STUDIES ON BOVINE COCCIDIA [APICOMPLEXIA: EIMERIIDAE] IN PARTS OF PLATEAU STATE, NIGERIA

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CERTIFICATION

This is to certify that the research work of this thesis by ABISOLA TITILAYO OLUWADARE [PGNS/7090/91] were carried out under my supervision.

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DECLARATION

I HEREBY DECLARE THAT THIS THESIS IS A RECORD OF MY ORIGINAL WORK AND TO THE BEST OF MY KNOWLEDGE, NO PART OF IT HAS BEEN PRESENTED TO ANY INSTITUITION FOR THE AWARD OF ANY HIGHER DEGREE.

A.T. OLUWADARE (MRS).

DEDICATION

To the Almighty God

AND

To my Husband Adetunji Oluwadare

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ABSTRACT

A parasitological examination of 2,500 faecal samples of cattle was carried out in Plateau State, Nigeria, to determine prevalence, seasonal distribution and sources of various species of *Eimeria* in both sexes, age groups, breeds and husbandry systems. Effects of temperatures on sporulation of *Eimeria* oocysts and chemical analysis of the *Eimeria* oocysts were also determined.

Out of 2500 samples examined, 1567 i.e 62.68% were positive for twelve species of *Eimeria*. *E. alabamensis* occurred in 220 [8.80%], *E. auburnensis* 806 [32.24%], *E. bovis* 914 [36.56%], *E.brassiliensis* 240 [9.60%], *E. bukidnonensis* 580 [23.20%], *E. canadensis* 236 [9.44%] *E. cylindrica* 556 [22.24%], *E. ellipsoidalis* 722 [28.88%], *E. pellita* 279 [11.16%]. *E subsphserical* 295 [11.80%], *E. wyomingensis* 445 [17.80%] and *E. zurnii* 1043 [41.72%]. *E.zurnii* 54.88% was predominant in the Jos Abattoir. *E. cylindrica* 81.02% in Naraguta, *E. auburnensis* 76.08% in Nassarawa Gwom, *E. zurnii*, 97.52% in Rukuba, *E. bovis* 29.36% in Vom and *E. ellipsoidalis* 94.62% in Zallaki.

Mixed infections of 2-12 species were found in 1457 [58.28%] faecal samples with 178 [7.12%] positive for two parasites; 324 [12.96%], for three parasites; 401[16.04%], for four parasites; 280 [11.20%], for five parasites; 160 [6.40], for six parasites; 72 [2.88%], for seven parasites; 11 [0.44%], for eight parasites; 10 [0.40%], for nine parasites; 8 [0.32%], were positive for ten parasites; 8 [0.32%], for eleven parasites; 5 [0.20%], or twelve parasites. Only 110 [4.40%] harboured single infections The most infected age group was 10-14 months old with infection rate of 79.30%. Other age groups were 0-4 months 43.75%;

5-9 months 65.90%; 15-19 months 72.33%; 20-24 months 61.11%; and 25 months and above 43.20%. There was statistically significant difference in the rate of infection between age groups 10-14 months and 25 months and above, between 10-14 months and 0-4 months [P<0.1] The calves first shed *Eimeria* oocysts between 14 and 84 days of their lives. The parasites were more prevalent in bulls than in cows, but there was no statistically significant difference in the rate of infection between bulls and cows. [P>0.05]. N'dama breed carried the lowest infection [44.36%] while the Muturu carried the highest infection rate of 83.76%. There was a statistically significant difference in the rate of infection between N'dama and Muturu breeds [P<0.05]. Cattle grazed on pastures were more infected than those raised either on mud floor pens or on concrete floor pens. The prevalence rates were 70.70%, 62.48% and 56.73% respectively. The cow beef cattle had the highest rate of infection of 69.15% while the dairy cattle had 55.06% infection rate. There was a statistically significant difference in the rate of infection between the beef cattle and dairy cattle [P<0.05].

The major source of infection was the pastures, having contamination rate of 40.77%. Others were beddings 32.38%; feeds 28.05% and udders 29.17%. There was a statistically significant difference in the rate of contamination between pastures and feeds [P<0.01] and between pastures and udders [P<0.01].Infection was higher during the dry season 68.35%, than during the wet season, 59.31%. There was no statistically significant difference in the infection rate between dry and wet season [P>0.05]. Low temperature inhibited sporulation of *Eimeria* oocysts while high temperatures increased sporulation. The morphological features of *Eimeria* oocyst types encountered varied in sizes, shapes and inclusions. Twelve Amino acids were found in the sporulated bovine *Eimeria* oocysts in this study, 9 essentials and 4 non-essentials amino acids.

CHAPTER ONE

INTRODUCTION AND LITERATURE REVIEW

1.1 INTRODUCTION

The term coccidiosis applies to the disease condition caused by infection with one or more of the many species of coccidia. Coccidia are a group of parasitic protozoans, which invade certain cells of the intestinal epithelium, caeca, often in other organs like liver and kidney. Each species of coccidia produces different host parasite interaction; as such there are many kinds and degrees of coccidiosis. The disease only occurs if an animal is subjected to heavy infection or its resistance is lowered. It is important at the outset to differentiate between infection and disease. The presence of infection does not invariably lead to the development of clinical signs of disease. Low level of challenge can actually be beneficial by stimulating protective immune responses in the host (Catchpole *et al* 1993). The disease is cosmopolitan, occurring in practically all kinds of vertebrates including fowls, cattle, pigs, sheep, goats, cats and dogs (Ajayi 1973). The problem of identification of species is simplified by the fact that parasites are host specific, each

species occurs in a single or in a limited group of related hosts. Of many described genera of coccidia the genus *Eimeria* contains the species of major economic importance in cattle. Internal structure of the sporulated occysts is the characteristic used to distinguish this genus from several others that may occasionally be encountered. The oocysts of all genera, when freshly passed, consist of a thickened outer wall and rounded mass nucleated protoplasm. Not until sporulation has occurred do the distinguishing characteristics become apparent. In the genus *Eimeria* four sporocysts develop, each containing two banana-shaped sporozoites. This is distinguished from another genus *Isospora* containing many species from wild birds. *Isospora* contains two sporocysts each containing four sporozoites.

The causative agent of bovine coccidiosis is of the genus *Eimeria* of the family Eimeriidae. Bovine coccidiosis is an infectious disease of cattle which produces bloody scours or red diarrhoea, dysentery, weight loss and death. The disease is said to be more severe during dry hot and sunny conditions usually considered unsuitable for oocyst development (Marquadt 1960, Marquadt *et al* 1960, Parker and Jones 1987, Wilber *et*

al 1994, Ahmed *et al* (1992). Bovine coccidiosis has long been of interest because of its economic importance. In U.S.A for example annual estimate loss has been put at 200 million dollars (About 28 billion Naira) as of 1993 (Taylor and Catchpole 1994). The disease causes a lot of economic loss in livestock production industries all over the world (Foreyt, Parish and Foreyt 1981).

The disease occurs mostly in young animals, but occasionally it occurs in calves over 6 months of age or even in adults (Joyner *et al* 1996, Macmerinam and Elliot 1995, Svensson *et al* 1993). The most serious losses are seen in dairy herds where large numbers of calves are kept. Older cattle are carriers, and they continue to pass oocysts in the faeces (Waggoner *et al* 1994 and Holliman 2000).

There are thirteen known species of bovine *Eimeria*. These are *E.alabamensis* Christensen 1941, *E.auburnensis*, Christensen and Porter *1939, E. bovis,* Fiebiger *1912,* E.brassiliensis Torres and Ramos 1939, *E.bukidnonensis* Tubangui 1931, *E.canadensis* Bruce 1921, *E.cyclindrica* Wilson, 1931, *E.ellipsoidalis* Becker and Fye 1929, *E.illinoisensis* Levine and Ivens 1967, *E.pellita* Supperer 1951,

E.subspherica Christensen 1941, *E.wyomingensis* Huizinga and Winger 1942 and *E.zurnii* Rivolta 1878, Martin 1909.

Calves become infected by ingesting sporulated oocysts along with their feed or water. The severity of disease depends upon the number of oocysts they ingest. If few oocysts are ingested, no symptoms will be noticed, but if a large number is ingested, severe disease and even death may occur. However, subclinical infection may cause retardation of growth and add greatly to financial loss. Crowding and lack of sanitation greatly increase the disease hazard. Successive passage of coccidia from one animal to another often builds up infection to a pathogenic level. Long and Millard (1979) showed that animals under nutritional stress are liable to respond adversely to coccidial infection. There is a remarkable degree of specificity both in regards to the host and in part of the host in which development takes place. Coccidia that invade the small intestine generally produce less pathogenic effects (Gregory 1990). This is because in ruminants the small intestine is very long, providing a large number of host cells and allowing the potential for enormous parasite replication with minimal damage. If absorption is

impaired, the large intestine is capable of compensating to some extent. In the large intestine, the rate of cellular turnover is much less and there is no compensatory effect from other regions of the gut. Coccidia that invade the large intestine are thus more likely to cause pathological changes, particularly if large numbers of sporulated oocysts are ingested over a short period of time. Those coccidia that produce small endogenous stages and develop in epithelial cells of the villi produce minimal lesions. In contrast coccidia that infect stem cells in the crypt of epithelium cause extensive lesions, preventing replacement of damaged epithelium. Coccidia with large endogenous stages can evoke either localized or diffused lesions because of the large numbers of parasites produced. In cattle *E.bovis* and *E.zurnii* are considered the main pathogens (Ernst and Benz 1986). These species affect the large intestine of the host because they have large endogenous stages; therefore they can kill stem cells, thus impairing cellular repairs (Radostits and Rocksdale 1980, Fox 1985, Taylor and Catchpole 1994). Effects of coccidial infection may be exacerbated if different species that affect different parts of the gut are present. Similarly concurrent

infections with other disease-producing agents such as helminths, bacteria and viruses may affect the severity of disease. Pavorvirus infection is thought to aggravate coccidiosis in calves (Durham *et al* 1985). Calves infected with intestinal nematode along with coccidia had higher intensity of coccidiosis (Davis *et al* 1959 Agnihotri 1994 and Wariuru *et al* 2000).

All ages of cattle are susceptible to disease. During the first few months of life, the majority will probably have been infected and may not show signs of disease. Those that reach adulthood are highly resistant to pathogenic effects of the parasites, but they 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. In the young, the colostrum provides passive immunity during the first few weeks of life. Thereafter, animals acquire resistance to coccidia as a result of active immunity. An animal's resistance to coccidia infection can be reduced by adverse conditions such as dietary changes, prolonged travel, extremes of temperature and weather conditions (Gregory 1990,

Hasbullah *et al* 1990 and Waruiru *et al* 2000). According to nutritional status; mineral and vitamin deficiencies can influence resistance to infection. Suckling animals who benefit from colostral intake may forage less, and hence pick-up fewer oocysts from pasture. Well-nourished animals may simply be able to fight off infection more readily. Mineral deficiencies can affect the immune response of infection.

1.2 LITERATURE REVIEW

Lee and Armour (1959) carried out a survey of the coccidial oocysts in Nigerian cattle, and 11 species were identified. These included *E.alabamensis* Christensen 1941, *E.auburnensis,* Christensen and Porter 1939*, E. bovis,* Fiebiger *1912, E.brassiliensis* Torres and Ramos 1939, *E.bukidnonensis* Tunbagui 1931, *E.canadensis* Bruce 1921, *E.cyclindrica* Wilson, 1931, *E.ellipsoidalis* Becker and Fye 1929, *E.subspherica* Christensen 1941, *E.wyomingensis* Huizinga and Winger 1942 and *E.zurnii* Rivolta 1879, Martin 1909.

Hasche and Todd (1959) reported that out of 355 cattle examined in Wisconsin, 26% had *E.ellipsoidalis*, whereas 20% were infected with

E.cylindrica, similarly 6% were infected with *E.brasilliensis*, whereas 42% and 3% were positive of *E.bukidnonensis* and *E.canadensis* respectively. Fitzgerald (1962) conducted field studies on the incidence of coccidia in young Hereford calves during grazing and feeding seasons in Alabama. He encountered seven species of *Eimeria* and observed that *E.zurnii* was the causative agent of winter coccidiosis. Majaro and Dipeolu (1981) reported on the survey of coccidiosis in trade cattle, sheep and goats in Nigeria. Faecal examination showed that nine species of *Eimeria* were identified, and *E.bovis* and *E.zurnii* were the predominant species. In another investigation, Kasim and Al-shawa (1985) studied the prevalence of *Eimeria* in the faeces of cattle in Saudi Arabia and observed that out of the 205 cattle studied, 34.1% of the individual samples were positive, and mixed infection of 2 to 4 species were found in 15.7% of the specimens. *E.zurnii* and *E.bovis* were predominant. Ernst *et al* (1987) determined the prevalence of coccidial oocysts from crossbreed beef calves in Bahia grass in coastal plain of Georgia. Out of 534 faecal samples collected, 86.0% contained one or more species of coccidian oocysts; 13 species were found, and *E.bovis*

was the predominant species. Parker and Jones (1987) examined the faecal samples of unweaned calves from birth to eight months of age and discovered that most calves shed at least nine species of *Eimeria* by 3-4 months old. Oda and Nishida (1990) carried out a field survey on the prevalence of bovine coccidia in prefectures of Japan in autumn and found that out of 1,015 faecal samples examined, 59.0% contained coccidial oocysts. The prevalence was highest in the animals between 6 and 11 months of age.

Hasbullah *et al* (1990), examined faecal samples from 2,019 cattle in Japan for a period of 12 months and 19.3% were found to be positive, and *E.bovis* was the most dominant species. Svensson *et al* (1993), found out that *Eimeria* oocysts were shed in calves during their first 3 weeks after turn out to pasture. The number of *Eimeria* oocysts per gramme and the dry matter content of 449 faecal samples taken from 54 calves in 8 herds in South West Sweden were determined during the last 2 weeks before and first 3 weeks after the animals were turned out to pasture. *E.alabamensis*, accounted for most of the increase but small numbers of the oocysts of *E.bovis, E.auburnensis, E.cylinderica*,

E.pellita, E.zurnii, *E.bukiduonensis, E.ellipsoidalis* and *E.subspherica* were found.

Mundim *et al* (1994) examined faecal samples from calves in Uberlanda in Brazil, and out of 55 faecal samples examined 47.0% had *Eimeria* oocysts in their faeces. Nine species were found; *E.bovis* occurred in 36%, *E.zurnni* in 34.0% and *E.ellipsoidallis,* 31.5%. Penzhorn, Knapp and Speer (1994) collected faecal samples from free ranging American cattle in Montana. The following results were obtained: *E.bovis* 97.0% *E.canadensis* 32.0%, *E.brassillensis* 3.2% and *E.auburnensis* 9.7%. Arslan and Tuzer (1998), in Turkey, examined 768 faecal samples of cattle, and the species encountered and their prevalence rates were, *E. alabamensis* 4.98%, *E. auburnensis* 27.0% *E. bovis* 34.0%, *E. canadensis* 12.0%, *E. cylindrica* 7.9%, *E. ellipsoidalis* 14.0% and *E. zurnii* 26.0%. Hooshmand, Svensson and Uggla (1994) infected Swedish calves with *E.alabamensis* and found the prepatent period to be 6 to 8 days. The clinical signs were mostly diarrhoea, loss of appetite and depression. Growth rates were significantly reduced for 18 days after inoculation, but 71 days after, they did gain back their weights.

Protein available to the ruminant for nutritional needs is supplied by microbial and dietary sources (Wilkerson *et al* 1993). Microbial protein supply to the deodenum can meet between 50 and 90% of metabolisable protein requirement of beef cattle (Parker 2000). Because of the large quantity of protein provided by microorganisms, analyses on rumen microbial protein were carried out by Goedeken *et al* (1990), Wilkerson *et al* (1993), Rohr and Lebzein (1991) and Klemesrud *et al* (2000) and 10 to 13 types of amino acid were discovered. Pattilo and Becker (1995) found that protein and polysaccharides were present in the sporocyst wall of some *Eimeria* oocysts during cytochemical investigation. Loser and Gornnert (1965) reported that *Eimeria* oocysts wall contains o-dioxy-phenol-protein; consequently the oocyst wall is very resistant to various physical and chemical factors.

There are 20 types of amino acids, (11 essentials and 9 non-essentials), and their functions are as follow as described by Harper (1971):

1.2.1 Alanine.

This is an important source of energy for muscle. It is the primary source of sugar metabolism. It boosts immune system by producing antibodies. Lack of alanine leads to hypoglycemia, muscle breakdown and fatigue.

1.2.2 Aspartic acid.

This is interconvertible with asparagines and therefore shares the same functions. They are both involved in immune system function by enhancing immunoglobulin production and anti-body formation. They both help the liver by aiding the removal of ammonia. Lack of aspartic acid and asparagine causes calcium and magnesium deficiencies.

1.2.3 Cysteine and cystine.

Both are interconvertible; they are protective against radiation. They are protective against radiation. They are essential in growth, maintenance and the repair of skin. Lack of cysteine and cystine causes chemical sensitivity and food allergy.

1.2.4 Glutamic Acid.

This increases energy, accelerates wound healing and ulcer healing. It plays major role in DNA synthesis. Lack of glutamic acid causes ulcer.

1.2.5 Glutamine.

This involves in muscle strength and endurance. It is essential for helping to maintain normal and blood sugar levels. It is also essential to gastrointestinal function by providing energy to small intestine. Lack of glutamine causes chronic fatigue syndrome.

1.2.6 Glycine.

This forms part of the structure of hemoglobin. It involves in glucacon production and assists in glycogen metabolism. Lack of glycine produces anaemia, viral infection, hypoglycemia and chronic fatigue syndrome.

1.2.7 Proline.

The main functions are that it is a critical component of cartilage and hence health of joints, tendons, and ligaments. It is involved in keeping heart muscle strong. It works in

conjuction with vitamin C in keeping skin and joint healthy. Lack of proline causes chronic liver diseases.

1.2.8 Serine.

It is used in maintaining blood sugar levels. It boosts immune system by assisting in production of antibodies and immunoglobulins. Lack of serine causes total body gamma and neutron irradiation and hypoglycemia.

1.2.9 Arginine.

This is essential for normal immune system activity and wound healing. It assists with regeneration of damaged liver. It is the most potent amino acid in releasing insulin. Lack of arginine causes immune deficiency syndrome.

1.2.10 Histidine.

This is found in high concentration in haemoglobin. It is useful in treating aneamia due to relationship to haemoglobin. It assists in maintaining proper blood pH. Lack of histidine causes aneamia.

1.2.11 Isoleucine.

This is involved in muscle strength, endurance and muscle stamina. It is involved in formation of heamoglobins. Lack of isoleucine causes obesity and acute hunger.

1.2.12 Leucine.

It has all the properties of isoleucine. It is a potent stimulator of insulin and it helps in bone and skin healing. Lack of leucine causes depression, acute hunger, and vitamin B deficiency in pernicious aneamia.

1.2.13 Lysine.

It inhibits viral growth and it helps form collagen, connective tissue present in bones, ligaments tendons and joints. It assists in the absorption of calcium. Lack of lysine causes anaemia, weight and hair loss and irritability.

1.2.14 Methionine.

This assists in breakdown of fats. It helps to reduce blood cholesterol levels. It assists in the removal of toxic wastes from the liver. It helps prevent disorder of hair, skin and nails. Lack of Methionine causes obesity.

1.2.15 Phenylalanine.

This helps in major part of collagen formation. It is a powerful antidepressant. It enhances mood clarity of thought, concentration and memory, and it suppresses appetite. Lack of phenylalanine causes depression, obesity and cancer.

1.2.16 Threonine.

This is required in formation of collagen. It helps prevent fatty deposits in the liver. It aids in production of antibodies. Lack of threonine causes depression, muscle spasticity and epilepsy.

1.2.17 Tryptophan.

This stimulates growth hormones, lowers risk of arterial spasms and effective in some forms of depression. Lack of tryptophan causes depression insomnia and chronic fatigue syndrome.

1.2.18 Tyrosine.

It increases energy and it improves mental clarity and concentration. It is an effective antidepressant. Lack of tyrosine causes depression and chronic fatigue syndrome.

1.2.19 Valine.

The main functions of valine are that it is involved in muscle strength, endurance and muscle stamina. Lack of valine causes hunger, obesity and neurological deficit.

1.3 LIFE CYCLE OF BOVINE *EIMERIA*

The life cycle of a typical bovine coccidium involves only one host, and the development is in 3 phases viz: schizogony, gametogony and sporogony. Oocysts, after leaving the cow by way of faeces, sporulate under favourable conditions to become the infective stage in 2 - 7 days. The infective, sporulated oocyst containing 4 sporocysts, each of which contains 2 sporozoites, enters the host passively by ingestion. The animal ingests the oocyst along with food and or water from external environment. Infection from the ingested oocysts occurs whenever excystation takes place in the lower part of the small intestine and also in the caecum within 24 hours after introduction of oocysts (Hammond, McCowin and Shupe 1954, Nyberg and Hammond 1965). Excystation releases the contained sporozoites. Two separate stimuli are necessary for excystation (Nyberg *et al* 1967). The first is provided by carbon

dioxide and the second by trypsin, and bile carbon dioxide is said to stimulate the activation or production of an enzyme or an enzymic rate limiting of the micropyle. The second stage of excystation is pH dependent, and it effects the escape of the sporozoites. Bile facilitates the entry of trypsin through the altered micropyle which then digests the sporocystic plug, permitting escape of the mobile sporozoites. Doran (1906) considers that the sporozoites may also secrete enzymes that attack the plug. The liberated sporozoites emerge through the narrow opening of the micropyle where steida body formerly was, and remains within the oocyst wall. The sporocyst residuum is usually destroyed during this process. Liberated sporozoites penetrate quickly within seconds into intestinal epithelium of the host where further development takes place (Hammond, Anderson and Miner 1973). They are engulfed by macrophages and are carried by them through lamina propria of the villi to reach the epithelium in the depths of the glands of Leiberkuhn. The next stage is the asexual reproduction or schizogony.

1.3.1 Schizogony.

This process is initiated when sporozoites enter the epithelial cell and

become rounded up. Development in bovine coccidia occurs within the nucleus. The rounded up sporozoite becomes trophozoite, and within a few days the nucleus of the trophozoite divides by schizogony (mutiple fission) to become a schizont. The nucleus in schizont is considered to be of the mitotic type (Pellerdy 1974). Initially the cytoplasm is undivided, but later the daughter nuclei are each surrounded by a clear zone of cytoplasm and eventually a number of elongate fusiform organisms are produced. These are called the first generation merozoites.

The numbers of merozoites that are formed in the first generation schizont vary according to species. In *E.bovis,* more than 100,000 first generation merozoites are released, and they then enter other epithelial cells in the area and continue the cycle of asexual development. In some species this results in second generation schizonts. In some other species the second generation schizont is larger than the first whereas in some it is smaller. The number of merozoites produced also varies according to the species e.g. the second generation schizonts of *E.bovis* are extremely small, about 8.9 - 10 microns and form not more than 30 - 36 merozites

(Hammond *et al* 1973). The second generation merozoites may proceed to a third or more generations of asexual reproduction or they may differentiate into sexual or gametogenous forms.

1.3.2 Gametogony.

The sexual process in coccidiosis is broken down into 2 periods viz: - the gametogenesis period during which formation of male and female gametes occurs and the fertilization period. The factors responsible for the initiation of gametogenous cycle are not fully understood. Although generally considered to be genetically determined, host responses may play a role through phenotypic determination in terminating schizogony. The gametogenesis in *Eimeria* is characterized by the fact that one comparatively large macrogamete always develops from one macrogamont but a multitude of small, motile flagellated microgametes are formed from one microgamont. During macrogametogenesis there is an accumulation of nutritive substances. In the young macrogamate small granules are initially found in the vicinity of the nucleus; later these enlarge and become scattered over the cytoplasm, the larger granules being found on the periphery of the cell. These are plastic

granules or wall forming granules that form the wall of oocyst following fertilization of the macrogamate. The process of macrogametogenesis can be divided into two periods. The first is the period of gametocyte growth and is accompanied by a reproduction of nuclei. Growth of gametocyte and division of the nucleus lead to the formation of a polynucleus microgametocyte with a characteristic peripheral distribution of nuclei. The second period is one of differentiation and formation of microgametes. During this period the nuclei assume a coma-shape and accumulate on the periphery of the cell leaving a residual mass of cytoplasm in the cell. Rupture of microgamont liberates the microgametes which fertilize the macrogametes. Fertilization by microgametes may occur at any point on the surface of the macrogamate. A zygote is formed, and the oocyst wall is laid down around it. When the cyst wall is complete, the oocyst is extended from the tissue and passed to the exterior.

1.3.3 Sporogony.

With few exceptions, sporulation does not occur until the oocyst is shed to the exterior of the body. Initially the zygote almost fills the oocyst

cavity, but within a few hours outside the host, the protoplasm contracts from the wall of the oocyst to form a sporont and leaves a clear space between it and the wall. The sporont divides into four sporoblasts and remaining cytoplasm being left as an oocystic residual body. The sporoblasts are initially more or less spherical, but later elongate into ovoid or ellipsoid bodies which then become sporocysts by laying down a wall of refractile material around each sporoblast. The protoplasm inside each sporocyst further divides to form two sporozoites. Protoplasm remaining from the division is left as a sporocystic residual body.

The time required for sporulation to the infective stage is a specific feature of each species of coccidium and is used as a characteristic in identification. Oxygen and adequate moisture are necessary for the sporulation and at constant temperature. Temperature also has been an important influence on sporulation. The optimum temperature for sporulation is about 30^{o}C. In general sporulated oocysts are more resistant to desiccation and cold, and may survive for up to two weeks at temperature of - 12^{o}C to 20^{o}C. Unsporulated forms are killed in 96

hours at these temperatures.

1.4 MORPHOLOGY OF BOVINE *EIMERIA* OOCYSTS

The oocysts of the following *Eimeria* species of cattle have been described. Species differentiation is based on the following characteristics.

1.4.1 *Eimeria alabamensis*, Christiensen 1941.

The oocysts range between 13μ and 24μ in length by 11 to 36μ in diameter. The shape is typically pyriform with variations. There is no micropyle and the wall is thin, delicate, homogenous, transparent and slightly thinner at the narrow end. The oocysts appear colourless and crystalline under low magnification, but under oil immersion the wall has a grayish - lavender to pale brownish yellow tint, fading to light yellow at the narrow end. Sporulation time is between 96 hours and 120 hours. Sporulated oocysts contained elongated tapered sporocysts, each having two indistinct sporozoites. A polar granule is presumably absent.

1.4.2 *Eimeria auburnesis*, Christensen and Porter 1939.

The oocysts are typically elongate, ovoidal, varying between tapered

and sub-ellipsoidal in form. A micropyle is present and appears as a gap in the wall at the tapered end covered by a thin black line considered possibly represents an operculum. The walls are smooth but varying in structure from the transparent type to a rare semi-transparent heavily mamillated type. Sporulation time is between 48 and 72 hours. The oocysts range from 32μ to 45μ long by 20μ - 25μ wide.

1.4.3 *Eimeria bovis*, Christensen 1941.

The oocysts are ovoidal blunted across the narrow end. The oocysts range from 23μ to 34μ long and 17μ to 23μ wide. The oocyst wall is smooth homogenous, transparent, greenish brown in colour. Micropyle is present, appears at a higher area of the wall. Sporulation time is 48 hours - 72 hours at room temperature. The wall is composed of a heavy inner layer and a very thin transparent outer layer. An oocyst residuum and polar granule are present. Sporocyst residuum is present.

1.4.4 *Eimeria brasiliensis*, Torres and Ramor 1939.

The oocysts are ellipsoidal, about 34μ - 42μ long and 22μ - 29μ

wide. The oocyst wall is smooth and yellowish-green in colour. The wall is composed of a single layer and is covered by micropylar cap. An oocyst polar granule is present. Oocyst residuum is absent but sporocyst residuum is present. Sporulation time is about 6 days - 7 days.

1.4.5 *Eimeria bukidnonensis*, Tubangui 1931.

The oocysts are pear-shaped to oval. They are yellowish brown to dark brown in colour. They are 31μ to 44μ long and 20μ - 27μ wide. The oocyst wall is about 2μ to 4μ thick, except at the micropylar end where it is thin. It is composed of 2 layers; the outer layer is thick and the inner layer has a tough membrane. Lee (1954) described the wall as radially striated. The oocyst wall is speckled and rather rough. The micropyle is conspicuous about 3.5μ -7μ wide. An oocyst residuum and polar granule are absent. The sporocysts are elongated about 14μ - 22μ by 9μ - 12μ. A steida body is possibly present. Definite sporocyst residual material is absent. Sporulation time is 4 days -7 days.

1.4.6 *Eimeria canadensis*, Bruce 1921.

The oocyst shape is typically ellipsoidal, varying from nearly cylinderical to stoutly ellipsoidal. They are about 28μ - 37μ by 20μ - 27μ. The oocyst wall is smooth, transparent slightly yellowish-brown in colour. The micropyle is an inconspicuous gap in the wall at one end, appearing covered with a thin dark reflection line. An oocyst residuum and polar granules are absent. Sporulation time is 72 hours.

1.4.7 *Eimeria cylindrica*, Wilson 1931.

The oocysts measure 16μ - 27μ long by 12μ - 15μ wide. The shape is typically cylindrical but may vary from ellipsoidal to narrow cylindrical. The oocyst wall is thin, colourless, smooth, homogenous and transparent. The micropyle is imperceptible. Oocyst residuum and polar granules are absent. A sporocyst residuum is present, but there is no sporocyst steida body. Sporulation time is about 48 hours.

1.4.8 *Eimeria ellipsoidalis*, Becker and Frye 1929.

Oocysts are from 12μ - 27μ long by 10μ - 18μ wide. The shape is predominantly ellipsoidal with some spherical to subspherical forms. Oocyst wall is thin homogenous and transparent. An oocyst residuum and polar granule are absent. A sporocyst residuum is present. No micropyle present.

Sporulation time is between 48 hours and 72 hours.

1.4.9 *Eimeria pellita*, Supperer 1952.

The oocysts are ovoid with a flattered small end about 36.1µ - 40µ by 26µ - 30.2µ The oocyst wall is relatively thick and dark-brown. The surface of the oocyst bears numerous small uniformly distributed protuberances in the form of small blunt points that give the wall velvety appearances. There is a micropyle at the small end. An oocyst polar granule and residuum are absent. The sporocysts are elongated without steida body. A sporocyst residuum is present, usually compact. The sporozoites lie lengthwise in sporocysts with 2 refractile globules. It is possible that *E.pellita* is a synonym of *E.bukidnonensis.* However it differs from it in the velvety appearance described for its oocyst wall. The oocyst wall of *E.bukidnonensis* has been described as speckled. Other differences are that sporocyst residuum is prominent in *E.pellita* and absent in *E.bukidnonensis*. The sporocysts of *E. bukidnonensis* are somewhat pointed at one end while those of *E.pellita* are not pointed. Sporulation time is between 10 days and 12 days.

1.4.10 *E.subspherica*, Christiensen 1941.

The oocysts are the smallest to of all the bovine *Eimeria* species. They are about 9µ - 11µ long by 8µ - 12µ wide. They are ellipsoidal to subspherical in shape. The oocyst wall is uniformly thin, smooth, homogenous and transparent, with no visible mircopyle. The oocyst appears colourless to a faint yellow tint and fragile. Oocyst residuum and polar granules are absent. The sporocysts are pale, spindle-shape, without a sporocyst residuum. Sporulation time is 4 days - 5 days.

1.4.11 *Eimeria wyomingensis*, Huizinga and Winger 1942.

The oocysts are similar to those of *E.bukidnonensis* but the oocysts are smaller. The oocysts are ovoidal in shape, measuring 37µ - 44.9µ by 26µ - 30.8µ. The oocyst wall is thick with a yellowish-brown to greenish-brown colour, and slightly speckled. The micropyle is conspicuous. Sporulation time is 5 days - 7 days.

1.4.12 *Eimeria zurnii*, Rivolta 1878, Martin 1909.

The oocysts are spherical, subspherical to ellipsoidal, measuring 15µ - 22µ by 13µ - 18µ. The oocysts appear colourless and the wall is thin, homogenous and transparent. There is no visible micropyle. Oocyst polar granule and residuum are absent. Sporocyst residuum is absent. Sporulation

time is 3 days at 20^{o}C, 9 days - 10 days at 12^{o}C, 23 hours - 24 hours at 30 ^{o}C - 32.5^{o}C. (Marquardt *et al* 1960).

1.5 PATHOGENESIS OF BOVINE COCCIDIA

Coccidia are obligate, intracellular parasites whose development within the cytoplasm of epithelial cells results in the death of each cell which is parasitized. The effect on the host depends on the magnitude of the initial infective dose and the number of cells invaded at the onset by the sporozoites. The effect also depends on the spread of infection during schizogony, which is affected to a great extent by immunity acquired by the host. As increasing numbers of organisms enter sexual phase (gametogenesis) infection of new cells by merozoites diminishes and the disease gradually abates. When many cells of the intestinal epithelium are parasitized at one time the denuded mucosa may bleed greatly and intense inflammation involves the lamina propria and sometimes the sub mucosa. As large numbers of epithelial cells are destroyed the remaining epithelium is eliminated to replace that which was host. This eventually causes hyperplasia of the intestinal epithelium, which is cast into long papillary ponds as replacement of the epithelial cells exceeds

their loss. Coccidia gametogenesis is most numerous in that the lesion exhibiting this hyperplasia. This is in contrast to the erosive haemonhyic stage which organisms in various stages of schizogony are most common.

Different species of bovine coccidia manifest a tendency to localize in different parts of intenstine. *E.zurnii* and *E.bovis* occur mainly in the caecum, colon and last part of the ileum, whereas, *E.alabamensis* is an intranuclear parasite occurring within the nuclei of the epithelial cells at the tips of villi. Coccidia life history is self-limiting, merozoites and gametocytes are the pathogenic stages causing rupture of the cells they invade with consequent exfoliation of the epithelial lining of the intestine. Oocysts count is often very low when the disease is at its peak since the oocysts have not yet been formed. Exfoliation of the epithelium mucosa causes diarrhoea and in severe cases hemorrhages into the intestinal lumen and the resulting hemorrhagic anaemia may be fatal, leading to death of the animals. If the animal survives this stage of the life cycle of the coccidia terminates without further damage.

Prepatent period ranges from one to four weeks depending on the dose of

oocysts, length of intestine, length of oocysts exposure to external environment and the age of the host. Under practical conditions constant reinfection occurs and waves of pathogenic stages succeed each other (Blood and Henderson 1974)

Considering pathogenesis on individual basis *E.zurnii* is the most pathogenic, while *E.bovis* is rated second. In Europe *E.zurnii* is the most frequent cause of bovine coccidiosis. The acute disease is characterized by haemorrhagic diarrhoea, and the condition may become so intense that the faeces are frank blood. Teresmus is marked; there is anaemia, weakness and emaciation. In severe infections death may occur as early as 7 days after the onset of clinical signs. At post mortem the major lesions occur in the large intestine, though general catarrhal enteritis may be present in both the small and large intestine. In severe cases the caecum and colon may be filled with semifluid hemorrhagic material or even frank blood with fibrinous clot. The epithelium may slough away leaving large denuded areas, which are infiltrated with lymphocytes and leukocytes. In less acute cases the mucous membrane is roughened and spotted with petechial hemorrhages. Smears from the mucosa show very

large number of developmental stages of oocysts.

In *E.bovis* infection, the later stages of development of the first stage schizont cause distortion of villi and disruption in the case with the second schizont. It is the gametocytic stages, which cause the greatest pathogenic effect. Hammond (1964) estimated that if the full potential of *E.bovis* were to be realised, 1,000 oocysts could result in the destruction of 24 billion intestinal cells. In experimental infection, Hammond *et al* (1944) found that an infective dose of 125,000 oocysts or more caused marked signs of illness with diarrhoea occurring on the 18th day when faeces were streaked with blood. A calf given 125,000 oocysts became moribund, and with higher doses animal became moribund or died within 3 - 4 weeks of infection.

In severe infections majority of the crypts of the large intestine and sometimes of the terminal part of the small intestine are destroyed, the epithelial layer denuded and the lumen of the intestine filled with blood. The mucosa is necrotic and sloughed and this damage may extend to the sub mucosa, the wall of the intestine is congested and edematus, thickened with petechial or diffuse hemorrhages. Large number of

gametocytes and oocysts are visible microscopically.

The pathogenicity of *E.alabamensis* is low under field conditions and is generally considered to be unimportant in clinical bovine coccidiosis. Disease may be produced if large numbers of oocysts are given to young calves. Davis *et al* (1955) found that 140 million oocysts produced yellowish green diarrhoea, admixed with blood in 14-month-old animals. The small intestine showed hyperaemia, destruction of the epithelium, a leukocytic infiltration and oedema.

The effect of *E.auburnensis* is also low under field conditions. Profused green diarrhoea was produced in a 2-week-old calf given 8,000 oocysts by Christensen and Porter (1939). Clinical signs appearing between the 9th and 15th day of infection. Davis and Bowman (1952) reported the passages of blood and mucus with straining, in artificial infections with large numbers of oocysts and in natural outbreak. *E. ellipsoidalis* is also thought to be of minor pathogenic significance, (Holliman 2000). Boughton (1945) reported that *E. ellipsoidalis* might cause diarrhoea in young calves 3 months of age, and Hammond et al (1963), showed that a varying degree of immunity developed after infection with 50,000 to 1

million oocysts. *E. subspherica* is not known to be pathogenic, while the endogenous developmental cycles of other bovine *Eimeria* species are unknown and no pathogenesis is ascribed to them.

1.5.1 Factors Affecting the Pathogenicity of Coccidia

Host - Parasite Relationship.

A successful parasite is one that infects every available host causing minimal damage. This ultimate, harmonious co-existence is however easily upset by factors affecting either host or parasite leading to clinical signs of disease in the host.

Site of Development.

The coccidia that invade the small intestine generally produce less pathogenic effect (Gregory 1990). This is because the calves have long small intestine providing a large number of host cells and allowing the potential for enormous parasite replication with minimal damage. If absorption is impaired, the large intestine is capable of compensating to some extent. In the large intestine the rate of cellular turnover is much less and there is no compensatory effect from other region of the gut. Coccidia that invade the large intestine are thus more likely to cause

changes particularly if large numbers of oocysts are ingested over a short period of time. Those coccidia that produce small endogenous stages and develop in epithelial cells of the villi produce minimal lesions. In contrast coccidia that infect stem cells in the crypt epithelium may produce more extensive lesions by preventing replacement of damaged epithelium. Coccidia with large endogenous stages can evoke either localised or diffuse lesions because of the large number of parasites produced. In bovine *Eimeria, E.bovis* and *E.zurnii* are considered the main pathogens (Erst and Benz 1986). They affect large intestine and have large endogenous stages and can kill the stem cells.

The effect of coccidial infection may also be exacerbated if different species that affect different parts of the gut are present. Similarly concurrent infections with other disease - producing agents such as helminths, bacteria and viruses may affect the severity of disease. Pavovirus infection is thought to aggravate coccidiosis in calves (Durham *et al* 1985)

Effect of Age on Susceptibility To Infection

All ages of calves are susceptible to infection but younger ones are more

susceptible to disease. During the first few months of life, the majority will probably have been infected and may or may not show signs of disease. Those that reach adulthood are highly resistant to the pathogenic effects of the parasite 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. Svensson *et al* (1993) discovered that calves started shedding *Eimeria* oocysts as early as 2 weeks. However in the young calves colostrum provides passive immunity during the first few weeks of life; thereafter they acquired resistance to coccidial infection as a result of active immunity. An animal resistance to coccidial infection can be lowered by adverse conditions such as dietary changes, prolonged travel, extremes of temperature, weather conditions, changes in environment or severe concurrent infection (Gregory 1990).

Nutritional status, mineral and vitamin deficiencies can influence resistance to infection. Suckling calves as well as those benefiting from colostral intake may forage less and hence pick up fewer oocysts from pasture. Well nourished calves may simply be able to fight off infection

more readily. Many deficiencies can affect the immense response to infection.

1.6 CLINICAL SIGNS OF BOVINE COCCIDIOSIS

The clinical symptoms caused by various coccidia are similar in all animals. Mild fever may occur in the early stage, but in most clinical cases the temperature is normal or subnormal. The first sign of illness is usually the sudden onset of severe diarrhoea with foul smelling fluid faeces containing mucus and blood. The blood may appear as a dark, tarry staining of the faeces or as streaks or charts of fresh red blood. Anaemia is variable depending on the amount of blood loss. It may be extreme with ash-white pallor of the mucosa. There is weakness, staggering and dyspnoea. Severe dehydration, emaciation and complete anorexia are common. The period of the disease is usually 5-6 days and survivors undergo a convalescent period of some weeks and regain condition slowly. In mild cases, poor growth and anaemia only result. Nervous signs like convulsions could be observed in calves and other cattle during outbreak.

1.7 SURVIVAL AND VIABILITY OF OOCYSTS IN EXTERNAL ENVIROMENT.

The survival of oocysts in external environment depends on 3 basic factors, namely, temperature, humidity and free access to oxygen. The possibility of oocysts development on the soil and their ultimate viability will not be identical in all soils or at all times of the year. This has been shown in a series of investigations conducted in different countries (Horton - Smith 1947, Kogan 1956 and Krylov 1960). Wilber *et al* (1994) compared oocysts survival in hosts from random rich and random poor soils and discovered that elevated random content of soil may have adverse effect on sporulation of coccidia while it still was intracellular within host.

Sporulation of oocysts in the external environment can only occur in certain temperature ranges, in most cases at a temperature between 18 ^{o}C and 20^{o}C, Ajayi (1976) found out that temperature of 5^{o}C and 10^{o}C inhibited sporulation of ovine *Eimeria* oocysts, but when the same oocysts were subsequently incubated at 25^{o}C they sporulated.

Lack of oxygen will also impede the sporulation of oocysts. If oocysts are placed in ordinary water the bacteria inside the water will compete with oocysts for oxygen and sporulation may not take place.

Marquardt *et al* (1960) showed that *E.zurnii* sporulated when oxygen deficit was only 10% or less when deficit was increased and in complete absence of oxygen no development took place.

Lack of humidity had also been shown to cause wrinkling of oocyst wall due to loss of water. Marquardt (1960) showed that at 20% relative humidity, 12% of oocysts formed sporozoites and the rest died. But at 75% humidity, about 51% of the oocysts sporulated. Graat *et al* (1994) reported that temperature at 21^{o}C and 35% relative humidity had no significant influence on ocyst sporulation.

Chemicals also have been shown to have effects on sporulation of oocysts. Some chemicals are known to penetrate though the cell walls of oocysts, causing cessation of development. Thus, Marquardt *et al* (1960) showed that 80% of oocysts of *E.bovis* placed in a solution of mercuric chloride died only 3% sporulated. Also, oocysts recovered from coxytrol – treated rabbits failed to sporulate well, most of them being destroyed or

distorted morphologically (Ajayi and Anthony, 1983).

1.8 DIAGNOSIS

Bovine coccidiosis can be diagnosed from combination of history, signs and gross lesions at necropsy and microscopic examination of scrapings of the intestinal mucosa and of faeces. Diarrhoea or dysentery accompanied by inappetence is suggestive of coccidiosis in calves. Secondary pneumonia is often present. Microscopic examination is necessary to determine whether the lesions are due to coccidia or to some other agent. However, diagnosis will be missed if one relies only on finding oocysts in the faeces. There may be none there at all in the acute stage of *E.zurnii* coccidiosis. Similarly the mere presence of oocysts in the faeces is not proof that coccidiosis is present. To be sure of a diagnosis scraping should be made from the affected intestinal mucosa and examined under the microscope. It is not enough to look for oocysts but schizonts, merozoites and young gametes should be recognised.

1.9 CONTROL OF BOVINE COCCIDIOSIS

The more oocysts ingested at early susceptible age, the worse the disease will be. There are several methods one can use to control bovine

coccidiosis.

1.9.1 Management.

Calves kept indoors on damp bedding are particularly at risk. Also those on contaminated heavily stocked pastures particularly in cold weather. Therefore reduction of stocking density and raising of food and water troughs to avoid contamination will help to reduce the risk (Catchpole 1989). Young calves should be kept off heavily contaminated pastures when they are most susceptible. Good feeding of dams prior to parturition and creep feeding of their progeny will also help to boost resistance to coccidiosis. Individual housing also helps in preventing coccidial infection (Pavlasek *et al* 1984).

1.9.2 Chemotherapy.

If control by management is impracticable or ineffective, medication can be considered. Decoquinate can be used for prevention of coccidiosis in calves (Fitzgerald and Mansfield 1969). Waggoner, *et al* (1994) used lasalocid acid and decoquinate against coccidiosis in calves and found that there was little advantage in weight gain or performance when calves with subclinal coccidiosis were medicated with the anticoccidial agents.

Macmerinan and Elliot (1995) concluded that mixing lasalocid in milk replacer or fresh milk is an effective method of protecting young calves against early infection with coccidia.

Sulplumethazine was found to reduce the severity of experimental *E.zurnii* or mixed species infection given at the rate of 7.25g per 4.5kg body weight followed by 3.6g daily for 3 days (Davis and Bowman 1954). Sulphadimidine was recommended for three days and had been found not sufficient to control the infection, but administration of the drug for 12 days or more resulting in trascient absence of oocyst with excretion recommencing two or three weeks later.

Hammond (1964) indicated that the use of Amprolium used for chicken coccidia would control *E.bovis* coccidiosis in calves when given in milk for 3 weeks. However, it is not effective when given as a single dose 13 days after infection.

Monensin has been used, although it has never been licensed as an anticoccidial for bovine coccidiosis (Stockdale 1981). It is marketed as a growth promoter for cattle in which it has side effect of reducing oocyst output dramatically. It has also been shown to give good results for chemotherapy of coccidiosis (Calhoun *et al* 1969, Gregory *et al* 1983). Elisade *et al* (1993) used salinomycin and found that it was effective in the control of coccidiosis in cattle.

1.9.3 Immunological Contro.l

Control of coccidiosis in chickens, using either controlled doses of live unattenuated coccidia or precocious strains has been extensively researched (Shirley 1992). In ruminant like cattle poor protection was obtained with continuous low-level inoculations of *E.bovis* (Fitzgerald 1967). In contrast, a severe single heavy challenge with the parasite induced protective immunity for six months or longer (Senger *et al* 1959, Fitzgerald 1967).

Colostral transfer of antibodies may provide protection to calves infected with *E.bovis* (Fiege *et al* 1992). The immunity to coccidia that develops is thought to be species specific although there is evidence that

some cross protection between species may occur. A humoral response to *E.bovis* develops in calves between 10days and 22 days after innoculation of oocysts (Andersen *et al* 1965). Attempt to transfer passive immunity by injection of antiserum has not been successful (Fitzgerald 1964). Evidence for a cell mediated immune (CMI) response to *E.bovis* was reported by Klesius *et al* (1977) and it has been suggested that CMI is probably more important in resistance against infection than humoral immunity (Hughes *et al* 1989).

It is unlikely that live virulent vaccines could be used in cattle. Control of coccidial infections has been reported in calves given irradiated occysts of *E.bovis* (Fitzgerald 1968); *E.bovis* and *E.auburnensis* (Ziegler 1982) and *E.zurnii* (Mielke, Rudnik and Hiepe 1993). Development of an optimum immunisation regimen for cattle is therefore a possibility but not without practical problems. Ultimately the administration of recombinant antigens may provide a more satisfactory means of vaccination (Taylor and Catchpole 1994).

1.10 AIMS

The aims of this study are: -

(1) To determine the prevalence of bovine coccidia species, in relation to age groups, exes, breeds and husbandry of cattle systems and the seasonal distribution of the *Eimeria* species encountered in the cattle.

(2) To determine the species of *Eimeria* oocysts contaminating the different environmental media and prefectures (leading to coccidial infections for cattle) in parts of Plateau State, Nigeria.

(3) To ascertain at what ages newly born calves shed different coccidial oocysts in their faeces.

(4) To determine the effects of different ranges of temperatures on the sporulation of bovine *Eimeria* oocysts.

(5) To measure and describe the morphologies of *Eimeria* species encountered, in cattle in parts of Plateau State, in Nigeria.

(6) To determine the Amino acid profile of the oocysts of *Eimeria* encountered in parts of Plateau State, Nigeria.

CHAPTER TWO

MATERIALS AND METHODS

2.1 DESCRIPTION OF STUDY AREA.

The study area comprises Jos North Local Government Council (JNLGC), Jos South Local Government Council (JSLGC) and Bassa Local Government Council (BLGC) of Plateau state (Fig 1).

Plateau State of Nigeria as described in Plateau State diary (2000) derives its name from the geographical landscape that predominates in this part of the country which is often referred to as Jos Plateau. The plateau highlands stand at an average height of 400 metres above sea level with peaks rising over 1,289m above sea level. Jos Plateau, covers nearly 26,899 square kilometers, possesses the most conspicuous features in the federation. It is a slightly undulating highland rising from steep encampment from the riverine plains of river Benue and descending towards Bauchi.

Located in the middle belt zone of the country, it lies between longitude $8^{o}22'$E and latitudes $8^{o}22'$N and $10^{o}24'$N. The northern part of the state is rocky and the area contains within its infrastructure, chains of hills

and many captivating rock formations. Its picturesque landscape ranges from bare rocks, artificial hillrocks and deep gorges from years of tin mining wastes in Jos. The state shares common boundaries with four of the 36 states of the federation. To the South West is Nasarawa State, while to the North West and North East are Kaduna and Bauchi States, and to the South East is Taraba State. The state provides a hydrographical head for many rivers in the Northern areas, several of which are fast flowing and in the process developed to waterfalls. Parts of the Plateau highland zone are Jos North, Jos South and Bassa Local Government Council Areas, where this work was carried out. Though situated in the tropical zone, the climate of the state is nearest equivalent of temperate climate. There are two seasons, the dry season and the wet season. The dry season is usually from October to April and the wet is from May to September. On account of the altitude and moderate rainfall, the climate on the Plateau is pleasant. The weather conditions are controlled by moist Southwesterly winds during the cold months. The average temperature is about 18^{o}C. The mean annual rainfall is about 0.127mm. The relative humidity is seldom uncomfortably high

and

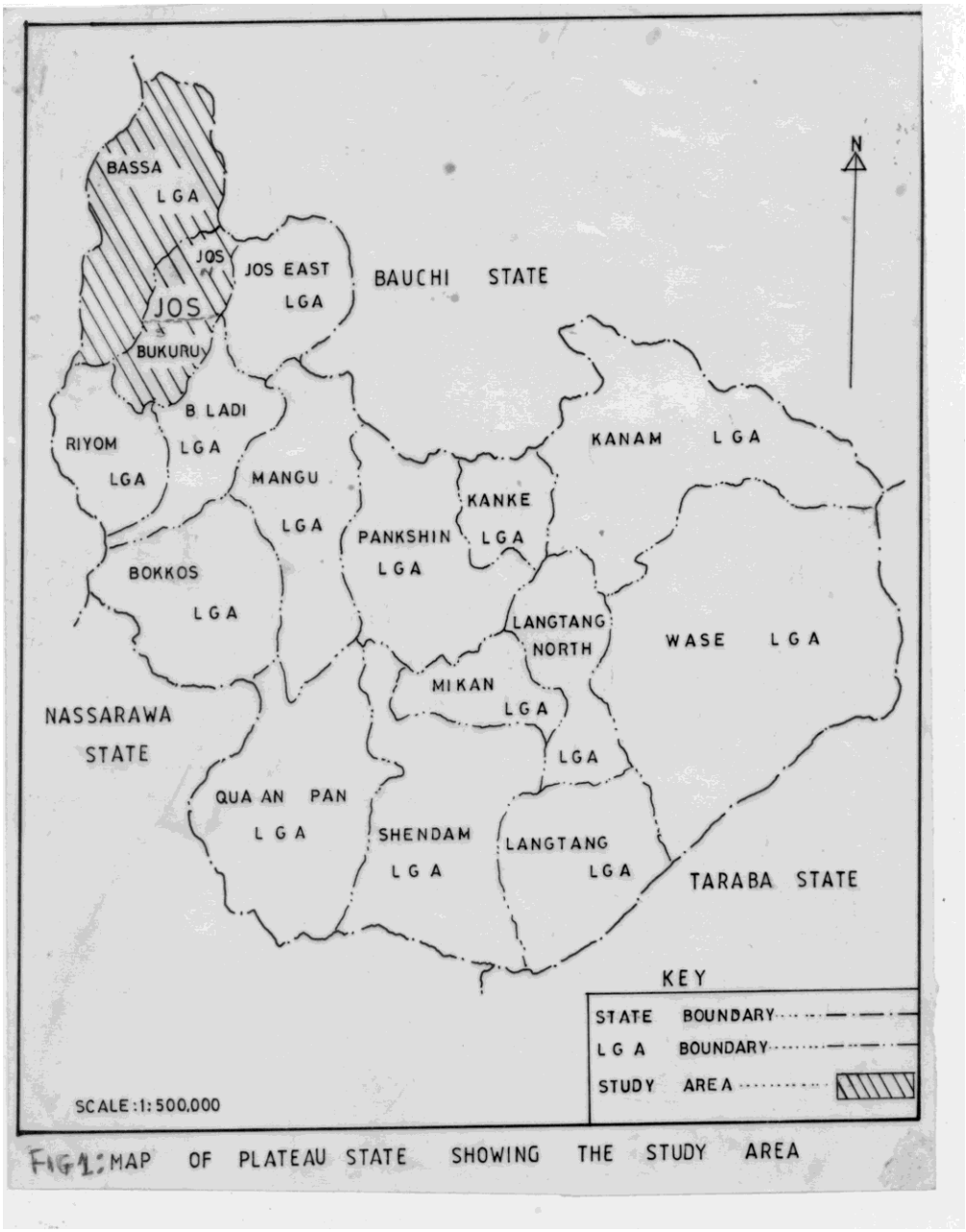

FIG 1: MAP OF PLATEAU STATE SHOWING THE STUDY AREA

during the dry season low values are recorded. December is the coldest month while March and April are the hottest months. The vegetation is closest to Guinea Savannah, and it is characterised by scattered trees, shrubs and grass savannah. Jos Plateau provides the finest grazing for animals in Northern Nigeria. There are food pasture, adequate water supplies and a comparative freedom from disease. The vegetation and climate are very suitable for livestock production mainly poultry, piggery, dairy and cattle rearing. This gives good investment potentials.

Naraguta Village in Jos North Local Government Area is surrounded by hills (Naraguta hills). It was observed that the Anaguta tribes were mostly the Villagers living among the hills and farm in the fertile basin formed by the Delimi River. It is about 6km Northwest of Yelwa with a population of over

21,000. Apart from mining and farming the Hausas living in Naraguta are Craftmen, tanning leather. The vegetation is mainly grassland.

Nassarawa Gwom also in Jos North Local Government Area lies within the Basin of Delimi River, a tributary of the Shari River System, which flows to the North East and drains into Lake Chad. On account of altitude, Nassarawa Gwom experiences cooler temperatures and in some cases higher rainfall figures as in the surrounding town.

Rukuba Village in Bassa Local Government (BLG) about 15km west of Jos. It is a rural setting lacking social infrastructures and amenities, which Jos enjoys. Most of the houses are thatched-roof huts, grouped together and enclosed by a mud wall to demarcate one family compound from another. The Village is situated on a hill overlooking the Rukuba Cantonment. The vegetation is mainly dense shrubs and grass with trees.

Vom in Jos South Local Government Area is located in the grassland of Plateau at about 1300m altitudes, which depicts cool weather. It has rainfall of about 0.145mm annually. It is a large area of excellent well-watered pasture with ample farming land. Animal husbandry is more than arable farming in this area. Kuru River provides water for irrigation

in this area.

Zallaki Village in Bassa Local Government Area is situated between Saminaka in Kaduna State and Bauchi in Bauchi State. It is hilly in the South but the North of the district belongs to Kaduna region. Terrace farming is done around isolated villages. There is a considerable export of firewood to Jos from this place and not much of cattle rearing is done here except at the company, Brewery Agro Research Company, in the Village.

2.2 COLLECTION OF FAECES FROM CATTLE

Faecal samples were collected directly from the recta of 2,500 cattle of different age groups, breeds, both sexes and different husbandry systems. The samples were collected from cattle located in the areas shown in Figures 2-6. Collections were made early in the morning between 6.am and 9.am before the animals were set out for grazing. The samples were collected randomly. Feacal samples were also collected from 52 calves between the ages 1day and 84 days in order to determine ages at which oocysts of *Eimeria* species were first discharged by them. Samples collected were put seperately in

prelabelled containers carrying the information sated abovel. The samples were taken to the laboratory for microscopic determination of species of *Eimeria* contained in them on the same day. Whenever the samples could not be examined on the same day they were kept in the refrigerator at 5^{o}C and examined on the following day. Samples were collected for 2 years from January 1992 to December 1993. In 1992, a total of 1,125 faecal samples were collected, comprising 675 from cows and 450 from bulls. In 1993, a total of 1,375 faecal samples were collected comprising 843 from cows and 532 from bulls. As a result, faecal samples were collected from the same numbers of cattle distributed as follows:

2.2.1 Vom.

(a) National Veterinary Research Institute (NVRI), Four hundred and eighty-nine (489) faecal samples of cattle were collected, comprising 64 of Adamawa breed (beef), 21 of Wadara breed (beef), 105 of Holstein Frezian breed (dairy), 103 of N'dama breed (beef), 60 of Red Bororo breed (beef), 24 of Sokoto Gudali breed (beef) and 112 of White Fulani breed (beef). The system of husbandry was concrete floor.

(b) West African Milk Company (WAMCO): This is Located in Vom. Two hundred and ninety-one (291) faecal samples of cattle were collected comprising of Holstein Frezian breed and mainly used for dairy. The system of husbandry was also concrete floor.

2.2.2 Zallaki village.

Breweries Agro Research Company (BARC): Two hundred and fifteen (215) faecal samples were collected from Holstein Frezian cattle comprising 135 from dairy cattle and 80 from beef cattle. The system of husbandry was concrete floor.

2.2.3 Abattoir.

Four hundred and sixty-one (461) faecal samples of cattle were collected comprising 91 of Adamawa breed (69 beef and 22 dairy), 44 of Wadara breed (beef),39 of Holstein Frezian breed (beef), 43 of Muturu breed (beef), 87 of N'dama breed (61 beef and 26 dairy), 48 of Red Bororo breed (33 beef and 15 dairy), 52 of Sokoto Gudali breed (21 beef and 31 dairy) and 57 of White Fulani breed (38 dairy and 19 beef). The system of husbandry was free range.

2.2.4 Naraguta.

Three hundred and thirty-two (332) faecal samples of cattle were collected, comprising of 42 of Adamawa breed (29 beef and 13 dairy), 33 of Wadara breed (beef), 28 of Muturu breed (beef), 106 of N'dama breed (65 beef and 41 dairy), 70 of Red Bororo breed (36 beef and 34 dairy), 45 of Sokoto Gudali breed (12 beef and 33 dairy), and 8 of White Fulani breed (beef). The system of husbandry was mud pen.

2.2.5 Nasarawa Gwom.

Five hundred and ten (510) faecal sample of cattle were collected, comprising of 105 of Adamawa breed (43 beef and 62 dairy), 33 of Wadara breed (beef), 25 of Holstein Frezian breed (beef), 26 of Muturu breed (beef), 101 of N'dama breed (51 beef and 50 dairy), 45 of Red Bororo breed (30 beef and 15 dairy), 104 of Sokoto Gudali breed (69 beef and 35 dairy) and 71 of White Fulani breed (29 beef and 42 dairy). The systems of husbandry were free range (423) and mud pen (87).

2.2.6 Rukuba.

Two hundred and two (202) faecal samples of cattle were collected, comprising 26 of Adamawa breed (10 beef and 16 dairy), 30 of Wadara breed (beef), 20 of Muturu breed (18 beef and 2 dairy), 46 of Red Bororo

breed (43 beef and 3 dairy), 41 of Sokoto Gudali breed (21 beef and 20 dairy) and 39 of white fulani breed (2 beef and 19 dairy). The system of husbandry was mud pen.

BREED OF CATTLE	LOCATIONS WHERE FAECAL SAMPLES WERE COLLECTED				
	Abbatoir	Naraguta	Nasarawa Gwom	Rukuba	Vom
Adamawa	91	42	105	26	64
Holstein Frezian	39	-	25	-	396
Muturu	43	28	26	20	-
Ndama	87	106	101	-	103
Red Bororo	48	70	45	46	60
Sokoto Gudali	52	45	104	41	24
Wadara	44	33	31	30	21
White Fulani	57	8	71	39	112
Total	461	332	510	202	780

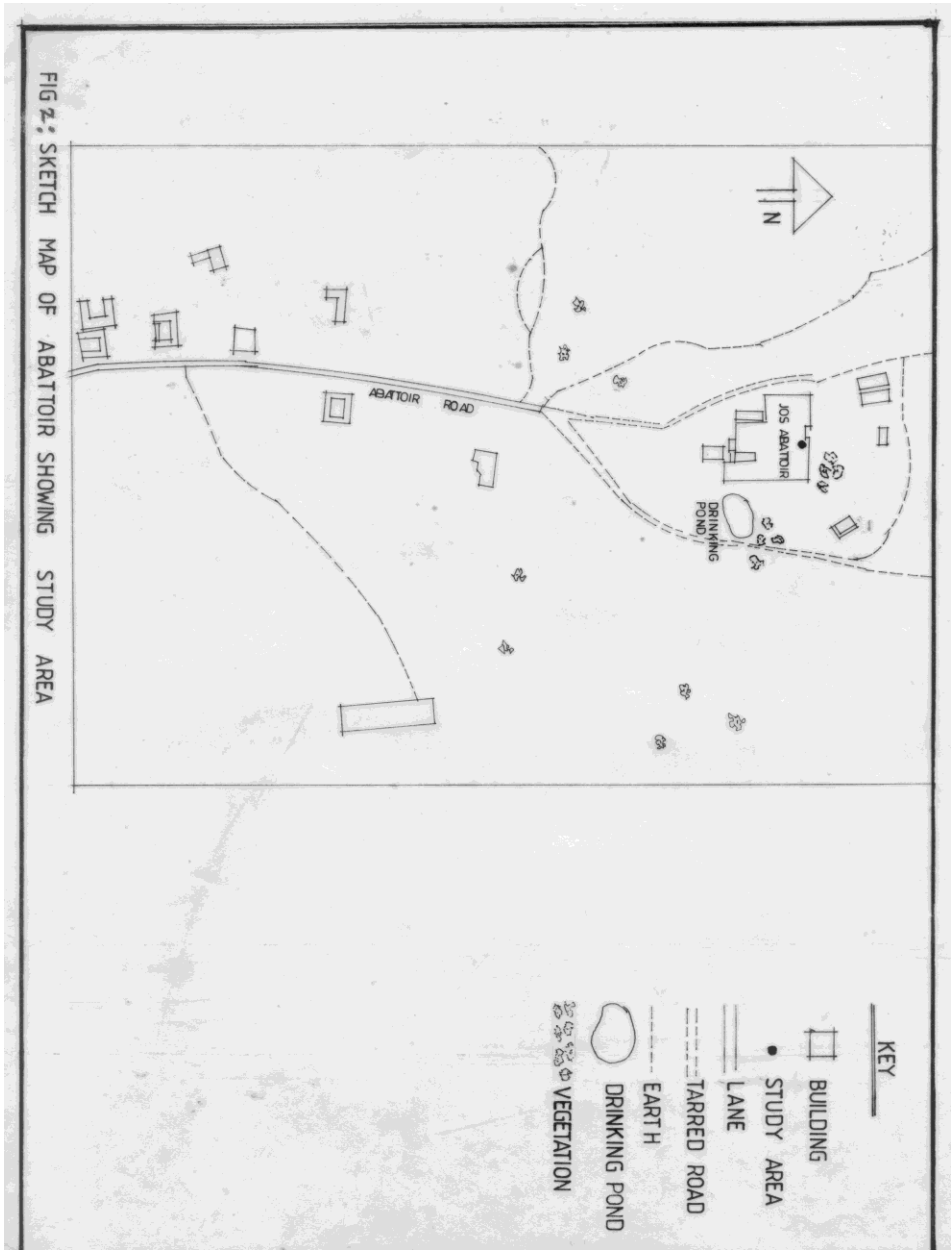

FIG 2: SKETCH MAP OF ABATTOIR SHOWING STUDY AREA

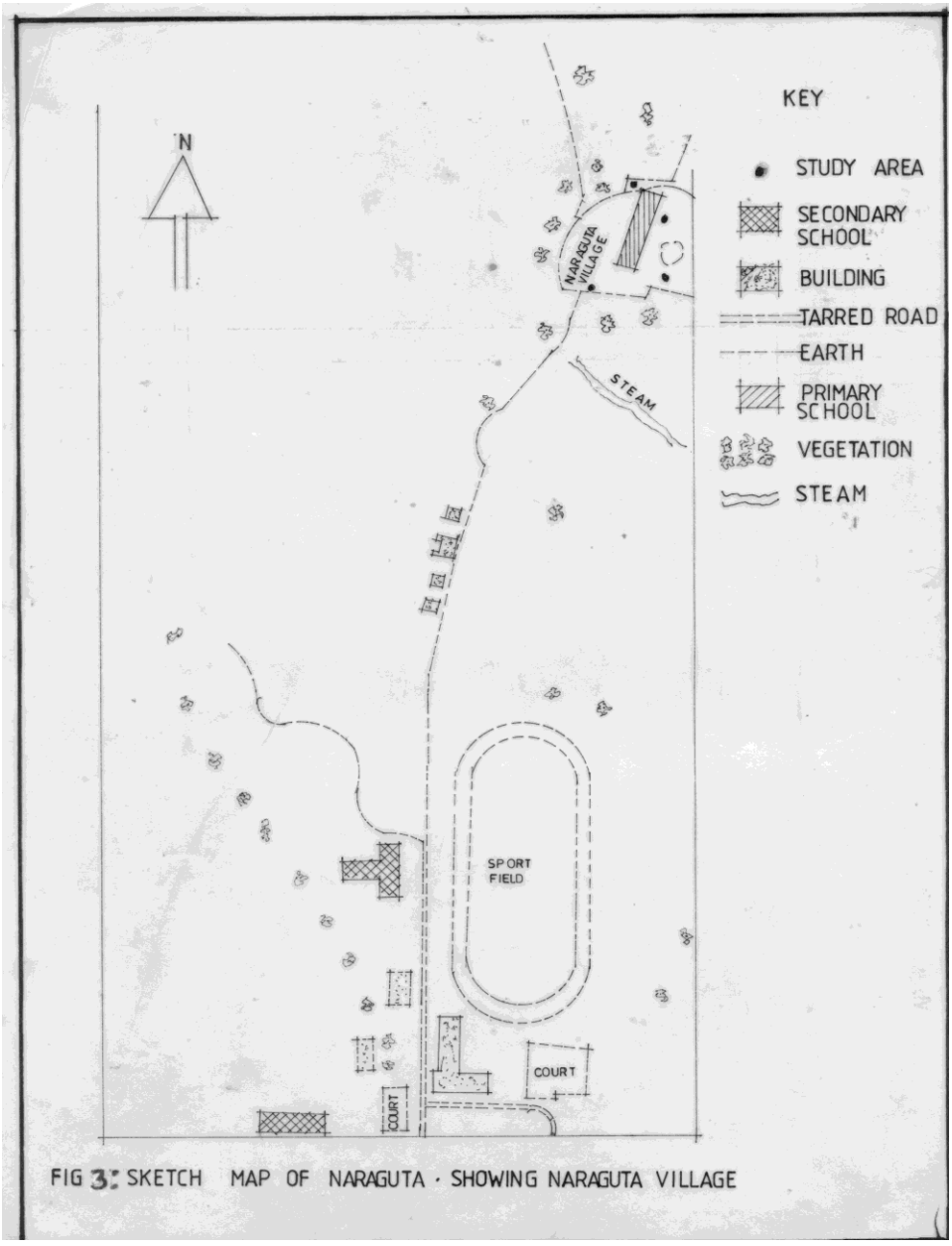

FIG 3: SKETCH MAP OF NARAGUTA · SHOWING NARAGUTA VILLAGE

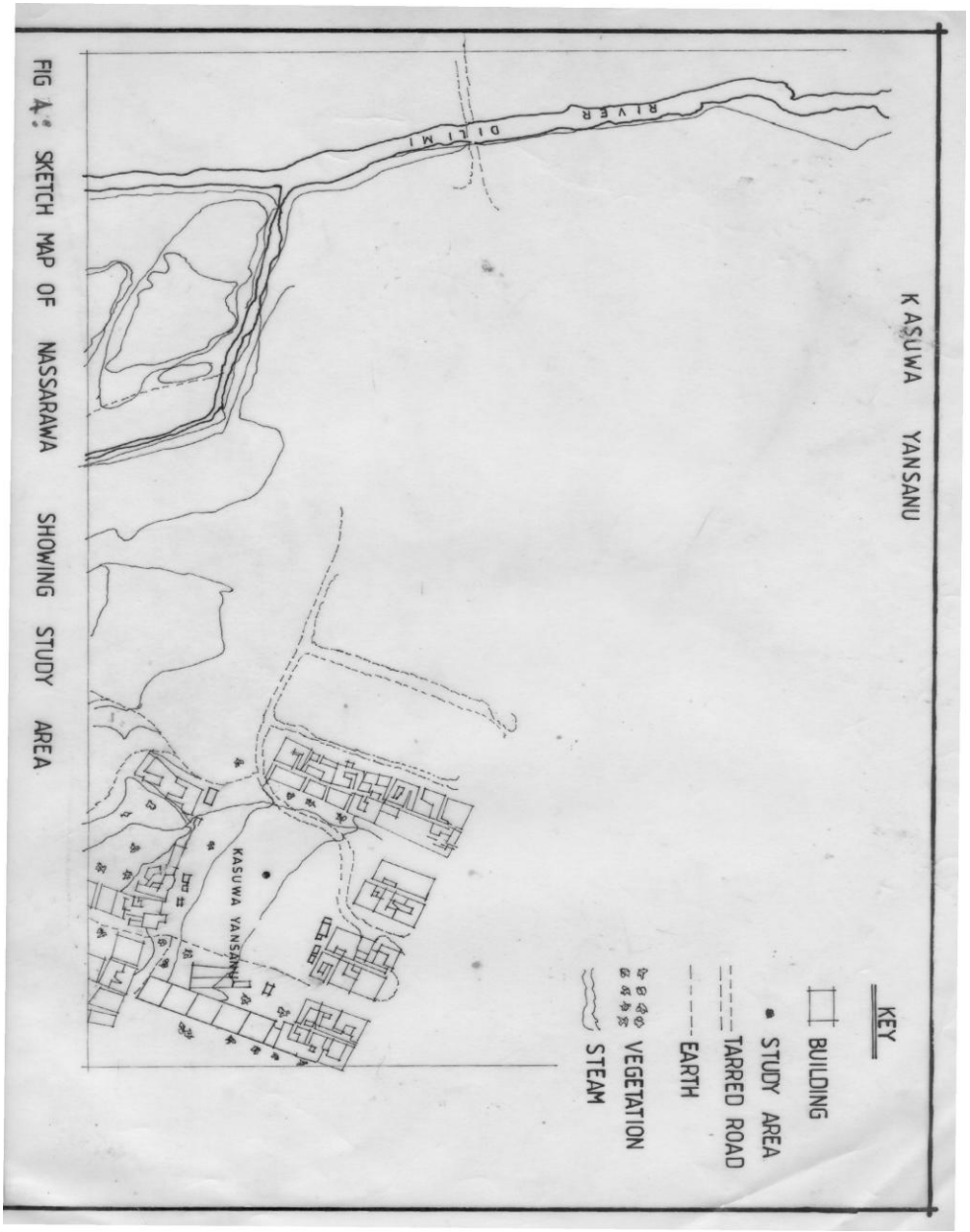

FIG 4: SKETCH MAP OF NASSARAWA SHOWING STUDY AREA

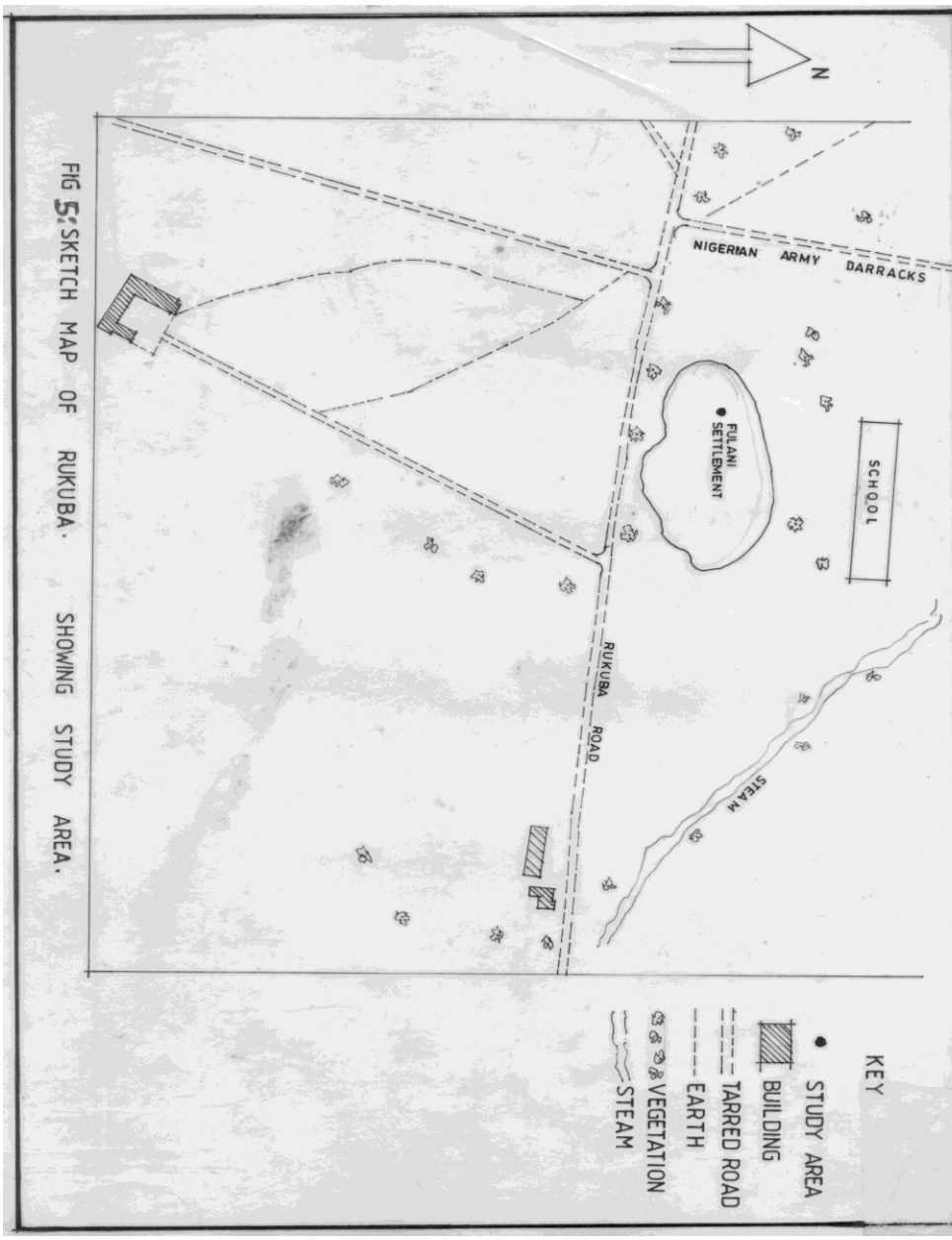

FIG 5: SKETCH MAP OF RUKUBA. SHOWING STUDY AREA.

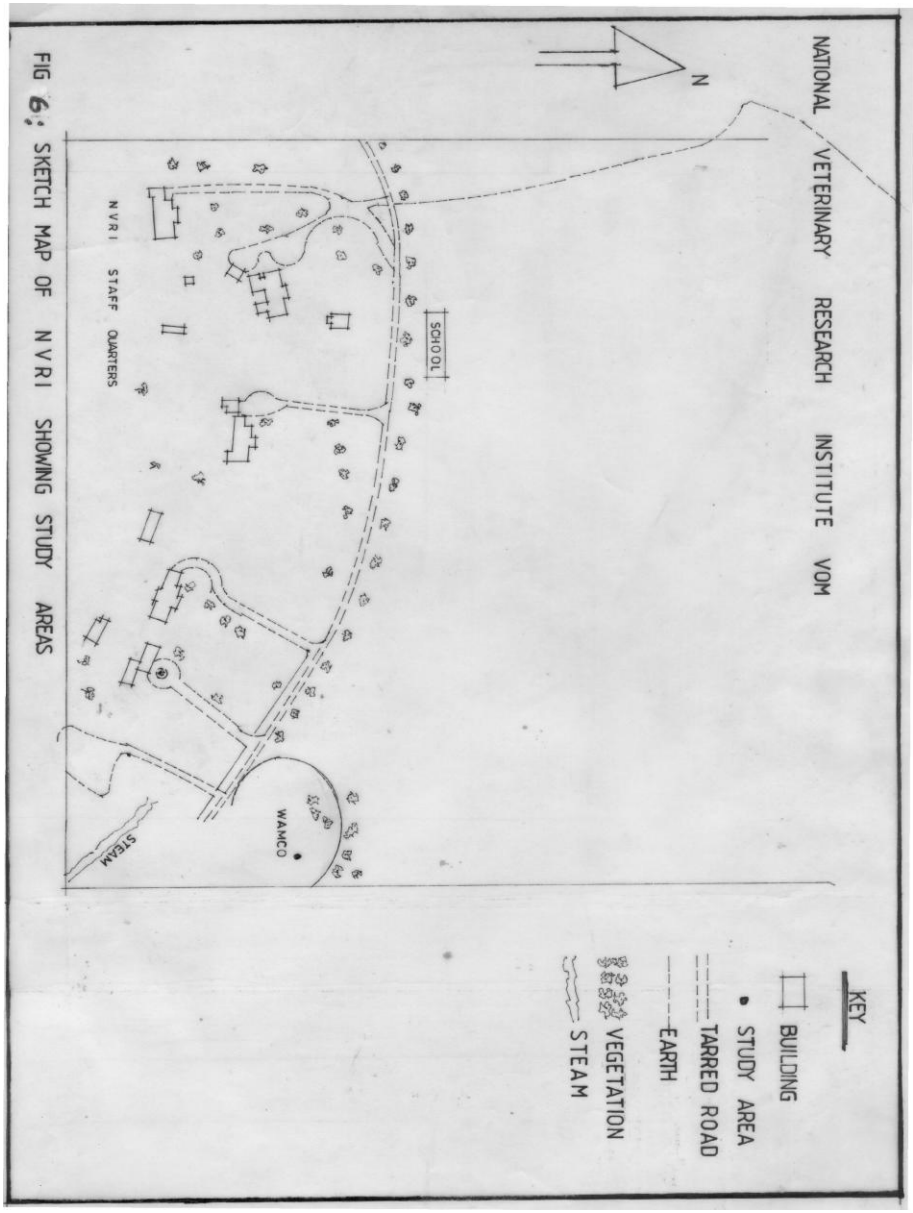

FIG 6: SKETCH MAP OF N V R I SHOWING STUDY AREAS

2.3 COLLECTION OF FAECAL SAMPLES FROM ENVIROMENTAL MEDIA One hundred and fifty (150) samples each of pasture (grasses), animal feeds and bedding, and each weighing one kilogram (1kg), were randomly taken from various locations mentioned above. Each sample was put into a prelabelled 10litre beaker and taken to the laboratory for microscopic examination for *Eimeria* species contained in it. Also udders and teats of each of the 350 randomly selected cattle from the study areas were washed with clean tap water into a large-mouth bottle, allowed to settle for 30 minutes and supernatant discarded. A 5g portion of each sediment was examined as described under 2:5 below.

2.4 MICROSCOPIC EXAMINATIONS OF THE FAECAL SAMPLES

A 5g portion of each of the 2,500 faecal samples collected from 2.2 above was weighed out using a Metler balance and put in a 50ml gl beaker. Twenty-two (22ml) of water was added, mixed thoroughly and

poured into a 100ml glass beaker through a strainer with 16 meshes per 2.5cm. The 50ml glass beaker was rinsed with 8ml of water and the total fluid poured into four (4) 15ml conical tip centrifuge tubes. After centrifugation at 1,500rpm for 5 minutes, the supernatant was decanted and a sugar solution (specific gravity 1.25) added to the sediment, until the tube was about half full. The content of each test tube was thoroughly mixed with a wooden applicator stick. With the aid of a medicine dropper, more sugar solution was added until a convex meniscus was formed on top of the tube. A 22mm^2 glass coverslip was placed on top of each tube and left for 30 minutes. Then, each glass coverslip was briskly lifted up and placed on a clean glass slide, not allowing formation of air bubbles. The entire area under each coverslip was examined under a swift binocular microscope at x40. The types of *Eimeria* encountered were counted and recorded separately. The total number of oocysts observed was recorded under each species and the overall total which gave the oocyst load per 5g of faecal sample was the sum of all oocyst types of the identified species in the faecal sample. Oocyst types were identified by references to the works of Lee and Armour (1959), Joyner *et al* (1966),

Norton *et al* (1974), Courtney *et al* (1976) and Taylor and Catchpole (1994).

2.5 PROCESSING AND *EXAMINING* FAECAL MATERIALS FROM ENVIROMENTAL MEDIA

Each sample collected in 2.3 above was analysed as described by MAFF (1977) and Ajayi *et al* (1997). Tap water was added into the 1kg sample in a prelabelled container, covered and shaken vigorously in order to wash the faeces attached to each medium specimen. Each solution of faecal material was then mixed thoroughly and allowed to settle for 30 minutes. The clear supernatant was decanted together with any unwanted debris. Each sediment was thoroughly mixed and 5g of the mixture in each container was analysed for *Eimeria* oocysts. Each sample was analysed on the day of collection in order to avoid additional sporulation of oocysts. The sporulation rates of the species of *Eimeria* in each sample were determined according to the methods of Ajayi (1976). Oocysts were differentiated into species by reference to the works of Lee and Armour (1959), Joyner *et al* (1966), Courtney *et al* (1976), Norton *et al* (1974) and Taylor and Catchpole (1994).

2.6 SPORULATION OF *EIMERIA* OOCYSTS.

This was carried out according to the method of Ajayi (1976). A solution of 2.5% potassium dichromate was added to each faecal sample, which contained most of the *Eimeria* species in a beaker, mixed thoroughly with a wooden applicator and poured into a Petridish. Each Petridish was left on the bench in the laboratory to allow sporulation. There after, every 24hours, the culture of oocysts was mixed thoroughly and with the aid of medicine dropper, a drop of the culture was placed on a glass slide, covered with a glass coverslip and examined under the microscope to determine when sporulation occurred. When sporulation of oocysts was completed after 14 days, the Petridish containing oocysts was covered up and stored in a refrigerator at 5^{o}C until needed. A total of 5 Petridishes of sporulated oocysts were stored.

2.7 MEASUREMENT OF *EIMERIA* OOCYSTS

The dimensions of the sporulated *Eimeria* species in the Petridish in 2:6 above were measured using a swift (binocular) microscope equipped with a

calibrated eyepiece micrometer. To measure absolute lengths, the length of the oocyst was measured from the micropilar cap (if any) down to the other end of the oocysts. The width of the oocyst was measured from one side of the outer layer of the oocyst wall across the other side of the outer layer. One hundred sporulated oocysts of each species were measured and average measurement of different oocysts was taken. Detailed appearance by observation of typical oocysts was written. All the inclusions of a sporulated oocyst were measured individually.

Oocysts were identified again by consulting identification keys of Lee and Armour (1959), Norton *et al* (1974), Courtney *et al* (1976) and Taylor and Catchpole (1994).

2.8 CHEMICAL ANALYSIS OF SPORULATED *EIMERIA* OOCYSTS.

Sporulated bovine *Eimeria* oocysts were collected from stored culture using floatation technique described in section 2.4. The coverslip containing sporulated oocysts was washed with distilled water into a Petri-dish. The Petri-dish was placed under a dissecting microscope and with the aid of medicine dropper the oocysts were carefully removed and

placed in a weighed glass Petri-dish. An amount of 1g of the oocysts was collected and was used for the analysis after drying in an oven at 40 C using Heidolph evaporator (Model WI).

The sample was defatted into extraction thimble with chloroform and methanol mixture using soxlet extraction apparatus as described by AOAC (1980). About 200mg of fat-free sample was weighed in a Metler digital balance (AE100) into a glass ampoule. 7ml of 6N hydrochloric acid was added and passing nitrogen gas through the solution expelled oxygen. This was to avoid the possibility of oxidation of cystine and methionine (Benitez, 1980). The glass ampoule was then sealed with bunsen burner flame. The ampoule and the contents were hydrolysed in an oven at 105 C for 22 hours. Immediately after cooling it was filtered through non-absorbent cotton wool. The filterate was dried in an oven at 40 C. The amino acids in the flask were diluted with 5ml of sodium citrate buffer (pH 2.0). 5 microlitre of the sample was loaded into a catridge of Technicon Sequential multi Sample Amino Acid Analyzer (TSM). 60ml of ninhydin and 48ml hydrazine sulphate reagents were combined on the manifold of TSM to form hydridantin.

A segment reagent stream flow under the analyzer column to join with the eluting buffers. The stream carrying the amino acid reagent mixture went through heating bath where development of the colour reaction product occurred. The absorbance was proportional to the concentration of each amino acid and was measured by the colorimeter inside the machine.

The net height (NH) of each peak from the chromatograph was measured. The half-height (NH/2) of each peak on the chart was measured (width at NH/2). The area of each peak was obtained by multiplying the height with the width at half height. Since internal standard was used, the norleucine equivalent (NE) individual amino acids in the mixturer was calculated using the formular below.

$$\text{Norleucine Standard (Nestd)} = \frac{\text{Area of Norleucineor (NH/W) nleu}}{\text{Area of each amino acid or (NHxW (AAA))}}$$

W (nleu) = width of Norleucine peak

Where:

W (nleu) =Width of peak Norleucine

(WAA) = width of each amino acid peak

NH = Net height of each amino acid peak

Reference to the NE above, a constant Sstd was calculated for each amino acid.

Sstd = Nestd x Mol weight x uMAA std.

Where:

Nestd = Norleucine equivalent in the standard.

Mol. Weight = Molecular Weight of the amino acid.

uMAA std = Micromole of standard (0.025).

The amount of each amino acid present in the sample was calculated in g/16N using the formular.

Concentration (g/16gN)=NH x Width at NH/2 x Sstd x c

Where:

$$C = \frac{\text{dilution x16}}{\text{Sample weight (g) x 10 \%N x volume loaded.}}$$

NH = Net height of Norleucine

W (nleu) =Width of height of Norleucine.

%N = Percentage Nitrogen Sample.

Volume loaded Basic Column = 5ul

Acid/Neutral Column =5ul

Dilution = x5

2.9 STATISTICAL ANALYSIS

Data collected on prevalence and numbers of *Eimeria* oocysts in faecal samples of cattle and from beddings, pastures and udders were statistically analysed using Student t-test. The test statistic was applied at 0.01 and 0.05 levels of significance to test whether or not there were significant differences in the following:

(I) Between the overall prevalence of *Eimeria* species in different areas studied.

(ii) Between *Eimeria* species and in different age groups of cattle.

(iii) Between the prevalence of *Eimeria* and in both sexes of cattle.

(iv) Between prevalence of *Eimeria* species and in different breeds of cattle.

(v) Between prevalence of *Eimeria* species in cattle and in the systems of husbandry.

(vi) Between prevalence of *Eimeria* species in dairy and in beef cattle.

(vii) Between species and sporulation rates of *Eimeria* oocysts contaminating

environmental medial, and

(viii) Between seasonal prevalence of *Eimeria* species in cattle and in sexes.

CHAPTER THREE

RESULTS

3.1 OVERALL PREVALENCE OF *EIMERIA.*

The overall prevalence of *Eimeria* species in the cattle is shown in Table 1.Out of 2,500 cattle whose feacal samples were examined, 1,567 (62.68%) were found to be positive for 12 species of *Eimeria*. The most prevalent species were *E.zurnii*, which occurred in 1043 (41.72%), *E.bovis* which occurred in 914 (36.56%) and *E.auburnensis*, which occurred in 806 (32.24%). These are known to be the most pathogenic species of all bovine coccidia. The prevalence rates of the others were *E.ellipsoidalis* in 422 (28.88%), *E.bukidnonensis* in 580 (23.20%), *E.cylinderica* in 556 (22.24%), *E.wyomingensis* in 445 (17.80%), *E.subspherica* in 295 (11.80%), *E.pellita* in 279 (11.16%), *E.brassiliensis* in 240 (9.60%), *E.canadensis* in 236 (9.44%) and *E.alabamensis* in 220 (8.80%). The ranges and the averages of the population of the oocysts of the species in 5g faecal samples are also shown in the Table. The highest average oocyst population was that of *E.auburnensis*, which was 56,900 while the lowest oocyst population was that of *E.pellita* which was 28,200. The sporulated and unsporulated oocysts of the 12 species are shown in plates I - XII.

TABLE 1
Prevalence of *Eimeria* species in 2,500 cattle in Parts of Plateau State, Nigeria.

Species of ***Eimeria***	***Number Positive***	***Prevalence (%)***	***Oocyst Population in 5g faecal sample***	
			Average (x10³)	***Range (x10³)***
E alabamensis	*220*	*8.80*	*34.2*	*31.8-77.2*
E. auburnesis	*806*	*32.24*	*56.9*	*18.0-80.8*
E. bovis	*914*	*36.56*	*32.5*	*16.2-74.1*
E brassilliensis	*240*	*9.60*	*42.1*	*16.5-79.7*
E.bukidnonensis	*580*	*23.20*	*31.8*	*6.5-68.5*
E. canadensis	*236*	*9.44*	*45.8*	*38.0-88.4*
E. cylindrical	*556*	*22.24*	*36.1*	*21.8-55.6*
E. ellipsoidallis	*722*	*28.88*	*35.6*	*28.2-77.4*
E. pellita	*279*	*11.16*	*28.2*	*17.1-35.8*
E. subspherica	*295*	*11.80*	*35.1*	*13.0-80.8*
E wyomingensis	*445*	*17.80*	*29.4*	*25.6-56.9*
E. zurnii	*1043*	*41.72*	*40.8*	*28.6-58.9*

3.2 SPECIES OF *EIMERIA* ENCOUNTERED IN DIFFERENT PREFECTURES IN PARTS OF PLATEAU STATE, NIGERIA.

Table 2 shows the prevalence of *Eimeria* species in different areas in Plateau State. The predominant species in Jos abattoir in Jos South Local Government Area was E. *zurnii* , which occurred, in 253 (54.88%) of 461 bovine faecal samples examined. The predominant species in Naraguta of Jos North Local Government Area, was *E. cylindrica* which occurred in 269(81.02%), of 332 bovine faecal samples examined there, while the predominant species in Nasarawa Gwom, also in Jos North Local Government Area was *E. auburnensis* which occurred in 321 (62.94%) of 510 faecal samples examined.

In Rukuba Village of Bassa Local Government Area (BLGA), the most commonly encountered species was *E. zurnii*, which occurred in 197 (97.52%) of 202 faecal samples examined. The predominant species in Vom of Jos South Local Government Area was *E. bovis*, which occurred, in 229 (29.36%) of 780 faecal samples examined.

In Zallaki Village also in Bassa Local Government Area the predominant species was *E. ellipsoidallis*, which occurred, in 192 (89.30%) of 215

faecal samples examined. Rukuba had the highest prevalence of bovine *Eimeria* oocyst infection which occurred in 178 (88.12%) out of 202 feacal samples examined. Vom had the lowest prevalence which occurred in 401 (51.41%) out of 780 feacal samples of cattle examined. Others were; Abattoir, 292 (63.34%) out of 461 feacal samples examined, Naraguta 253 (76.21%) out of 332 feacal samples examined, Nassarawa Gwom 296 (58.04%) out of 510 feacal samples examined and Zallaki 147 (68.37%) out of 215 feacal samples examined.

There was statistically significant difference in the rate of infection between Rukuba and Vom areas and also Naraguta and Vom ($P>0.05$). There was also statistically significant difference in the rate of infection between Rukuba and Zallaki village ($P>0.05$). There was no statistically significance difference in the rates of infection between one Local Government Area and another. ($P>0.05, df =22, t=0.154$).

TABLE 2

Prevalence of *Eimeria* species in cattle in Different Prefectures in Parts of Plateau State, Nigeria.

Species	Prefectures					
Eimeria	Abbatoir	Naraguta	Nassarawa. Gwom	Rukuba	Vom	of Zallaki
	n=461	n=332	n=510	n=202	n=780	n=215
	Numbers of samples positive and prevalence rate in population					
E. alabamensis	18(3.90)	31(9.34)	67(13.14)	50(24.75)	14(1.79)	40(18.60)
E. auburnesis	200(43.38)	9(2.71)	*321(62.94)	151(74.75)	86(11.03)	155(72.09)
E. bovis	82(17.79)	120(36.14)	214(41.96)	14(6.93)	*229(29.36)	155(72.09)
E. brassilliensis	47(10.20)	65(19.58)	38(7.45)	41(20.30)	24(3.08))	25(11.63)
E. bukidnonensis	5(1.08)	178(53.61)	132(25.88)	67(33.17)	50(6.41)	58(26.98)
E. canadensis	45(9.76)	80(24.10)	29(5.69)	41(20.30)	16(2.05)	25(11.63)
E. cylindrica	52(11.28)	*269(81.02)	70(13.73)	79(39.11)	51(6.54)	35(16.28)
E. ellipsoidalis *192(89.30)	52(11.28)	78(23.49)	155(30.39)	161(79.70)	79(10.13)	
E. pellita	32(6.94)	7(2.11)	61(11.96)	98(49.51)	36(4.62)	50(23.26)
E. subspherica	40(8.68)	53(15.96)	66(12.94)	102(50.50)	25(3.21)	9(4.19)
E. wyomingensis	55(11.93)	107(32.23)	95(18.63)	58(28.71)	53(6.79)	27(12.56)
E. zumii	*253(54.88)	207(62.35)	136(26.67)	*197(97.52)	175(22.44)	75(34.88)

*Most Predominant

3.3 FREQUENCY OF *EIMERIA* IN 5g FAECAL SAMPLES OF 2,500 CATTLE IN PARTS OF PLATEAU STATE, NIGERIA.

Table 3 shows the frequency of *Eimeria* species in 2,500 faecal samples of cattle with mixed infections of 2-12 different species encountered in 1,457 (58.28%) of the faecal samples examined. The minimum number of species identified from any individual animal was 1 and the maximum was 12. The commonest combinations were 3 and 4 species which occurred in 324 (12.96%) and 401 (16.04%) samples respectively.

TABLE 3

Frequency of *Eimeria* species in 5g faecal samples of 2,500 cattle in Parts of Plateau State, Nigeria.

Number of Species of *Eimeria*	0	1	2	3	4	5	6	7	8	9	10	11
Number of samples positive	933	110	178	324	401	280	160	72	11	10	8	8
Frequency (%)	37.32	4.40	7.12	12.96	16.04	11.20	6.40	2.88	0.44	0.40	0.32	0.32

3.4 OVERALL FREQUENCY DISTRIBUTION OF *EIMERIA* SPECIES IN 2,500 CATTLE IN PLATEAU STATE, NIGERIA.

The overall frequency distribution of different combinations of infections in 2,500 cattle is shown in Table 4. There were 12 different combinations of 2 infections totaling 178 (7.12%), 25 different combination of 3 infections totalling 324 (12.96%) and 19 different combinations of 4 infections totaling 401 (16.04%). There were 12 different combinations of 5 infections totaling 280 (11.20%), 9 different combinations of 6 infections totaling 160 (6.40%), 5 different combinations of 7 infections totaling 72(2.88%), 4 different combinations of 8 infections totaling 11 (0.44%) and 2 different combinations of 9 infections totaling 10 (0.40%). For 10, 11 and 12 infection there was 1 combination totaling 8(0.37%), 8(0.32%) and 5(0.20%) respectively.

TABLE 4

Frequency Distribution of Negative, Single and Mixed Infections of *Eimeria* Oocysts in 2,500 cattle in Parts of Plateau State, Nigeria.

Combination of Infections and Parasites	Frequency of Occurrence		
	Number	Total	%
No. Infection	933	933	37.32
Single Infections			
E.alabamensis	3		
E.auburnesis	12		
E.bovis	16		
E.brassilliensis	6		
E.bukidnonensis	5	110	4.40
E.canadensis	5		
E.cylindrica	9		

E.ellipsoidallis	12
E.pellita	3
E.subspherica	10
E.wyomingensis	6
E.zurnii	*23*

Mixed Infections

		Frequency of occurrence	
A	**Two parasites**	**Number**	**Total**
	E. aub + E.bov	*8*	

E. aub + E.bukid	*16*		
E. aub + E.ellips	*21*		
E. bov + E.cylind	*21*		
E. bov + E.canad	*16*		
E. bov + E.bukid	*21*		
E. bov + E.ellips	*12*	*178*	7.12
E. bukid + E.cylind	*14*		
E. bukid + E.zurn	*18*		
E. cylind + E.subs	*8*		
E. wyom + E.aub	*13*		
E. wyom + E.zurn	*10*		

Parasites	Frequency of Occurrence		
	No	Total	%
I V Three parasites			
E. alab + E.aub +.bukid	8		
E. alab + E.aub + E.bov	4		
E. alab + E.bukid +E.bov	8		
E.alab + E.bukid + ellips	8		
E. alab + E.clind +E.zurn	5		
E. alab + E.bukid E.zurn	3		
E.aub+E.bov+E.pell	21		

E. aub + E.bov + E.subs	*18*		
E. aub + E.bov + E.zurn	*17*		
		324	*12.96*
E. aub+ E.cylind+E.pell	*10*		
E.bov +E.brassil+E. cylind	*14*		
E. bov + E.brassill + E.zurn	*5*		
E. bov + E.canad + E.wyom	*18*		
E. bov + E.canad + E.zurn	*16*		
E. aub + E.cylind + E.wyom	*9*		
E. bov + E.wyom + E.zurn	*17*		
E. bov + E.cylind + E.ellips	*6*		
E. bov + E.ellips + E.aurb	*25*		
E. bov + E.ellips + E.zurn	*4*		
E.bov + E.pell + E.zurn	*9*		

E. cylind + E.ellips + E.subs *3*

E. cylind + E.ellips + E.zurn *18*

E. ellips + E.bukid + E.wyom *10*

E. ellips + E.subs + E.zurn *18*

E. ellips + E.wyom + E.zurn *8*

	Frequency of Occurrence		
	No	Total	%
v ***Four parasites***			
E. alab + E.bov + E.ellips + E.zurn	27		
E. alab + E.aurb + E.bov + E.wyom	18		
E. alab + E.aurb + E.bov + E.zurn	25		
E. alab + E.bov + E.wyom + E.zurn	4		
E. aub + E.bov + E.brassil + E.zurn	19		
E. aub + E.bov + E.cylind + E.wyom	27		

E. aub + E.bov + E.subs + E.zurn	37	401	16.04
E. aub + E.brassil + E.cylind + E.zurn	38		
E. aub + E.canad + E.ellips + E.wyom	28		
E. aub + E.cylind + E.ellips + E.wyom	18		
E. aub + E.ellips + E.wyom + E.zurn	25		
E. bov + E.brassil + E.ellips + E.zurn	25		
E. bov + E.brassil + E.pell + E.zurn	9		
E. bov + E.bukid + E.ellips + E.zurn	15		
E. bov + E.bukid + E.pell + E.zurn	4		
E. cylind + E.ellips + E.pell + E.zurn	13		
E. cylind + E.ellips + E.subs + E.zurn	30		
E. ellips + E.subs + E.pell + E.wyom	13		
E. cylind + E.subs + E.wyom + E.zurn	28		

v **Five parasites**

ı

E. alab + E.bov + E.bukid + E.Ellips + E.zurn	28		
E. aub + E.bov + E.bukid + E.cylind + E.zurn	35		
E. aub + E.bov + E.bukid + E.subs + E.zurn	38		
E. aub + E.cylind + E.ellips + E.wyom + E.zurn	18	280	11.2
E. aub + E.bukid + E.canad + E.cylind + E.subs	20		
E. bov + E.cylind + E.ellips + E.pell + E.aurb	16		
E. bov + E.cylind + E.ellips + E.wyom + E.zurn	15		
E. brassill + E.cylind + E.aub + E.wyom + E.zurn	17		
E. bukid + E.canad + E.aub + E.wyom + E.zurn	21		
E. bukid + E.cylind + E.aub + E.wyom + E.zurn	21		
E. cylind + E.ellips + E.pell + E.aub + E.zurn	19		
E. ellips + E.pell + E.aub + E.wyom + E.zurn	15		

		Frequency Of Occurrence		
		No	Total	%
VII	**Six Parasites**			
	E. aurb + E.bukid + E.ellips + E.bov + E.subs + E.zurn	28		
	E. aurb + E.bukid + E.ellips + E.cylind + E.subs +E.bov	11		
	E. brassil + E.bov + E.canad + E.ellips + E.alab + E.zurn	25		
	E. aurb + E.alab + E.bov + E.brassil + E.ellips + E.zurn	12	160	6.40
	E. bov + E.canad + E.cylind + E.aurb + E.ellips + E.zurn	15		
	E. bov + E.bukid + E.brassil + E.ellips + E.sub + E.zurn	13		
	E. bov + E.bukid + E.cylind + E.ellips + E.pell + E.zurn	24		
	E. bov + E.aurb + E.cylind + E.ellips + E.pell + E.zurn	27		
	E .bov + E.ellips + E.aub + E.bukid + E.pell + E.zurn	5		
VIII	**Seven Parasites**			

E. aurb + E.bov + E.brassil + E.bukid + E.canad + E.ellips + E.zurn	25			
E. aub+ E.bov + E.bukid + E.cylind + E.pell + E.ellips + E.zurn	31	72	2.88	
E. bov + E.canad + E.bukid + E.ellips + E.pell + E.aub + E.zurn	12			
E. bov + E.bukid + E.ellips + E.alab + E.pell + E.wyom + E.zurn	2			
E .bov + E.bukid + E.ellips + E.subs + E.pell + E.wyom + E.zurn	2			

IX Eight Parasites

E .alab + E.aurb + E.bov + E.bukid + E.canad +E.ellips + E.pell + E.zurn	1		
E. alab + E.aurb + E.bov + E.bukid + E.canad +E.ellips + E.brassil + E.zurn	3		
E. alab + E.aurb + E.bov + E.bukid + E.canad +E.ellips + E.wyom + E.zurn	4	11	0.44
E. bov + E.bukid + E.canad + E.cylind + E.ellips +E.subs + E.pell + E.zurn	3		

Nine Parasites

X

E. alab + E.aurb + E.bov + E.brassil + E.bukid +E.ellips + E.subs + E.pell +E.zurn	7	10	0.40
E .alab + E.aurb + E.bov + E.brassil + E.bukid +E.ellips + E.wyom + E.pell +E.zurn	3		

XI Ten Parasites

	E.alab + E.aurb + E.bov + E.brassil + E.bukid +E.canad + E.ellips + E.wyom + E.pell +E.zurn	8	8	0.32
XII	**Eleven Parasites**			
	E.alab+E.aurb+E.bov+E.brassil+E.bukid+E.canad+E.ellips+E.wyom+E.cylind+E. pell+E.zurn	8	8	0.32
XIII	**Twelve Parasites**			
	All parasites	5	5	0.2

3.5 PREVALENCE OF *EIMERIA* SPECIES IN DIFFERENT AGE GROUPS OF CATTLE IN PARTS OF PLATEAU STATE, NIGERIA.

The prevalence of *Eimeria* species in different age groups of cattle is recorded in Table 5. The most infected age group of cattle was the 10-14 months old, of which 360 (78.28%) of the 454 faecal samples examined were positive. The least infected age group of cattle was the 25 months

old and above, of which 289 (41.34%) of the 669 faecal samples examined were positive for *Eimeria* oocysts. The others were 0-4 months in 35 (43.75%) out of 80 faecal samples examined, 5-9 months in 114 (65.90%) out of 175 faecal samples examined, 15-19 months in 415 (72.32%) out of 571 faecal samples examined, 20-24 months in 356 (61.11%) out of 553 faecal samles examined. There was statistically significant difference in the rates of infection between calves that were 0-4 months and those that were 10-14 months, ($P<0.01$ $df = 22$, $t=-6.186$). Also there was statistically significant difference in the rates of infection between cattle in the age groups of 10-14 months and those of 25 months and above ($P<0.01$ $df=22$, $t=5.301$).

TABLE 5

`Overall Prevalence of *Eimeria* species in different age groups of 2,500 cattle in Parts of Plateau State, Nigeria.

Age of cattle (month)	Total No. Exam.	Total No +ve	*E.alab*		*E.aurb*		*E.bovis*		*E.brassil*		*E.bukid*		*E.canad*		*E.cylind*		*E.ellips*		*E.pell*		*E.subs*		*E.wyom*		*E.zurn*	
			No +ve	%	No +ve	%	No +ve	%	No +ve	%	No +ve	%	No +ve	%	No +ve	%	No +ve	%	No +ve	%	No +ve	%	No +ve	%	No +ve	%
0-4	80	35	7	8.8	25	31.3	25	31.3	8	10.0	16	20.0	6	7.5	14	17.5	15	18.8	6	7.5	8	10.0	15	18.8	35	43.8
5-9	173	114	16	9.3	61	35.3	71	41.0	19	11.0	43	24.9	18	10.4	41	23.7	50	28.9	17	9.8	19	11.0	33	19.1	83	48.0
10-14	454	360	54	11.9	234	51.5	270	59.5	62	13.7	149	32.8	60	13.2	147	32.4	230	50.7	92	20.3	93	20.5	109	24.0	272	59.9

15-19	571	413	56	9.8	216	37.8	251	44.0	59	12.1	165	28.9	64	11.2	163	28.5	205	35.9	85	14.9	87	15.2	113	19.8	298	52.2
20-24	553	356	47	8.5	160	28.9	165	29.8	40	7.2	102	18.4	46	8.3	100	18.1	149	26.9	47	8.5	49	8.9	95	17.2	176	31.8
25 & above	669	289	40	6.0	110	16.4	132	19.7	42	6.3	105	15.7	42	6.3	91	13.7	73	10.9	32	4.8	39	5.8	80	12.0	179	26.8
Total	2,500	1,567	220	8.8	806	32.2	914	36.6	240	9.6	580	23.2	236	9.4	556	22.2	722	28.9	279	11.2	295	11.8	445	17.8	1043	41.78

3.6 AGES AT WHICH OOCYSTS OF DIFFERENT *EIMERIA* SPECIES WERE FIRST DETECTED IN FAECAL SAMPLES OF 52 CALVES IN PARTS OF PARTS OF PLATEAU STATE.

The ages of cattle at which oocysts of different *Eimeria* species were first detected in the faecal sample of 52 calves were recorded in Table 6. It was observed that the age at which the calves first shed oocysts was between 14 days and 84 days of age, when 9 different species of *Eimeria* were identified during the first shedding of oocysts. The first to be shed was *E. alabamensis* on day 14, and thereafter, *E. ellipsoidallis* on day 15, *E.zurnii* on day 16, *E. auburnensis, E. bovis* and *E. cylindrical* on day 26, *E. brassilliensis* and *E. bukidnonensis* on day 28, *E. subspherica* on day 30, *E. pellita* on day 38 *E. wyomingensis* on day 61 and *E. canadensis* on day 84.

The average oocyst population in 5g of faecal samples is also recorded also in Table 6. The lowest average oocyst population was 13,200 for*E. pellita,* and the highest average oocyst population was 35,000 for *E. subspherica.*

TABLE 6

Ages at which Oocysts of different *Eimeria* species were first detected in faecal samples of 52 calves in Parts of Plateau State.

Species of *Eimeria*	Age of Calves (days)		No. of Calves	Mean No.of Oocyst per 5g of faeces x10^3
	Range	Mean		
E. alabamensis	14-38	18	12	15.0
E. auburnensis	26-54	33	25	21.4
E. bovis	26-44	38	48	28.1
E. brassilliensis	28-84	54	42	18.4
E. bukidnonensis	28-68	44	28	16.2
E. canadensis	80-84	81	52	30.3
E. cylindrical	26-80	40	52	22.5
E. ellipsoidalis	15-56	36	49	24.2
E. pellita	38-84	42	31	13.2
E. subspherica	30-83	65	52	35.0
E. wyomingensis	61-84	72	25	17.1
E.zurnii	16-45	30	52	22.8

3.7 *EIMERIA* SPECIES IN 2,500 CATTLE IN SEXES ON PARTS OF PLATEAU STATE, NIGERIA.

Table 7 shows the prevalence of *Eimeria* species in both sexes of 2,500 cattle. Out of 1,518 faecal samples of cows examined, 902 (59.42%) were positive, and out of 982 faecal samples of bulls examined 665 (67.72%) were positive. There was no statistically significant difference in the rates of infection between male and female cattle. ($P>0.05$, $df=22$, $t=13.125$).

Table 7
Prevalence of *Eimeria* species in relation to sex of cattlea.

Sex of Cattle	Number Examined	Positive Number	Prevalence (%)
Female	1,518	902	59.42
Male	982	665	67.72
Total	2,500	1,567	62.68

3.8 PREVALENCE OF *EIMERIA* SPECIES IN 1518 COWS IN PARTS OF PLATEAU STATE, NIGERIA.

Out of the 1518 cows whose faecal samples were examined 902 (59.42%) were found to be positive for *Eimeria* oocysts. However 123(8.10%) were found to be positive for *E. alabamensis*, 441(29.05%) were found to be positive for *E.auburnensis*, 543(35.77%) were found to be positive for *E. bovis*, 135(8.89%) were founnd to be positive for *E. brassiliensis*, 346(22.79%) were found to be positive for *E. bukidnonensis*, 137(9.03%) were found to be positive for *E. canadensis*, 329(21.67%) were found to be positive or *E. cylindrica*, 428(28.19%) were found to be positive for *E. ellipsoidalis*, 165(10.87%) were found to be positive for *E. pellita*, 174 (11.46%) were found to be positive for *E. subspherica*, 256(16.86%) were found to be positive for *E. wyomingensis*, and 621(40.91%) were found to be positive for *E. zurnii*.

Infection was encountered in all age groups of the cows with infection ranging between 41.00% and 78.70%. The parasites were more common in the cows (heifers) 10-14 months old, with 200 (78.74%) of them carrying heavier infection than in any other age group. There was statistically significant difference in the rates of infection between heifers of the age group 10-14 months old and those 0-4 months old ($P< 0.05$) and also between age group 10-14 months old and those 25 months old and above (P, 0.05).

TABLE 8

Prevalence of *Eimeria* species in 1,518 Cows in Parts of Plateau State, Nigeria.

Age of cattle (month)	Total No. Exam.	Total No +ve (%)	*E.alab*		*E.aub*		*E.bovis*		*E.brassil*		*E.bukid*		*E.canad*		*E.cylind*		*E.ellips*		*E.pell*		*E.subs*
			No +ve	%	No +ve	%	No +ve	%	No +ve	%	No +ve	%	No +ve	%	No +ve	%	No +ve	%	No +ve	%	No +ve
0-4	52	23 (44.2)	4	7.7	10	19.2	12	23.1	4	7.7	7	21.1	4	7.6	10	19.2	11	21.1	5	10.0	4
5-9	113	74 (65.5)	9	8.0	30	26.5	40	35.4	10	8.8	25	22.1	11	9.7	25	22.1	36	31.9	10	8.9	10
10-14	254	200)78.7)	24	9.4	96	57.5	117	46.4	33	13.0	25	32.3	35	14.0	86	34.4	113	44.5	41	16.1	42
15-19	332	234 (70.5)	26	7.8	298	29.8	135	40.7	309	9.3	82	25.9	36	10.8	80	24.1	114	34.5	36	10.8	38
20-24	306	182 (59.5)	23	7.5	90	29.4	90	29.4	28	9.1	60	19.6	26	8.4	57	18.6	80	26.1	33	10.7	30
25 & above	461	189 (41.0)	37	8.0	116	25.2	149	32.3	31	6.7	86	18.7	25	5.4	71	15.4	74	16.5	40	8.6	50
Total	1,518	902 (59.4)	123	8.1	441	29.1	543	35.8	136	9.0	346	22.8	137	9.0	329	21.7	428	28.2	165	10.9	174

KEY.

E.alab = *E.alabamensis*
E.aurb = *E.aurbunesis*
E.bovis = *E.bovis*
E.brassil = *E.brassilliensis*
E.bukid = *E.bukidnonensis*
E.canad = *E.canadensis*
E.cylind = *E.cylindrica*
E.ellips = *E.ellipsoidallis*
E.pell = *E.pellita*
E.sub = *E.subspherica*
E.wyom = *E.wyomingensis*
E.zurn = *E.zurnii*

3.9 PREVALENCE OF *EIMERIA* SPEICIES IN 982 BULLS IN PARTS OF PLATEAU STATE, NIGERIA

Out of the 982 bulls whose faecal samples were examined 665 (67.72%) were found to be positive for *Eimeria* oocysts. However 97 (9.88%) were found to be positive for *E. alabamensis*, 365 (37.17%) were found to be positive for *E. auburnensis*, 371 (37.78%) were found to be positive for *E. bovis*, 104 (10.59%) were found to be positive for *E. brassiliensis*, 234(23.83%) were found to be positive for *E. bukidnonensis*, 99(10.08%) were found to be positive for *E. canadensis*, 227 (23.12%) were found to be positive for *E. cylindrica*, 294(29.94%) were found to be positive for *E. ellipsoidalis*, 114(11.61%) were found to be positive for *E. pellita*, 121 (12.32%) were found to be positive for *E. subspherica*, 189 (19.25%) were found to be positive for *E. wyomingensis*, and 85 (8.66%) were found to be positive for *E. zurnii*.

Bulls in all age groups carried cocidial infections ranging from, 42.90% to 80.00%. The parasites were more commonly encountered in bulls of 10-14 month olds than in any other age group. There was a significant difference in the rates of infection between the 10-14 months bulls and 0-4 months and also between 10-14 month olds and 25 month olds and above. ($P<0.05$).

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TABLE 9

Prevalence of *Eimeria* species in 982 bulls cattle in Parts of Plateau State, Nigeria.

Age of cattle (month)	Total No. Exam.	Total No +ve (%)	*E.alab*		*E.aurb*		*E.bovis*		*E.brassil*		*E.bukid*		*E.canad*		*E.cylind*		*E.ellips*		*E.pell*		*E.sub*
			No +ve	*%*	*No +ve*	*%*	*No +ve*	*%*	*No +ve*	*%*	*No +ve*	*%*	*No +ve*	*%*	*No +ve*	*%*	*No +ve*	*%*	*No +ve*	*%*	No +ve
0-4	28	12 (42.9)	2	7.1	9	32.1	8	28.6	2	7.1	4	14.3	3	10.7	4	14.3	5	217.9	2	7.1	2
5-9	60	40 (66.7)	6	10.0	20	33.3	22	36.7	6	10.0	14	23.3	6	10.0	10	16.7	16	26.7	7	11.7	6
10-14	200	160 (80.0)	25	12.5	98	49.00	90	45.0	26	13.0	57	28.5	25	12.5	59	29.5	72	36.0	30	15.0	39
15-19	239	179 (74.9)	27	11.3	92	38.5	91	38.1	30	12.5	64	26.8	26	10.8	54	22.6	71	29.7	31	13.0	29
20-24	247	174 (70.5)	20	8.1	85	34.4	90	36.4	22	8.9	55	23.3	20	8.1	55	22.3	70	28.3	24	9.7	30
25 & above	208	100 (48.1)	17	8.2	61	29.3	70	33.7	18	8.6	40	19.2	19	9.1	45	21.6	60	28.9	20	9.6	20
Total	982	665 (67.7)	97	9.8	365	37.2	371	37.8	104	10.6	234	23.8	99	10.1	227	23.1	294	29.9	114	11.0	121

3.10 PREVALENCE OF *EIMERIA* SPECIES IN DIFFERENT BREEDS OF CATTLE IN PLATEAU STATE.

Table 10 shows the prevalence of *Eimeria* species in different breeds of cattle. The most infected breed of cattle was the Muturu. Out of the 117 faecal samples of the Muturu breed of cattle examined 98, (83.76%) were infected. The least infected breed of cattle was the N'dama. Out of the 408 faecal samples of N'dama breed of cattle examined, 181 (44.36%) were infected. The other infected breeds were Adamawa, in which infection was found in 250 (76.22%), out of their 328 faecal samples examined; Wadara in 112 (69.57%), out of their 161 faecal samples examined; Holstein Frezian 336 (49.78%), out of their 675 faecal samples examined; Red Bororo in 183 (70.93%), out of their 258 faecal samples examined; Sokoto Gudali in 200 (75.19%), out of their 266 faecal samples examined; and White Fulani in 208 (72.47%), out of their 287 faecal samples examined.

There was a statistically significant difference in the rate of infection between the breeds of N'dama and Muturu ($P<0.05$). There was also a statistically significant difference in the rate of infection between the

breeds of Adamawa and Muturu; between Wadara and Holstein Frezian; between Holstein Frezian and Muturu, and between Muturu; and N'dama (P=<0.05, df=22, t=2.156, 2.558, -2.971, 3.432 and 2.305) respectively.

Table 10

Distribution of *Eimeria* species in different breeds of cattle in Plateau State, Nigeria

Breed of Cattle	Number Examined	Number Positive	Prevalence (%)
Adamawa	328	250	76.22
Wadara	161	112	69.57
Holstein Frezian	675	336	49.78
Muturu	117	98	83.76
N'dama	408	181	44.36
Red Bororo	258	183	70.93
Sokoto Gudali	266	200	75.49

White fulani	287	208	72.10
Total	2,500	1,567	62.68

3.11 RELATIONSHIP BETWEEN THE OCCURRENCE OF *EIMERIA* SPECIES IN CATTLE AND THE SYSTEMS OF HUSBANDRY IN PARTS OF PLATEAU STATE, NIGERIA.

In Table 11 the relationship between the prevalence of *Eimeria* species in cattle and the system of husbandry is recorded. The parasites infected a greater population of cattle that were grazed on pastures (free range), compared with those raised in either mud floor pens or concrete floor pens. Out of 809 faecal samples of cattle on free range examined, 572 (70.70%) were infected. Out of 621 faecal samples of cattle raised in mud pen floor examined, 388 (62.48%) were infected. From cattle raised on concrete floor, out of 1,070 faecal samples examined, 607 (56.73%) were infected. However the levels of parasitism between cattle raised on

concrete floor pens and free range was statistically significantly different ($P<0.05$) and also between cattle raised on concrete floor pens and mud floor pens ($P< 0.05$). The intensity of contamination by oocysts in different husbandry systems followed a similar trend with the highest oocyst counts 156,410.oocysts per 5g faecal matters produced by cattle grazed under free-range system.

The predominant *Eimeria* species found in free range cattle were *E. bovis, E. cylindrica, E. subspherica* and *E. zurnii.* From mud pens, *E. bovis*, *E. subspherica* and *E. zurnii* were commonly encountered. From concrete floor pens *E. alabamensis, E. bovis* and E. *zurnii* were encountered.

Table 11

Relationship between Prevalence of *Eimeria* species in cattle and the systems of husbandry in Plateau State, Nigeria

	Free Range	Mud Pen	Concrete floor
Number Examined	809	621	1,070
Number Infected	572	388	607
Prevalence (%)	70.70	62.48	56.73
Average Number of oocysts/5g faeces	156,410	145,860	109,300
Predominant *Eimeria* species	*E.bovis*	*E.bovis*	*E.alabamensis*
	E.cylindrica	*E.subspherica*	*E.bovis*
	E.subspherica	*E.zurnii*	*E.zurnii*
	E.zurnii		

3.12 *EIMERIA* SPECIES IN 2,500 DAIRY AND BEEF CATTLE IN PARTS OF PLATEAU STATE NIGERIA.

Table 12 shows the prevalence of *Eimeria* species in 2,500 dairy and beef cattle. Out of the 1048 dairy cattle whose faecal samples were examined 577 (55.06%) were found to be positive. Out of the 1452 beef cattle whose faecal samples were examined, 990(68.18%) were found to be positive. However, 325 (69.15%) of the 470 cows beef whose faecal samples were examined, were found to be positive, while 665 (67.72%) of the 982 bulls whose feacal samples were examined were found to be positive for *Eimeria* oocysts.

The least infected cattle were the dairy cattle (55.06%) while the highest infected cattle were the beef cows with (67.72%) infection rate. There was no statistically significant difference in the rates of infection between the dairy and the beef cattle. ($P<0.05, t=1.796$ df=22)

TABLE 12

Prevalence of *Eimeria* species in Dairy and Beef Cattle in Parts of Plateau State, Nigeria.

aub		*E.bovis*		*E.brassil*		*E.bukid*		*E.canad*		*E.cylind*		*E.ellips*		*E.pell*		*E.subs*		*E.wyom*		E.*zurn*	
	%	No +ve	%	No +ve	%	No +ve	%	No +ve	%	No +ve	%	No +ve	%	No +ve	%	No +ve	%	No +ve	%	No +ve	%
8	21.3	298	28.4	84	8.0	238	22.7	74	7.1	126	12.0	204	19.5	110	10.0	100.0	9.5	176	16.8	427	40.7
	46.4	245	52.1	52	11.1	108	23.0	63	13.4	203	43.2	234	49.8	55	4.7	74	15.7	80	17.0	197	41.9
5	36.2	371	36.4	104	10.5	234	22.4	99	10.0	227	21.2	294	27.9	114	11.0	121	12.3	189	19.2	419	42.6
5	32.2	914	36.6	240	9.6	580	23.2	236	9.4	556	22.2	722	28.9	279	11.2	295	11.8	445	17.8	1043	41.7

3.13 SPECIES AND SPORULATION RATES OF *EIMERIA* OOCYSTS CONTAMINATING ENVIRONMENTAL MEDIA AND UDDERS OF CATTLE.

The major source of infection was from the pastured as shown in Table 13. The average contamination rate was 40.77%. The lowest source of contamination was from udders with contamination rate of 29.22%. The beddings and feeds had contamination rates of 31.06% and 38.06% respectively. The rate of oocyst sporulation was highest in pastures (33.67%) and lowest on udders (10.75%). The predominant species of *Eimeria* from the four media was *E. zurnii*, with the highest contamination rate of 82.0% and sporulation rate of 78.0% in pastures. There was no statistically significant difference in the rate of contamination between pastures and feed, but there was a highly statistically significant difference in the contamination rate between feeds

and udders $P<0.01$, $df=22$ $t=-4.495$. Also there was a statistically significant difference in contamination rate between beddings and udders $P<0.01$ $df=22$, $t=-3.559$.

TABLE 13

Species of Eimeria	PASTURES (150) No. and Contam. Rate (%)	Sporulation (%)	BEDDINGS (150) No. and Contam Sporulation Rate (%)	(%)	FEED S (150) No. and Contam Rate (%)	Sporulation (%)	UDDERS (300 No. and Conta Rate (%)
E. alabamensis	36 (24.00)	37.00	25(16.67)	9.00	56 (37.33)	35	108(36.00)
E. auburnesis	96 (64.00)	48.00	76(50.67)	49.00	38 (25.33)	55	106(35.33)
E. bovis	102(68.00)	51.00	76(50.67)	38.00	61 (40.67)	60	100(33.33)
E. brassilliensis	32 (21.33)	16.00	23(15.33)	8.00	25 (16.67)	15	105(35.00)
E. bukidnonensis	77 (51.33)	40.00	51(34.00)	17.00	39 (26.00)	26	70 (23.33)
E. Canadensis	19 (12.67)	7.00	18(12.00)	8.00	28 (18.67)	27	103(34.33)
E. cylindrical	41 (27.33)	18.00	48(32.00)	42.00	28 (18.67)	14	98(32.67)
E. ellipsoidalis	92 (61.33)	56.00	60(40.00)	29.00	41 (27.33)	20	132(44.00)
E. pellita	45 (30.00)	23.00	24(16.00)	6.00	16 (10.67)	11	28(9.33)
E. subspherica	43 (28.67)	22.00	38(25.33)	19.00	46 (30.67)	25	43(14.33)
E. wyomingensis	28 (18.67)	8.00	27(18.00)	12.00	59 (39.33)	42	56 (19.33)
E. zurnii	123(82.00)	78.00	93(62.00)	56.00	68 (45.33)	38	101(33.67)
Average	61.17 (40.77)	33.67	48.58 (31.06)	24.42	42.08 (28.06)	30.67	87.50 (29.22)

3.14 SEASONAL PREVALENCE OF *EIMERIA* OF CATTLE IN PARTS OF PLATEAU STATE, NIGERIA.

Table 14 shows the overall seasonal prevalence of *Eimeria* in cattle. Out of the 932 faecal samples examined during the dry season (November - March) 637 (68.35%) were positive, while out of the 1568 faecal samples examined during the wet season (April - October) 930 (59.31%) were positive. The rate of infection was higher during the dry season than during the wet season.

During the dry season the month of March had the highest rate of infection (77.95%) as well as the highest rate of sporulation (46%).

During the wet season the month of April had the highest rate of infection and sporulation (72.38% and 38%) respectively.

There was no significant difference in the rate of infection between each month

during the dry season and also during the wet season.

Also there was no statistically significant difference in the rate of infection between dry season and wet season. ($P>0.05$) $df=10$, $t=0.335$.

TABLE 14

Seasonal Prevalence of *Eimeria* in Cattle in Parts Plateau State

Season	Number Examined	Number Infected	Infective Rate (%)	Oocyst Sporulation Rate (%)
Dry Season (Months)				
November	190	113	59.47	27
December	139	92	66.19	30
January	205	140	68.29	24
February	203	140	68.97	32
March	195	152	77.95	46
Total	932	637	68.35	X=31.80
Wet Season (Months)				
April	181	131	72.38	38
May	294	179	60.88	20
June	178	98	55.06	16
July	265	139	52.45	24
August	192	107	55.73	18
September	271	163	60.15	15
October	187	113	60.43	26

Total	1568	930	59.31	X=22.53

3.15 SEASONAL PREVALENCE OF *EIMERIA* IN CATTLE IN PARTS OF PLATEAU STATE.

Table 15 shows seasonal prevalence of *Eimeria* in both sexes of cattle. Out of the 360 faecal samples of the bulls examined during dry season 281 (78.1%) were positive and out of the 572 faecal samples of the cows examined, 356 (62.24%) were positive. During the wet season, out of the 622 faecal samples from bulls examined 384 (61.7%) were positive, and out of the 946 faecal samples of the cows examined, 546 (57.72%) were positive. The highest rate of infection during the dry season was in the month of March for both bulls and cows. The lowest was in the month of November.

The highest rate of infection during the wet season was in the month of April for both bulls and cows and the lowest was in the month of July.

There was no significant difference in the rate of infection between the bulls and the cows during the wet and dry season ($P>0.05$).

TABLE 15

Seasonal Prevalence of *Eimeria* in both sexes of 2,500 cattle in Parts of Plateau State.

Season 1992/93	Number Examined		Number Infected		Prevalence (%)	
	Bulls	Cows	Bulls	Cows	Bulls	Cows
Dry Season (Months)						
November	79	111	52	61	65.82	54.95
December	44	95	34	58	77.27	61.05
January	80	125	68	72	85.00	57.60
February	77	126	57	83	74.03	65.87
March	80	115	70	82	87.50	71.30
Total	360	572	281	356	78.06	62.24
Wet Season (months)						
April	79	102	64	67	81.01	65.69
May	95	199	64	115	67.37	57.79
June	76	102	40	58	52.63	56.86

July	103	162	60	79	58.25	48.77
August	92	100	47	60	51.09	60.00
September	108	163	68	95	62.96	58.28
October	69	118	41	72	59.42	61.02
Total	622	946	384	546	61.74	57.72

3.16 AVERAGE SPORULATION RATES OF BOVINE *EIMERIA* OOCYSTS UNDER DIFFERENT TEMPERATURES IN THE LABORATORY.

The average sporulation rates of *Eimeria* oocysts under different temperatures in the laboratory are recorded in Table 16. The control temperature was the average room temperature (28.8^{o}C). The trend of development was that the higher the temperature, the faster and higher are the rates of sporulation. The low temperatures of 5^{o}C and 10^{o}C inhibited the sporulation of most oocysts but did not kill them. At 20^{o}C and room

temperatures the rate of sporulation was slow until 7th to 9th day. At 25^{o}C and 30^{o}C,sporulation was from 15% to 94%, except for *E. pellita* that started sporulating on the 3rd day at the same temperature. At higher temperatures of 35^{o}C and 40^{o}C about 60% of the oocysts seemed to sporulate quickly but later degenerated.

TABLE 16

Average Sporulation Rates (%) of *Eimeria* Oocysts Under Different Temperatures.

Day After incubation	Temperatures								
	5°C	10°C	15°C	20°C	RMT°C	25°C	30°C	35°C	40°C
				E.alabamensis					
1	0	0	3	15	28	51	60	70	0
3	0	0	22	40	39	62	71	61	0
5	0	7	31	48	66	77	77	52	0
7	1	15	48	56	78	89	90	35	0
9	8	23	57	67	89	91	52	0	0
				E.auburnensis					
1	0	0	0	7	20	35	58	65	9
3	0	0	0	32	40	51	67	76	0
5	0	2	16	38	65	80	89	30	0
7	0	15	35	56	81	92	91	21	0
9	0	25	42	67	91	92	91	0	0
				E.bovis					
1	0	0	0	0	0	51	62	50	0
3	0	0	0	45	59	69	89	20	0

0	0	5	61	67	92	90	0	0
0	0	28	88	92	78	51	0	0
6	15	49	93	92	43	20	0	0

ay Temperatures

ter cubation	5°C	10°C	15°C	20°C	RMT°C	25°C	30°C	35°C	40°C
	0	0	0	0	35	44	61	65	38
	0	0	0	0	56	68	91	50	21
	0	0	7	15	71	79	20	0	15
	0	0	38	38	91	90	4	0	0
	0	1	49	61	91	91	0	0	0

E.bukidnonensis

0	0	0	0	3	35	61	89	78
0	0	0	0	41	53	92	57	55
0	0	0	0	63	69	25	30	36
0	0	0	11	69	82	20	20	15
0	0	5	38	85	93	10	11	5

E.canadensis

1	0	0	0	2	38	30	41	35	0
3	0	0	0	45	59	56	58	55	0

5	0	0	0	78	80	92	90	29	0
7	0	0	7	91	89	70	90	0	0
9	0	5	37	91	90	53	25	0	0

E.cylindrica

1	0	0	0	0	0	31	68	59	5
3	0	0	0	0	40	53	91	27	0
5	0	0	0	2	59	65	51	0	0
7	0	1	15	39	71	89	15	0	0
9	0	25	38	61	90	40	0	0	0

Day	Temperatures								
	5°C	10°C	15°C	20°C	RMT°C	25°C	30°C	35°C	40°C

E.ellipsoidallis

1	0	0	0	0	2	15	40	46	36
3	0	0	0	0	41	30	59	89	6
5	0	0	0	2	76	56	91	23	0
7	0	0	7	39	88	91	70	5	0
9	3	5	28	60	94	94	30	0	0

E.pellita

1	0	0	0	0	0	0	20	41	68
3	0	0	0	0	4	15	60	79	41
5	0	0	0	2	48	65	90	20	15

7	0	0	1	33	70	91	43	1	2
9	0	0	28	50	93	91	5	0	0

E.subspherica

1	0	0	0	4	20	56	60	61	0
3	0	0	0	26	61	71	65	51	0
5	0	0	5	53	82	91	77	22	0
7	0	0	38	71	93	93	91	5	0
9	0	5	51	84	93	93	91	0	0

E.wyomingensis

1	0	0	0	0	2	38	48	57	0
3	0	0	0	0	40	55	69	91	0
5	0	0	0	17	67	79	85	20	0
7	0	0	1	41	80	93	90	0	0
9	0	0	23	61	89	93	93	0	0

Day	Temperatures								
	5°C	10°C	15°C	20°C	RMT°C	25°C	30°C	35°C	40°C

E.zurnii

1	0	0	0	5	15	25	60	60	35
3	0	0	1	40	48	54	72	89	2
5	0	5	40	61	74	77	91	40	0
7	0	21	48	72	90	90	45	21	0

9	0	42	60	80	93	90	10	1	0

3.17 MORPHOLOGICAL FEATURES OF BOVINE *EIMERIA* OOCYSTS ENCOUNTERED IN PLATEAU STATE, NIGERIA

Table 17 shows the morphological features of *Eimeria* oocysts types varied from one species to the other. 50 oocysts were measured for each species.

3.17.1 *E.alabamensis*: The oocysts (Plate 1) were pear shaped and pyriform. The dimensions were 16.0µ - 25.0µ by 12.2µ - 17.1µ (mean, 19.5µ by 14.3µ). The oocyst wall composed of two thin transparent layers. The colour was light brownish yellow outside and dark brown inside. The average thickness of the cell wall was 0.5µ. There was no micropyle present. Oocyst residuum was absent.

The Sporocysts were elongate. The average dimensions were 8.2µ by 3.8µ. Sporocysts residuum was absent. The sporozoites were elongate with one end narrower than the other and lying head to tail in the sporocysts. One to two globules were present in the sporozoite. The length of sporulation was 4 days to 5 days.

3.17.2 *E.auburnensis.* The oocysts (Plate 2) were ovoidal and elongate in shape. The dimensions were 39.2µ to 43.7µ by 24.5µ to 28.0µ (mean, 38.0µ by 24.7µ). The oocyst wall was composed of double thin layers. The outside wall was very smooth and thicker

than the inner wall. The colour of the oocyst wall was light brown. The average thickness of the wall was 0.68μ. The presence of micropyle was visible, and the average length was 4.3μ. Micropylar cap was absent. There was no oocyst residuum.

The sporocysts were elongate and the average dimension was 18.4μ by 10.2μ. Sporocysts residuum was present and visible. The sporozoites were elongate with one end narrower than the other, lying head to tail inside the sporocysts. Two globules were visually present in each sporozoite. The length of sporulation was 2-3 days.

3.17.3 *E.brassiliensis.* The oocysts (Plate 3) were elliposidal in shape. The dimensions were 31.0μ to 39.5μ by 21.2μ to 28.0μ(mean, 34.1μ by 25.6μ). The oocyst wall was composed of two layers. The inner layer is thicker than the outer layer. The colour of the oocyst was yellowish-brown. The average thickness of the cell wall was 1.91μ. Presence of micropylar cap was visible, measuring 8.5μ to 10μ wide by 2.2μ to 3.5μ high, (mean, 8.8μ by 2.7μ). The micropylar cap was centrally placed at the micropylar end of the oocyst. The micropyle was also visible, measuring an average length of

6.4μ. There was a portion of polar granule in the areas of micropyle. There was appearance of brightly refractile residual body situated behind the micropyle. Oocyst residuum was absent.

The Sporocysts were elongate and the average dimension was 18.3μ by 7.5μ. There was absence of

sporocyst residuum. The sporozoites were elongate with one end narrower than the other, lying head to tail inside the sporocysts. One to two globules were visible in each sporozoite. The length of sporulation was 6-7 days.

3.17.4 *E.bovis*. The oocysts (Plate 4) were ovoid and blunted at the narrow end. The dimensions were 25.0μ to 32.0μ by 18.0μ to 22.4μ (mean, 28.5μ by 20.0μ. The oocyst wall was composed of smooth double layers. The inner layer was thicker than the outer layer. The average thickness of the cell wall was 1.1μ. The colour of the cell wall was yellowish green. The micropyle appeared as a gap in the cell wall at the narrow end. The average dimension of the micropyle was 3.8μ. There was no micropylar cap, and oocyst residuum was absent. The sporocysts were elongate and the average measurement was

15.3μ by 6.8μ. Sporocyst residuum was present. The sporozoites were elongate with one end narrower than the other, lying head to tail inside the sporocysts. One globule was visible inside each sporozoite. The length of sporulation was 2-3 days.

3.17.5 *E.bukidnonensis.* The oocysts, (Plate 5) were pear-shaped and pyriform. The dimensions of the oocysts were 36.1μ to 49.2μ by 26.0μ to 37.2μ (mean 43.8μ by 32.0μ. The oocysts were composed of double thick cell walls. The cell walls were dark and radically striated. The average thickness of the cell wall was 2.8μ. The oocyst colour was yellowish-brown. There was presence of a micropyle. The micropylar end was flattened. The average length of the micropyle was 2.8μ. There was no micropylar cap, and oocyst residuum was absent.

The sporocysts were elongate and the mean dimensions were 20.1μ by 13.8μ. Sporocyst residuum was absent. The sporozoites were elongate with one end narrower than the other, lying head to tail inside the sporocysts. One big globule was visible in each sporozoite. The sporulation time was 5-7 days.

3.17.6 *E.canadensis.* The oocysts (Plate 6) were ellipsoidal in shape, having dimensions of 29.1μ to 36.2μ by 21.0μ to 26.2μ (mean, 32.5μ by 22.4μ). The oocysts were composed of two thick cell walls that were yellowish in colour. The average thickness of the cell wall was 0.6μ. There was presence of a micropyle having an average length of 4.2μ. There was no oocyst micorpylar cap. Oocyst residuum was absent. The sporocysts were elongate and the average measurement was 18.3μ by 7.6μ. Sporocyst resiuduum was absent. The sporozoites were elongate with one end narrower than the other, lying head to tail inside the sporocyst. Two to three globules were visible inside each sporozoite. The length of sporulation was 3-5 days.

3.17.7 *E.cylindrica.* The oocysts (Plate 7) were cylindrical in shape. The dimensions of the oocysts were 17.0μ to 29.8μ by 12.4μ to 16.5μ (mean, 28.0μ by 23.8μ. The oocysts were composed of double thin walls. The oocyst walls were colourless. The average thickness of the cell wall was 0.8μ. There was no micropyle. Oocyst residuum was absent.

The sporocysts were elongate, and the average measurement was 11.4μ

by 7.1μ. Sporocyst residuum was absent. The sporozoites were elongate, with one end narrower than the other, lying head to tail inside the sporocyst. One small globule was visible inside each sporozoite. The length of sporulation was 2-3 days.

3.17.8 *E. ellipsoidalis.* The oocysts (Plate 8) were predominantly ellipsoidal in shape. The dimensions of the oocysts were 13.2μ to 25.0μ by 10.7μ to 18.1μ (mean, 20.1μ by 14.5μ). The oocysts composed of double walls; the inner wall was thicker than the outer wall. The average thickness of the cell wall was 1.3μ, and the colour was yellow. Micropyle was not visible. There was no oocyst residuum.

The sporocysts were elongate with average dimension of 11.2μ by 6.8μ. The sporocyst residuum was visibly present. The sporozoites were elongate with one end narrower than the other, lying head to tail inside the sporocysts. One small globule was visible in each sporozoite. The length of sporulation was 2-3 days.

3.17.9 *E.pellita.* The oocysts (Plate 9) were egg shaped. The dimensions were 38.9μ to 48.5μ by 26.8μ to 37.4μ (mean, 39.5μ by

27.9μ). The oocysts had thick double walls with the outer wall thicker than the inner wall. The colour of the oocyst wall was dark brown with velvet appearance. The average thickness of the cell wall was 2.2μ. Micropyle was visible like an operculum at the narrow end of the oocyst. The micropylar end was flattened and the average length was 4.5μ. There was no micropylar cap. There was no oocyst residuum.

The sporocysts were elongate with average dimensions of 23.7μ by 15.9μ. Sporocyst residuum was absent. The sporozoites were elongate, with one end narrower than the other, lying head to tail inside the sporocyst. One large globule was seen inside each sporozoite. The length of sporulation was 10-12 days.

3.17.10 *E. subspherica.* The small oocysts (Plate 10) of this species were subspherical in shape. The dimensions were 9.0μ to 13.0μ by 8.80μ to 12.0μ(mean, 11.5μ by 10.6μ. The oocysts composed of thin double cell walls that were transparent. The average thickness of the cell wall was 0.7μ and the colour under oil immersion was light yellow. There was no micropyle, and oocyst residuum was absent.

The sporocysts were elongated and difficult to measure. The average dimension was 8.1 by 3.6. There was no sporocyst residuum. The sporozoites were difficult to differentiate from the sporocyst, and globules were not visible. The average length of sporulation was 4-5days.

3.17.11 *E.wyomingensis.* The oocysts (Plate 11) were broadly-ovoidal and pyriform in shape. The dimensions were 35.8µ to 46.6µ by 26.6µ to 31.5µ (mean 39.8µ by 28.4µ). The oocysts were composed of two thick cell walls, the inner wall thicker than the outer wall. The average thickness of the cell wall was 2.5µ. The colour of the cell wall was yellowish brown. There was a micropyle with an average length of 2.8µ. There was no oocyst residuum.

The Sporocysts were elongate with average dimension of 20.1µ by 12.3µ. There was no sporocyst residuum. The sporozoites were elongate with one end narrower than the other, lying head to tail inside the sporocysts. One globule was visible inside each sporozoite. The average length of sporulation was 3-5 days.

3.17.12 *E.zurnii*.The oocysts (Plate 12) were spherical in shape. The

dimensions were 14.9μ to 19.8μ by 13.4μ to 17.3μ (mean 17.6μ by 15.7μ). The oocysts were composed of two thin cell walls that were transparent and colourless. There was no micropyle. The average thickness of the cell wall was 0.6μ. There was no oocyst residuum. The sporocysts were elongate with an average dimension of 12.1μ by 10.2μ.There was no sporocyst residuum. The sporozoites were elongate with one end narrower than other, lying head to tail inside the sporocysts. One tiny globule was visible inside each sporozoite. The average length of sporulation was 2-3 days.

Figures 1 to 12 show the microphotograghs and diagrammatic representations of the sporulated and unsporulated oocysts of the twelve species of *Eimeria* encountered in this study.

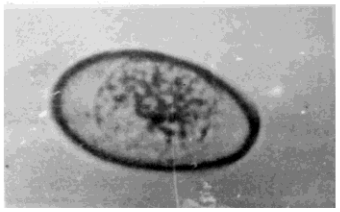
TABLE 17

Morphological features of Bovine *Eimeria* oocysts encountered in Plateau State, Nigeria.

Species of Eimeria	Shape and Colour	Oocyst Wall and length (µ)	Oocyst Dimension (µ)	Micropyle and dimension	Micropylar cap	Oocyst Residuum	Spor Shap Dimens
E.alabamensis	Pear shaped, Pyriform, light and brownish yellow	The wall is single. Thin and transparent. Thinner at the narrow end (0.5)	L.16.0-25.0 B.12.2-17.1 X.19.5 x 14.3	Not Present	Not seen	Not seen	Elongat 8.2x3.8
E.auburnesis	Ovoidal in shape and colourless	It has double wall. Smooth and thin (0.7)	L.39.2-43.7 B.24.5-28.0 X.38.0 x 24.7	Present 4.3µ	Not seen	Not seen	Elongat 18.4x10
E.brassilliensis	Ellipsoidal and yellow in colour	Smooth and a single layer (1.9)	L.31.0-39.5 B.21.2-28.0 X.34.06-25.6	Present 6.4µ	Present	Not seen	Elongat 18.3x7.
E.bovis	Ovoid and blunted at narrow end. Greenish brown in colour	Smooth, inner layer is thick and outer layer is thin (1.1)	L.25.0-32.0 B.18.0-22.4 X.28.5 x 20.6	Present 3.8µ	Not seen	Not seen	Elongat 15.3x6.
E.bukidnonensis	Pear shaped, Pyriform and yellowish brown	Double thick and dark walls (2.8)	L.36.1- 49.2 B.26.0 - 37.2 X.43.8 - 32.0	Present 2.8µ	Not seen	Not seen	Elongat 20.1x13

Shape and Colour	Oocyst Wall	Oocyst Dimension length & width(µ)	Micropyle and dimension	Micropylar cap	Oocyst Residuum	Sporocyst Shape and dimension (µ)	Sporocyst Residuum
Ellipsoidal in shape and yellowish in colour	Single thin wall (0.6)	L.29.1 - 36.2 B.21.0 - 26.2 X32.5 x 224.4	Present 4.2µ	Not seen	Not seen	Elongate 20.1x13.8	Not seen
Cylindrical in shape and colourless	Single thin wall (0.8)	L.17.0 - 29.8 B.12.4 - 16.5 X.28.0 x 13.8	Not seen	Not seen	Not seen	Elongate 11.4x7.1	Not seen
Ellipsoidal and yellowish in colour	Thick and transparent (1.3)	L.13.2 - 25.0 B.10.7 - 18.1 X.20.1 x 14.5	Not seen	Not seen	Not seen	Elongate 11.2x6.8	Present
Egg shape, dark brown with velvet appearance	Very thick (2.2)	L.38.9 - 48.5 B.26.8 - 27.4 X. 39.5 x 27.9	Present 4.5µ	Not seen	Not seen	Elongate 23.7x15.9	Not seen
Subspherical in shape, light yellow in colour	Thick and transparent (0.7)	L.9.0 - 13.0 B.8.0 - 12.0 X.11.5 x 10.6	Not seen	Not seen	Not seen	Elongate 8.1x3.6	Not seen
Ovoidal pyriform in shape and yellowish brown in colour	Thick (2.5)	L.35.8 - 46.6 B.26.6 - 31.5 X.39.8 x 28.4	Present 2.8µ	Not seen	Not seen	Elongate 20.1x12.3	Not seen

Spherical colourless	Thick and transparent (0.6)	L.14.9 - 19.8 B.13.4 - 17.3 X.17.6 x 15.7	Not seen	Not seen	Not seen	Elongate 12.1x10.2	Not seen



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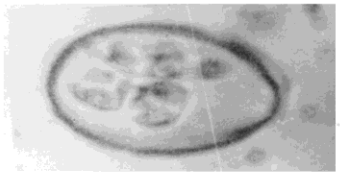
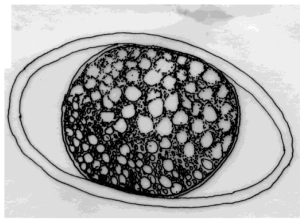
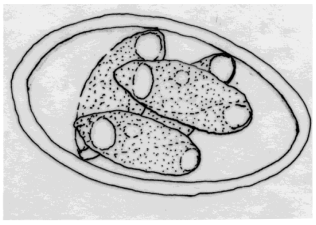


PLATE 1; PHOTOMICROGRAPH OF UNSPORULATED AND SPORULATED *E alabamensis*





DIAGRAMATIC REPRESENTATION OF UNSPORULATED AND SPORULATED *E alabamensis*

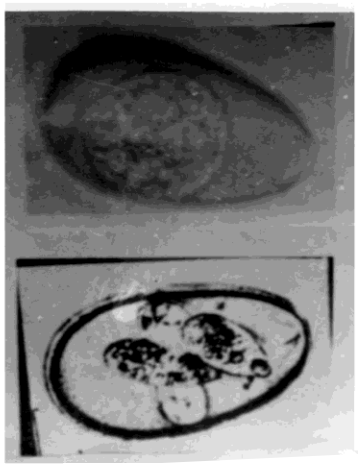


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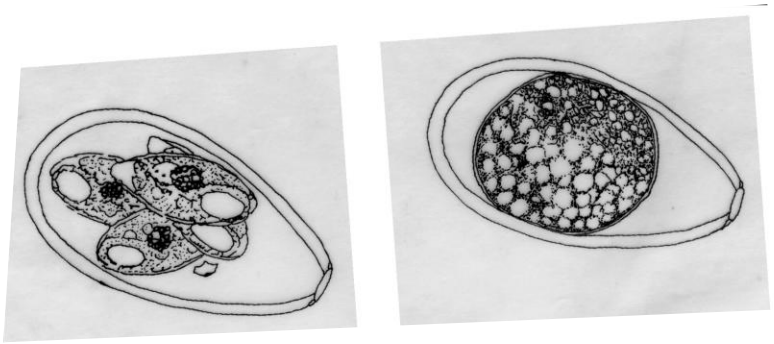
PLATE 2; PHOTOMICROGRAPH OF UNSPORULATED AND SPORULATED *E auburnensis*



DIAGRAMATIC REPRESENTATION OF SPORULATED AND UNSPORULATED *E auburnensis*

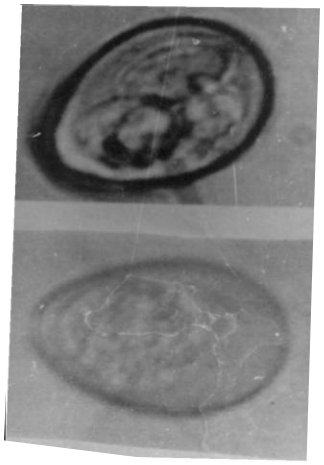


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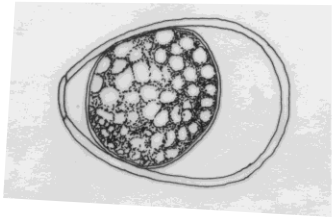
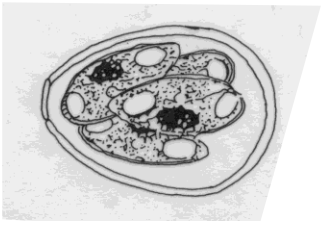
PLATE 3: PHOTOMICROGRAPH OF SPORULATED AND UNSPORULATED *E bovis*





DIAGRAMATIC REPRESENTATION OF UNSPORULATED AND SPORULATED *Ebovis*

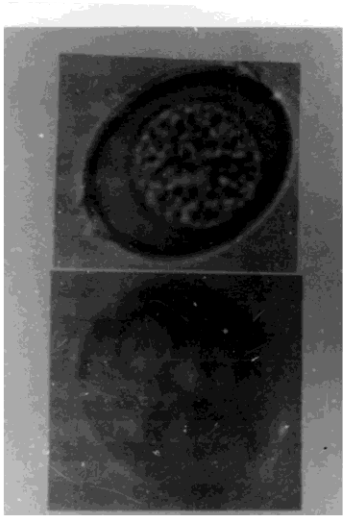


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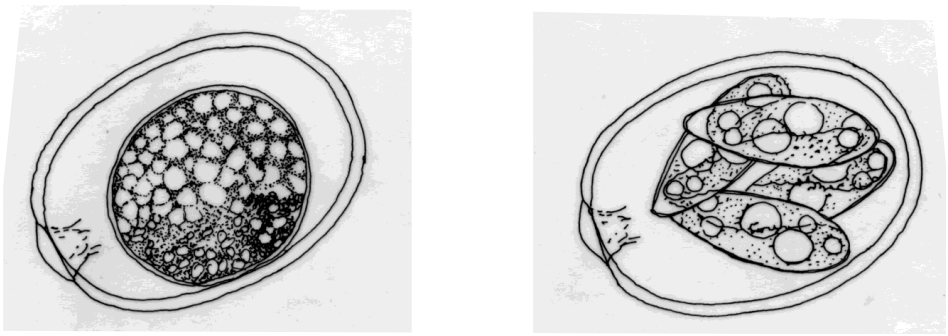
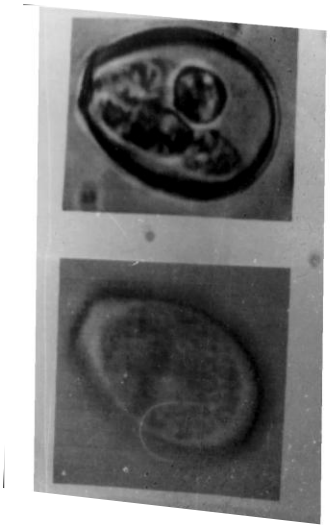
PLATE 4; PHOTOMICROGRAGH OF UNSPORULATED AND SPORULATED *Ebrassiliensis*



DIAGRAMATIC REPRESENTATION OF UNSPORULATED AND SPORULATED *Ebrassiliensis*



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PHOTOMICROGRAPH OF UNSPORULATED AND SPORULATED *EBUKIDNONENSIS*

DIAGRAMATIC REPRESENTATION OF UNSPORULATED AND SPORULATED

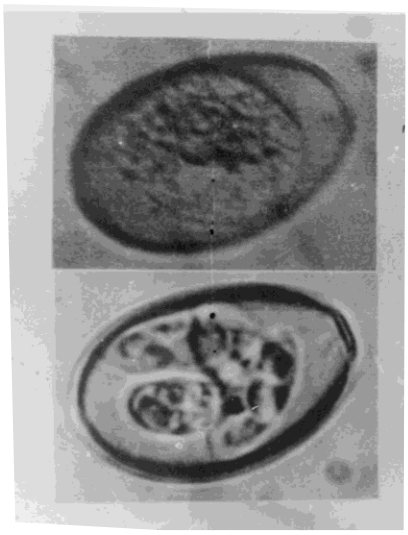

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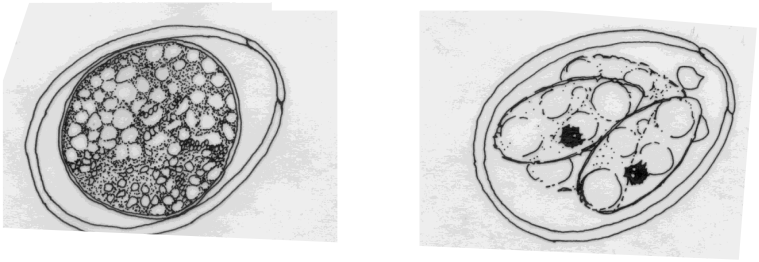
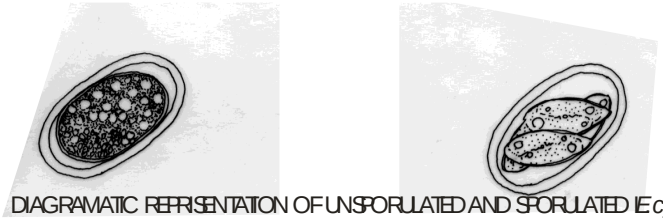
PLATE 6: PHOTOMICROGRAPH OF UNSPORULATED AND SPORULATED *Ec anadensis*.



DIAGARAMATIC REPRESENTATION OF UNSPORULATED AND SPORULATED iE. Canadensis.

X1000

PLATE 7 PHOTOMICROGRAPH OF UNSPORULATED AND SPORULATED *Ecylindrica.*



DIAGRAMATIC REPRISENTATION OF UNSPORULATED AND SPORULATED I*Ecylindrica.*

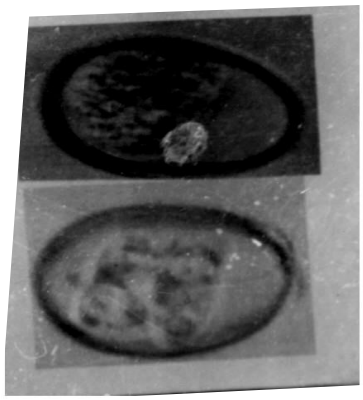


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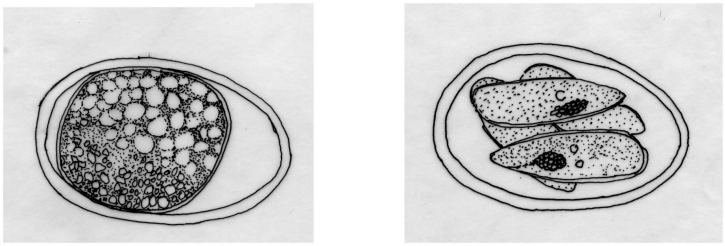
PLATE 8; PHOTOMICROGRAPH OF UNSPORULATED AND SPORULATED *E ellipsoidalis*



DIAGRAMATIC REPRESENTATION OF UNSPORULATED AND SPORULATED *E ellipsoidalis*

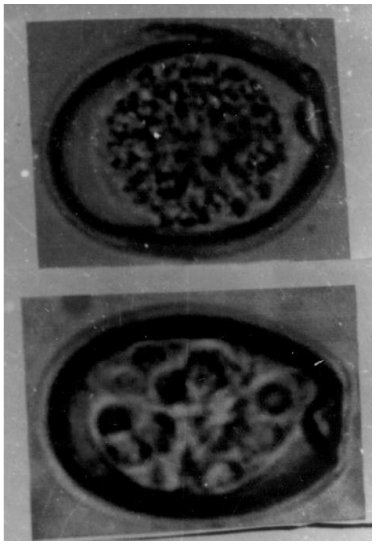


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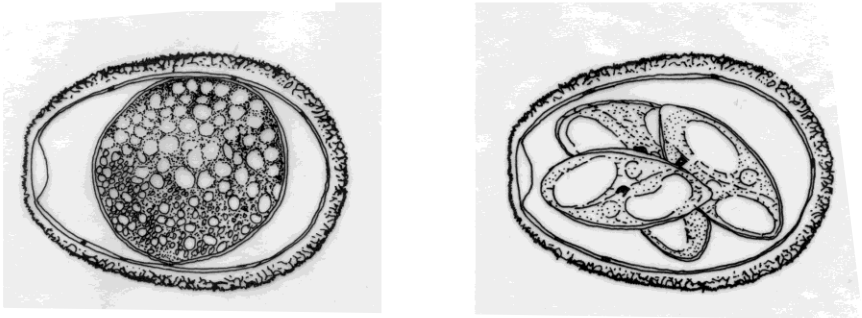
PLATE 9; PHOTOMICROGRAPH OF UNSPORULATED AND SPORULATED *E.pellita*



DIAGRAMATIC REPRESENTATION OF UNSPORULATED AND SPORULATED *E.pellita.*

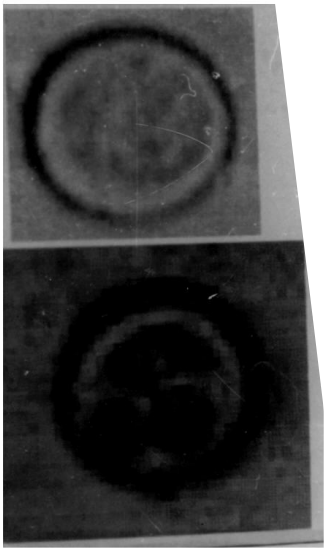


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PLATE 10 ;PHOTOMICROGRAPH OF UNSPORULATED AND SPORULATED *E.subspherica.*

DIAGRAMATIC REPRESENTATION OF UNSPORULATED AND SPORULATED *E.subspherica*

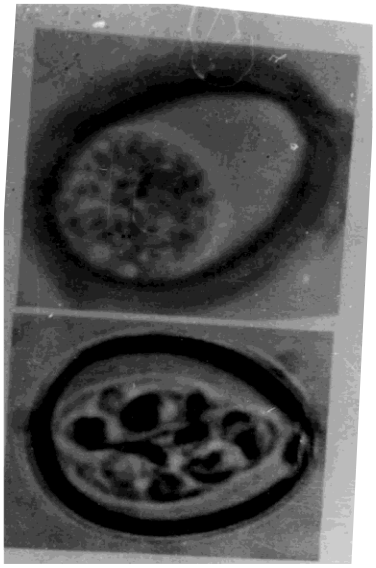

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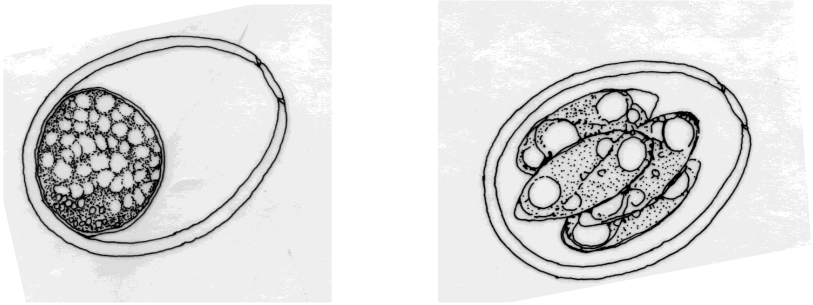
PLATE 11; PHOTOMICROGRAPH OF UNSPORULATED AND SPORULATED *E wyomingensis*



DIAGRAMATIC REPRESENTATION OF UNSPORULATED AND SPORULATED *E wyomingensis*

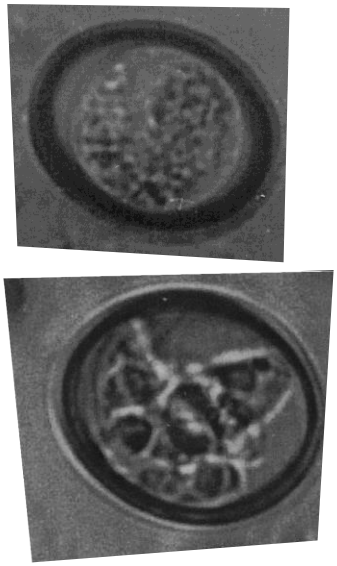


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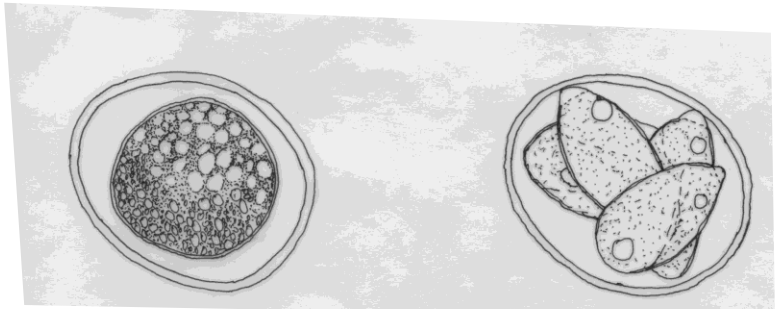
PLATE 12; PHOTOMICROGRAPH OF UNSPORULATED AND SPORULATED *E zurnii*



DIAGRAMATIC REPRESENTATION OF UNSPORULATED AND SPORULATED E.zurnii

3.18 AMINO ACID PROFILE AND CONCENTRATION OF SPORULATED BOVINE *EIMERIA* OOCYSTS

The composition of essential and non-essential amino acids in sporulated bovine *Eimeria* oocysts is shown Table 18 below. Out of the 20 known amino acids, 13 were found in this study, 9 essentials and 4 non-essentials. Leucine had the highest concentration of amino

acid (1.12g/100g protein) among the essential amino acids, while methionine had the lowest concentration (0.16g/100g protein). Others were arginine (0.43g/100g protein), histidine (o.37g/100g protein), phenylalanine (0.35g/100g protein), threonine (0.26g/100g protein), valine (0.25g/100g protein), lysine (0.21g/100g protein) and aspartic acid (0.18g/100g protein).

Glutamic acid had the highest concentration of amino acid (2.17g/100g protein) among the non-essential amino acids, while proline had the lowest concentration (0.33g/100g protein). Others were tyrosine (0.91g/100g protein) and alanine (0.54g/100g protein).

Table 18: Amino Acid Profile And Concentration Of Sporulated Bovine *Eimeria* Oocysts

Amino Acid	**Concentration (g/100gProtein)**
Essential	
Lysine	**0.21**
Histidine	**0.37**
Arginine	**0.43**
Aspartic Acid	**0.18**

Threonine	**0.26**
Valine	**0.25**
Methionine	**0.16**
Leucine	**1.12**
Phenylalanine	**0.35**
Non-Essential	
Glutamic Acid	**2.17**
Proline	**0.33**
Alanine	**0.54**
Tyrosine	**0.91**

CHAPTER FOUR

DISCUSSION

The previous record of the work carried out on bovine *Eimeria* in Plateau State was by Lee and Armour (1959). Eleven species were identified then, but no prevalence studies were carried out. In this study, twelve species of bovine *Eimeria* were identified. The new additional species was *E.pellita* (Supperer 1952). In Nigeria the

highest number of *Eimeria* species identified was thirteen in Bauchi (Fabiyi and Bawa 1995). Other workers in Nigeria who identified *Eimeria* species were Majaro and Dipeolu (1980) in a herd of N'dama cattle, Obasaju *et al* (1981) and Majaro and Dipeolu (1981) in trade cattle, sheep and goat in Ibadan. The present study shows that cattle in Plateau State harbours a wide variety of *Eimeria* and it is the most comprehensive work done in this group of parasites in Nigeria.

The overall prevalence of *Eimeria* species in this study was 62.68% (Table 1) and the most prevalent among the 12 species encountered were *E.zurnii* 41.73%, *E.bovis* 36.56%, and *E.auburnensis* 32.34%. These findings agree with those of Fabiyi and Bawa (1995) who worked on cattle coccidia in Bauchi and also with the findings of other workers in other countries; Ernst *et al* (1987) in beef cattle in Georgia; U.S.A. Mundin *et al* (1994) in calves in Brazil ; Aslan and Tuzer (1998) in Turkey; Bhattacharya *et al* (1998) in India and Waruiru *et al* (2000) in Kenya. According to Levine (1923), *E.bovis* and *E.zurnii* are the most pathogenic of bovine coccidia with *E.zurnii* in particular being associated with both acute and chronic diseases.

E.alabamensis is becoming increasingly recognised as a cause of diarrhoea. Svensson *et al* (1994) and Marshall *et al* (1998), described the role of E.*alabamensis* in a diaorhoeic condition of calves, but its exact significance remains to be determined (Holliman 2000). However no cases of clinical coccidiosis were encountered in the present study.

In this study, predominant *Eimeria* species were observed in different prefectures (Table 2). *E.zurnii* was predominant in Naraguta and Rukuba village with 62.35% and 97.52 infection rates respectively. *E.bovis* with 41.96 % was predominant in Nassarawa Gwom; *E.cylinderica* with 81.02% in Naraguta village, *E.auburnensis* 74.75% in Naraguta and *E.ellipsoidallis* with 89.30% in Zallaki village. These findings agree with those of Kasim and Al-shawa (1985) in Saudi Arabia, Oda and Nishida (1990) in Japan and Marshall *et al* (1998) in UK. Rukuba area had the highest prevalence (97.52%) while Vom had the lowest prevalence (29.36 %). This area had low prevalence because cattle were well kept on concrete floors. Abattoir also had low prevalence because cattle kept in this area were adults which had

developed some level of immunity that prevented productions of *Eimeria* populations (Taylor and Catchpole 1994, Fabiyi and Bawa 1995 and Wariuru 2000).

Mixed infections of 2 to 12 species of *Eimeria* were encountered in this study (Tables 3 and 4). The commonest combinations were 3 to 4 compare with 2 to 8 mixed infection observed in trade cattle in Bauchi by Fabiyi and Bawa (1995) and 2 to 4 in Saudi Arabia by Kasim and Alshawa (1985). This indicates that bovine coccidia species can be found in various combinations of species in healthy cattle.

The most infected age group of cattle in this study was 10 - 14 months olds (Table 5). The least infected age group was 25 months and above. Similar findings were reported by Fabiyi and Bawa (1995) in trade cattle in Bauchi and by other workers in other countries; Fitzgerald in Hereford calves on summer and winter ranges in Utah, (1962); Ward, *et al* (1979) in cows in USA, Oda and Nishida (1990) in dairy and beef cattle in Japan and Munyua and Ngotho(1990) in cattle in Kenya. These show that cattle of any age are substantially susceptible to coccidial infections but their susceptibility tends to decrease in older

cattle resulting in lower prevalence of the parasites in adult cattle. Adult cattle are generally carriers of coccidia. The low infection in young cattle might be due to passive immunity from colostrum during the first few weeks of life. Resistance acquired by calves continues more or less into adulthood. It has been suggested that trickle infection with regular low dose of oocysts will stimulate a better immunity. This eventually accounts for the low infection in the adult cattle according to Gunning and Wessels (1996) and Bhattacharya *et al* (1998).

The age at which calves shed *Eimeria* oocysts in this study was between 14 days and 84 days (Table 6). This is similar to the findings of Parker and Jones (1990) in unweaned beef calves in Australia where unweaned calves shed oocysts as early as 12 to 13 days, and Bejsovec (1986) in Australia where calves shed *Eimeria* oocysts during their first 13 days of life. This shows that most calves ingest sufficient sporulated oocysts within a few days of birth and that cows are the primary source of infection where calves are kept with their dams.(Oetjen 1993; Herrick 1990 and Fayer and Yvore 1989).

The prevalence of 7) but infection was higher in bulls than cows in this study (Table statistically, there was no significant difference between the rates of infection (P>0.05). These findings agree with those of Fabiyi and Bawa (1995) in Bauchi and Wuruiru *et al* (2000) in Kenya. The infections in both sexes suggested that sex of the host does not influence the prevalence or intensity of infection with *Eimeria* coccidia.

The most infected age group of cattle in bulls and cows in this study (Tables 8 and 9) was 10 - 14 months and the least infected age group was 25 months and above. The rates of infection between the cattle of 10 - 14 months age group and those 0 - 4 months old, were statistically significant (P< 0.050). These findings agree with those of Fabiyi and Bawa (1995) in Bauchi , Munyua and Ngotho (1990) in Kenya and Wariuru *et al* (2000) in Kenya. This shows that the parasites were commonly encountered in the yearlings more than any other age group. In this study the most infected breed of cattle (Table 10) was the Muturu breed (83.76%) and the least infected breed of cattle was the N'dama breed (44.36%). This was statistically significant(P

cattle sheep and goat in Ibadan. De jode (1992) reported that N'dama breed are highly resistant to diseases. The prevalence of infection in Holstein Frezian was also low (49. 78%) probably because they are cross breed and hence inherited the trait of high resistance from their pure breed parent. Also they are mainly dairy animals, they are therefore well-fed and kept on concrete floor pens.

Cattle grazed on pastures had higher prevalence of *Eimeria* infection than those raised on mud pens and concrete pens in this study (Table 11). These findings are similar to those of Bejsovec (1986) in Australia, Penzhorn *et al* (1994) in USA, Svensson (1993) in dairy calves in Sweden (1993) and in grazing calves in Sweden (Svensson, 2000) and Oetjen (1993) in dairy calves and replacement heifers in Wisconsin, U.S.A. These various workers have therefore established that cattle kept on pastures (free range) have higher rates of infections than those kept in pen or mud houses. The similarities between their findings and the present findings further show that pastures are the main source of contamination and infection of animals by *Eimeria* oocysts.

In this study the beef cows had the highest rate of infection (69.15%) (Table 12), while the least infected cattle were the dairy cattle (55.06%). There was no statistically significant difference in the rate of infection between the dairy and beef cows ($P>0.05$). These findings agree with those of Oda and Nishida (1990) in Japan. This shows that coccidia are commonly present in both dairy and beef cattle.

Pastures were the major source of *Eimeria* infection in this study (Table 13). The average contamination rate was 40.77% compare with udders (29.22%) which had the lowest rate of infection. The beddings and feeds had contamination rates of 31.01% and 28.06% respectively. The rates of infection were statistically significant between udders and feeds ($P<0.01$). The average rate of oocyst sporulation was also highest in pastures (33.67%) and lowest in udders (10.75%). These findings agree with those of Ajayi *et al* (1997) in Jos, Nigeria and other workers from other countries, Mage, Fayer and Yvore (1989) in suckler calves in France; Hayat *et al* (1994) in calves buffaloes in Pakistan ; Marshall *et al* (1998) in calves after turnout in UK and Svensson (1995) who in Sweden reported that calves turned out of

pastures that had been grazed only by calves had higher rate of infection than calves turned out to pastures grazed previously by older cattle or horse. Also that calves fed on hay harvested from pastures grazed by cattle had been reported to have higher infection rate than calves fed on hay from coccidia free field Svensson (1997 and 2000). In this study, the rate of infection was higher during dry season than during the wet season (Table 14). There was statistically no significant difference in the prevalences between the two seasons ($P>0.05$). This is similar to the findings of Hasbullah *et al* (1990) in beef cattle herd in Japan, Hayat *et al* (1994) in in Pakistan; compare to the findings of Fayer and Yvore (1989) in USA and Wariuru *et al* (2000) in Kenya, where coccidia infection was higher during wet season than during the dry season. The increase in rate of infection during dry season has been attributed to stress such as over-crowding, long trekking in search of food and water and change of food (Ernst and Benz 1981). Also in the present study the higher rate of infection might be due to cattle being fed on contaminated food and water. The lower rate of infection during the wet season might be due to the fact that oocysts were

washed away by rains, hence there was reduction in the numbers *Eimeria* oocysts for cattle to ingest. The present results suggest that even though the availability of oocysts may be low during the wet season, they will still contribute to pasture contamination at the start of dry season. The month of March had the highest prevalence (77.95%) during the dry season and the month of April (72.38%) during the wet season. This could be as a result of high temperatures during these months, which may facilitate very rapid sporulation of *Eimeria* oocysts.

Both bulls and cows were infected during the wet and dry seasons (Table 15) but the rate of infection was not statistically significant, ($P>0.05$).

Effects of temperature ranges on sporulation of *Eimeria* oocysts show that the higher the temperature the faster and higher the rate of sporulation in this study (Table 16). At $40^{o}C$ no viable oocysts were observed after 5 days in all the *Eimeria* oocyst types except those of *E. bukidnonensis* (36%) and *E. pellita* (15%). These findings are similar

to the findings of Ajayi (1976) in ovine coccidia in Nigeria; Larsen *et al* (1989) in Denmark; Parker and Jones (1990) in Australia.

The morphological features of *Eimeria* oocysts types encountered varied in shapes and sizes in this study (Table 17). Identification of oocyst types was very tedious and tasking, but after a lot of practices correct identification was made with little difficulty. It was observed that Nigerian bovine *Eimeria* oocysts were bigger in dimension than those reportd from other countries.

In this study *E.alabamensis* had variations in shape. All intermediate form from elliposidal to subcylinderical described for *E.alabamensis* oocysts by Christensen (1941) were encountered. The dimensions of the oocyst (19.54μ by 14.3μ) were similar to those of Vom oocysts described by (Lee and Armour 1959) and Joyner *et al* (1966) in U.K. The oocyst was, however, slightly bigger than the original description of it by Christiensen (1941) which was 18.9μ by 13.4μ.

The oocyst of *E.auburnensis* in general had smooth walls. The average measurement of 38.0 μ by 24.7 μ obtained in this study was similar in length to, but wider in width than Christiensen and Porter's (1939) and

Lee and Armour's (1959) original measurement (38.4μ by 23.1μ), and also similar to the description of Taylor and Catchpole's (1994) in U.K.

The oocyst of *E.bovis* was easily identified because of its ovoidal shape. It was similar in shape to *E.alabamensis* but significantly larger. Other ovoidal species encountered in this study were *E.auburnensis, E.wyomingensis* and *E.bukidnonensis,* but *E.bovis* was smaller than any of these. The measurement of (28.5 μ by 20.6μ) obtained in this study was similar to Vom oocyst described by (Lee and Armour 1959) but slightly bigger than the Alabama oocyst, (27.7μ by 20.3μ) described by Christiensen (1941). The colour of *E.bovis* which was yellowish-green differed slightly from the Alabama oocyst which was yellow. Other features, apart from the size, agree with the findings of Taylor and Catchpole (1994) in U.K.

The outstanding features of *E.brassiliensis* were the presence of polar cap as described by Torres and Ramos (1939) in Brazil; Lee and Armour (1959) in Vom, Nigeria and Joyner *et al* (1966) in U.K. Other similar features were presence of micropyle and the yellowish colour

of the cell walls. The measurement of the oocyst (34.06μ by 25.6μ) was smaller than that recorded by Torres and Ramos (1939) and Supperer (1952) respectively. The size was similar to Vom oocyst (Lee and Armour 1959).

E.bukidnonensis had distinctive characteristics of the wall, micropyle and colour similar to those of Tabangui (1931) in U.S.A; Christiensen (1938 and 1941) in New York and Alabama respectively, Lee and Armour (1959) in Vom and Courtney *et al* (1976) in USA. The dimensions (43.8μ by 32.0μ) were smaller than the ones of Tanbagui (1931) which was 48.6μ by 35.4μ but bigger than Alabama oocyst which was (38.0μ by 26.0μ) recorded by Christiensen (1941).

E.canadensis oocyst was found to be similar in shape to Alabama oocysts described by Christensen (1941), Bruce (1921) in Canada and Taylor and Catchpole (1994) in U.K. The size of the oocyst (32.5μ by 22.4μ) is similar to Alabama oocyst (32.5μ by 23.4μ) and to the finding of Taylor and Catchpole (33.0μby 23.0μ), but smaller than the Canadian oocyst (33.0μ by 26.0μ).

There was no difficulty in identifying *E.cylindrica* because of its distinctive parallel sides in the middle of the body. The measurement (23.0μ by 13.8μ) was remarkably close to the original description by Wilson (1931) in Virginia (23.3μ by 13.3μ), Christiensen (1941) in Alabama (23.0μ by 13.9μ) and Taylor and Catchpole in UK (23.0μ by 14.0μ).

The oocysts of *E.ellipsoidallis* varied in shape from subspherical to cylindrical but bigger in size than *E.subspherica* and did not have parallel sides like *E.cylindrica*. The shape and colour of the cell wall were similar to the description of Becker and Frye (1929) in New York, Lee and Armour (1959) in Nigeria and Norton *et al* (1976) in USA. The size of the oocyst (20.1μ by 14.5μ) was smaller the New York oocyst (23.4μ by 15.9μ) by Christiensen (1941) and bigger than those described by Talyor and Catchpole (1994) in UK (17.0μ by 13.0μ), but similar to the Vom oocyst, Lee and Armour (1959).

The oocyst of *E.pellita* was similar to that of *E.bukidnonensis* but it was easily identified by the sporocysts, which were not pointed at their ends as in *E.bukidnonensis.* *E.pellita* also had one flattened end and

thick dark brown wall without striation as in *E.bukidnonensis.* The sporulation time of 10-12 days was the longest among all the *Eimeria* species encountered. The measurement, (39.5µ by 27.0µ) was bigger than the original description of Australian oocyst (36.10µ by 26.5µ) by Supperer (1952) but similar to the U.K oocyst (40.0µ by 28.0µ), Taylor and Catchpole (1994).

The oocyst of *E.subspherica* was the smallest in size of all oocyst types encountered in this study. The shape was typically subspherical and similar to the Vom oocyst, the Alabama oocyst and the U.S.A oocyst (Lee and Armour 1959, Christiensen 1941, and Courtney *et al* 1976) respectively. The size of the oocyst (11.5µ by 10.6µ) was similar to Vom oocyst (11.4µ by 10.4µ).

E.wyomingensis oocyst had thick double cell walls, ovoidal in shape and stouter than *E.auburnensis*. The oocyst description was similar to the Wyoming oocyst described by Huizinga and Winger (1942), Lee and Armour (1959). The size of the oocyst (39.8µ by 28.4µ) was similar to the U.K oocyst (40.0µ by 28.0µ) described by Taylor and

Catchpole (1994) and theVom oocyst (40.0μ by 28.3μ) described by Lee and Armour (1959).

The oocyst of *E. zurnii* was spherical with thin transparent walls. It was not difficult to identify. The measurement (17.6μ by 15.7μ) and other features agree very closely with those recorded by Tubangui (1931) in Mundanao; Christensen (1941) in Alabama, Lee and Armour (1959), Joyner *et al* (1966) in USA and Taylor and Catchpole (1994) in UK.

Thirteen amino acids were found in the sporulated bovine *Eimeria* oocysts in this study, 9 were essentials and 4 were non-essentials. Leucine had the highest concentration of protein (1.12g/100g protein) among the essential amino acids, while glutamic acid had highest protein concentration (2.17g/100g protein) among the non-essential amino acids.

Since protein supply to duodenum of ruminant is from microbial and dietary sources (Wilkerson *et al* 1993), the amino acids found in the sporulated bovine *Eimeria* oocysts in this study may have been transported from the outside cell wall of the lumen into the epithelium

cells of the lumen where the oocysts are embedded.

Pattilo and Becker (1995) found out that protein and polysaccharides were present in the sporocysts of *Eimeria*. The protein (amino acids) may have helped in the penetration of the sporocysts into the epithelium cells after the ingestion of the oocysts. Constant supply of the amino acids in the lumen to bovine coccidian parasites helps in the successive multiplication of the sporozoites, which cause more damage to the intestine of the cattle.

The present results of 62.68% prevalence of bovine coccidiosis in part of Plateau State is an indication that a large number of cattle in the State harbour *Eimeria* coccidia. This high level of infection will normally result in continuous contamination of pastures, and paddocks with *Eimeria* oocyst. This means that cattle in general are at higher risk of being infected with *Eimeria* oocysts. This is a cause for concern in management of cattle in Plateau State.

Some aspects of cattle management can help to reduce the incidence of coccidiosis among the cattle, such as follows: -

(1) Housing of cattle should be well ventilated so as to reduce moisture level and temperature for oocyst sporulation and survival. This will reduce the concentration of oocysts and the availability of oocysts to susceptible calves. Thorough cleaning and disinfection of housing with a product effective against coccidial oocysts will reduce oocyst production.

(2) Prompt removal of calves from the dam will reduce their infection as some calves have been found to shed oocysts by 14 to 17 days of age. All affected cattle with bovine coccidiosis should be isolated and promptly with effective anticoccidials treatment.

(3) In many cases access to feed troughs, hay feeders and silage sacks are not adequate for control . This lack of control can cause faecal contamination and transmission of coccidiosis. Therefore feed should be protected from feacal contamination and evenly distributed. Water supplies deserve the same scrutiny. Natural water sources (e.g. ponds and streams) are well known loci of coccidiosis outbreak, especially during dry season. Therefore, clean protected water supplies should be available at all times.

(4) Pastures can be difficult to manage. Growing cattle maintained on pastures can be very susceptible to coccidia and such infection may become clinical. The most common procedure is to turn calves out on pastures not grazed by any cattle in current or previous grazing season. (Svensson, Hessle and Hoglund 2000).

(5) The use of coccidiostats in feed and water is very cost effective and should be used where young calves exist in the environment. Also medicated starter feed should be used for calves. Deworming cattle regularly will reduce the stress of coccidial infection (Wariuru *et al* 2000).

4.1 SUMMARY OF RESULTS

Prevalence study of bovine coccidia was carried out in parts of Plateau State Nigeria. A total of 2,500 faecal samples of cattle of both sexes, different age groups, different breeds and different husbandry systems were examined for *Eimeria* oocysts.

Out of the 2,500 faecal samples of cattle examined 1567 (62.68%) were positive for *Eimeria* oocysts. The most prevalent species were *E. zurnii* in 1043 (41.72%), *E.bovis* in 914 (36.56%) and *E.auburnensis* (32.24%) of

the samples (Table 1). *E. pellita* is the new species of *Eimeria* encountered for the first time in Nigeria. Predominant species were observed in different prefectures, *E.zurnii* was predominant at the Jos Abattoir and at Rukuba, *E. bovis* in Vom, *E. auburnensis* in Nassarawa Gwom, *E.cylindrica* in Naraguta and *E. ellipsoidallis* in Zallaki (Table 2). Rukuba had the highest rate of infection which was 88.61%. There was no significant difference in the rates of infection between the different prefectures ($P>0.05$).

Mixed infections of 2-12 difference species were found in 1457 (58.28%) faecal samples examined and the commonest combinations were 3 and 4 different species (Table3). Other different combinations of parasitic infections were found in the 2,500 faecal samples of cattle examined (Table 4). The most infected age group of cattle was the 10-14 months olds with 79.28% infection rate and the least infected was age group of cattle 25 months old and above with 41.34% infection rate (Table 5).

Statistically, there was a significant difference in the rate of infection between age groups 10-14 months old and 0-4 months old and age groups

10-14 months old and 25 months and above ($P<0.01$ and $P<0.01$) respectively.

The age at which calves first shed *Eimeria* oocysts was between 14 days and 84 days (Table 6). The oocyst species that was first shed was *E. alabamensis* 14 days after birth of the cattle and the last to be shed was *E. cylindrica* 84 days after birth. The cows had a lower rate of infection of 59.42% than the bulls with 67.12% infection rate (Table 7). There was no significant difference in the rate of infection between the bulls and the cows ($P>0.05$).

The most infected breed of cattle was the Muturu with 83.76% infection rate and the least infected was the N'dama with infection rate of 44.30% in Table 10. There was a significant difference in the rate of infection between N'dama and Muturu breeds, ($P<0.05$). Cattle grazed on pastures had a higher rate of infection of 70.70% compared to those raised on concrete floor with an infection rate of 56.73%, or mud floor pens with an infection rate of 62.48% Table 11. The intensity of contamination by oocysts in different husbandry systems followed similar trend with the highest oocyst counts produced by cattle grazed on pastures i.e. free

range (156,400). The female beef cattle had the most infection rate of 69.15% and the dairy cattle had the least rate of infection of 55.0% in Table 12. There was no significant difference in the rate of infection between dairy and beef ($P>0.05$).

The major source of infection was from pastures with infection rate of 41.88% and the lowest source of contamination was from udders with infection rate of 21.42% in Table 13. The beddings and feeds have contamination rates of 31.61% and 25.06% respectively. There was no significant difference in the rate of contamination between pastures, and beddings ($P>0.05$), but there was significant difference in the contamination rate between pastures and udders ($P<0.01$). The rate of infection was higher during the dry season (68.35%) than the wet season (59.31%) in Table 14. The month of March had the highest prevalent (77.95%) during dry season and April (72.38%) during wet season. The rate of sporulation was also highest in these months of March and April 46.0% and 38.0% respectively. The bulls had higher infection rate during the dry and wet the seasons (78.1% and 61.7%) while cows had lower rate of infection (61.7% and 57.7%) in Table 15. There was no significant

difference in the rate of infection between bulls and cows during the wet and dry seasons (P>0.01). Low temperatures slowed down the rate of sporulation of the oocysts while high temperatures increased the rate of sporulation (Table 16). The morphological featuresof *Eimeria* oocysts types encountered varied in sizes and shapes (Table 17).

Thirteen types of Amino acid were identified, in the sporulated *Eimeria* oocysts 9 were essentials and 4 were non-essentials (Table 18). The essential amino acids encountered were lysine, histidine, argininea spartic acid, threonine, valine, methionine, leucine phenylalanine, and the non-essential ones were glutamic acid, proline, alanine, tyrosine.

4.2 CONTRIBUTION TO KNOWLEDGE

(1) This is the first time that an all-encompassing prevalence studies on bovine coccidia involving as many as 2,500 faecal samples of cattle of both sexes, different age groups, breeds and husbandry systems is carried out in Plateau State and indeed in Federal Republic of Nigeria. The results of this study will help in formulating effective control measures

against the parasites.

(2) *Eimeria pellita* makes an additional species identified along with the eleven species previously identified by Lee and Armour (1959) in the Vom area of Plateau State.

(3) Works have been done on bovine coccidia in Nigeria by Majaro (1980). Majaro and Dipeolu (1981), Obasaju *et al* (1981) Princewill and Amakoromo (1981) and Fabiyi and Bawa (1995). All these works were on prevalence studies. The present study is the first one in which relationship between prevalence of *Eimeria* species in cattle and the systems of cattle husbandry is studied in Nigeria. The results show that cattle grazed on pastures are at more risk than those raised on concrete floor or mud floor pens.

(4) The present work is the first in which the effects of different temperature ranges on sporulation of *Eimeria* oocysts is carried out in Nigeria. The results obtained show that low temperatures reduce bovine *Eimeria* oocyst sporulation while higher temperatures increase the rates of sporulation.

(5) The present study is also the first in Nigeria in which Amino Acids

profile of sporulated bovine *Eimeria* oocyst is analysed. This effort resulted in the establishment of 13 amino acids, 9 of which were essentials and 4 non-essentials.

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