intensively reared sheep flocks in Zaria area. This could assume economic importance during the rainy and pre-dry seasons and among the weaner lambs.

Two sets of cages were designed and constructed for experimental rearing of coccidia-free lambs. The details of the construction were described. Six Yankasa and six Uda lambs removed from their dams within 6 hours of birth were used. The lambs were reared free of coccidia for a period of nine weeks. However, patent infection became apparent by the 13th week involving two Uda lambs which died in the 15th

week. The experiment was terminated at the 17th week. This study showed that it is possible to raise coccidia-free lambs in this environment. It is recommended that coccidia-free lambs should be used for the purpose for which they are reared within 5 to 10 weeks using our rearing conditions.

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CHAPTER 1

1.1 GENERAL INTRODUCTION

The application of Intensive and Semi-intensive husbandry systems of sheep production has been found to predispose sheep flocks to coccidiosis (Fitzgerald and Mansfield, 1978; Foreyt et al., 1979). In these husbandry systems routine antihelmintic administration eliminates parasitic gastro-enteritis as a cause of unthriftiness in confinement - reared sheep. The research efforts at controlling the coccidia which remain as a cause of the unthriftiness was reviewed by Gregory et al. (1982). As a general rule, coccidiosis is not an important problem in range sheep which are not likely to be herded in the same area for any length of time.

Coccidia oocysts have been recovered from the faeces of lambs as early as second week of life (Pout et al., 1966). The oocyst numbers reached a peak at 8 to 12 weeks of age and later declined to the same level as the adult animals at about 24 weeks of age. However, the pre-lambing, and post-lambing ewes have been found to discharge large numbers of oocysts in their faeces, thus becoming sources of infection and re-infection to other animals in the flock (Pout, 1974).

The epidemiology of natural coccidial infections in sheep at range has been described in European breeds of sheep (Michael and Probert, 1970; Chapman et al., 1973; Pout, 1973; Ajayi and Todd, 1977a). The prevalence of the disease in feedlot lambs was described in the literature by

several authors including Christensen (1941).

In tropical Africa, there is scanty information on ovine coccidiosis. The little available information is on epidemiological studies (Fabiyi, 1980; Majaro and Dipeolu, 1981; and Vercruysee, 1982). In these studies the authors based their results on descriptions of species of Eimeria and coccidial oocysts burden in the faeces of sheep of unknown management on only one occasion. In a case where the oocysts burden was related to seasons (Majaro and Dipeolu, 1981), trade sheep were sampled, which were not resident in the zone of sampling.

The objectives of the present study are to provide more information on:

(a) Incidence of coccidial infections in sheep flocks in the northern guinea savanna zone of Nigeria, in relation to season, age and management types.

(b) Raising of coccidia-free lambs under our experimental conditions.

CHAPTER 2

2.1 REVIEW OF OVINE COCCIDIAL INFECTION

2.1.1 Introduction

Ovine coccidiosis is a common infection of sheep, which becomes clinical under circumstances such as where sheep are kept in large numbers (Newson and Cross, 1930; Deem and Thorp, 1940; Baker et al., 1972). Clinical manifestation of coccidiosis is characterised by diarrhea, dehydration, loss of appetite and body weight.

Variable numbers of species of Eimeria are present in sheep. Eleven species of Eimeria have been studied closely and four were found pathogenic in sheep. These include Eimeria nina kohlyakimovae, E. arloingi, E. faurei and E. crandallis (Lotze, 1952, 1953a; 1953b and Pout, 1965).

Although clinical coccidiosis sometimes occurs in sheep in Nigeria, there is no recommended control programme as is practised in the Poultry Industry. However, some drugs are available in the market for prophylactic and therapeutic treatment of ovine coccidiosis (Gregory et al., 1982).

The purpose of this review is to examine the literature of ovine coccidiosis in order to evaluate the status of the disease in Nigerian breeds of sheep.

2.1.2 The Parasite

Eimeria is a genus of the family Eimariidae, a division of the order Eucoccidiorida which is a member of the class Sporozoa (Levine, 1973). The parasite has a world wide

distribution.

A total of sixteen species of Eimeria exist in the literature, but eleven species have been closely studied. These include Eimeria faurei, E. arloingi, E. parva, E. ahsata, E. ninakohlyakimovae, E. crandallis, E. pallida, E. granulosa, E. intricate, E. punctata, and E. Ovina (Levine, 1962; Shah, 1963; Fabiyi, 1980; Fayer, 1980; and Vercruysee, 1982).

The identification of species of Eimeria in sheep is based on the morphological characteristics of the unsporulated and sporulated oocysts such as colour, shape, size and presence or absence of micropylar cap. Other criteria include prepatent period, sporulation time and site of lesion in the intestine (Shah, 1963; Pout, 1965; Catchpole, et al., 1975). The detailed description of these species are summarized in Table 1.

2.1.3 Factors affecting survival and infectivity of oocysts

Three factors known to affect the infectivity and survival time of coccidia oocysts are humidity, temperature and oxygenation. Oocysts discharged in the faeces are unsporulated and not infective, until after undergoing exogenous development at suitable temperatures and relative humidity. Long (1980) reported that sporulation process takes place at temperatures between 12-39^{o}C, the optimum temperatures being between 29-31^{o}C. Low temperatures apparently are not detrimental because oocysts are still

Table 1. Characteristics of Oocysts of Eimeria occurring in sheep

Species and structure	Size (microns)	Prepatent period (days)	Sporulation time (hours)	Reference	Shape index
Eimeria ahsata					
Ellipsoidal or ovoid, micropyle present, micropyle has a cap. No residual body. Wall smooth, double layered, pink, yellowish or brown colour, Polar granules present.	29-44 by 17-29	18-21	36-72	Levine et al (1962)	1.1-1.5
Eimeria crandallis					
Spherical to ellipsoidal, narrow micropylar end with a cap. Broadly ovoid sporocysts. Polar granules presenc.	18-26 by 15-20	15-20	24-72	Lenine et al (1962)	1.2-1.3
Eimeria granulosa					
Piriform, ellipsoidal, micropyle has a cap at the broad end.	23-37 by 17-26	11-15	72-96	Shah (1963)	1.3-1.4
Eimeria intricata					
Largest oocysts of all ovine Eimeria. Ellipsoidal or slightly ovoid. Oocyst wall is thick, opaque and striated, brown in colour and pronounced polar cap present.	39-59 by 27-47	20-27	72-120	Shah (1963)	1.2-1.4
Eimeria ninakohylakimovae					
Ellipsoidal or sub-spherical to ovoid. Micropyle has no cap.	16-28 by 14-23	11-15	24-96	Levine and Ivens (1970)	1.1-1.2

Table 1. (continued)

Species and structure	Size (microns)	Prepatent period (days)	Sporulation time (hours)	Reference	Shape index
Eimeria ovina					
Ellipsoidal to ovoid with straight sides. Slightly flattened at micropylar end. Micropyle has a cap.	23-36 by 16-24	19-21	48-96	Shah (1963)	1.4-1.5
Eimeria pallida					
Ellipsoidal, two layered smooth and colourless wall. Micropyle has no cap.	12-20 by 8-15	11-15	24-96	Shah (1963)	1.3-1.5
Eimeria parva					
Spherical, ovoid, ellipsoidal or subspherical. Two layered wall. Microphyle inconspicuous and no cap.	12-23 by 10-19	11-15	24-48	Levin (1973)	1.2
Eimeria punctata					
Ellipsoidal or subspherical to ovoid. Slightly flattened at micropylar end. Microphyle has no cap.	18-26 by 16-21	10-13	36-48	Landers (1952) Shah (1963)	1.1-1.2
Eimeria arloingi					
Ellipsoidal or slightly ovoid, slightly flattened at micro- phyle end. Two smoothh layered wall. Sporocyst truncated at one Microphyle has no cap.	23-26 by 16-26	20-21	24-48	Levin et al. (1952) Lotze (1953a)	1.0-1.4
Eimeria faurei					
Ovoid, microphylar end is narrow and slightly flattened. Micropyle inconspicous, no cap.	25-36 by 19-28	9-10	24-96	Levine (1973)	1.3

highly infective after the lowest winter temperatures (Fayer, 1980). At temperatures below 12°C, there is a temporary inhibition of sporulation. Sporulation continues when the ambient temperatures rise to above 12°C. Unsporulated oocysts held at 8°C for eight weeks were still able to sporulate when returned to optimum temperature (Long, 1980). Temperatures of 35°C and above inhibit or reduce sporulation of the oocysts in sheep (Marquardt, 1960).

The importance of adequate moisture was indicated by Ellis (1938). He noted that at constant temperatures, oocysts of E. tenella were killed by decrease in relative humidity. The survival and infectivity of the oocysts in the faeces were tested at 19, 37, 58 and 80 per cent relative humidity. Goodrich (1944) found that the outer membrane of oocysts in impervious to fluid, but is easily fractured by drying. The studies on survival of oocysts under natural conditions by Fayer (1980), show 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. Coccidia oocysts survive in aerobic conditions.

2.2 PREDISPOSING FACTORS TO OVINE COCCIDIAL INFECTIONS

Incidence of ovine coccidiosis is influenced by the host and management factors. The host factors include age,

stress, nutritional status, intercurrent infections and immune status of the animal. The management factors are confinement, stocking density and hygiene.

2.2.1 Host factors

Young animals are more susceptible to coccidial infection than the adults. Irrespective of husbandry system, young lambs are found to discharge more numbers of coccidia oocysts in their faeces than the adult sheep. Pout et al., (1966) examined at weekly intervals, faecal samples from a flock of lambs and their ewes from the second to the 20th week of age. They found coccidia oocysts in the faeces of lambs at two weeks old. The peak of oocysts production was reached at 8-12 weeks of age. Thereafter the oocysts numbers declined, and by the time the lambs were 24 weeks old the oocysts counts were at the same level as the adult ewes. Joyner et al. (1966) also found higher faecal oocysts burden in lambs than the older sheep they sampled.

Animals that had recovered from infection with Eimeria are frequently resistant to re-infection. This has been shown by Chapman (1974). He found that lambs that showed peak oocysts production or 50,000 oocysts per gramme of faeces failed to produce clinical coccidiosis when challenged with 100,000 sporulated oocysts prepared from field infection. The author administered bethamethasone to lambs at 10 mg per lamb over a period of time to suppress immune response of the lambs. He obtained increase in oocysts numbers and reduction in weight gain in the treated

lambs. Shumard (1959) challenged lambs which had been experimentally infected previously with a mixed inoculum of species of Eimeria and found no death as a result of the challenge.

2.2.2 Management factors

Under the intensive and semi-intensive husbandry systems, coccidiosis may become a problem. In an investigation into the aetiology of outbreaks of diarrhea in intensive indoor reared lambs in England, Taylor et al. (1973) found that diarrhea was caused by E. ninakohlyakimovae and E. arloingi. The outbreaks occurred among lambs kept on solid floors covered with straw bedding, whereas those on raised metal floors without bedding were not affected.

In Jos Plateau of Nigeria, Fabiyi (1980) observed clinical coccidiosis in sheep tethered and in which feeds were offered on the floor.

The type of feed fed to lambs predispose them to clinical coccidiosis evidenced by severe scouring. Deem and Thorp (1940) found that lambs fed beet tops and straw showed more scouring than those fed alfalfa hay. Pout and Catchpole (1974) showed that diet has an effect on the response of lambs to coccidial infections. Some coccidia-free lambs on low and high planes of nutrition were infected with a mixture of species of Eimeria. Those lambs on the high plane of nutrition differed from those on the low plane

of nutrition in the pattern of response to the infection. The latter showed an earlier commencement of oocysts production, high oocysts output and longer period of severe diarrhea than the former.

In the extensive system of management the clinical disease is seldom encountered except where animals congregate in large numbers as may occur around water points, and under inadequate housing. Pout and Harbutt (1968) examined sheep for coccidiosis at different stocking rate and found that those lambs stocked at higher rate showed poorer performance and unthriftiness. Over crowding of pastured animals on irrigated pasture or around surface water holes in draught conditions may also predispose them to coccidial infection (Blood et al., 1979).

In New Zealand, a serious outbreak of coccidiosis was described by Salisbury et al. (1953) on a highly improved pasture in which stocking rate was incriminated.

Where animals are raised extensively and fattened intensively in feedlots as in America, Britain and Australia, coccidiosis becomes a problem. Seddon (1952) in Australia, Levine (1961) and Mahrt and Sherrick (1965) in America reported outbreak of clinical coccidiosis in feeder lambs, about three weeks after the lambs were introduced into feedlot.

2.3 SOME EPIDEMIOLOGICAL FEATURES OF COCCIDIAL INFECTIONS

2.3.1 Extensive system

In the extensive system of sheep production, the ewes and lambs are grazed together until weaning.

Since ingestion is the method of infection, pre-lambing lambing and post-lambing ewes, and the formites contaminated by them become the sources of coccidia for naturally acquired infections (Pout, 1973). Changes in the external environment can be influential in determining the type of infection exhibited by sheep (Long, 1980).

Vercruysee (1982) carried out a survey of coccidial infections in domestic sheep in Senegal. These animals were from northern and eastern parts of Senegal, a Sahelian zone with a long dry season (October to June). Eimeria oocysts were found in 94 per cent of the sheep examined. A mean oocysts burden of 14,800 oocysts/gm of faeces was reported. The highest number of oocysts was 1,920,000 per gramme. No seasonal fluctuation occurred in the percentage distribution of positive sheep. The author did not state in which month the highest oocysts burden was recorded.

In Nigeria, a survey of range and trade sheep for coccidia oocysts carried out in the northern and southern parts of the country showed prevalence rates of 80 to 90 per cent (Fabiyi, 1980; Majaro and Dipeolu, 1981).

In Ibadan, a humid zone, Majaro and Dipeolu (1981), reported prevalence rate of 80 per cent in trade sheep

sampled for faecal oocysts. The oocyst production reached a peak in the months of August and September. The period falls within the wet season. The season is characterized by high relative humidity (97 per cent) ambient temperature ($27\pm1^{o}C$) and high precipitation. All these climatic factors combined enhanced spontaneous sporulation of oocysts, thereby enhancing the epizootiology of the infection (Long, 1980). In a similar climatic condition on the Jos Plateau in the month of May clinical cases of ovine coccidiosis were on the increase (Fabiyi, 1980).

2.3.2 Intensive system

The intensive system of sheep production involves continuous housing or zero grazing. The feeds and water are brought to the animals indoors.

The semi-intensive system is more commonly practised. The semi-intensive system covers all degrees of compromise between range management and zero grazing. It usually involves controlled grazing of fenced improved pastures with supplementary concentrate feeding.

Feedlot is a type of intensive system in which large numbers of animals are brought into confinement for the purpose of fattening for a short period of time ranging from 90 to 120 days. It is a common practice in the mid-west of U.S.A., Australia and Britain. The prevalence of coccidial infections in feedlot lambs in Britain range from 70-100 per cent on arrival (Deem and Thorp, 1939). During the period

inside feedlot, more animals become infected and by the third week all are infected. Christensen (1944) reported that the period of expectation of clinical coccidiosis in feedlot lambs is 10-21 days after the lambs entered the feedlot.

In Nigeria the feedlot system is relatively new, but is practised in farms owned by Institutions, state government and some private farmers. Adewuyi et al. (1985) advocated the use of rams between the ages of one and half to three years as feeder animals in the northern guinea savanna zone of Nigeria as compared to weaner lambs (3-5 months) being used in Europe and Australia. There is a preference for large and old rams in Nigeria market. There are no published records on problems of feedlot lambs in Nigeria or the influences of coccidia in intensively reared sheep.

2.4 CLINICAL AND PATHOLOGICAL FINDINGS

Diarrhea is the most consistent sign of clinical coccidiosis in sheep. Other signs include anorexia, lessitude, loss of weight, blanching of skin and subnormal temperatures before death (Robertson, 1953; Mahrt and Sherrick, 1965; Pout, 1974). In heavy infections, watery faeces with strings of mucus and blood may be discharged at frequent intervals and tenesmus is pronounced (Newson and Cross, 1930; Lotze, 1952, 1953a, 1953b).

Four species of Eimeria are found to be pathogenic in sheep. These include E. arloingi, E. ninakohlyakimovae, E.

crandallis, and E. faurei (Lotze, 1952, 1953a; 1953b; Robertson, 1953; Shumard, 1957; Pout, 1965, 1974). In natural infections, it is assumed that the predominant pathogenic species of Eimeria caused the lesions observed.

Eimeria arloingi

Lotze (1952), in an experimental infection with E. arloingi, found severe watery diarrhea 13 days after inoculation of sheep with 10,000 sporulated oocysts. Later, anorexia, and lassitude were observed.

Pout (1974) found that these lesions referred to as "flat mucosa" were more confined to the jejunum.

Eimeria ninakohlyakimovae

Clinical infections of Eimeria ninakohlyakimovae in sheep is characterised by severe bloody diarrhea and rapid loss of weight. The severity of these clinical signs depends on the volume of inoculum and duration of infection (Lotze, 1953b). A pure strain of E. ninakohlyakimovae produced diarrhea with bloody mucus in 3 months old lambs innoculated with 500,000 sporulated oocyst (Lotze, 1953b). Bloody diarrhea was produced by the innoculation of 2 years old sheep with 1 million sporulated oocysts of E. ninakohlyakimovae (Lotze, 1953b). Similar lesions were described by Shumard (1957) in a lamb that died 15 days after receiving 7 million sporulated oocysts of Eimeria ninakohlyakimovae.

An histological section through haemorrhagic areas of

the ileum showed large schizonts and sexual stages of the parasite in the epithelial cells in the infections of 15 or more days duration. Rama et al. (1977) described some petechiae and greyish raised areas in the ileum and jejunum in lambs experimentally infected with Eimeria ninakohlyakimovae.

Eimeria crandallis

Pout (1974) found that when lambs were given 2,500 Eimeria crandallis sporulated oocysts daily for seven days, no noticeable effect was seen. However, 250,000 oocysts daily for seven days caused lassitude, soft grey faeces, indications of abdominal pain and death of one lamb.

The parasite caused lesions in the ileum such as oedema and thickening of the walls (Pout, 1974; Gregory et al., 1980). There was disorientation of the villi architecture and reduction of epithelial cell height.

Eimeria faurei

Lotze (1959) observed that Eimeria faurei interfered with protein metabolism and this was responsible for the blanching of skin seen in the infected lambs.

2.5 PATHOGENESIS

Infection with coccidia follows the ingestion of viable sporulated oocysts as contaminants of feed and water (Blood et al, 1979). After the sporulated oocyst is ingested, the sporozoites excyst and invade intestinal epithelial cells and develop within these cells into Schizonts. The

merozoites derived from these Schizonts may re-invade other intestinal epithelial cells to give rise to further generations of Schizonts. Eventually merozoites develop into male and female gametocytes. The fusion of these gametocytes produced the terminal oocysts which are discharged into the faeces.

The merozoites, schizonts and the gametocytes are the pathogenic stages (Lotze, 1953b; Pout, 1974). They cause rupture of the epithelial cells they invade with consequent exfoliation of the epithelial lining of the intestine. The exfoliation of the mucosa causes diarrhea. In severe cases, the blood capillanes are ruptured resulting into haemorrhages (Lotze, 1952, 1953b).

2.6 DIAGNOSIS

In sheep, the tentative diagnosis of coccidiosis is based on clinical signs, presence of large numbers of oocysts in the faeces and lowered feed consumption. The diagnostic procedures usually employed to detect presence of coccidia oocysts in faeces is salt floatation (MAFF, 1977). Faust (1939) used zinc sulphate solution (S.G. 1.18), while Parfitt (1958) adopted a modified McMaster technique and used sodium chloride solution (S.G. 1.2) and zinc sulphate solution (S.G. 1.4). In addition, intestinal scraping is made and examined under phase-contrast microscope for developmental stages, while intestinal specimens are taken for histopathological preparations.

2.7 CONTROL OF COCCIDIAL INFECTIONS IN SHEEP

Sheep live in perpetual contaminated environment, thus exposing young lambs to infection and older lambs to frequent re-infection. Control of coccidial infection in sheep therefore could be tackled by preventive medication and treatment of diseased animals.

Relatively few drugs have been tried with success in the control of coccidial infection. The need for use of medications in the form of drench, drinking water, and or mixed in feeds to prevent build up of coccidia oocysts in the environment of the sheep has not been recognized to be as important as it is in the Poultry Industry. Bergstrom and Maki (1974) and Fitzegerald and Mansfield (1978) have shown that appropriate medication added to the feed of sheep effectively controlled the level of coccidial infections and improved feed efficiency. The medication is usually given continuously in water (Shumard and Eveleth, 1956), mixed in feed (Bergstrom and Maki, 1974) and as salt lick (Foreyt et al., 1981).

Ajayi and Todd (1977b) recorded some success with 500 mg/kg/day of aureomycin-sulphamethazine compound mixed in feed. Amprolium added to feed in an amount which gave approximately 50 mg/kg body weight daily has been tried to prevent coccidial infection in lambs (Hammond et al, 1967). Recently attention has been directed to the ionophorus groups of antibiotic compounds as potential coccidiostats.

Monensin and lasalocid are two of such compounds. Monensin added to feed at 17 mg and 33 mg/kg body weight was found by Foreyt et al. (1979) to prevent clinical and subclinical diseases in the lamb.

A single dose of tetracycline at 5 mg/kg body weight administered parenterally to lambs during first week of life reduced oocysts discharged at the later age (Lotze and Leek, 1970).

Treatment of ovine coccidiosis is better approached on flock basis. The primary concern in coccidiosis is the potential for the contamination of the environment and consequent spread of infections between animals. Chemotherapeutic agents of various kinds have been tried and recommended for the treatment of clinical coccidiosis in sheep. These include Sodium fluoride, Sulphonamides and antibiotics.

Excretion of oocysts by lambs with experimental coccidiosis ceased after oral administration of sodium fluoride at two doses of 100 mg/kg or preferably 50 mg/kg twice daily for three days (Svanbaev, 1961).

A schedule of treatment for sheep using Sulphamethazine recommended by Horton-Smith (1958) consists of an initial dosage of 0.1 g/kg and maintainance doses of 0.05 g/kg intramuscularly daily for 3 to 5 days. Sulphonamide given in water is preferable to feed for clinically infected lambs, because thirst is less affected by coccidiosis than appetite (Shumard, 1957).

Nitrofurazone and Furazolidone have been used successfully in the treatment of coccidiosis in lambs and kids. A daily dose of 100 mg (2 tablets) of Furacin (R) orally has effectively prevented mortality in lambs during an epizootic of Eimeria faurei (Tarlatzis et al., 1957). Furazolidone has also been tried orally at 7 mg, and 10 mg/kg body weight respectively. They found that 10 mg/kg body weight produced better result as no mortality occurred among the treated lambs.

Experimental studies that will guide the use of coccidiostats in ovine practice in Nigeria under the different management systems are yet to be done. Coccidiostats available for field use such as Amprolium, Sulphamethazine and Furazolidone are based on the manufacturer's recommendations as there is no published information about their efficacy.

CHAPTER 3

3.1 EPIDEMIOLOGICAL SURVEY OF OVINE COCCIDIAL INFECTIONS IN ZARIA AREA

3.1.1 Introduction

The climatic condition in many parts of Nigeria is suitable over prolonged period of time for the sporulation and survival of coccidia oocysts. Routine faecal examinations showed that sheep pass varying numbers of oocysts during all seasons of the year with more frequency and heavier burden in the wet season (Akerejola *et al.*, 1979).

Intestinal coccidiosis caused mainly by *E. faurei, E. arloingi* and *E. intricate* was reported in young lambs in Jos Plateau (Thompson and Hall, 1931). Fabiyi (1980) in Jos Plateau identified more coccidia species such as *E. ovina, E. parva, E. faurei* and *E. crandallis*. In addition, *E. granulosa, E. ahsata, E. ninakohlyakimovae, E. intricata* and *E. pallida* were reported. He associated *E. ahsata* and *E. ninakohlyakimovae* with pathogenic infections in young sheep reared in confinement. Majaro and Dipeolu (1981) surveyed trade sheep and showed that the above species of *Eimeria* were also present. Akerejola *et al.* (1979) mentioned that coccidiosis is a major cause of diarrhea in housed sheep.

Ovine coccidiosis is of economic importance in areas where there are large concentrations of sheep. In Zaria area, different management techniques are used to raise

sheep. The aim of this study is to relate the different management types and coccidia prevalence in sheep so as to evaluate the importance of the disease in each setting.

3.2 MATERIALS AND METHODS

The survey was conducted between April, 1983 and March, 1984 in the Northern Guinea Savanna zone of Nigeria characterised by a hot dry season lasting for between three and four months (February - Apri/May). This is preceded by a cold dusty harmattan period of three months (November - January). The wet season is usually between mid-May and mid-October.

3.2.1 Sampling sites

Four locations in the zone were chosen for this study: The National Animal Production Research Institute (NAPRI), Shika, Zaria, which is situated at latitude 11°12'N and longitude 7°33'E was selected as flock I. The breeds of sheep on the farm are Yankasa, Uda, Balami and their crosses with Suffox. In this study only the Yankasa was sampled because the other farms visited are stocked with only Yankasa breed of sheep. The Institute practises a semi-intensive type of management with ewes and lambs being kept together indoor for four to six weeks before being allowed to graze following parturition.

The University farm, situated three kilometers east of NAPRI was selected as flock II. Only one breed of sheep, the Yankasa is kept on the farm. The semi-intensive

husbandry system is also practised. In this farm, the ewes and lambs stay in the shed for only seven days before being allowed to go for grazing.

A private livestock farm, situated at Dumbi, 44 kilometers south-west of NAPRI was selected as flock III. Yankasa is the only breed of sheep kept on the farm. The semi-intensive husbandry system is practised, but the lambs and their ewes are never separated at any time. The whole flock always run together for grazing.

The Sheep Improvement Sub-centre, located at Pambegwa, 65 kilometers south-east of NAPRI was designated flock IV. The farm belongs to the Kaduna state government. The breeds of sheep on this farm include Yankasa, Balami and their crosses with Balouchi rams. The husbandry system practised on this farm is semi-intensive type. The post-lambing ewes and their lambs are kept for four weeks in confinement.

The summary of the management of the flocks during the period of this study is given in Table 2.

3.2.2 Sampling techniques

Twenty per cent of the sheep population of each flock within the age range of one month to five years were sampled. Each flock was visited twice during the pre-rainy (April - June), rainy (July - September), pre-dry (October - December) and dry (January - March) seasons, similar to the seasons described by Hore (1970).

Faecal floatation procedure using saturated sodium

chloride solution (S.G. = 1.18) was used. 2 grammes of faeces was weighed from each sample macerated and dissolved in 15 ml of the floatation medium in a Test tube. The test tube was covered with a 18x18 cm coverslip for 5 minutes. The coverslip placed on glass slide and observed under 10x objective lens of a microscope. The coccidia oocysts were scored as practised in the Ahmadu Bello University, Department of Parasitology and Entomology Laboratory.

a) Negative score means no infection

b) + score means 1-10 oocysts per field

c) ++ score means 11-20 oocysts per field

d) +++ score means over 20 oocysts per field

These scores correspond to light, moderate and heavy infections.

In order to determine the morphological characteristics of the oocysts from each flock, oocysts were sporulated in sufficient quantities of 2.5 per cent potassium dichromate solution in a Petri dish at room temperature for seven days. One hundred sporulated oocysts from each flock were examined under 40x objective using a calibrated microscope (magnification factor = 3.1 U) for morphological details. These include length, width, presence of micropylar cap and shape. The length and the width of each oocyst are the product of the respective eye piece micrometer reading and magnification factor. The shape index (SI) was obtained by dividing the length by the width.

3.3 RESULTS

The observations made relating to management practises, health facilities available to the farm and location have been summarised in Table 2.

In Table 3, the prevalence of coccidia oocysts in each farm appear to be higher in the dry season except in Flock I It became apparent that the lowest percentage prevalence in coccidia for each flock occurred in the pre-rainy season. However, NAPRI farm (Flock i) appeared to have the highest prevalence figures for rainy and pre-dry seasons, while the University farm (Flock II) had the highest prevalence figure for the dry season. The animals in Flock III did not show much seasonal fluctuation in coccidia prevalence.

Table 4 however, related the age groups of animals sampled to the prevalence figures obtained. The lowest prevalence figures were recorded in the one to six months old age group, while the highest was in the seven to fifteen months old age group for all the flocks except Flock IV. In Flock IV, the lowest prevalence figure was recorded in the adult ewes and the highest in the one to six months old age group. Sheep between seven and fifteen months old recorded the highest prevalence figure and it occurred in Flocks I and III.

In Figure I, the range of the shape index is 1.0 - 2.3 with modes of 1.2, 1.5 and 2.0 for Flock I. The distribution is therefore multimodal. Oocysts isolated from

Flock II have shape indices range of 1.0 - 1.8 and a mode of 1.3 (Figure II). The oocysts have shape indices between 1.2 and 1.4. In Figure III, the shape index range is between 1.0 and 1.8 with a mode of 1.3. The distribution is monomodal. Large percentage of oocysts isolated in Flock IV have shape index 1.3 (Figure IV). The distribution of the shape index is monomodal.

Table 2. Management systems of sampled flocks

	Flock I	Flock II	Flock III	Flock IV
Location	National Animal Production Research Institute, Shika	Ahmadu Bello University Farm, Shika	Private Livestock Farm, Dumbi	Sheep Improvement Subcentre, Pambegwa
Breed of sheep	Yankasa	Yankasa	Yankasa	Yankasa
Total sheep population	487	264	251	557
Housing	Pens, concrete floor and walls 1.5 - 2.0 metres high, room made of aluminium sheets cleaned fortnightly.	Sheds, metal fence on sides, and concrete floor. Roof made of aluminium sheets. Floor cleaned daily.	A single large room. Concrete floor covered with wood shavings ceiling, large windows. Wood shaving changed fortnightly.	Pens, with open yards. Walls raised to the ceiling. Rooms swept daily.
Feeding	Concentrate, improved sown pasture, mineral salts and hays.	Concentrates, farm residues and hays.	Farm residues, grazing open field.	Farm residues and sown pasture.
Grazing	Paddocks	Open field and farm land	Open field and farm land	Paddocks
Health programme	Adequate	Adequate	Inadequate	Inadequate
Management (Pre-weaning)	The ewes and lambs stay in pens (rooms) for 4 to 6 weeks before they are sent out for grazing	The ewes and lambs stay in the shed for about 7 days before they are allowed to graze	The lambs run with the adults from day old. The lambs are not separated from the adults	The lambs and ewes stay in lambing house and open yard for one month before they are allowed grazing

Table 3. Prevalence of *Eimeria* Oocysts in faeces of sheep in relation to season

Flock types	Number of samples tested	Number Positive	Percentage Positive	Level of Infection*		
				+	++	+++
Pre-rainy season (April - June)						
I	105	31	29.4	31	0	0
II	56	13	23.2	13	0	0
III	85	47	55.2	41	6	0
IV	103	44	42.7	39	4	1
Rainy season (July - September)						
I	65	60	92.3	52	7	1
II	50	38	76.0	36	2	0
III	56	29	51.7	28	1	0
IV	91	48	52.7	45	3	0
Pre-dry season (October - December)						
I	64	64	100.0	45	15	2
II	51	35	68.6	34	1	0
III	ND	ND	ND	ND	ND	ND
IV	56	50	89.9	37	12	1
Dry season (January - March)						
I	65	44	67.6	32	11	1
II	50	40	90.0	27	12	1
III	58	45	77.5	40	5	0
IV	66	54	81.8	52	2	0

* 0 = no oocysts found
\+ = 1-10 oocysts per field = light infection
++ = 11-20 oocysts per field = moderate infection
+++ = > 20 oocysts per field = heavy infection
ND = Not done

Table 4. Prevalence of Eimeria Oocysts in faeces of sheep in relation to age groups

Flock Types	Age group (months)	Number of Samples Tested	Number of samples positive				Total positive	Percentage positive
			Pre-rainy	Rainy	Pre-dry	Dry		
I	1 - 6	45	6	5	1	0	12	26.7
	7 - 15	45	4	12	14	10	36	88.9
	over 15	207	20	43	46	32	141	68.1
	Total	297	30	60	61	42	163	61.2
II	1 - 6	35	3	11	0	0	14	40.6
	7 - 15	49	4	6	16	13	39	79.5
	over 15	130	12	21	20	24	77	59.2
	Total	214	19	37	36	37	129	59.8
III	1 - 6	20	8	3	ND*	0	11	55.0
	7 - 15	20	4	5	ND	12	21	88.5
	over 15	162	39	23	ND	33	95	58.9
	Total	202	51	31	ND	45	127	66.5
IV	1 - 6	53	24	16	0	0	40	75.4
	7 - 15	97	9	18	22	30	79	71.1
	over 15	162	11	11	28	25	75	46.3
	Total	312	44	45	50	55	194	64.3

* ND = Not done.

Fig.1. Frequency distribution of shape indices of coccidia oocysts isolated from National Animal Production Research Institute, Shika.

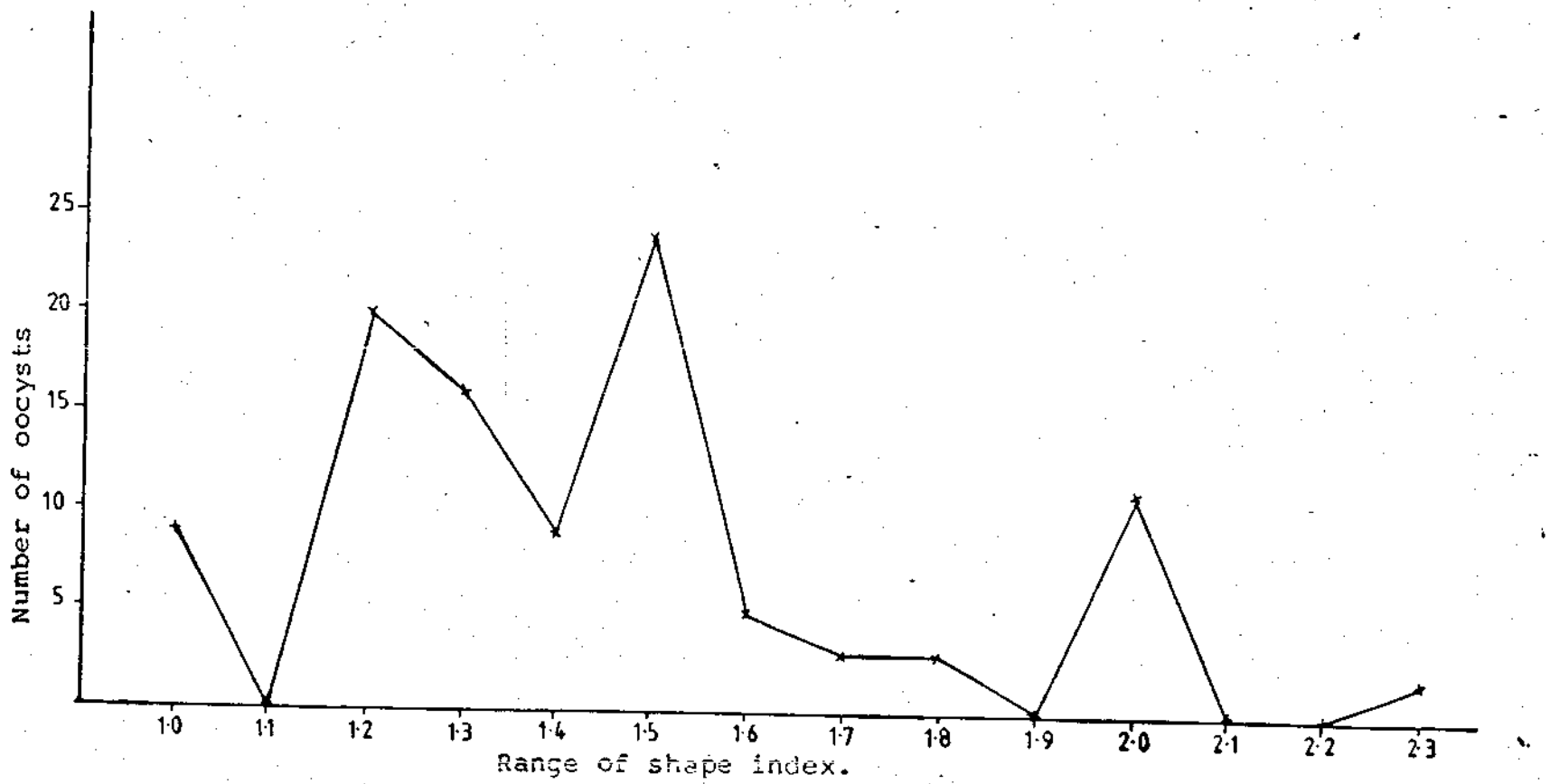


FIG 2. Frequency distribution of shape indices of coccidia oocysts isolated from the University Farm, Shika.

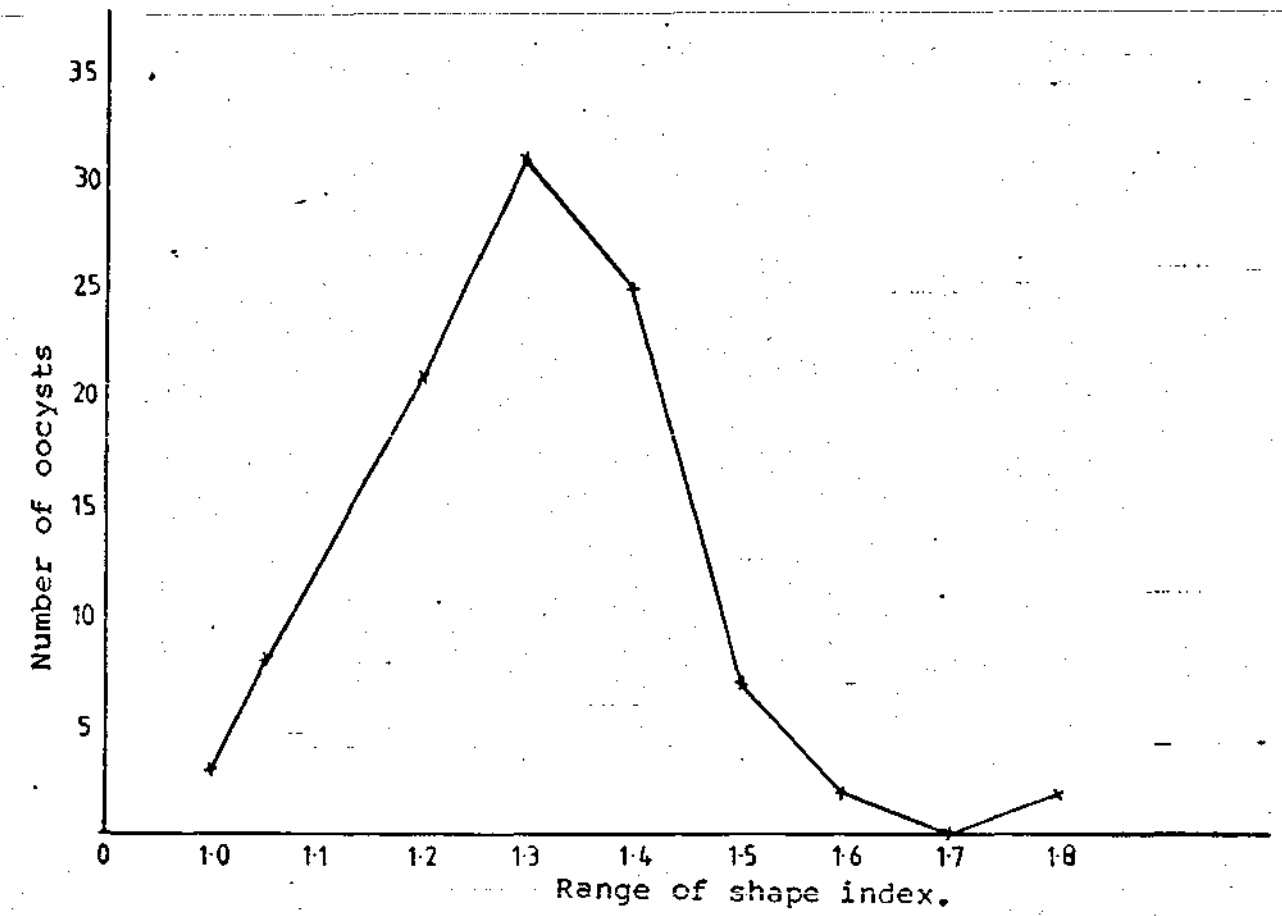


FIG 3. Frequency distribution of shape indices of Coccidia oocysts isolated from a private farm, Dumbi.

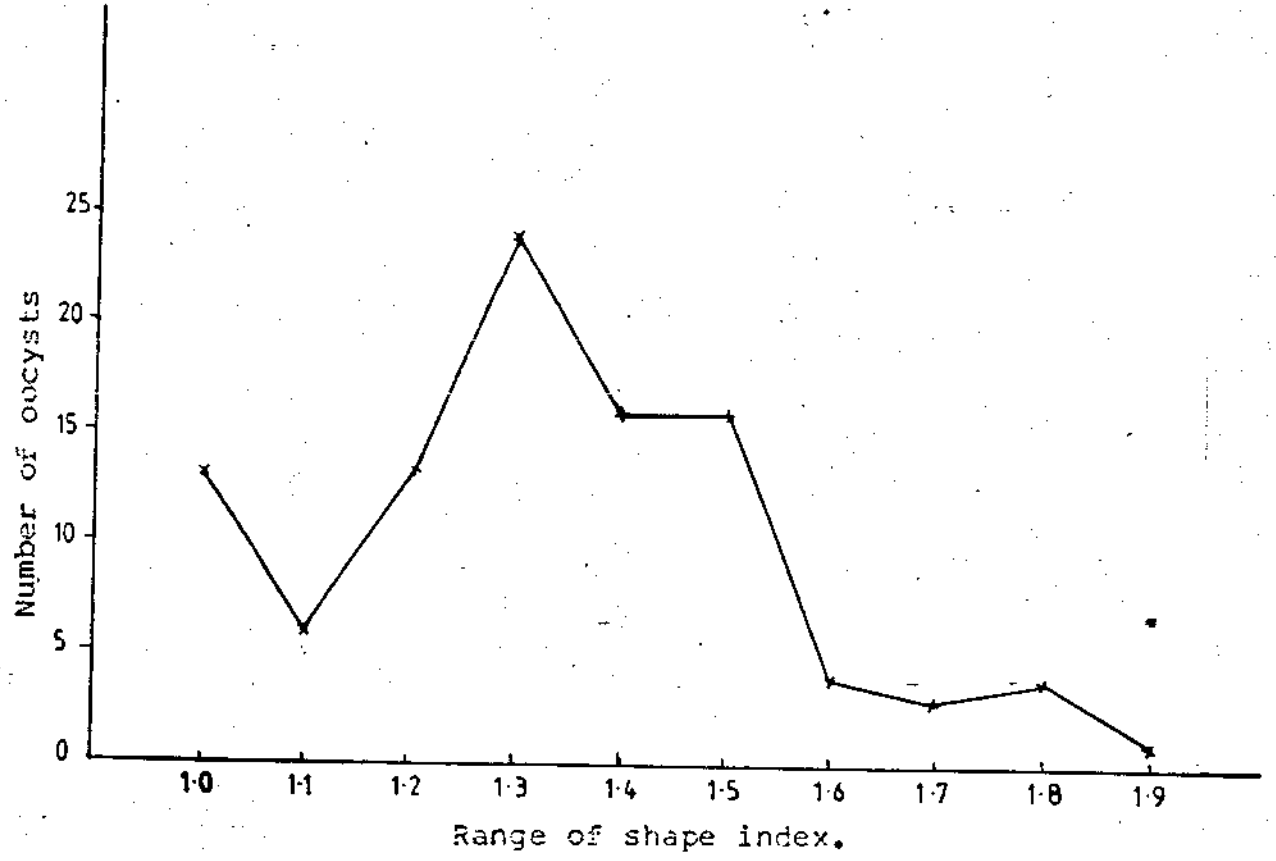
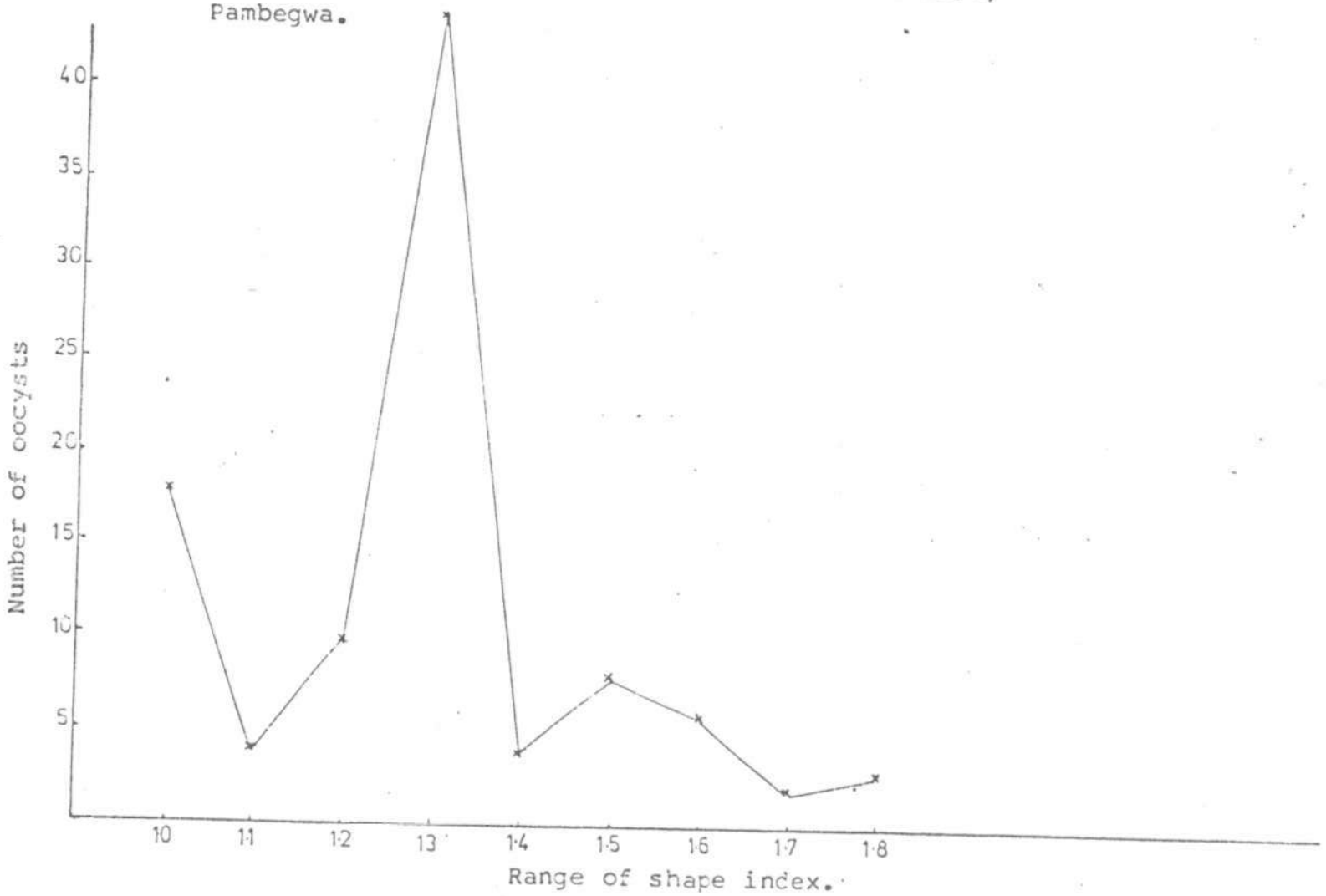


Fig.4 Frequency distribution of shape indices of coccidia oocysts isolated from sheep improvement subcentre, Pambegwa.



3.4 DISCUSSION

The high prevalence of coccidia oocysts found in faecal samples of sheep during this investigation indicates that infection with Eimeria spp. is common in this ecologic zone.

Previous investigations had been on trade sheep and sheep kept by nomadic herdsmen in which coccidia may not be a problem (Fabiyi, 1980; Majaro and Dipeolu, 1981). This is why we selected sheep flocks with restricted grazing and defined management practises. The differences in prevalence of coccidia oocysts encountered in the farms surveyed might be a consequence of such factors, as housing, management of the pre-weaning and post-weaning lambs.

In the humid zone of Nigeria, Majaro and Dipeolu (1981) observed peak oocysts production in April to September, which coincided with the wet season. This does not however relate to season or management because they sampled different animals at different times. For control purposes the same animals should be sampled in the different seasons particularly when the management system is defined. In this study the peak oocysts production were recorded during the rainy and pre-dry seasons (July - December) and lowest figures recorded during the pre-rainy season (April - June). The pre-rainy season is characterised by high temperatures, dryness, and long direct sunlight period which might reduce oocysts infectivity.

There are no published records on age distribution of

coccidial infections in Nigeria. In this study, two age groups showed high prevalence of coccidial infections. These are 7-15 months of age in Flocks I, II and II and 1-6 months of age in Flock IV. Two factors could be responsible for the predisposition of these age groups to coccidial infections. The first is the physical separation of the lambs from the dams resulting into dietary stress (Pout, 1969), and second, bringing susceptible young lambs together with older lambs at weaning (Baker et al. 1972). These factors were present in all the four flocks. One important observation in this study is that the indigenous Yankasa breed of lambs attained levels of oocysts burden similar to that of their parent ewes at an older age (> 7 months) than was reported in exotic breeds (5 months) by Pout, et al. (1966) and Pout (1973).

Although species differentiation is not one of the objectives of this study, the knowledge of the predominant species of Eimeria in each flock is important in assessing the economics of the control programme under the prevailing husbandry system. The results showed that sheep in flock I carry multiple infections involving about four species. In flocks II and IV, one single species of Eimeria predominates while in flock III about two predominant species of Eimeria were involved. The frequency modes of the shape indices that ranged between 1.2 and 1.5 in flocks II, III and IV indicate the presence of more than one species of Eimeria on

these farms. These species of Eimeria may include pathogenic species such as E. ninakohlyakimovae, E. faurei, E. arloingi, and E. crandallis whose shape indices fall within the above range. Thus, in flock II and III, all the four pathogenic species may be present in high percentages. In flock IV all but E. ninakohlyakimovae are likely to be in abundance.

The species of Eimeria isolated from sheep in flock I have a wide range of shape indices. This could be due to overcrowding effect and influence of several species on reproduction may affect shape index (Tyzzerd, Theilor and Jones, 1932; Brackett and Bliznick, 1952).

In addition to breeding of sheep and goats, the farm operates feedlot programme. The rams are purchased from different local markets in this ecological zone. Christensen (1941) also observed that such rams carry different species of Eimeria. Thus, in flock I the sheep might have been exposed to different species of Eimeria ranging from the smallest with shape index 1.0 to the largest with shape index 2.0, such as E. ninakohlyakimovae, E. intricata respectively.

CHAPTER 4

4.1 OBSERVATIONS ON EXPERIMENTAL REARING OF COCCIDIA-FREE LAMBS IN SHIKA RESEARCH FARM

4.1.1 Introduction

Coccidia oocysts are ubiquitous in the environment where susceptible hosts are raised, and are easily dispersed by wind and water. Raising lambs free of coccidia oocysts therefore requires stringent isolation measures. The techniques for raising coccidia-free lambs under different conditions have been described (Shumard and Eveleth, 1956; Pout, et al., 1973; Catchpole, et al., 1976; and Yvore, et al., 1980). They raised coccidia-free lambs for periods that ranged between four and eight weeks after which the lambs were used for experimental coccidial infections.

Coccidia free lambs would be required for assessing the pathogenicity of Eimeria spp in sheep in Nigeria. Multiple coccidial infections is the rule in the field, hence the need to get coccidia free lambs to study graded doses of pure and mixed infections. The significance of coccidia-free lambs could also be as control in experimental infections to monitor the management technique of the experimental animals in ensuring that it is only the inoculated coccidia that were responsible for the observed changes during the period of observation.

The purpose of this experiment is to attempt to rear coccidia-free lambs using less complicated technique under our conditions.

4.2 MATERIALS AND METHODS

4.2.1 Animals, Origin and Breeds

Yankasa and Uda breeds were selected for this study. Yankasa is the most widely distributed and most numerous sheep breed in Nigeria (Adu and Ngere, 1979). It is found throughout the area north of latitude 14°N. The Yankasa is intermediate in size between the southern dwarf sheep and the long-legged Uda in the far north. It has a typical white coat-colour with black patches around the eyes, ears, muzzle and sometimes feet. Lamb birth weights range between 2.00 and 4.00 kg. On the other hand, the Uda breed of sheep is found throughout the Sahelo-Sudan vegetation zone of Nigeria. The Uda is a large long-legged sheep with a convex face. It has at the anterior half of the body black or brown coat-colour, while the posterior half is white. The ear is long, large and pendulous. Lamb birth weights range between 2.5 and 4.5 kg.

Six Yankasa and six Uda lambs from a group of ewes bred specifically for this study were removed from their dams within 24 hours of birth during a period of one week.

4.2.2 Management technique

The management technique for raising coccidia-free lambs described by Catchpole et al. (1976) was adopted with a number of modifications to suit the local conditions. The details are described below.

Two sets of cages made up of four compartments each

were constructed (Plate I). The cages were made of 2 x 2 cm soft wood, and raised 20 cm above the ground level. The floors were made of fencing wire of 5 cm gauge (Plate II) and placed on top of this, was perforated zinc roofing material (Plate III). The perforations were 2 cm in diameter and 5 cm apart. This combination allows for efficient cleaning of the compartments and provides strength to withstand the increasing weight of the lambs as they grow. Each compartment (66 x 75 x 100 cm) held two or three lambs, and had feed and water troughs fitted to the front panel. The cages were placed in a large isolation room about 300 m away from the nearest sheep pen. The walls and floors of this room were scrupulously scrubbed before the cages were introduced.

The lambs were taken to the cages within 3 to 6 hours of birth, and each lamb received 10 ml of pooled serum from the dams subcutaneously, to provide a source of gamma globulin (Catchpole et al, 1976). The lambs were then taught to suckle from human feeding bottle. Pooled whole cow milk from modern milking parlour was fed to the lambs at 100-200 ml per lamb three time daily. At four to five weeks of age, concentrate was fed and clean fresh water provided throughout.

Everyday, the feeders and drinkers and the compartments were washed with hot water instead of fresh tap water initially being used. The lambs were kept for 18 weeks.

Plate I; A cage for rearing coccidia-free lambs.

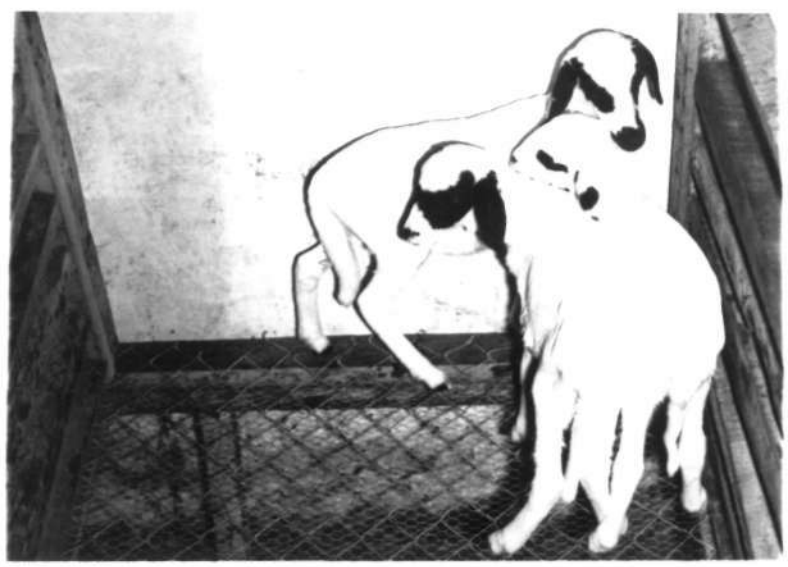


Plate II: The floor of the cage with the fencing wire and net

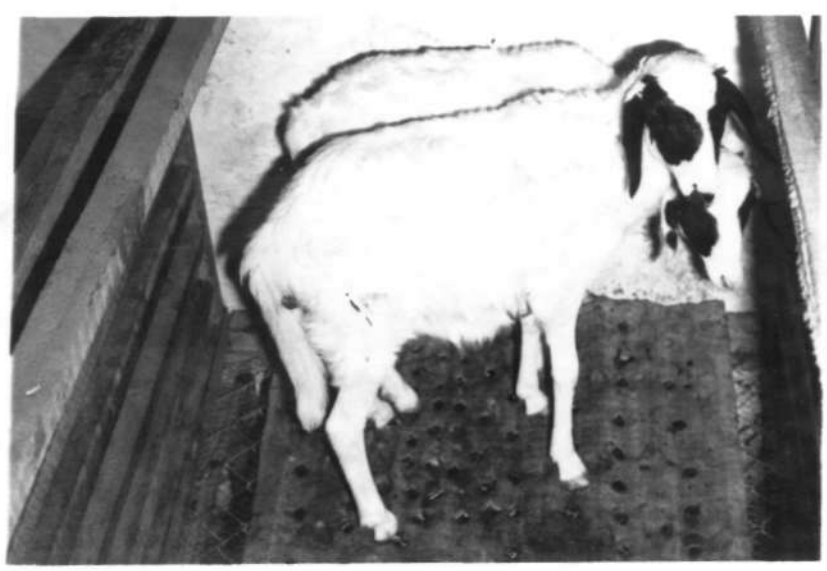


Plate III: The floor of the cage showing the perforated zinc roofing sheet

4.2.3 Laboratory Procedure

Initially sterile swabs were used to scoop faeces from the rectum of the lambs twice weekly. This is to avoid trauma of the rectum. At four weeks old faeces were recovered from the lambs using index finger and polythene bags. Saturated sodium chloride solution (SG = 1.18) was used as the floatation medium. The oocysts were concentrated by coverslip and examined under 40x objective of the microscope for presence of coccidia oocysts.

Blood samples were taken weekly for estimating the packed cell volume (PCV), haemoglobin concentration (Hb) and total protein (TP). The packed cell volume (PCV) was estimated using a Hawksley(1), microhaematocrit centrifuge. The haemoglobin concentration was estimated as cyano methaemoglobin in a coulter haemoglibinometer(2), while the serum level in the capillary tubes used is determining the PCV was poured into the Refractometer(3) to estimate the total serum protein (TP).

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1 = Microhaematocrit centrifuge, Hawkshey, England.

2 = Coulter Electronics Ltd. Harpendon, England.

3 = American Optical Corp. Keene, N.H., U.S.A.

4.3 RESULTS

All the lambs remained free from coccidia from day one to nine weeks of age. Coccidia oocysts were observed in the faeces of one Yankasa and two Uda lambs in the tenth week. Two Uda lambs had clinical coccidiosis in the 13th week characterised by bloody diarrhea, anorexia, and slight incoordination of the head and limbs. The lambs died in the 15th week. The necropsy revealed thickened and edematous mesentaries. The small intestinal contents were fluid and streaked with blood and mucus. The summary of the data collected during the rearing period are shown in Figure 5.

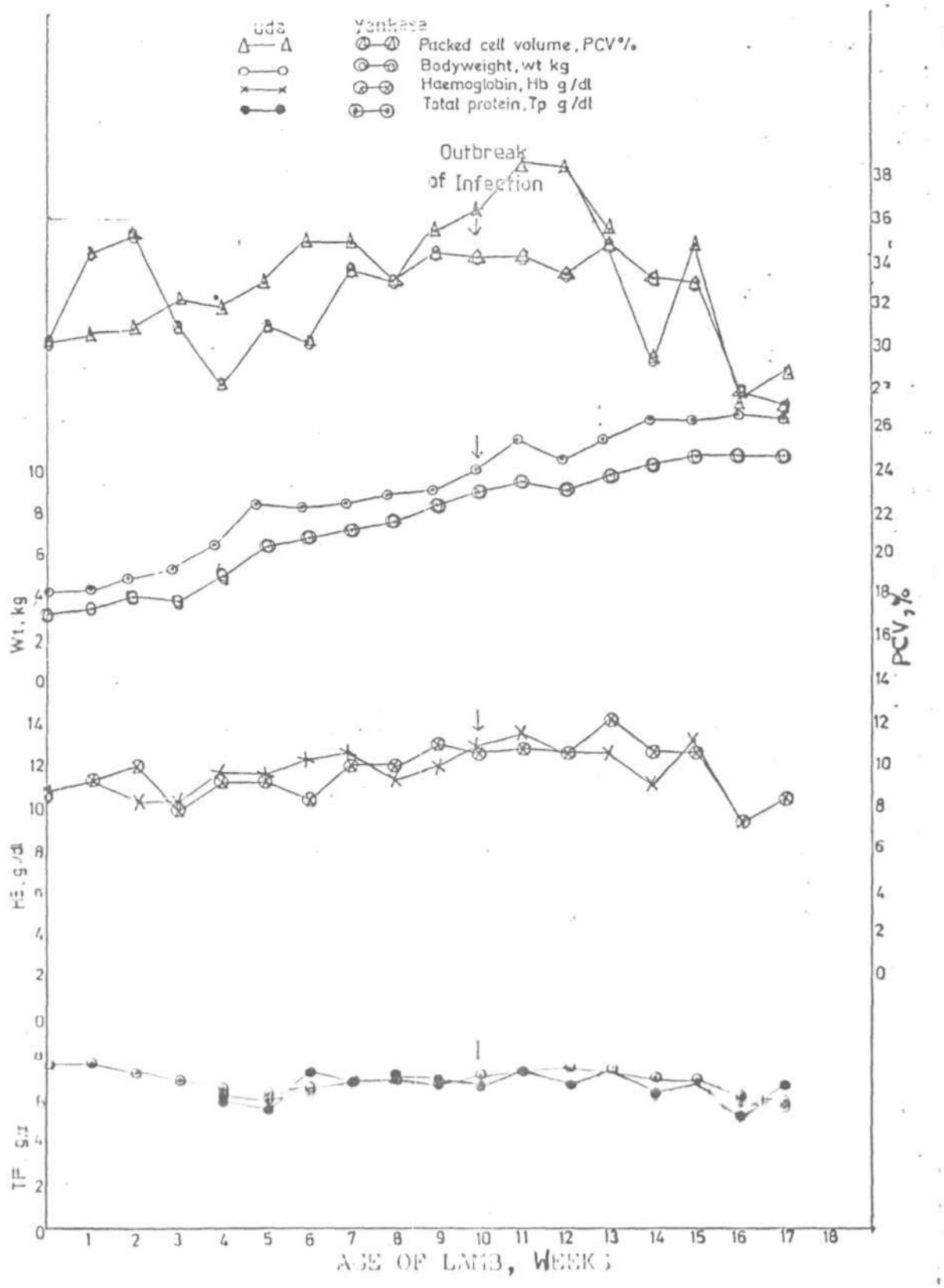
4.3.1 Coccidia oocysts discharge

Coccidia oocysts were first observed in one Yankasa and two Uda lambs in the tenth week of life. In the 11th week, four Yankasa and five Uda lambs were discharging coccidia oocysts in their faeces. Patent infection became apparent in all the lambs in the 13th week of life. The level of infection was low during the patent infection.

4.3.2 Haematology

The weekly mean values of PCV and HB for the Yankasa lambs are shown in Figure 5. The PCV reading ranged between 27.37 and 35.2 per cent and average Hb readings were between 9.27 and 14.3 g/dl. The weekly mean values of TP did not fluctuate appreciably throughout the rearing period. There was a drop in the PCV and Hb values between weeks 3 and 4 and another in weeks 15 and 17.

Fig. 5: Mean total protein haemoglobin levels, packed cell volume and body weight of Yankasa and Uda lambs raised coccidia-free.



In Figure 5, the Uda lambs had average PCV reading that ranged between 27.83 and 38.6 per cent and average Hb reading that ranged between 9.26 and 13.6 g/dl. The TP values were between 5.56 and 7.72 g/dl. There was a drop in the levels of PCV and Hb between weeks 12 and 14. A slight increase in the values occurred in the following week and a decrease in latter weeks.

4.3.3 Growth pattern

The growth curve of the Yankasa lambs is shown in Figure 5. There was little change in body weights attained during the first three weeks of life. Thereafter, a steady gain in body weight was observed. There was a slight drop in body weight gained in the 11th week but picked up in the following week.

In Figure 5, the growth curve of the Uda lambs is presented. There was no appreciable body weight gains in the first three weeks of life. A steady growth was observed between the third and 11th week. A drop in body weight gains was recorded in the 12th week, second week after patent infection was apparent in all the lambs. The mean body weight was regained a week later and increase in body weight gains observed thereafter.

4.4 DISCUSSION

The results showed that the rearing technique used in this study was able to keep the lambs free of coccidial infection for about seven weeks. The growth patterns of the two breeds of lambs were similar during this period. A higher rate of weight gain noticed in the Uda lambs may be due to the fact that Uda is a larger breed. The PCV, HB and TP values during the same period were within the normal range for the age group (Oduye, 1976).

By the tenth week, two Uda and one Yankasa lambs were discharging coccidia oocysts in their faeces. Infection became apparent in all the lambs in the 13th week and two Uda lambs died at the age of 15 weeks. During the patent infection, the mean body weight for the two breeds remained on the increase. Though the rate of weight gain was lower than during the pre-infection period, the difference was not significant. This could be due to the low level of infection. However, this level of infection affected the PCV and HB levels. The effect was more pronounced in the Uda than Yankasa lambs. The fact that two Uda lambs died of coccidiosis may indicate that Uda breed is more susceptible to coccidiosis than Yankasa breed.

From this study it seems safe to use the management technique for raising coccidia-free lambs for five weeks so that about 4-5 weeks of experimental work can be done thereafter before complications develop.

In a situation where coccidia-free lambs are required for a period longer than seven weeks, a number of improvements could be suggested. One such improvement would be provision of metal cages and sterilized feed. The metal cages would be easier to clean and disinfect. Autoclaved feeds would eliminate oocysts contamination via this source.

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Appendix 'A'

OOCYSTS CHARACTERISTICS

Origin: National Animal Production Research Institute, Shika

Serial No.	Length (um)	Width (um)	Mic. cap	Shape Index
1	26.81	19.15	A	1.4
2	22.98	15.32	A	1.5
3	30.64	15.32	P	2.0
4	26.81	15.32	P	1.8
5	26.81	19.15	P	1.4
6	26.81	15.32	P	1.8
7	30.64	15.32	P	2.0
8	22.98	19.15	A	1.2
9	22.98	15.32	P	1.5
10	30.64	19.15	A	1.6
11	30.64	15.32	P	2.0
12	30.64	19.15	P	1.6
13	22.98	19.15	P	1.2
14	30.64	22.98	P	1.3
15	22.98	19.15	A	1.2
16	30.64	15.32	P	2.0
17	30.64	19.15	P	1.6
18	30.64	19.15	P	1.6
19	30.64	15.32	P	2.0

NB: MIC.Cap = Polar Cap, A = Absent, P = Present.

Serial No.	Length (um)	Width (um)	MIC. Cap	Shape Index
20	34.47	15.32	P	2.3
21	30.64	15.32	P	2.0
22	30.64	15.32	A	2.0
23	15.32	15.32	A	1.0
24	22.98	19.15	P	1.2
25	15.32	15.32	A	1.0
26	30.64	22.98	P	1.33
27	22.98	15.32	P	1.5
28	22.98	15.32	P	1.5
29	30.64	19.15	P	1.6
30	22.98	19.15	A	1.2
31	15.32	11.49	A	1.3
32	30.64	15.32	P	1.3
33	22.98	15.32	A	1.5
34	30.64	19.15	P	1.6
35	22.98	22.98	A	1.0
36	30.64	22.98	P	1.3
37	45.96	30.64	P	1.5
38	22.98	22.98	A	1.0
39	22.98	22.98	A	1.0
40	22.98	19.15	P	1.2
41	22.98	15.32	A	1.5
42	22.98	15.32	A	1.5
43	30.64	22.98	P	1.3
44	61.28	30.64	P	2.0

Serial No.	Length (um)	Width (um)	MIC. Cap	Shape Index
45	26.81	15.32	P	1.8
46	22.98	15.32	P	1.5
47	45.96	30.64	P	1.5
48	45.96	26.81	P	1.7
49	15.32	15.32	A	1.0
50	45.96	26.81	P	1.7
51	45.96	38.3	P	1.2
52	45.96	38.3	P	1.2
53	22.98	15.32	P	1.5
54	38.3	30.64	P	1.25
55	22.98	19.15	A	1.2
56	22.98	15.32	A	1.5
57	22.98	15.32	P	1.5
58	45.96	34.47	P	1.3
59	45.96	30.64	P	1.5
60	22.98	15.32	P	1.5
61	38.64	15.32	P	2.0
62	22.98	15.32	P	1.5
63	45.96	30.64	P	1.5
64	45.96	34.47	P	1.3
65	45.96	3.3	P	1.2
66	22.98	15.32	P	1.5
67	22.98	15.32	P	1.5
68	22.98	15.32	P	1.5

Serial No.	Length (um)	Width (um)	MIC. Cap	Shape Index
69	22.96	19.15	A	1.2
70	22.98	19.15	A	1.2
71	22.98	15.32	P	1.5
72	22.98	19.15	A	1.2
73	22.98	15.32	A	1.5
74	22.98	15.32	A	1.5
75	46.87	34.37	P	1.4
76	48.43	34.37	P	1.4
77	43.75	37.5	P	1.2
78	46.87	34.37	P	1.4
79	43.75	35.94	P	1.2
80	46.87	34.37	P	1.4
81	46.87	34.37	P	1.4
82	46.87	34.37	P	1.4
83	43.75	35.94	P	1.2
84	23.00	16.75	P	1.3
85	43.75	35.94	P	1.2
86	50.0	37.5	P	1.3
87	50.0	40.625	P	1.2
88	50.0	40.625	P	1.2
89	12.5	9.375	P	1.3
90	15.62	12.5	A	1.3
91	15.62	12.5	A	1.3
92	15.62	12.5	A	1.3
93	21.87	21.87	A	1.0

Serial No.	Length (um)	Width (um)	MIC. Cap	Shape Index
94	15.62	15.62	A	1.0
95	15.62	12.5	A	1.3
96	12.5	12.5	A	1.0
97	46.87	37.5	P	1.3
98	12.5	9.37	A	1.3
99	15.62	9.37	A	1.6
100	21.87	18.75	A	1.2

Appendix 'B'

OOCYSTS CHARACTERISTICS

Origin: University Farm

Serial No.	Length (um)	Width (um)	Mic cap	Shape Index
1	22.98	17.23	P	1.3
2	26.81	22.98	P	1.2
3	28.72	22.98	P	1.3
4	22.98	17.23	P	1.3
5	49.79	34.47	P	1.4
6	47.87	34.47	P	1.4
7	51.70	36.38	P	1.4
8	51.70	36.38	P	1.4
9	42.13	38.3	P	1.1
10	49.79	34.47	P	1.4
11	47.87	34.47	P	1.4
12	21.06	19.15	A	1.1
13	22.29	19.15	P	1.2
14	53.62	38.30	P	1.4
15	45.96	34.47	P	1.3
16	45.96	32.55	P	1.4
17	45.96	38.3	P	1.2
18	45.96	38.3	P	1.2
19	26.81	19.15	P	1.4
20	42.13	22.98	P	1.8

NB: MIC. Cap = Polar Cap, A = Absent, P = Present.

Serial No.	Length (um)	Width (um)	MIC. Cap	Shape Index
46	45.96	34.47	P	1.3
47	45.96	30.64	P	1.5
48	24.89	15.32	P	1.6
49	49.79	38.3	P	1.3
50	26.81	19.15	P	1.3
51	22.98	15.32	P	1.5
52	15.32	15.32	A	1.0
53	26.81	19.15	P	1.4
54	22.98	19.15	A	1.1
55	26.81	26.81	A	1.0
56	49.79	38.3	P	1.3
57	45.96	34.47	P	1.3
58	49.79	38.3	P	1.3
59	45.96	34.47	P	1.3
60	49.79	36.38	P	1.4
61	49.79	38.3	P	1.3
62	19.15	15.32	A	1.2
63	51.70	32.5	P	1.6
64	24.89	15.32	P	1.2
65	22.98	19.15	P	1.2
66	22.98	17.23	P	1.3
67	22.98	19.15	P	1.2
68	45.96	34.47	P	1.3
69	49.79	36.3	P	1.3
70	47.87	34.47	P	1.4

Serial No.	Length (um)	Width (um)	MIC. Pop	Shape Index
46	45.96	34.47	P	1.3
47	45.96	30.64	P	1.5
48	24.89	15.32	P	1.6
49	49.79	38.3	P	1.3
50	26.81	19.15	P	1.4
51	32.98	15.32	P	1.5
52	15.32	15.32	A	1.0
53	26.81	19.15	P	1.4
54	22.98	19.15	A	1.1
55	26.81	26.81	A	1.0
56	49.79	38.3	P	1.3
57	45.96	34.47	P	1.3
58	49.79	38.3	P	1.3
59	45.96	34.47	P	1.3
60	49.79	36.38	P	1.4
61	49.79	38.3	P	1.3
62	19.15	15.32	A	1.2
63	51.70	32.8	P	1.6
64	24.89	15.32	P	1.2
65	22.98	19.15	P	1.2
66	22.98	17.23	P	1.3
67	22.98	19.15	P	1.2
68	45.96	34.47	P	1.3
69	49.79	38.3	P	1.3
70	47.87	34.47	P	1.4

Serial No.	Lergth (um)	Width (um)	MIC. Cap	Shape Index
71	53.62	38.3	P	1.4
72	53.62	38.3	P	1.4
73	49.79	34.47	P	1.4
74	49.79	36.38	P	1.4
75	22.98	19.15	P	1.2
76	19.15	25.32	P	1.3
77	49.79	34.47	P	1.4
78	45.96	34.47	P	1.3
79	22.98	21.06	A	1.1
80	22.98	19.15	A	1.2
81	42.13	34.47	P	1.2
82	45.96	34.47	P	1.3
83	42.13	34.47	P	1.2
84	49.79	30.64	P	1.5
85	19.15	15.32	A	1.3
86	22.98	17.235	P	1.3
87	45.96	34.47	P	1.3
88	22.98	15.32	A	1.5
89	22.98	19.15	P	1.2
90	45.96	34.47	P	1.2
91	19.15	19.15	A	1.0
92	42.13	38.3	P	1.1
93	26.61	19.15	P	1.4
94	45.96	34.47	P	1.3
95	42.13	34.47	P	1.2

Serial No.	Length (um)	Width (um)	MIC. Cap	Shape Index
96	38.3	22.98	P	1.6
97	45.96	34.47	P	1.3
98	45.96	32.55	P	1.3
99	22.98	19.15	A	1.2
100	38.3	34.47	A	1.1

Appendix 'C'

OOCYSTS CHARACTERISTICS

Origin: Dumbi Farms Ltd, Dumbi

Serial No.	Length (um)	Width (um)	Mic. Cap	Shape Index
1	21.7	15.5	P	1.4
2	24.8	18.6	P	1.33
3	27.9	18.6	P	1.5
4	21.7	15.5	P	1.4
5	24.8	21.7	A	1.14
6	24.8	18.6	P	1.33
7	43.4	27.9	P	1.5
8	40.3	27.9	P	1.44
9	34.1	27.9	P	1.22
10	34.1	24.8	P	1.37
11	46.5	24.8	P	1.875
12	31.0	24.8	A	1.25
13	24.8	18.6	A	1.33
14	18.6	18.6	A	1.0
15	21.7	18.6	A	1.16
16	27.9	18.6	P	1.5
17	24.8	21.7	A	1.14
18	21.7	18.6	P	1.16
19	37.2	21.7	A	1.71

NB: MIC. Cap = Polar Cap, A = Absent, P = Present.

Serial No.	Length (um)	Width (um)	MIC. Cap	Shape Index
20	24.8	18.6	P	1.33
21	31.0	24.8	P	1.25
22	24.8	18.6	P	1.33
23	31.0	24.8	A	1.25
24	27.9	18.6	P	1.5
25	24.8	21.7	P	1.14
26	24.8	24.8	A	1.0
27	27.9	15.5	P	1.8
28	18.6	18.6	A	1.0
29	27.9	21.7	P	1.28
30	27.9	18.6	P	1.5
31	27.9	18.6	P	1.5
32	27.9	18.6	P	1.5
33	27.9	21.7	P	1.28
34	27.9	18.6	P	1.5
35	43.4	24.8	P	1.75
36	18.6	15.5	A	1.2
37	31.0	21.7	P	1.42
38	27.9	21.7	P	1.28
39	21.7	15.5	A	1.4
40	24.8	18.6	A	1.33
41	27.9	18.6	A	1.33
42	24.8	21.7	A	1.14
43	24.8	18.6	A	1.33
44	21.7	18.6	A	1.16

Serial No.	Length (um)	Width (um)	MID. Cap	Shape Index
45	31.0	18.6	P	1.66
46	24.8	18.6	A	1.33
47	24.8	15.5	P	1.6
48	24.8	15.5	A	1.6
49	27.9	18.6	P	1.5
50	18.6	18.6	A	1.0
51	24.8	18.6	A	1.33
52	31.0	24.8	P	1.25
53	21.7	18.6	A	1.16
54	18.6	18.6	A	1.0
55	21.7	15.5	A	1.4
56	31.0	18.6	P	1.66
57	24.8	18.6	P	1.33
58	24.8	18.6	A	1.33
59	18.6	18.6	A	1.0
60	31.0	24.8	P	1.25
61	21.7	18.6	A	1.16
62	24.8	18.6	P	1.33
63	27.9	18.6	A	1.5
64	31.0	21.7	P	1.42
65	40.3	27.9	P	1.4
66	27.9	18.6	P	1.5
67	40.3	27.9	P	1.4
68	40.3	27.9	P	1.4
69	27.9	21.7	A	1.28

Serial No.	Length (um)	Width (um)	MIC. Cap	Shape Index
70	31.0	21.7	A	1.42
71	27.9	27.9	A	1.0
72	18.6	18.6	A	1.0
73	31.0	21.7	P	1.42
74	18.6	12.4	A	1.5
75	24.8	24.8	A	1.0
76	27.9	18.6	P	1.5
77	31.0	21.7	P	1.42
78	43.4	27.9	P	1.5
79	24.8	15.5	A	1.6
80	43.4	24.8	P	1.75
81	18.6	15.5	A	1.2
82	15.5	12.4	A	1.25
83	18.6	18.6	A	1.0
84	21.7	18.6	A	1.16
84	18.6	15.5	A	1.2
85	18.6	15.5	A	1.2
86	18.6	18.6	A	1.0
87	18.6	15.5	A	1.2
88	31.0	21.7	P	1.43
89	31	27.7	P	1.43
90	34.1	18.6	P	1.83
91	24.8	18.6	P	1.33
92	24.8	21.7	P	1.14
93	27.9	18.6	P	1.5

Serial No.	Length (um)	Width (um)	MIC. Cap.	Shape Index
94	31	21.7	A	1.42
95	18.6	18.6	P	1.0
96	18.6	18.6	P	1.0
97	40.3	24.8	P	1.62
98	34.1	27.9	P	1.22
99	21.7	18.6	P	1.16
100	24.8	18.6	P	1.33

Appendix 'D'

CYSTS CHARACTERISTICS

Origin: Shuso Improvement Subcentre Pambegwa

Serial No.	Length (um)	Width (um)	Mic. Cap	Shape Index
1	22.98	19.15	P	1.2
2	15.32	13.40	P	1.1
3	15.32	11.49	A	1.3
4	19.15	11.49	P	1.6
5	15.32	11.49	P	1.3
6	11.49	11.49	A	1.0
7	32.98	19.15	A	1.2
8	15.32	11.49	A	1.3
9	15.32	11.49	A	1 3
10	19.15	15.32	A	1.3
11	19.15	17.22	A	1.1
12	15.32	11.49	A	1.3
13	19.15	19.15	A	1.0
14	26.81	19.15	P	1.4
15	26.91	15.32	A	1.7
16	19.15	15.32	A	1.3
17	22.98	15.32	A	1.5
18	22.98	19.15	A	1.2
19	19.15	15.32	A	1.3
20	19.15	17.2	P	1.1

NB: MIC. Cap = Polar Cap, A = Absent, P = Present.

Serial No.	Length (um)	Width (um)	HIC. Cap	Shape Index
21	15.32	15.3	A	1.0
22	19.15	15.32	A	1.3
23	22.98	17.23	A	1.3
24	22.98	17.23	A	1.3
25	22.98	19.15	A	1.2
26	19.15	15.32	A	1.3
27	15.32	15.32	A	1.0
28	21.06	11.49	P	1.8
29	21.06	11.49	A	1.8
30	22.98	15.3	A	1.5
31	19.15	15.32	A	1.3
32	30.64	19.15	A	1.6
33	11.49	11.49	A	1.0
34	15.32	11.49	A	1.3
35	19.15	15.32	A	1.3
36	19.15	15.32	A	1.3
37	15.32	15.32	A	1.0
38	15.32	11.49	A	1.3
39	15.32	11.49	A	1.3
40	19.15	15.32	A	1.3
41	30.64	19.15	P	1.6
42	2.98	15.32	P	1.5
43	19.15	11.49	A	1.6
44	15.32	15.32	A	1.0
45	26.81	19.15	P	1.4

Serial No.	Length (um)	Width (um)	MIC. Cap	Shape Index
46	19.15	15.32	A	1.3
47	19.15	15.32	A	1.3
48	22.98	19.15	A	1.2
49	11.49	11.49	A	1.0
50	19.15	15.32	A	1.3
51	15.32	11.49	A	1.3
52	15.32	15.32	A	1.0
53	19.15	15.32	A	1.3
54	19.15	15.32	A	1.3
55	19.15	15.32	A	1.3
56	19.15	15.32	P	1.3
57	22.98	15.32	P	1.5
58	11.49	11.49	A	1.0
59	11.49	11.49	A	1.0
60	11.49	11.49	A	1.0
61	15.32	11.49	A	1.3
62	26.81	19.15	P	1.4
63	19.15	15.32	A	1.3
64	22.98	19.15	A	1.2
65	22.98	19.15	P	1.2
66	21.06	15.32	A	1.4
67	22.98	15.32	A	1.5
68	22.98	19.15	A	1.2
69	15.32	15.32	A	1.0
70	22.98	19.15	A	1.2

Serial No.	Length (um)	Width (um)	NIC. Cap	Shape Index
71	22.72	19.15	P	1.5
72	15.32	9.5	A	1.6
73	15.32	15.32	A	1.0
74	19.15	11.49	A	1.6
75	30.64	22.98	P	1.3
76	19.15	15.32	A	1.3
77	34.47	19.15	P	1.8
78	22.98	19.15	A	1.2
79	22.98	15.32	A	1.5
80	15.32	11.49	A	1.3
81	22.98	15.32	A	1.5
82	19.15	19.15	A	1.0
83	19.15	15.32	A	1.3
84	19.15	15.32	A	1.3
85	19.15	15.32	A	1.3
86	19.15	15.32	A	1.3
87	19.15	15.32	A	1.3
88	22.98	15.32	A	1.5
89	19.15	15.32	A	1.3
90	7.66	7.66	A	1.0
91	15.32	15.32	A	1.0
92	19.15	15.32	A	1.3
93	30.64	26.81	A	1.14
94	19.15	15.32	A	1.3
95	15.32	11.49	A	1.3

Serial No.	Length (um)	Width (um)	MID. Cap	Shape Index
96	30.64	19.15	F	1.6
97	19.32	15.32	A	1.0
98	19.32	15.32	A	1.0
99	19.15	15.32	A	1.3
100	19.15	15.32	A	1.3

Appendix 'E': Total Protein, Haemoglobin levels and body weight of Yankasa Lambs

	AGE IN WEEKS																	
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Coccidia oocysts level											+	+	+	+	++	+	+	+
n											3	4	6	6	6	6	6	6
Body weight kg	3.16	3.3	4.0	3.75	5.08	6.51	6.86	7.16	7.71	8.5	8.9	9.4	9.0	9.75	10.12	10.62	10.62	10.6
PCV	30.3	34.40	35.2	30.9	28.2	30.9	30.25	33.66	33.0	34.4	34.2	34.2	33.5	34.75	33.25	33.0	27.75	27.3
SD	±1.03	±5.40	±4.6	±3.26	±1.87	±2.13	±1.54	±4.6	±2.89	±2.32	±0.83	±1.92	±1.22	±3.30	±2.66	±3.16	±6.29	±5.83
HB	10.82	11.28	11.98	9.93	11.18	11.14	10.38	10.0	11.9	12.94	12.66	12.86	12.77	14.3	12.7	12.62	9.27	10.4
SD	±0.16	±1.75	±1.36	±1.14	±1.77	±0.57	±0.55	±0.95	±1.33	±1.11	±0.82	±0.47	±1.22	±1.35	±0.77	±1.66	±2.00	±1.04
TP	7.63	7.62	7.22	6.85	6.43	6.18	6.55	6.71	6.78	6.54	6.96	7.04	7.30	7.17	6.75	6.70	6.05	5.9
SD	±0.99	±1.19	±0.22	±0.27	±0.44	±0.34	±0.33	±0.36	±0.59	±0.53	±0.62	±0.13	±0.33	±0.38	±0.34	±0.57	±0.34	±0.40

n = Number of sheep positive for coccidia oocysts.
\+ = 1-10 oocysts per field = light infection
++ = 11-20 oocysts per field = moderate infection
PCV= Packed Cell Volume, %
HB = Haemoglobin Concentration, g/dl
TP = Total Serum Protein, g/dl
SD = Standard Deviation of the means.

Appendix 'F': Total Protein, Haemoglobin levels and body weight of Uda lambs

	AGE IN WEEKS																	
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Coccidia oocysts level											+	+	+	+	+	+	+	+
n											2	3	6	6	6	5(1)	3(1)	4
Body weight kg	4.14	4.4	5.0	5.4	6.9	8.7	8.3	8.56	9.2	9.16	10.5	11.83	10.83	12.0	12.83	12.66	13.3	13.3
PCV	30.2	30.6	31.0	32.7	29.3	33.0	35.10	35.0	33.7	35.5	36.3	38.6	38.33	35.33	29.16	34.66	27.83	28.66
SD	±4.2	±1.81	±1.02	±1.39	±3.15	±2.20	±3.00	±1.0	±3.21	±3.04	±5.03	±3.05	±5.76	±2.08	±2.86	±1.52	±1.52	±3.01
HB	10.4	11.24	10.30	10.26	11.76	11.48	12.36	12.76	11.67	12.00	12.96	13.60	12.60	12.60	10.96	13.26	9.26	10.03
SD	±1.69	±1.0	±0.89	±0.63	±1.37	±0.81	±1.16	±0.15	±1.33	±1.33	±1.96	±1.3	±1.3	±1.3	±1.31	±1.09	±1.45	±1.35
TP	7.72	7.71	7.15	6.84	6.18	5.78	7.20	6.73	7.0	6.70	6.53	7.25	6.66	7.0	6.23	6.43	5.56	6.56
SD	±0.77	±0.5	±0.51	±0.44	±0.64	±0.77	±0.66	±0.70	±0.68	±0.86	±0.34	±0.35	±0.61	±0.34	±0.40	±0.40	±0.51	±0.51

NB: Number in bracket is number of dead sheep.
n = Number of sheep positive for coccidia oocysts.
\+ = 1-10 oocysts per field = light infection
PCV= Packed Cell Volume, %
HB = Haemoglobin Concentration, g/dl
TP = Total Serum Protein, g/dl
SD = Standard Deviation of the means.