CAPRINE COCCIDIOSIS:EPIDEMIOLOGICAL STUDIES IN SELECTED AREAS OF KENYA AND ASPECTS OF PATHOLOGY

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DECLARATION

a) This thesis is my original work and has not been presented for a degree in any other University.

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TO

MY LOVING PARENTS

MR AND MRS AYUB GITHIGIA

DEAR WIFE

CATHERINE NDUTA

AND MY SON GITHIGIA

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SUMMARY

This study was conducted in three phases. Phase one aimed at studying the prevalence and significance of coccidiosis in Kenyan goats from selected areas. The various species of Eimeria were also identified.

Faecal samples were obtained per rectum from goats in various selected areas of Central province, Eastern province and Rift Valley province.

These samples were analysed in the laborotary at Kabete Campus to give the oocysts per gram of faeces (OPG) and cultured in 2.5% Potassium dichromate for sporulation. Identification of the various species was done by morphological characteristics of the sporulated and unsporulated oocysts. These included colour, shape, sizes, and presence or absence of micropylar cap. These were compared with standard micrographs from Norton (1986) and O'Callaghan (1989).

The following species were identified Eimeria arloingi, E. hirci., E. ninakohlyakimovae, E. alijevi, E. christenseni, E. jolchijevi, E. caprovina, E. caprina and E. apsheronica. E. arloingi was most prevalent while E. caprina was the least prevalent.

The overall prevalence of the individual species were E. arloingi 37.67%, E. ninakohlyakimovae 24.44%, E. hirci 17.21%, E. alijevi 10.18%, E. christenseni 5.56%, E. caprovina 3.57%, E. jolchijevi 1.05%, E. apsheronica 0.21% and E. caprina 0.11%.

These percentages were obtained from the average proportion of oocysts of each species encountered and measured from 360

samples.

In terms of proportion of oocysts encountered E. arloingi had the highest percentage oocysts while E. caprina had the least. This study showed that Kenyan goats from the selected areas do harbour and shed coccidial oocysts and coccidiosis is prevalent.

Phase two of the study was aimed at studying the seasonal and age variation of mean oocysts per gram (OPG) and various species of Eimeria in Ngong Veterinary Farm and Kitengela over a period of three months.

Weekly samples were obtained from ten kids and ten adults from each farm. These samples were laboratory analysed to give the mean oocysts per gram and various species of Eimeria present in each sample identified. This data was then analysed statistically to give the variations due to season and age on the mean oocysts per gram (OPG) and the species of Eimeria.

Analysis of variance (ANOVA) tables were drawn from least square computer mean values to give the significance of the variations. Where $p<0.01$ it was considered highly significant while $p<0.05$ it was considered significant.

There was a highly significant variation in the mean OPG over the study period. The values were high for weeks with heavy rainfall and weeks that followed the rainy weeks and low for dry weeks.

There was also a highly significant variation in proportion of the individual Eimeria species in the total count. Eimeria arloingi had the highest square mean value of 52.06 ± 1.29 while

E. jolchijevi had the lowest value of 0.50 ± 1.31. E. hirci was the second highest with a value of 17.38. The others were E. ninakohlyakimovae 13.67, E. alijevi 12.63, E. christenseni 2.98, E. caprovina 0.77. E. apsheronica and E. caprina were not encountered in this study. This showed that E. arloingi was the most prevalent and common species encountered over the study period and E. jolchijevi the least.

The number of oocysts counted for each individual species was also highly significant. The highest number of oocysts counted per species were E. arloingi while E. jolchijevi oocysts were the lowest. E. alijevi were the second highest. The least square mean values were E. arloingi 50.45, E. alijevi 26.10, E. hirci 19.75, E. ninakohlyakimovae 14.84, E. christenseni 5.57, E. caprovina 2.12 and E. jolchijevi 0.9 per sample. E. arloingi was the most abundant species followed by E. alijevi while E. jolchijevi was the least abundant.

There was no significant variation in the levels of OPG shed by the various species of Eimeria and between different ages of the goats. The values were the same for kids (3-6 months) and adults (21-24 months) in both farms.

Between the two farms, the mean oocysts per gram (OPG) was highly significant. Ngong Veterinary farm had the highest mean value of 6850.50 while Kitengela had mean value of 1516.32. This showed that goats at Ngong were shedding more coccidia oocysts than those at Kitengela.

The number of oocysts per species counted for each farm was also highly significant. Ngong had the highest number of oocysts

per species with a least square mean value of 22.18 while Kitengela had a mean value of 11.51 per species. There was a higher number of oocysts per species at Ngong than at Kitengela. The proportion of parasite were the same for both farms in kids and adults with no significant variation.

Phase three of the study aimed at studying the pathology of natural infections.

Six kids aged between one and four weeks with naturally acquired infections were used. The species of Eimeria infecting these kids were identified as E. arloingi 45% (most prevalent), E. ninakohlyakimovae 15%, E. hirci 15%, E. alijevi 10%, E. caprovina 3% while E. jolchijevi, E. caprina and E. apsheronica composed 2%. 360 oocysts were observed from a pooled sample. The lesions in the intestinal tract were noted by type, size, location and distribution.

The macroscopic lesions were restricted to the small intestines. They were more marked in the jejunum.

The serosal surface was congested in all the kids while mucosal hemorrhages were observed in one kid in the jejunum and ileum.

Greyish-white nodular lesions were observed in two kids. In one kid they were multiple and distributed from the duodenum upto the ileum. They were more numerous in the jejunum where they appeared to fuse together measuring between 1-5mm in diameter. These were not visible from the serosal surface.

In the second kid the lesion was solitary measuring 1mm in diameter in the jejunum and visible from the serosal surface.

Microscopic lesions were found throughout the small intestines, caecum and colon but were more severe in the small intestines. There was mild subacute enteritis, congestion and oedema of the submucosa but were more severe in the small intestines.

The glandular epithelial cells were hypertrophied and some had macrogametes, microgametes and developing oocysts.

The macrogametes were of various sizes in all the sections. The developing oocysts were also of varying sizes in these sections and were distributed from the duodenum upto the colon.

Villi erosion was particularly marked in the distal jejunum and ileum while fusion occurred in the duodenum and proximal jejunum.

The main cellular reaction was mononuclear cell infiltration involving mainly lymphocytes, few plasma cells, macrophages and some eosinophils.

The greyish-white nodular lesions were hypertrophied glandular epithelial cells, fused villi, macrogametes, microgametes, developing and mature oocysts.

CHAPTER ONE

1.1 INTRODUCTION AND OBJECTIVES

Coccidiosis is a disease caused by protozoan parasites of the order Eucoccidiidae and affects mainly young animals.

It is manifested by profuse diarrhoea, weakness and emaciation. The disease is occasionally fatal. The most affected animals are those kept together under intensive husbandry especially where sanitary conditions are poor. It is also precipitated by bringing together young animals for intensive feeding, supplementation or for research purposes as observed by Opoku-Pare and Chineme (1979) in young goats in Nigeria. In such cases, outbreaks are common. In Kenya, Mugera (1968) reported on pathological changes in coccidiosis in experimental goats aged between 3 and 12 months from African farmers around the Faculty of Veterinary Medicine, Kabete. In goats, coccidiosis is caused by several species of the genus Eimeria. Among these species, Eimeria ninakohlyakimovae is the most pathogenic species but E. arloingi is responsible for most outbreaks (Pellerdy, 1974; Qadir, 1980). The revised nomenclature of Eimeria species in goats by Norton (1986) is adopted here.

Eimeria arloingi has the highest occurrence in the reported outbreaks of coccidiosis in goats. Several researchers from several countries have given the following prevalence rates of coccidia oocyst; 100% isolate in Kenya (Mugera, 1968), 58% in Nigeria (Opoku-pare and Chineme 1979), 98.8% in U.S.A. (Lima 1980a), and 94% in S.E.England (Norton, 1986). In Kenya,

Kanyari (1989) reported E. arloingi to be the most prevalent species followed by E. ninakohlyakimovae, E. alijevi, E. hirci and E. christenseni.

Caprine coccidiosis can be very acute with high mortality rates in goats particularly under the intensive system of husbandry. With the expected future increase in livestock raising under intensive system of husbandry due to shortage of land and the need to keep and feed the goats together for various purposes, the disease could be a serious hindrance to goat rearing in Kenya. This calls for proper investigation into the significance and prevalance of coccidiosis in Kenya and the species of Eimeria present.

In Kenya, little is known of coccidiosis in small ruminants. Mugera (1968) reported on pathology of coccidiosis in goats under experimental conditions using E. arloingi but the natural situation has not been examined. However some other workers in Kenya (Ulvund et al.1984; Omara-Opyene 1985) have reported the occurrence of both coccidiosis and helminthiasis in naturally infected sheep and cattle.

The need for Kenya to increase the available source of protein has called for increased utilization of marginal areas and in this respect goats have a role to play. It is therefore necesary to understand the prevalance and significance of diseases that can limit goat production in these areas and coccidiosis is one of them .

Much has been reported on E. arloingi as the major species that causes goat coccidiosis (Sayin, 1965; Mugera, 1968; Opoku pare and Chineme, 1979; Sayin et al, 1980; Lima, 1980a; Vujic and

Ilic, 1985; Norton, 1986). Also, several researchers have reported on the pathology of E. arloingi in goats. These include Mugera (1968) in Kenya goats, Pellerdy (1974), Opoku-pare and Chineme (1979) in Nigerian goats brought together for research, Sayin et al (1980) in Angora kids in Turkey and Guillous (1987) in young goats in France. Lotze (1953) reported on the pathogenesis of E. arloingi in sheep where he described the progressive advancement of the organism from the sporocyst stage up to the production of the oocysts. However, Smith et al (1960) confirmed that Lotze (1953) was working on E. ahsata and not E. arloingi.

Levine and Ivens (1970) established that the species of Eimeria which closely resembles E. arloingi in sheep was E. ovina. They showed that E. arloingi from goats could not be transmitted to sheep nor could E. ovina be transmitted to goats. From the above, it appears that Lotze (1953) was dealing with either E. ahsata or E. ovina and not E. arloingi. Sayin et al (1980) also worked on the pathogenesis of E. arloingi in a study of its life cycle and an attempt to transmit it to lambs. They established that E. arloingi is a goat pathogen while E. ovina infects sheep. In Kenya there is no report on the significance and prevalence of coccidiosis in goat.

OBJECTIVES.

The present study was undertaken with the following objectives:

1.To study and ascertain the distribution of coccidian parasites in goats from the selected areas in Kenya.

2.To identify the various species and their prevalence rates

in goats.

3.To determine the seasonal variation of mean oocyst per gram (OPG) of various Eimeria species in goats of various ages over a period of three months in selected localities.

4. To study the pathology of natural infections in kids and relate to the few reports available.

CHAPTER TWO.

LITERATURE REVIEW

2.1. THE ORGANISM - *EIMERIA* SPECIES

2.1.1 TAXONOMIC CLASSIFICATION (AFTER SOULSBY, 1982)

Phylum	Apicomplexa Levine, 1970
Class	Sporozoea Leuckart, 1879
Sub-class	Coccidia Leuckart, 1879
Order	Eucoccidiidae Leger and Duboscq, 1910
Sub-order	Eimeriina Leger, 1911
Family	Eimeriidae Minchiu, 1903
Genus	Eimeria Schneider, 1875
Species	In goat (Norton, 1986)
	Eimeria arloingi
	Eimeria ninakohlyakimovae
	Eimeria christenseni
	Eimeria caprovina
	Eimeria hirci
	Eimeria caprina
	Eimeria apsheronica
	Eimeria jolchijevi
	Eimeria alijevi

2.1.2 NOMENCLATURE AND IDENTIFICATION OF EIMERIA

The coccidia include the genera *Eimeria*, *Isospora*, *Hammondia*,

Toxoplasma, Besnoitia, Sarcocystis and Frenkelia (Fayer,1980). The identification of Eimeria spp is made on the basis of morphological characteristics, which are presence or absence of micropylar cap, colour, shape and size of the unsporulated and sporulated oocysts (Norton,1986; O'Callaghan, 1989).

2.1.2.1 Eimeria arloingi (Marotel, 1905; Martin, 1909)

The oocysts of E. arloingi are elongate, ellipsoid or ovoid and have a distinct micropylar cap on one side. The oocyst wall appears colourless to brown and is composed of two layers with a micropyle at one end (Levine, 1973; Mugera, 1968). The polar cap varies from a colourless inconspicuous flat operculum through transparent yellow to yellowish brown in colour (Mugera, 1968; Opoku-pare, 1978; Norton, 1986). According to Kheysin (1972) the size of the oocyst of E. arloingi varies between 20.9-31.9 by 16.5-23.1 microns (mean of 27.2 x 18.8 microns). However Opoku-pare and Chineme (1979) found them to average 29.7 x 20.7 microns with a range of 16.3-38.3 by 10.9-27 microns. According to Sloss (1972) oocysts of E. arloingi range between 17-42 by 13-27 microns. The sporocysts of E.arloingi are ovoid, have a residual body and measure 13 x 16 microns (Mugera, 1968). A polar granule is also present according to Kheysin, (1972)

2.1.2.2 Eimeria hirci (Chevalier, 1966)

Oocysts are round or ovoid.They measure 18-23 by 14 -19 microns (average 20.7 x 16.2 microns). They have a light yellow wall which carries a micropyle, furnished with a polar cap. One or more polar granules appear in sporulated oocysts but no oocyst residuum is formed. The sporocysts are broadly oval measuring 5.2

-7.5 microns by 8.8 -11.3 (average 10.1 x 6.5 microns) and most possess a small residuum. Sporulation takes 2-4 days.

2.1.2.3 Eimeria ninakohlyakimovae (Yakimoff and Rastegaeiff 1930)

Oocysts measure on average 24 x 18.8 microns and range between 20.5-29 microns long and 14 -23 microns wide. They are spherical or ovoid have no micropyle and micropylar cap. The cyst wall is thin, transparent and brownish-yellow. It consists of two layers the outer of which is brownish-yellow and one micron thick while the inner is 0.4 microns thick. Sporulation time is 1 -4 days. No oocyst residuum arises, but one or more polar granules are usually present. The sporocysts are elongate and ovoid measuring 4 -10 by 9 -14 microns. A sporocyst residuum lies amidst the sporozoites,which lie head to tail and with each enclosing one or two clear granules.

2.1.2.4 Eimeria alijevi(Musaev, 1970)

The oocysts are sub spherical or spherical. They measure 12 -23 by 10 -19 microns(average 16.5 x 14 microns) in size. The oocyst wall is smooth and uniformly thick. It is light yellow or colourless and consists of two layers of which the outer is thicker and the inner is thin and darker. The oocysts have no micropyle nor micropylar cap. The sporocysts measure 5 -9 by 7 - 13 (average 6 x 10 microns) in diameter. Sporulation takes two days. The oocysts possess polar granules, but no residuum arises. The sporocyst residuum is composed of few small granules.

2.1.2.5 Eimeria christenseni (Levine et al, 1962)

Oocysts are usually ovoid, sometimes ellipsoid and

occasionally flattened slightly at the micropylar end. They measure 34 - 41 microns in length by 23 -28 microns in width (average 38 x 25 microns). The wall is about one micron thick and is smooth, colourless or pale yellow, and double layered. The inner lining membrane of the oocyst wall wrinkles slightly at the micropylar end. The micropyle carries a prominent cap. The cap is mould shaped, colourless and measures 1 - 4 microns high by 2 -10 microns wide. Sporulation takes 2 -6 days. No oocyst residuum arises, but one to several polar granules are formed. The sporocysts are broad and spherical their size measures 8 -11 by 14 -18 microns (average 10 x 16 microns) and posses a residuum. The sporozoites lie head to tail, each enclosing a large refractile globule and in addition smaller globules are occasionally present.

2.1.2.6 Eimeria jolchijevi(Musaev, 1970)

The oocysts are ellipsoid, or like a broad-shouldered urn. They measure 22 - 35 in length by 17 - 25 microns in width (average 20.9 x 29.4 microns).The outer layer of the wall is 0.4 - 0.6 microns thick, is light yellow or yellowish green while the inner layer is 0.8 micron thick and brownish yellow in colour. The wall is lined by a membrane which is often wrinkled at the micropylar end. The micropylar cap is characteristically large, broad and flat and gelatinous in consistency. Sporulation takes 3 - 4 days. No oocyst residuum is formed, but one or more polar granules are present in the sporulated oocyst. The sporocysts are elongate ovoid measuring 8 - 9 by 13 - 16 microns. The sporocysts residuum consists of diffuse, granules, which occassionally

aggregate to a compact mass. The sporozoites lie head to tail and each enclose one or two clear globules.

1.2.7 Eimeria apsheronica (Musaev, 1970)

The oocysts are ovoid and measure 25 - 36 in length by 19 - 28 in width (average 29 x 21 microns). The wall is single layered and smooth. The colour varies from greenish, light yellowish brown to pale yellowish pink. It has a 2 -3 micron wide micropyle with no cap. Sporulation takes 1 -2 days. There is no oocyst residuum, only a polar granule. The broadly ovoid sporocysts are 8 - 9 by 4 - 6 and carry a stieda body at their pointed end. The sporozoites lie head to tail and possess one or two large clear globules.

2.1.2.8 Eimeria caprina (Lima, 1979a)

Oocysts are broadly ellipsoidal. They have a dark yellowish brown outer wall and wide micropyle with no micropylar cap. The average size of the oocysts is 32 in length x 23 in width. This species is not common (Norton, 1986).

2.1.2.9 Eimeria caprovina (Lima, 1980b)

Oocysts are slightly shorter and wider giving a more rounded appearance compared to E. caprina. The outer wall of the oocyst is colourless but the inner wall is dark yellowish brown. The micropyle is slightly wider than that of E. caprina. A feature which separates E. caprovina from all other goat coccidia is its ability to infect both goats and sheep (Lima, 1980b).The average size of the oocysts is 29 microns in length by 24 microns in width.

1.1.3 PREVALENCE OF THE EIMERIA SPECIES - REST OF THE WORLD AND KENYA

Svanbraev (1957) in Russia isolated the organism in 52% of 48 goats, Sayin (1965) found the prevalence to be 77% in Angora goats in Turkey. Opoku-pare and Chineme (1979) found that oocyst of E. arloingi composed an approximately 58% of their isolates during the investigation of pathology of acute intestinal coccidiosis in young goats from Nigeria. Other species that were isolated by these workers were E. ninakohlyakimovae and E. intricata. In U.S A., Lima (1980a) studied the occurrence of various species of coccidia in goat and found E. arloingi to have a prevalence of 98.8% . Other species that were isolated and their prevalence were E. hirci (92.6%), E. christenseni (58.2%), E. caprina (49.7%), E. ninakohlyakimovae (33.3%), E. alijevi (35.2%) and E. caprovina (1.9%).

Studies on coccidia of domestic goat, Capra hircus by Norton (1986) in S.E. England found E. arloingi oocysts to have a prevalence of 94%. The other species were E. hirci 69%, E. christenseni 64% E. caprina 55%, E. ninakohlyakimovae 48%, E. alijevi 42% E. apsheronica 23%, E. jolchijevi 8% and E. caprovina 4%. These findings agreed with the results of Lima (1980a) except that E. hirci and E. jolchijevi occurred more frequently in the U.S.A. In Yugoslavia, Vujic and Ilic (1985) found E. arloingi to be the major species causing coccidiosis in goats.

Sayin et al (1980) examined faeces from 353 goats in Ankara, Turkey and found that 54% of the goats haboured six Eimeria spp. These were E. arloingi (31.4%), E. christenseni (27.8%), E.

Wandallis (E.hirci) (0.3%), E. faurei (E.apsheronica) (27.6%), E. ninakohlyakimovae (22.3%) and E. parva (E. alijevi) (0.05%). In Pakistan, Hayat et al (1986) examined faecal samples from slaughtered 104 sheep and 260 goats and found 40.4% of the sheep and 28% of the goats to have Eimeria spp. They identified three species as E. ninakohlyakimovae, E. parva (E. alijevi) and E. granulosa . In Italy, Magi et al, (1987) studied Eimeria species in goats. Their results showed low levels of 300 - 800 oocysts per gram of faeces in 47 out of 50 goats and eight species of Eimeria were identified. E. arloingi was found in 70% of positive goats, E. ninakohlyakimovae in 68%, E. caprina in 40%, E. hirci; in 36% while E. alijevi and E. apsheronica were less frequent and E. christenseni and E. jolchijevi were uncommon. A mixture of three species was found in a third of the goats. A French researcher, Guillous, (1987) in an observation on an atypical acute coccidiosis in young goats revealed enteritis with large numbers of coccidia, E. arloingi, E. ninakohlyakimovae and E. parva (E. alijevi) being the major species that were identified. Kanyari (1988b) reported that Australian goats were mainly infected by a mixture E. ninakohlyakimovae, E. arloingi, E. alijevi, E. hirci, E. apsheronica and E. christenseni. Schrag (1968) reported on the incidence of coccidiosis in cattle, sheep and goats in some regions of South and East Africa, 87 % of 924 goats had coccidial oocysts. Seven species of Eimeria were isolated from these goats.

2.1.4 LIFE CYCLE AND LOCATION OF VARIOUS ENDOGENOUS STAGES

Members of the genus Eimeria with few exceptions are

considered monoxenous because the life cycle is completed in only one host and stenoxenous because usually each species parasitizes a single species of the host (Fayer 1980). The oocysts are found in faeces and in the environments contaminated with faeces of carrier or infected animals. The oocysts sporulate outside the mammalian host (exogenously) in the environment to form four sporocysts each with two sporozoites (oocysts tetrasporic and sporocyst are dizoic).

The sporulated oocyst is the infective stage and is ingested in feed. According to Hammond and Long (1972) excystation begins in the rumen with the lifting of the micropylar cap or with the splitting of the cap for those with caps. In cattle,the microplar cap of E. bovis thins and flattens in the rumen. Complete excystation occurs in the small intestines where the sporozoites are released and these then invade the epithelial cells of the villi. The endogenous stages of E. arloingi are located in the small intestines (Kheysin, 1972).

The sporozoites enter the epithelial cells where they transform into spheroidal trophozoites and then the first nuclear division (Schizogony) occurs resulting in a first generation schizont. Lotze (1953) observed that the sporozoites of E. arloingi migrate through tunica propria of villus where they cause no pathology. They then enter the endothelial cell linings of the central lacteal of the villi from where they enter into the central lacteals and multiply. Schizonts reproduce asexually by multiple fission to form a variable number of merozoites which are banana shaped. The merozoites escape from the host cell,

invade new epithelial cells, and undergo one or several more cycles of merogony to form second generation schizonts. Some merozoites enter new host cells and initiate gametogony which involves the formation of two sexually differentiated cells-the microgamont and the macrogamont.

The macrogamont gives rise to macrogamete while microgamont undergoes numerous nuclear divisions leading to the formation of numerous microgametes. Mature microgametes which are flagellated and motile fertilize the macrogamete resulting in a zygote. The zygote forms a wall and becomes an oocyst. All these occur in the epithelial cells lining the villi of the small intestines. The oocysts are released into the intestinal lumen and then discharged with faeces after which sporogony occurs as reported by Hammond and Long (1972). According to Kheysin (1972) mature schizonts of E. arloingi develop in the endothelium of the vessels of the villi and appear on the 13th - 21st day post infection. They reach about 150 microns in diameter with hundreds of thousands of merozoites being found inside them. Gamonts first appear on the 19th day after infection in case of E. arloingi.

2.1. 5 SPORULATION OF EIMERIA SPECIES, ITS REQUIREMENT AND DURATION.

Sporulation is the process of sporogony and naturally it occurs in the environment after the oocyst is shed in the faeces. Sporulation occurs in an environment with abundance of oxygen and sufficient moisture. Sporulation is retarded by the great numbers of bacteria which grow in faeces in water due to

competition for oxygen. If the bacteria are removed sporulation will take place (Pellerdy, 1974). Artificially oocysts can be cultured for sporulation in 2.0% solution of potassium dichromate ($K_2 Cr_2 O_7$) (Kheysin,1972). However Sayin et al (1980) found 2.5% ($K_2 Cr_2 O_7$)at 26^0 C as the best medium. In this solution, the oocysts have complete access to air and bacteria do not usually develop. Lack of oxygen impedes the primary phase of sporogony. Kheysin, (1972) reported that oocysts of Eimeria spp do not begin sporulation under anaerobic conditions and division of the nuclei does not occur.

During the sporulation of Eimeria oocyst, the first observation is the formation of four outgrowths on the surface of the spherical zygote. These are the sporoblasts which separate to form the pyramid stage. After the pyramid stage, the sporoblasts are formed again and stretched to become ovoid in shape. Then, a wall appears on their surface and sporoblasts develop to sporocysts. All these changes occur without nuclear division and can occur under anaerobic conditions. Complete sporulation takes place in the sporocysts so that sporozoites are formed by one nuclear division which occurs under aerobic conditions. Sporulation of oocysts washed free of faeces can occur in pure water without addition of antibiotics but the water has to be continually aerated. Potassium dichromate (2%) can also be used to preserve live oocysts for long periods. This solution does not penetrate the wall of the oocyst and will not therefore kill the zygote or the sporozoites. Kheysin (1972) records that most coccidian oocysts survive in this solution for

two years at room temperature but all die after three years. Davies et al. (1963) reported that oocysts covered with 2.0 mm of clean water sporulated slowly at 20 - 25^{0} C . At 32^{0} C, sporulation was accelerated but segmentation was abnormal while at 40^{o}C , the oocysts failed to show signs of sporulation. Unsporulated oocysts were killed in 3 days at 40^{o} C. Sayin et al (1980) found 26^{0} C to be the best temperature for sporulation in artificial conditions in the presence of 2.5% potassium dichromate.

According to Davies et al (1963) unsporulated oocysts can remain viable for more than 10 months if the temperatures are low, thus suggesting that oocysts might accumulate for long periods under field conditions and become infective again when appropriate conditions arose. A humidity deficit causes a wrinkling of the oocyst wall due to water loss. As a result the zygote is pressed by the collapsed walls.

2.2. THE DISEASE

2.2.1 INTRODUCTION:

Clinical coccidiosis in goats is manifested by profuse diarrhoea, weakness and emaciation, occasionally being fatal especially in young goats up to 12 months of age.In such animals the disease takes a protracted course as it affects mainly feed conversion leading to emaciation and growth retardation (Pellerdy, 1974). Predisposing factors and concurrent infection(s) which cause stress such as feeding errors, management failures, overcrowding and wet beddings play an important role in the establishment of the clinical illness as has been reported by Pellerdy (1974) and Opoku-pare and Chineme

(1979). Adverse weather and weaning could also precipitate the disease (Norton, 1986). Adult goats usually act as asymptomatic carriers and often pass coccidian oocysts in faeces thus acting as potential source of infection for the young kids. They will however occasionally go down with the disease when under stress or under concurrent infection.

2.2.2 INCIDENCE OF DISEASE IN KENYA AND OTHER PARTS OF THE WORLD

In Kenya, Mugera (1968) reported that E. arloingi was the main cause of coccidiosis in Kenya goats, while Ulvund et al (1984) and Omara- Opyene (1985) reported on coccidiosis in sheep and cattle respectively.

Coccidiosis in goats has been observed in almost all goat rearing countries of the world (Pellerdy, 1974). In Nebraska (U.S.A.) Christensen, (1940) observed 3.4% mortality in goats due to E. arloingi infection. Rao and Hiregaider (1954) regarded coccidiosis as one of the most serious infectious disease of goats in India. Favati and Guerrieri (1961) reported that E. arloingi infections were common in Italy while Schrag (1968) reported that 87% of goats were infected with Eimeria species in East Africa. In Greece Tsaglis, (1970) revealed extensive coccidial infection of goats with E. arloingi, E. crandallis(E. hirci), E. faurei(E. apsheronica), E. intricata and E. ninakohlyakimovae.

Opoku-pare and Chineme (1979) reported coccidial infection in Nigerian goats due to E. arloingi, E. ninakohlyakimovae and E. intricata while Sayin et al (1980) found similar results in Illinois,(U. S. A). In Australia, Howe (1980) stated that

coccidiosis is the single most important disease affecting goats kept in large numbers under intensive management and that modern practises of goat husbandry predispose to coccidiosis.

Norton (1986) in South East England observed that 98% of 422 samples from goats had coccidial oocysts. The most prevalent species were E. arloingi 94% , E. hirci 69%, E. christenseni 64% and E. caprina 55%. He also observed that E. hirci was predominant in adult goats while E. christenseni was found in kids only. E. ninakohlyakimovae caused thickening and petechiation of caecum.

2.2.3. EPIZOOTIOLOGY

Clinical coccidiosis occurs primarily among young animals usually of a few weeks to one year old (Mugera, 1968; Pellerdy, 1974; Opoku-pare and Chineme, 1979; Soulsby, 1982). In the field, pastures become reinfected every year mainly through the oocysts that are being shed by older carrier animals. These oocysts sooner or later become infective if conditions are conducive for sporulation. Opoku-pare and Chineme (1979) reported that warm and moist conditions with reduced sunshine are ideal for sporulation.

The young animals become infected after ingestion of the oocysts shed by carriers and eventually by themselves. The rate of shedding of oocysts may be promoted by stress (Opoku-pare and Chineme,1979). The young animals may also be infected by eating soil contaminated by oocysts as reported by Pellerdy (1974).

Guillous (1987) reported of an acute form of coccidiosis in 4 week- old kids caused by E. arloingi, E. ninakohlyakimovae and

E. parva (E. alijevi). In most cases the clinical disease is caused by a combination of upto six species of Eimeria (Pellerdy, 1974; Opoku-pare and Chineme, 1979; Lima, 1980a; Soulsby, 1982; Norton, 1986; Hayat et al 1986; Magi et al 1987). Infestation is signified by an abrupt increase of oocyst discharge which diminishes suddenly after reaching a peak.The peak oocyst discharge coincides with the first signs of clinical coccidiosis (Pellerdy, 1974).

Practical and experimental observations by Pellerdy (1974) and Opoku-pare and Chineme (1979) indicate that the main sources of coccidial infection in lambs and kids are moist shadowy areas like the surrounding areas of drinking troughs or wet soil litter. In such conditions, the oocyst survive longer. Furthermore high population density of young animals greatly favours the spread of coccidiosis.

2.2.4 CLINICAL SIGNS OF COCCIDIOSIS IN GOATS

Apart from debility, weakness, colic, dehydration and loss of appetite, diarrhoea is the most conspicuous sign. The faeces become liquid, almost waterly occasionally streaked with blood and have extremely foul odour while the perineal region is soiled.

Opoku-pare and Chineme (1979) observed that goats infected by a mixture of E. arloingi, E. ninakohlyakimovae and E. intricata began passing waterly faeces and became weak, unthrifty and dehydrated. They observed that 95% of them were scouring with most of them surviving for 4 to 7 days after showing the initial signs.

The course of the disease is usually 6 weeks in lambs and kids, the sick animals preferred to lie down and palpation disclosed abdominal pain (Pellerdy 1974; Soulsby,1982).

The lambs showed diarrhoea lasting few days, during which the animals lost considerable weight and weaker ones often died. Anaemia and occasionally paralysis develop in lambs if the disease takes a prolonged course. Mugera (1968) reported similar clinical findings in goat coccidiosis in Kenya.

Sayin (1965) produced coccidiosis in kids at 6-10 weeks of age with 25,000 E. parva (E. alijevi) oocysts. The kids developed a severe diarrhoea and several of them died. This led him to conclude that E. parva (E. alijevi) is the most pathogenic species to kids. Vujic and Ilic (1985) reported of diarrhoea and mortality of upto 18% in their study of goat coccidiosis using E. arloingi.

2.2.5. PATHOLOGICAL LESIONS AND THEIR LOCATION

2.2.5.1. GROSS LESIONS

Levine et al (1962) and Mugera (1968) observed focal greyish mucosal plaques in the mucosa of sheep and goats respectively infected with E. arloingi. They were visible from serosal surface, were more numerous in the duodenum and decreased progressively towards the distal end of the small intestines. However Opoku-pare and Chineme (1979) observed that the plaques were more numerous in the jejunum and less in the ileum. The plaques were absent in the duodenum and in the large intestines. Melikyan (1953) found lesions most extensively in the ileum, the jejunum and to a lesser extent in the duodenum.

Pellerdy (1974) reported repeated observations that E.

arloingi affects the mucosa of the terminal small intestine and occasionally the jejunum. Schizont laden villi may enlarge to such an extent that they become visible to the naked eye. The gametogonic stages may give rise to a pseudo-oedematous metaplasia of the villi (Deianas and Delitala, 1953), in which the latter transform to papilliform greyish white foci more than 0.5 mm in diameter, sharply demarcated against the sorrounding catarrhal inflammatory mucosa.

Sayin (1965) observed irregular yellowish plaques 0.3 - 0.4 mm in diameter in the small intestine of a goat. A massive infestation caused an oedematous swelling of the intestinal wall and mucosal scrappings contained many oocysts and gametogonic stages. The intestinal contents were liquid yellowish brown and contained flecks or streaks of blood and flaky patches of desquamated epithelium. Similar observations had been reported in sheep by Lotze (1953).

Smith et al (1960) described the gross lesions of E. ahsata coccidiosis as being inflammation, enlargement and oedematous infiltration of intestinal wall, and reddening of the Peyers patches.

Pande and Bhatia (1964) described a diffuse haemorrhagic enteritis in small intestine of lambs infected with E. ahsata, E. crandallis and E. ovina. There was also necrosis of lamina propria.

Giant schizonts of certain Eimerian species establish themselves in the central lacteal of the villi of the small intestine, abomasum and anterior large intestine of sheep and

goats causing what is called globidiosis. Levine (1973) suggested that the species be named E. gilruthi in the honour of Gilruth who first made the observation. The mucosa of the invaded areas become swollen and the epithelium desquamates from it, often in lentil-seed sized patches. The schizont laden villi enlarge enormously, eventually appearing as grossly visible greyish-white foci. Globidiosis was studied in Tanzania by Bwangamoi (1968) in an outbreak affecting 38 goats and in Kenya by Mugera and Bitakaramire (1968). They named the causative agent as Globidium (Eimeria) gilruthi.

Yvore et al (1980) have reported that a mixture of E. arloingi, E. christenseni and E. ninakohlyakimovae produced haemorrhagic enteritis and" papilloma- like" lesions in the small intestine of experimentally infected animals. Eimeria ninakohlyakimovae and E. caprina in goats and E. ovinoidalis in sheep destroy the stem cells in the crypts of the caecum and/or colon leaving the mucosa devoid of epithelium. According to Gregory (1983), coccidia attacking large intestine of ruminants are more likely to produce lethal effects than those species which develop in the small intestines.

Mugera (1968), Opoku-pare and Chineme (1979) observed that the infected goats usually have ascites, hydrothorax and hydropericardium. When the brain test was applied, it was found to be negative for Cowdria ruminantium (Opoku-pare and Chineme, 1979), hence they were not affected by the disease commonly called heartwater. Guillous (1987) found enteritis with large number of coccidia at post mortem observation on a typical acute coccidiosis in young goats.

2.2.5.2. MICROSCOPIC LESIONS

In goats with coccidiosis, Mugera (1968) observed severe diffuse subacute enteritis in the duodenum, jejunum and ileum with severe proliferation of the glandular epithelium. The epithelium of the tubular glands were hyperplastic and individual glandular cells were hypertrophied. The epithelial cells were filled with mature and immature macrogametes, microgametocytes, merozoites, schizonts and developing oocysts. When stained with haematoxylin and eosin, the macrogametes appeared as glistening orange-red globular bodies packed in the cells and often arranged as a chain of beads around the inner margins of the cell wall. Microgametes appeared as slender slightly pointed basophilic bodies. The developing oocysts, in epithelial cells had refractive eosinophilic walls and finely granular bluish pink contents.

Schizonts were seen in different developmental stages. Some had nuclei arranged in circles while in some, the nuclei were distributed throughout the whole schizont. Still, others had fully developed merozoites. The merozoites were straight with one end rounded and arranged in cluster pattern within the schizont. The main cellular reaction was infiltration mainly by macrophages, lymphocytes, plasma cells and eosinophils (Mugera 1968).

Opoku-pare and Chineme observed areas of mucosal necrosis with polymorphonuclear leucocyte infiltration. Extra- intestinal lesions of coccidiosis have been reported by Hammond and Long (1972) in chicken where there was inflammatory reaction in the

liver after E. tenella infection. Greven (1953), observed infiltration of the pericardium by granulocytes, mast cells and plasma cells, while Hammond and Long (1972), reported infiltration of the pancreas by granulocytes. In chicken E. brunetti causes a mucoid discharge into the intestinal lumen which favours the multiplication of Clostridium welchii which causes the necrotic enteritis associated with the parasite (Hammond and Long, 1972). Bhatia and Pande (1967) reported of giant Eimeria schizonts in mesenteric lymph node of a kid while Lima (1979b), described asexual and sexual stages of Eimeria parasite in the mesenteric lymph node of two kids naturally infected with a mixture of E. arloingi, E. christenseni and E. crandallis (E. jolchijevi). Kanyari (1989) reported immature and mature first generation schizonts in the mesenteric lymph nodes of goats experimentally infected with E. apsheronica

2.2.6. IMMUNITY AND RESISTANCE

Immunity to Eimeria species results in decreased production of oocysts after ingestion of infective oocysts. Immunity is specific to each coccidian species and therefore immunity to one species does not confer immunity to other species in the same host. Schizonts (asexual stages) provide the antigenic stimulation that results in immunity (Fayer, 1980).

It is not certain whether natural resistance increases with the age of the host and reduction in oocyst output, or whether as animals become older, they also become immune as a result of natural infections with coccidia. Young calves seem to be more susceptible than older calves to infection with E. bovis

(Hammond, 1964). Young rabbits are more susceptible than older ones to infections with E. intestinalis while young turkeys are more susceptible than older turkeys to infection with E. meleagrimitis (Hammond, 1964).

2.2.6.1. THE CROWDING FACTOR

As more oocysts are inoculated into a host, the number of oocysts produced per oocyst inoculated decreases. This phenomena is called the "crowding factor". One possible explanation is the very rapid development of an immune response. For poultry coccidia, E. acervulina, the species with the shortest life cycle, is the least subject to the crowding "phenomena", whereas E. necatrix, with the longest life cycle, is more subject to it (Fayer, 1980). The findings by Rose and Hesketh (1976) that the second generation schizonts are probably the most concerned with induction of immunity and that asexual stages are more susceptible to inhibition by immunity, tend to support this explanation. Another possible explanation for the crowding phenomena is that as the number of first and second generation schizonts increases, the area of healthy tissue left for development of subsequent stages decreases. Similarly, tissue damage from infection with one species may decrease the oocyst output of another species; infection with E. tenella decreases the oocyst output of E. necatrix.

2.2.6.2. NUTRITION

The nutritional state of the host affects the development of coccidia. Fayer, 1980 reviewed the nutritional requirements of coccidia. Vitamins A and K provide protection for the host but

are not nutritionally required by the parasite. Other vitamins such as thiamine, riboflavin and biotin are required by both the host and parasite, and known chemical antagonists of such vitamins are used as coccidiostats.

2.2.7. TREATMENT AND SUCCESS IN OTHER ANIMALS AND TRIALS IN YOUNG GOATS.

Yvore et al (1986) described the use of slow release sulfadimethoxine to treat naturally infected kids with E. arloingi at a dose of 1.25 gm per 5 kg body weight. This was calculated to release 50 mg Sulfadimethoxine per kilogram body weight every 24 hours for 5 days. This treatment was found to be more effective than a daily administration of an ordinary formulation of sulfadimethoxine. Polack et al (1987) used medicated feed for preventing coccidiosis in goats. In an intensive unit receiving weaned goats, supplementation of the concentrate for 4 weeks with decoquinate at 20 mg per kg body weight (giving a mean daily dose of 0.4 mg/kg body weight) reduced or stopped the excretion of the oocysts.

Deomand and Mortelmans (1956) had found good results with nitrofurazone against lamb coccidiosis in doses of 10 mg/kg body weight against E. arloingi (E. ovina) and to a lesser extent E. faurei and E. parva infection. Following up an initial sulphonamide therapy Theeswaran (1967) obtained a good response against coccidiosis in kids by treating them first with sulphonamides and then 1-20 mg nitrofurazone per kg body weight per day for five days.

Hammond and Kuta (1967) established that lambs infected experimentally with 50,000-100,000 E. ninakohlyakimovae(E.

ovinoidalis) oocysts discharged fewer oocysts and developed no clinical symptoms, if treated daily with 12.5 mg of amprolium, than untreated animals, which all became sick and with a few of them dying. Ross (1968) used medicated drinking water to provide 62.5 mg of amprolium and 3.2 mg of ethopabate per kg body weight for fourteen days in lambs naturally infected with coccidiosis and they recovered .

Horak and Raymund (1969) recommended amprolium to be given in daily doses of 50 mg per kg body weight for sheep and 100 mg per kg body weight for goats in the treatment of coccidiosis. Sulphonamides have been used to treat diseased birds and prevent development of acute infection. These include sulphaguanidine given continuously at 1-1.5% in feed and sulphadimidine applied in the drinking water for 5 days. These act by interfering with the life cycle of the parasite. However, there was need to develop a drug which could be added to the feed and without interfering with the stages that stimulated the development of the immunity. McDougald and Fuller (1986) carried out drug sensitivity of 99 isolates of coccidia from broiler farms in the U.S.A. The results revealed that 20% of the isolates were resistant to nicarbazin (125 parts per million), 46% were resistant to amprolium + ethopabate, (125 ppm + 4 ppm), 38% were resistant to monensin (110 ppm) and 29% were resistant to salinomycin (60 ppm). These results were based on the intestinal-lesion score reduction of 30% or more. Isolates with 50% or greater reduction of lesion score were considered sensitive. Thus 33% were sensitive to monensin, 53% to salinomycin, 67% to

nicarbazin while 39% were sensitive to Amprolium and Ethopabate.

Yvore et al.(1986) carried out treatment trials using a single administration of slow release sulphadimethoxine against coccidiosis in kids. Mixed naturally acquired infection with E. ninakohlyakimovae, E. arloingi and E. christenseni in 8 kids was treated by administration of "oblets" providing 1.25 gm sulphadimethoxine per 5 kg body weight, calculated to release 50 milligrams over 24 hours for 5 days. This treatment suppressed the rise in the oocyst counts. According to Brander et al (1982) no drug will cure coccidiosis once the clinical signs have developed otherwise the drugs work against schizont and merozoites thus preventing the completion of the life cycle.

2.2.7.1. DRUG RESISTANCE

Resistance to drugs can occur in coccidiosis. Control factors favouring the development of resistance are the continued exposure of large population of animals to the drug, and the use of the drug to suppress growth of the organism rather than eliminate it. This is especially so in intensive poultry management (Brander et al, 1982).

2.2.7.2.DRUGS REPORTED TO BE EFFECTIVE (After Brander 1982).

Most work has been done with poultry.Most coccidiostats protect against clinical illness while reducing but not eliminating oocyst output (Fayer, 1980).

1.Sulphaquinoxaline at 0.042% in drinking water or 0.05% in feed.

2.Amprolium hydrochloride at 0.0125% in feed. This acts on first generation schizonts and so it is important in the

early stages of infection.

3.Diaveridine This interfers with folic acid metabolism. Synergistic combination with sulphadimidine and sulphaquinoxaline at 0.001% diaveridine and 0.085% sulphaquinoxaline gives best results.

4. Nicarbazin at 0.0125% in feed.

5. Nitrophenide at 0.0125% in feed.

6. Arprinocid (Arprocox^{R}) at 60 ppm.

CHAPTER THREE

PART I. PREVALENCE OF EIMERIA PARASITES IN SELECTED AREAS.

3.1 MATERIALS AND METHODS

3.1.1 INTRODUCTION:

This involved the collection of faecal samples from selected areas.The aim was to study the significance and prevalence of coccidiosis in goats from these areas. Point prevalence which refers to the number of cases of disease or events detected in a population at any point in time was assessed in these areas. After cleaning and incubating the samples for sporulation the various species of Eimeria in these areas were identified.

3.1.2 Selected areas of study:

1. Kabete
2. Thika.
3. Murang'a.
4. Naromoru.
5. Ngong.
6. Embu.
7. Kitengela.
8. Machakos.
9. Naivasha.

3.1.3 Description of selected areas:

(i) Kabete:

The goats belonged to Veterinary Investigation Laboratories. The goats were grazed and supplemented with dry hay and

concentrates.

Kabete is high potential area with a March-May and October - November average rainfall,of 1022 mm per year.

(ii) Thika:

The goats belonged to a coffee estate farm under the name "Flame tree". They were browsers on short bushes and were not feed supplemented.

This area is warm, of high potential, with a bimodal average rainfall of 1020 mm per year.

(iii) Murang'a:

The goats belonged to a small scale farmer. They were browsers on thick bushes.

The area is near Aberdare Mountains which experience rain throughout the year,of average 1066 mm.

(iv) Naromoru:

The goats were browsers and grazers.

It is a marginal area with a prolonged dry period and an average rainfall of 700mm per year.The samples were obtained during the rainy season.

(v) Ngong Government farm:

Located south west of Nairobi. The goats were grazed on extensive grasslands. This is a rich agricultural area with rainfall of 850-1000 mm per year.

(vi) Embu Institute of Agriculture:

This is a rich agricultural area. The goats were browsers on short bushes with napier grass supplementation.

The area experiences heavy rainfall throughout the year with an

verage of 1238 mm per year.

(vii) Kitengela Government sheep and goat farm:

This is a marginal area which only experiences the long rains from March to June and is dry most of the year with an average annual rainfall of 550mm. They were browsers on short bushes.

(vii) Naivasha Goverment zero-grazing demonstration unit :

Goats were zero grazed on napier grass and vegetables. The area experience an average rainfall of 620 mm per year but is occasionally dry.

(ix) Machakos:

The area is within the same zone as Kitengela. The goats were browsers kept in a small scale farm. The average rainfall is 850-1000mm per year.

3.1.4 Goat breeds in the selected areas:

Thika, Murang'a, Naromoru, Kitengela and Machakos had the small East African goat breed.

Kabete, Ngong, Embu and Naivasha had the exotic breeds.Saanens were kept at Embu while Ngong and Kabete had a mixture of Toggenburgs and Anglonubians; Naivasha had a pure breed of Toggenburgs.

3.1.5 Manangement practices in each of the selected areas.

In the small holder farms, housing was not conducive to parasite build up. It was only in Naromoru where the housing was poor. In this case, the floor was wet and soiled. The house also had poor ventilation. There was also accumulation of faeces and manure.

For the large farms, Kitengela had the best housing system. The house was spacious, well ventilated and dry, with no accumulation of faeces as the house was swept daily and the manure taken out to a distance from the house. At Naivasha, the goats were housed on raised floor stalls which were well ventilated except that there was congestion of the animals. There was no accumulation of faeces.

At Ngong there was congestion and accumulation of manure and the floor was soiled.

3.1.6 Sampling Methods:

The goats were sampled indoors at each of the selected areas.They were sampled in the early afternoon before feeding except in Naivasha where they were sampled while still feeding (these were zero-grazed). The faecal samples were obtained per rectum and about 6 grams was secured from each animal and put into plastic cups. The cups were labelled with a record of location, age, breed, identification number, and the general body condition noted.

Where the flock was large, up to 24 samples were taken. In some cases, where the flock was small like in Embu and Machakos the samples were taken from the whole flock.

3.1.7.Sample Handling and Transport:

Labelled samples from each farm were put into separate plastic paper bags ready for laboratory analysis.

In the laboratory the samples were kept in the refrigerator at 4 ^{O} c overnight.

3.1.8 LABORATORY ANALYSIS:

3.1.8.1 Introduction to laboratory Methods:

This was done in the parasitology laboratory, at Kabete campus. The analysis included:

1. Oocysts per gram of faeces (OPG).
2. Concentration and cleaning of the oocysts.
3. Culturing of the oocysts for sporulation.
4. Concentration of the oocysts after culturing.
5. Identification of the species of Eimeria.
6. Determination of prevalence of each species on an individual animal basis.

3.1.8.2 Sample Handling in the laboratory before analysis:

The labelled samples were removed from the refrigerator the following morning. The labels were cross checked and the samples arranged in sequence on the laboratory bench.

3.1.8.3 Methods of sample analysis:

The analysis was done following the sequence in which the samples were arranged. Two grams of the faecal sample was added to 28 mls of saturated magnesium sulphate ($MgSO_4$) to make a volume of 30 ml in a plastic sample bottle. These were then homogenised using an electric homogeniser to release the oocysts. The suspension was then sieved through two successive tea strainers (sieves) into another plastic sample container. The sample mixture was allowed to stand for 3 minutes. The sieved material was filled into a McMaster slide using a clean pasteur pippete for the estimation of oocysts per gm of faeces (OPG). The McMaster slide was mounted on a microscope stage and focussed

ing a x10 objective and x10 eye piece lens.

3.1.8.4 Oocysts per gram of faeces:(OPG)

This was done by counting the oocysts in each column of the McMaster slide using manual counters. The average total oocysts count was then computed using the formular given below to give the OPG:

Two gram were added to 28 ml of salt solution to make 30 ml. Therefore, number of OPG of faeces is equal to

$$X/0.15 \times 30 \times 1/2 = X \times 100$$

Where $X/0.15$ = $\frac{\text{Total number of oocysts in counting chamber}}{\text{Volume Sample in one cm3}}$

x 30 = Total volume of sample (2 grammes + 28Mls)

x 1/2 = Correlation to 1 gramme of faeces (Sloss, 1987).

The OPG was recorded in the record sheet against the sample identification number.The procedure was repeated for all samples in a regular order.

3.1.8.5. Concentration and cleaning of the oocysts:

For positive samples 25 ml of remaining suspension was put into 50 ml plastic centrifuge tubes and filled with clean water to make a 50/50 dilution. The solution was thoroughly mixed and centrifuged at 2,000 r.p.m. for 8 minutes to sediment the debris and float the oocysts. The top 15 mls of the supernatant was siphoned into another centrifuge tube and filled with clean water, centrifuged for 10 minutes at 2,000 r.p.m. to sediment the oocysts and wash off the salt. The supernatant was poured off slowly leaving the bottom 2 ml. The procedure was repeated 3 times to concentrate and clean the oocysts. A drop of the suspension was remounted on the microscope stage to make sure

that the oocysts were still present.

3.1.8.6 Culturing of the oocysts for sporulation:

To the concentrated oocyst suspensions 2 ml of 2.5% potassium dichromate solution ($K_2 Cr_2 o_7$)were added. After a thorough mixing the mixtures were transferred to clean shallow petri dishes for sporulation. Each sample was treated individually with a regular order being kept. The petri dishes were labelled to correspond with the sample number and place of origin. The samples from Ngong were cultured in clean plastic petri dishes while those of Kitengela were cultured in clean glass petri dishes. These samples were cultured for 3 days at room temperature of 24^{o} C and aerated twice daily to facilitate sporulation (Khyesin, 1972; Opoku-pare and Chineme, 1979; Sayin et al 1980). Small long tipped droppers were used for aerating the samples. These were cleaned or changed after every sample.

3.1.8.7. Concentration of oocysts after sporulation:

After 3 days of incubation the samples were thoroughly mixed and put into 50 ml plastic centrifuge tubes. They were centrifuged for 10 minutes at 2000 r.p.m. to sediment the sporulated oocysts. The supernatant was slowly discarded leaving the bottom 1 ml. The tubes were then shaken to re-suspend the sporulated oocysts.

3.1.8.8 Identification of Eimeria species:

This was done by observing the morphological features, shape, size, and colour of the sporulated and unsporulated oocysts (Kheysin, 1972; Hammond and Long, 1972; Pellerdy, 1974; Opuku-pare and Chimene, 1979; Sayin et al, 1980; Vercruysse,

1982; Norton, 1986; O'Callaghan, 1979). From each sample a drop of the sporulated oocyst suspension was placed on a clean microscope slide using a small dropper and covered with a cover slip. The preparation was then mounted onto a microscope stage earliear calibrated using a micrometre slide and micrometre eye piece. (Anon, 1986; Sloss, 1987). The microscope was fitted with an ocular micrometre. The slide was first focussed at x 10, a scanning done throughout the slide before focussing at x 40.

Forty oocysts were differentiated from each sample. The details were recorded for each sample against the corresponding sample number. These were used to identify the various oocysts into species.The oocysts and sporocysts dimensions were compared to those reported by earier researchers in this field (Vercruysse 1982, Norton 1986, and O'Callaghan 1989).

3.1.9. Determination of prevalence of each species on sample basis:

The number of each species was recorded for every slide for every sample to show the most prevalent or common species. Photographs of the sporulated oocysts were taken.

RESULTS

PART I

4.1. Features of various species of Eimeria encountered.

Fig. 1-7 represent sporulated oocysts of various species encountered.

4.1.1. Eimeria arloingi (Fig. 1)

The oocysts were ellipsoid, smooth walled with a prominent micropyle which had a micropylar cap. The micropylar cap was on the narrow end. The sporocysts were elongate. Size of oocysts varied from 26-34 by 20-24 microns with an average 30 x 20 microns.

4.1.2. Eimeria hirci (Fig. 2)

The oocysts were spherical, smooth walled. They had a micropyle with a small micropylar cap. The sporocysts were ovoid. Sizes of the oocysts ranged from 18-24 by 16-22 with an average of 20 x 18 microns.

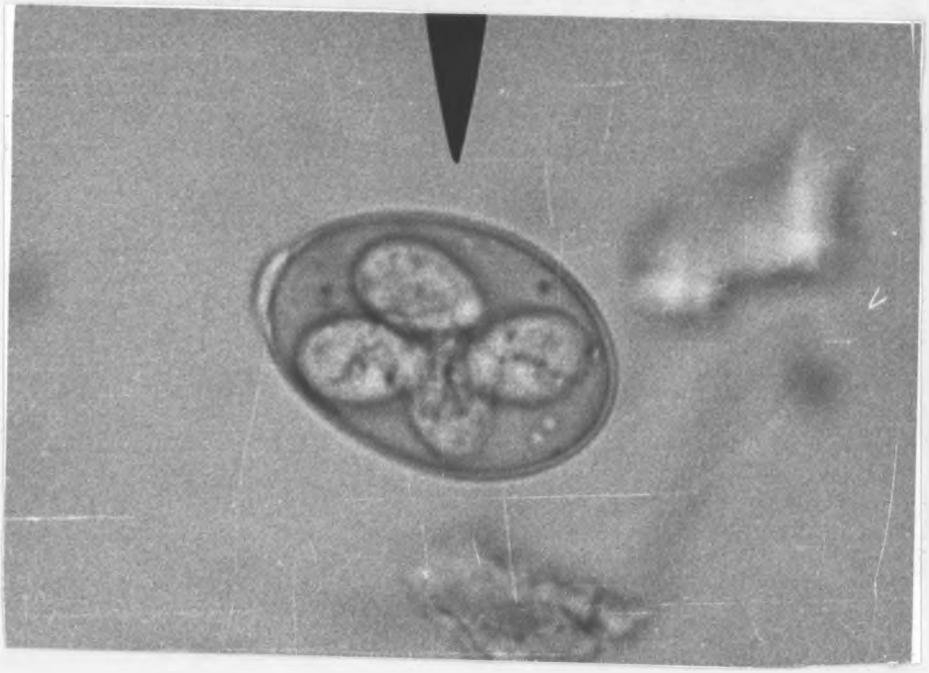
4.1.3. Eimeria ninakohlyakimovae (Fig. 3.)

Oocysts were spherical or ovoid. They were smooth walled without a micropyle or micropylar cap. The sporocysts were ovoid. The oocysts sizes ranged from 18 - 24 by 16 - 22 microns with an average of 22 x 18 microns

4.1.4. Eimeria alijevi (Fig. 4)

The oocysts were spherical with a smooth wall. The oocysts had no micropyle and no micropylar cap. The sporocysts were sub-spherical or spherical. The oocyst sizes ranged between 12-18 by 12-16 microns with an average of 16 x 12 microns.

Fig.1: Eimeria arloingi oocyst (x 2000)



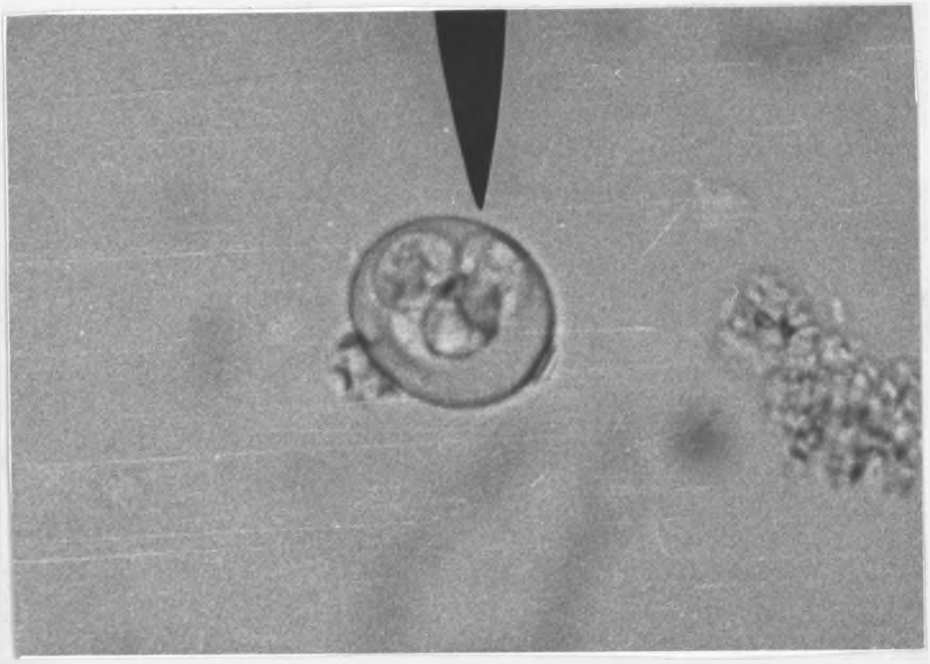


Fig.2: Eimeria hirci oocyst (x 2000)

4.1.5. Eimeria christenseni (Fig. 5)

This was the largest oocyst encountered. The oocysts were ellipsoid with a smooth wall. They had a prominent micropyle and micropylar cap. The cap was mould shaped. The sporocyst were spherical. The oocyst sizes ranged between 36-42 by 24 - 27 microns with an average of 38 x 25 microns.

4.1.6. Eimeria jolchijevi (Fig. 6).

The oocysts were either ellipsoid or broadly ovoid. The micropyle was evident with a characteristically large,broad and flat cap. The sporocysts were ovoid. The oocysts sizes ranged from an average of 31 x 23 microns .

4.1.7. Eimeria caprovina (Fig. 7)

Oocysts were broadly ovoid. They were smooth walled with a prominent micropyle but no micropylar cap. The sporocysts were elongate ovoid. The oocyst sizes ranged from 28-34 by 23 -25 microns with an average of 30 x 24 microns.

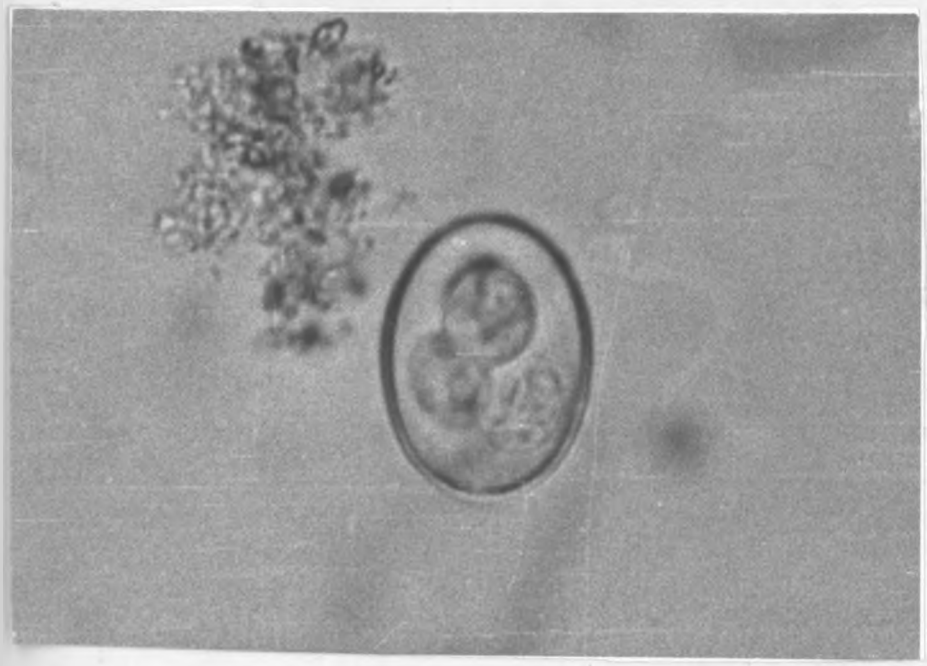
4.1.8. Eimeria apsheronica

The oocysts were ovoid with a single layered smooth wall. It had a micropyle with no micropylar cap. The sporocysts were broadly ovoid. The oocysts sizes ranged between 29-32 by 21-22 microns with an average of 31 x 23 microns.

4.1.9. Eimeria caprina

The oocysts were broadly ovoid. They had smooth wall with a wide micropyle with no micropylar cap. The sporocysts were ovoid. The oocysts average size was 32 x 23 microns.

Fig.3: Eimeria ninakohlyakimovae oocyst (x 2000)



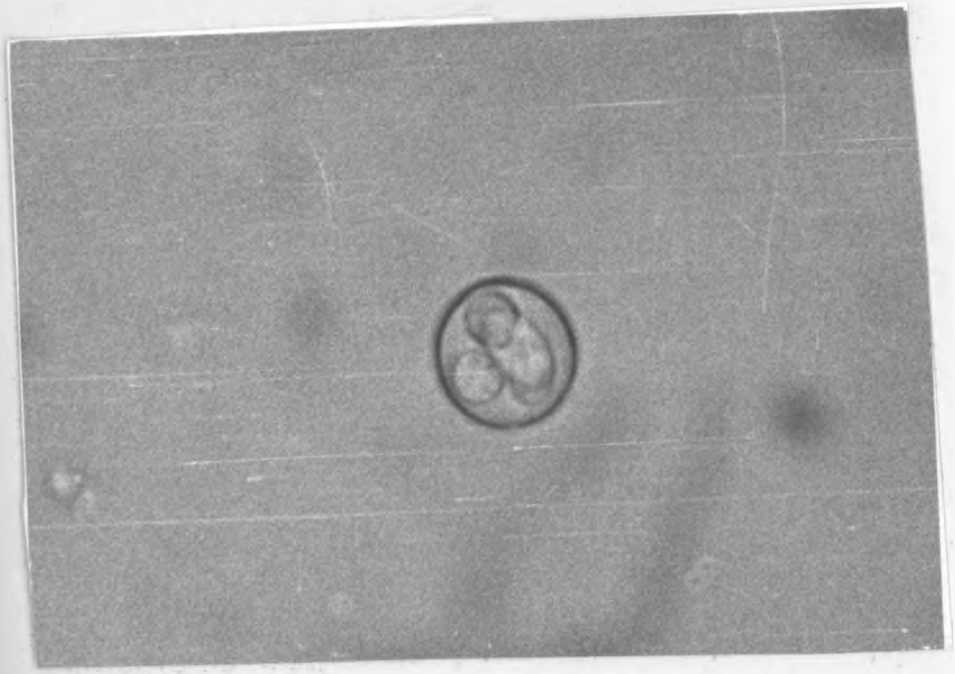
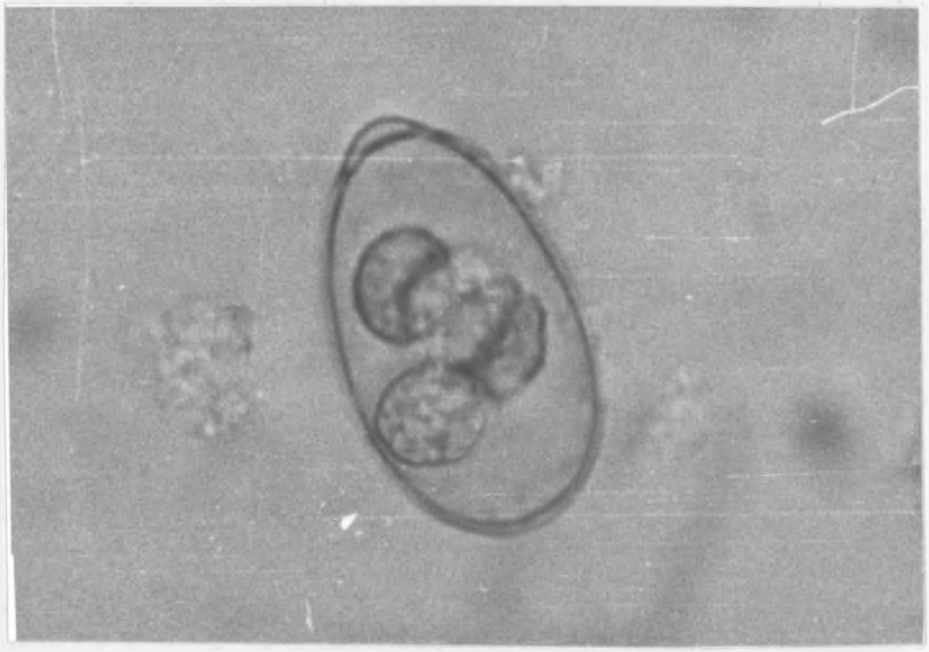


Fig.4: Eimeria alijevi oocyst (x 2000)

Fig.5: Eimeria christenseni oocyst (x 2000)



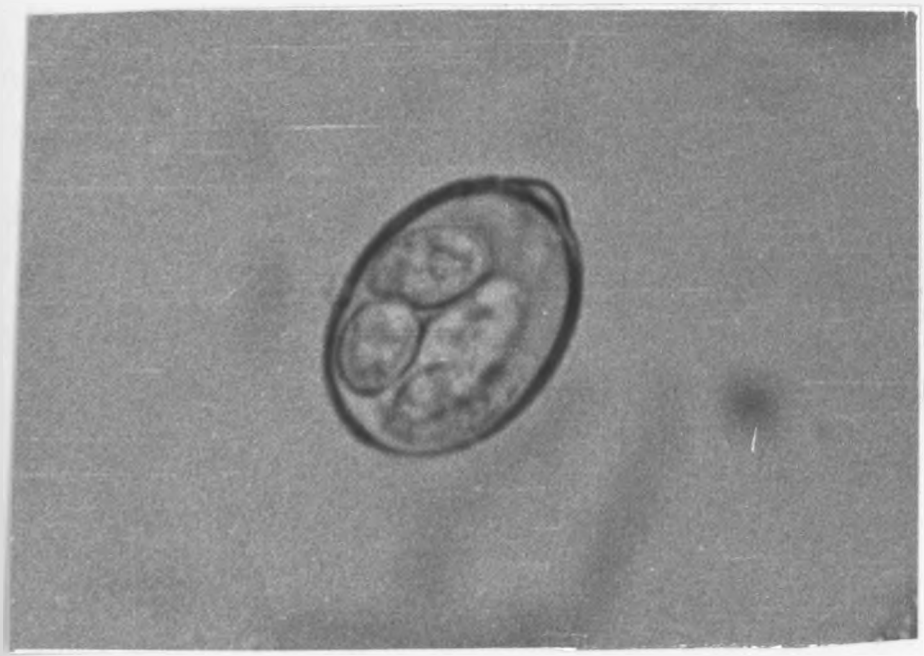
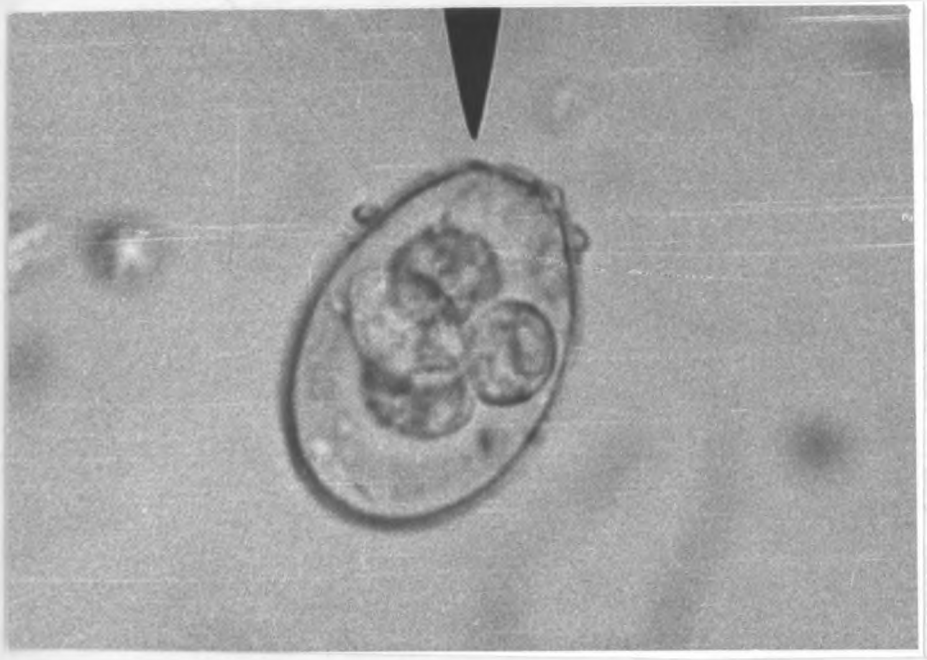


Fig.6: Eimeria jolchijevi oocyst (x 2000)

Eimeria caprovina oocyst (x 2000)



4.2: Prevalence of various Eimeria species.

Fig. 8 shows the percentage occurrence of Eimeria species in the selected areas.

Nine species of Eimeria were encountered in the study areas. These were E. arloingi E. hirci, E. ninakohlyakimovae, E. alijevi, E. christenseni, E. caprovina, E. apsheronica, E. caprina and E. jolchijevi. (Fig. 8).

The overall mean percentage prevalence for all the areas in the positive goats was a follows:(Table 1)

E arloingi 37.67%, E.ninakohlyakimovae 24.44%, E.hirci 17.21%, E alijevi 10.18% E. christenseni 5.56%, E.caprovina 3.57%, E jolchijevi 1.05% E. apsheronica 0.21% and E. caprina 0.11%.

E.arloingi, E. ninakohlyakimovae and E. hirci were most common while E. apsheronica and E. caprina were the least common. There was however variance in the occurrence of the species depending on the location and the age of the goats. These results are shown in Figures 9 -17.

At Kabete six species were encountered. The most prevalent was E. arloingi in both kids (less than six months) and adults (more than 18 months old) while the least was E. caprovina

The occurrence of the species of coccidia varied with the age of the goats as inferred above. E. hirci was only found in adults while E. caprovina and E.christenseni were only found in kids E.ninakohylakimovae was more prevalent in adults than in kids while E. alijevi was more prevalent in kids than in adults E.apsheronica. E.caprina and E. jolchijevi were not found in goats at Kabete (Fig. 9).

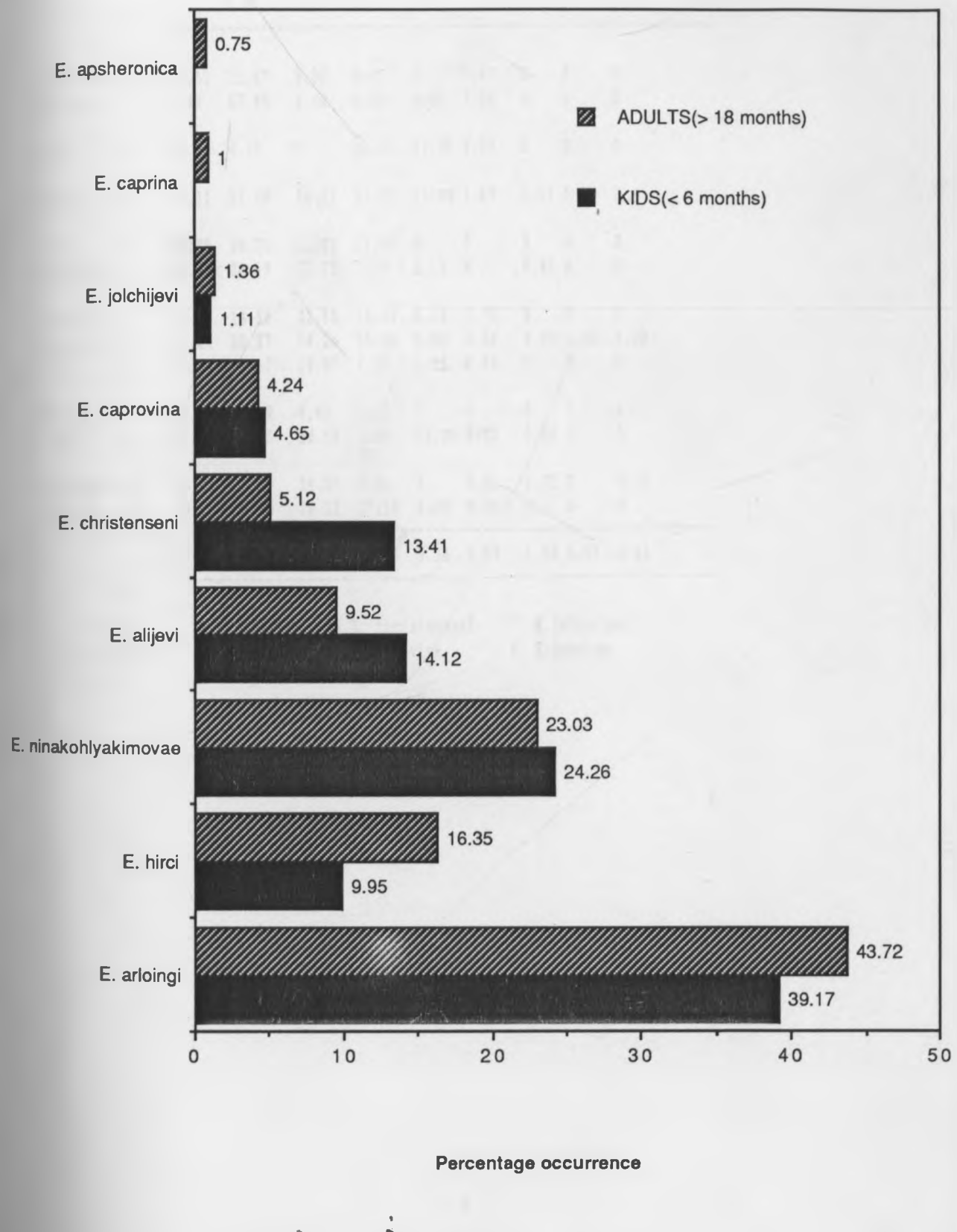


Fig. 8. Overall percentage occurrence of Eimeria species in the selected areas

1:PREVALENCE OF SPECIES OF EIMERIA IN AGE GROUPS IN SELECTED AREAS IN KENYA.

LOCATION	NUMBER	INDIVIDUAL SPECIES INDENTIFIED (PERCENT)*								
		1	2	3	4	5	6	7	8	9
1.Muranga	3	72.67	11.67	3.33	6.66	0	5.67	0	0	0
2.Marumoru	7	9.40	69.40	2.40	3.00	8.60	7.20	0	0	0
Kabete	10	47.50	4.18	0	24.50	19.75	4.07	0	0	0
Naivasha	10	27.11	11.78	24.11	22.33	11.89	1.67	1.11	0	0
1.Thika	19	44.03	29.75	11.92	14.30	0	0	0	0	0
2.Naivasha	10	48.50	24.13	11.12	3.75	2.13	0	0.37	0	0
1.Machakos	14	38.50	14.58	22.50	14.34	8.33	1.75	0	0	0
2.Marumoru	15	42.67	22.27	14.24	10.26	3.90	2.66	2.00	1.00	1.00
3.Ngong	21	40.59	21.47	19.87	7.12	2.12	8.88	0	0	0
1.Kabete	10	57.17	27.99	8.67	6.17	0	0	0	0	0
2. Embu	14	31.73	25.65	24.18	5.36	12.00	0.72	0.36	0	0
1.Kitengela	18	42.29	15.00	24.57	9.50	0	5.43	2.71	0	0.50
2.Muranga	10	48.00	16.44	10.12	17.22	2.22	6.00	0	0	0
Overall %		37.67	24.44	17.21	10.18	5.56	3.57	1.05	0.11	0.21

KEY: 1. E.arloingi
2. E.ninakohlya-komovae
3. E.hirci
4. E.alijevi
5.E. christenseni
6.E.caprovina
7. E.jolchijevi
8. E.caprina
9. E.apsheronica

At Murang'a (Fig. 10) six species were identified. E. loingi was the most prevalent in kids and adults while the ast prevalent species was E.christenseni. There was age riation in species prevalence. In kids (less than six months of e) E.arloingi was more prevalent than in adults (more than 18 nths of age).E. alijevi was more in adults than kids while E. ristenseni was only found in adult goats (over 18 months) E. sheronica, E.caprina and E.jolchijevi were absent in goats at urang'a

At Ngong where only adults goats (18 months) were available or sampling, E. arloingi was the most prevalent (40.58%), ninakohylakimovae was the second most prevalent (21.47%) while .christenseni was the least (2.12%). Eimeria apsheronica, caprina and E. jolchijevi were not encountered (Fig. 11)

At Thika samples were from adults goats (more than 18 nths old) (Fig.12). Four species of Eimeria were identified.The ost prevalent was E. arloingi (44.03%) followed by .ninakohylakimovae (29.75%) while E. hirci and E.alijevi had an qual prevalence of 11.92%.

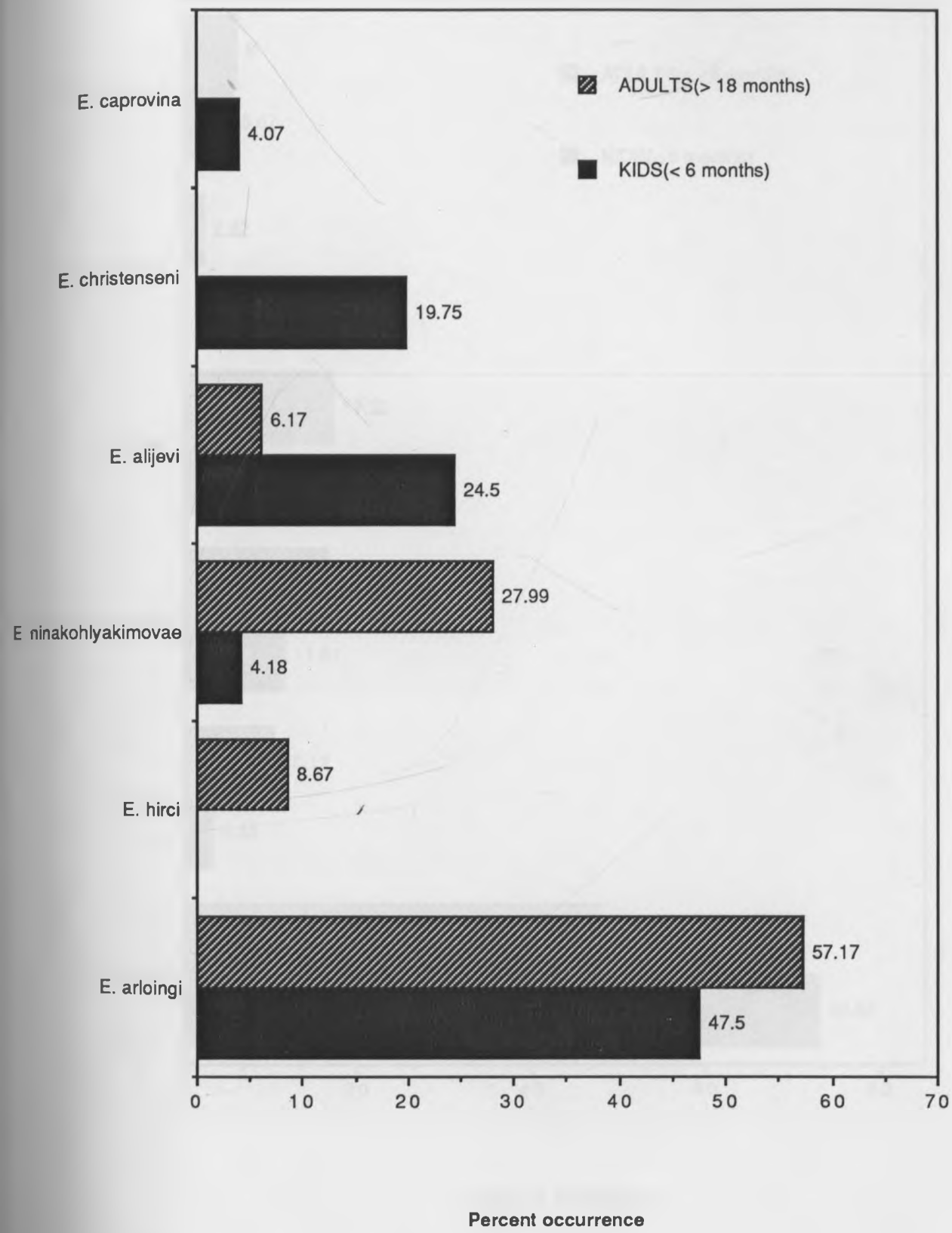


Fig. 9. Average percentage of Eimeria species at Kabete

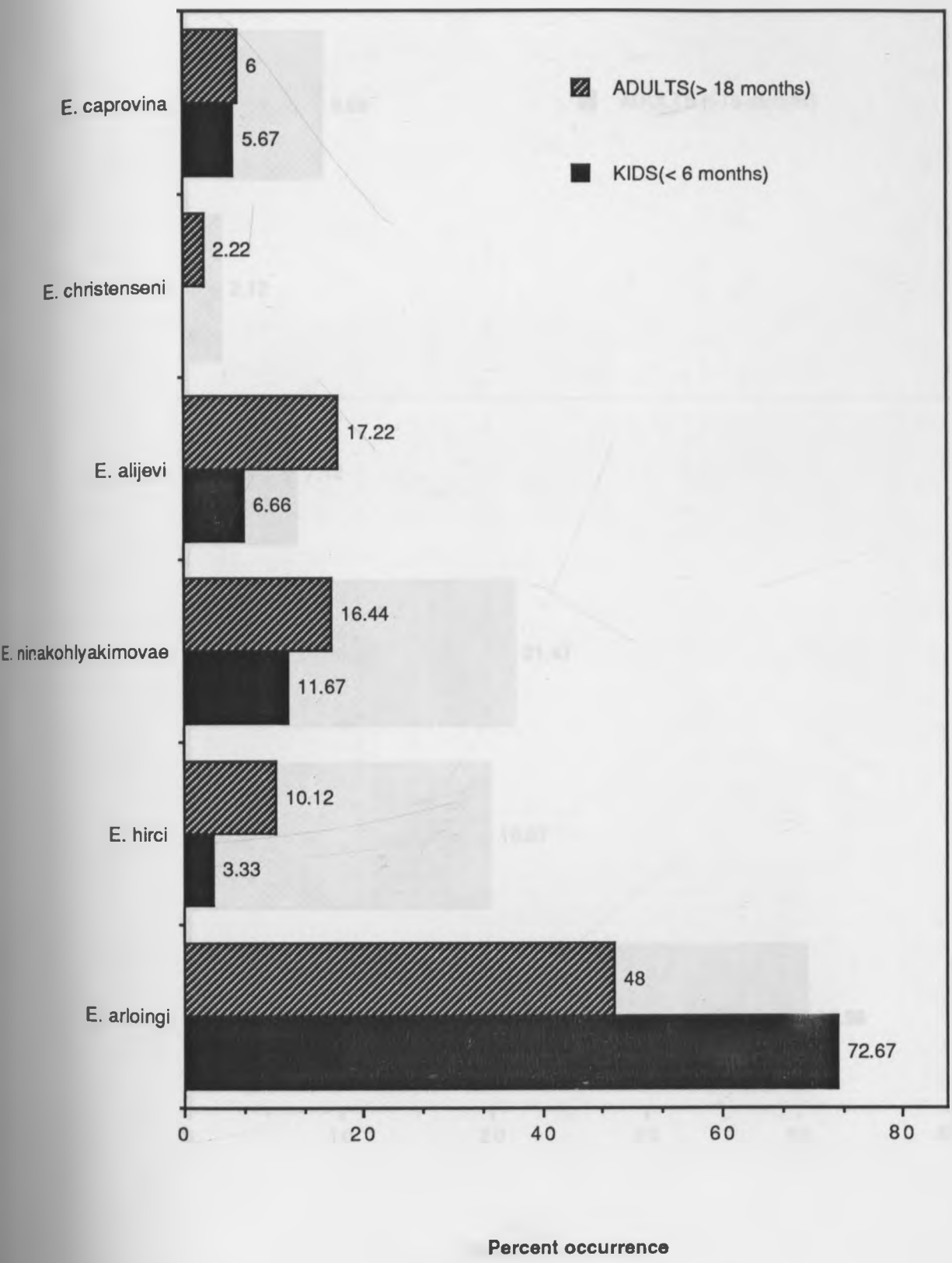


Fig. 10. Average percentages of Eimeria species at Muranga

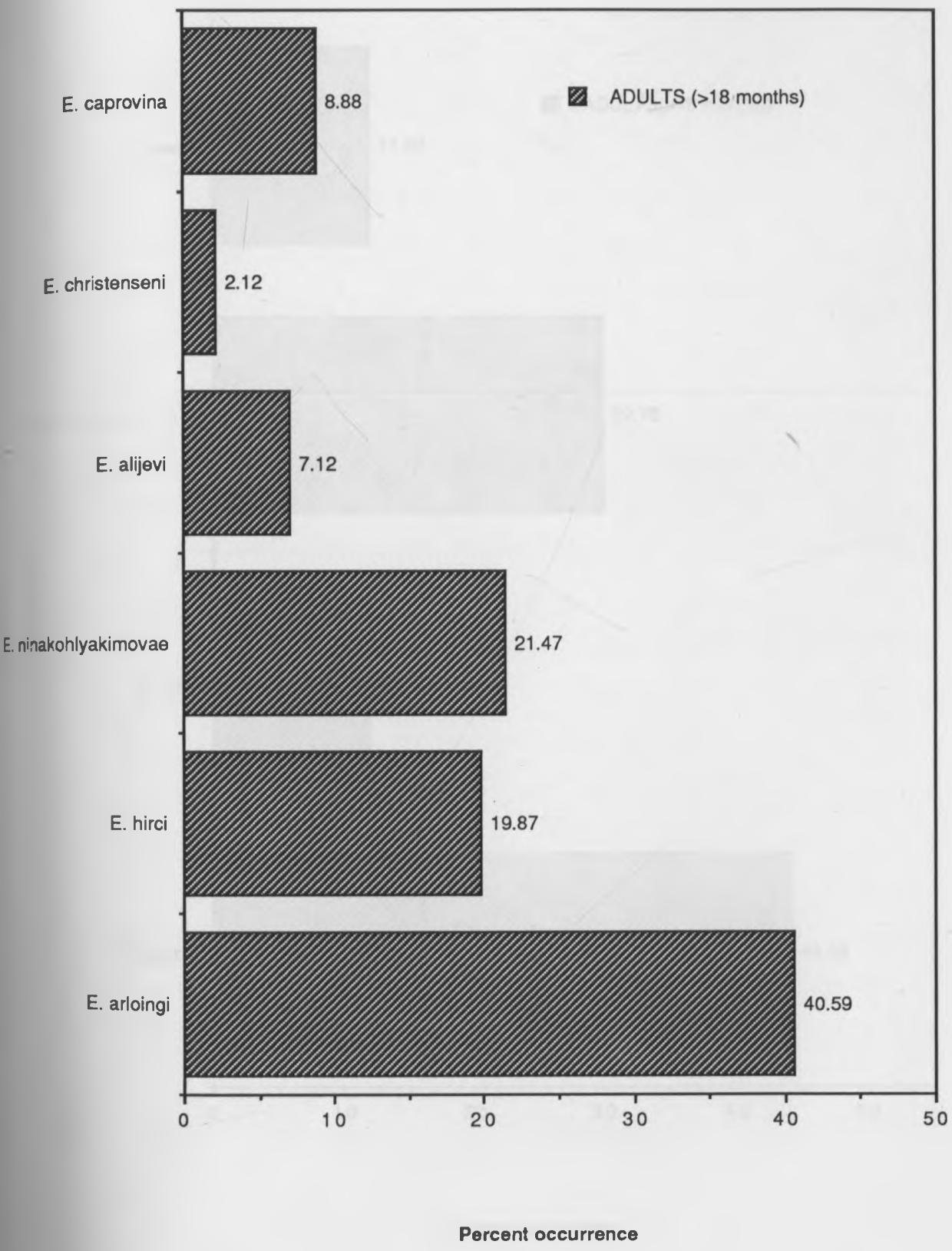


Fig. 11. Average percentages of Eimeria species at Ngong

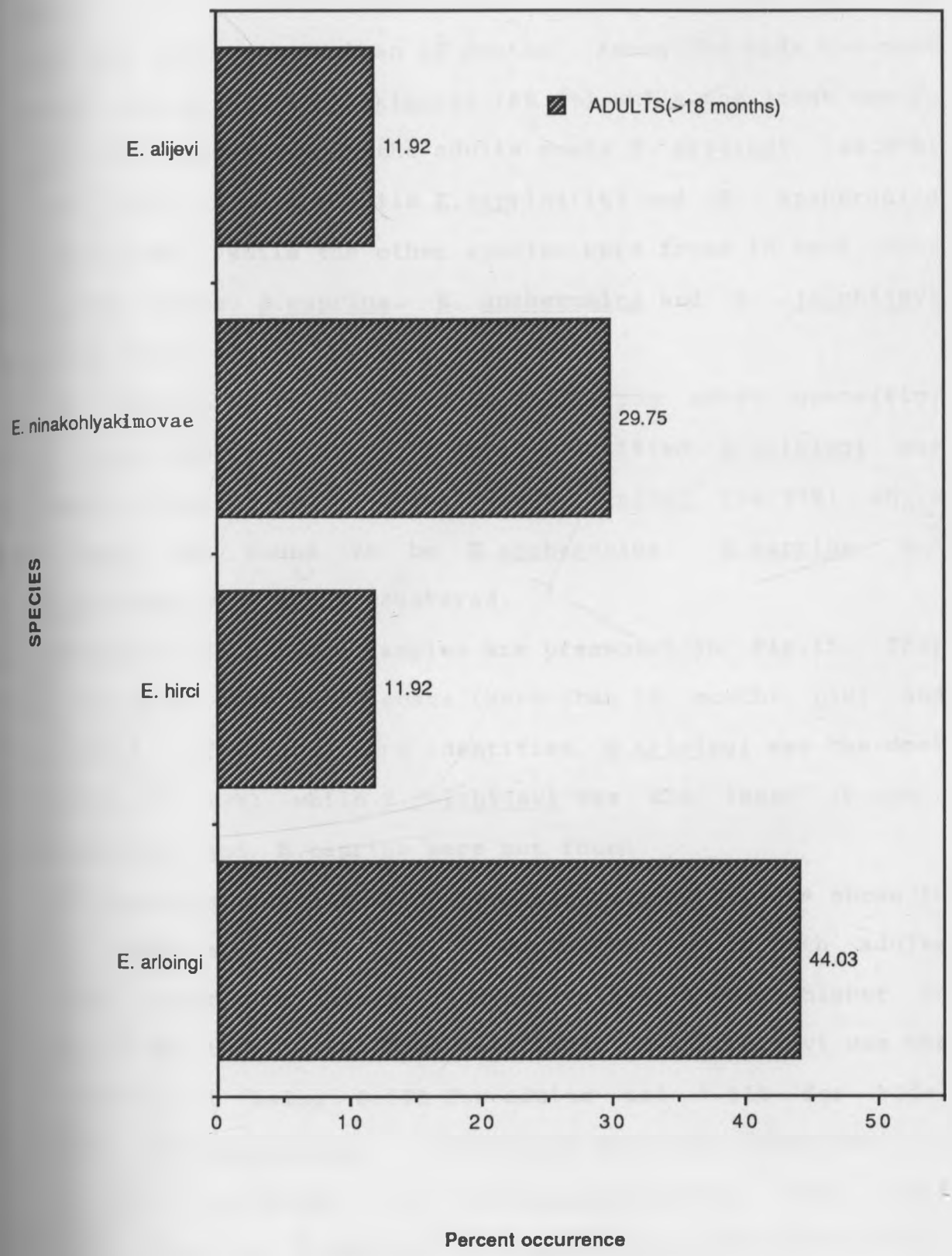


Fig. 12 Average percentages of Eimeria species at Thika

At Naromoru (Fig. 13) nine species of Eimeria were identified from both kids and adults.The occurrence of the coccidia species varied significantly among kids (less than six months) and adults (more than 18 months). Among the kids the most prevalent was E. ninakohylakimovae (69.4%) while the least was E. hirci(2.4%). However,among the adults goats E. arloingi (42.67%) was the most prevalent while E.caprina(1%) and E. apsheronica (1%) were least. While the other species were found in both kids and adult goats, E.caprina, E. apsheronica and E. jolchijevi were only found in the adults .

At Kitengela samples were obtained from adult goats(Fig. 14). Seven species of Eimeria were identified. E.arloingi was the most prevalent (42.29%) followed by E.hirci (24.57%) while the least was found to be E.apsheronica. E.caprina and E.christenseni were not encountered.

Results from Embu samples are presented in Fig.15. They were obtained from adult goats (more than 18 months old) and Seven species of Eimeria were identified. E.arloingi was the most prevalent (31.73%) while E.jolchijevi was the least (0.36%). E.apsheronica and E.caprina were not found.

At Naivasha sample results from kids and adults are shown in Fig.16. Seven species of Eimeria were identified in both adults and kids. E.arloingi was the most prevalent, being higher in adults (48.5%) than in the kids (27.11%). E. jolchijevi was the least prevalent being 0.37% for adults and 1.11% for kids. E.alijevi. E.christenseni and E.hirci were more prevalent in kids while E.arloingi and E.ninakohylakimovae were more prevalent in adults. E.caprina and E.apsheronica were not found

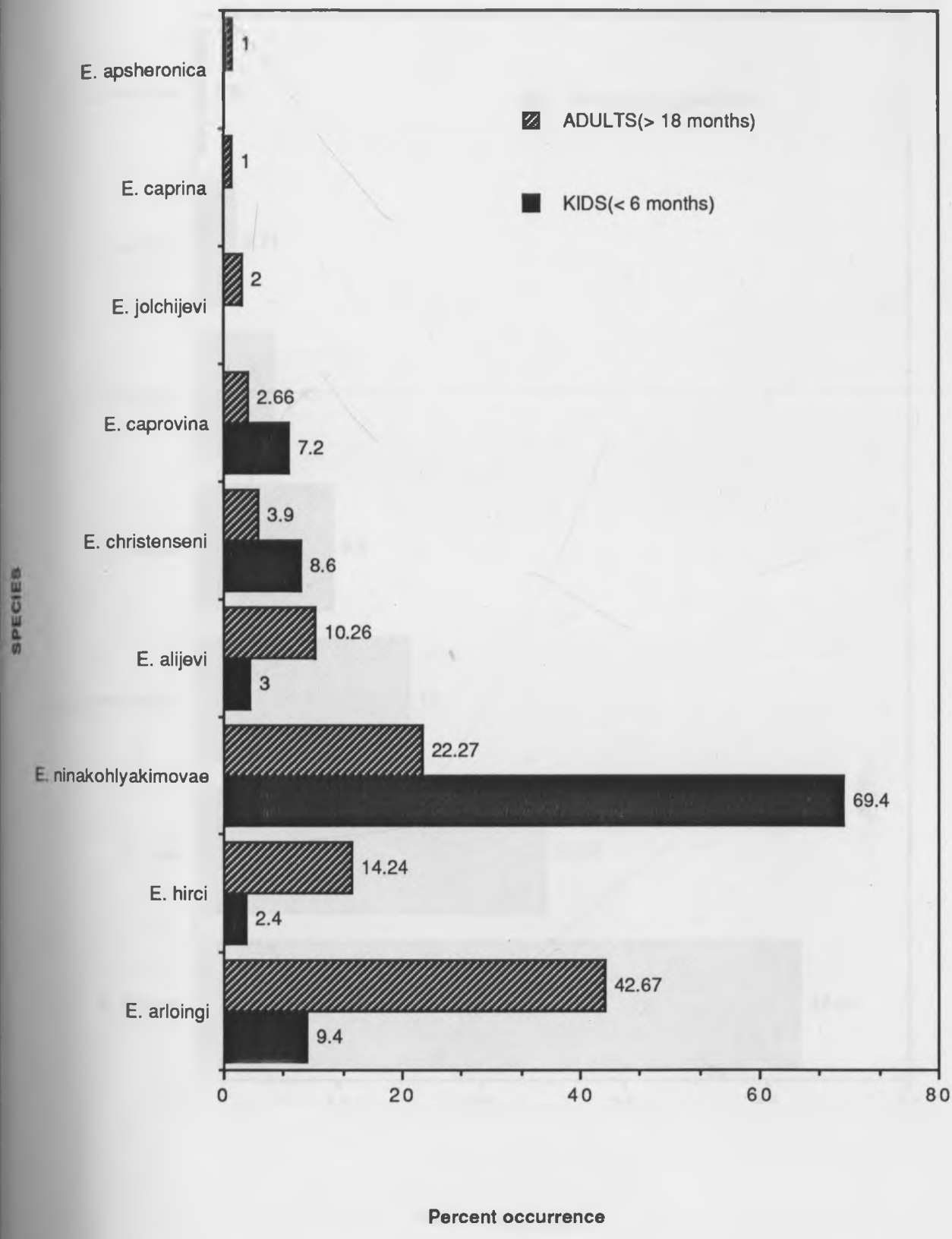


Fig. 13. Average percentages of Eimeria species at Naromoru

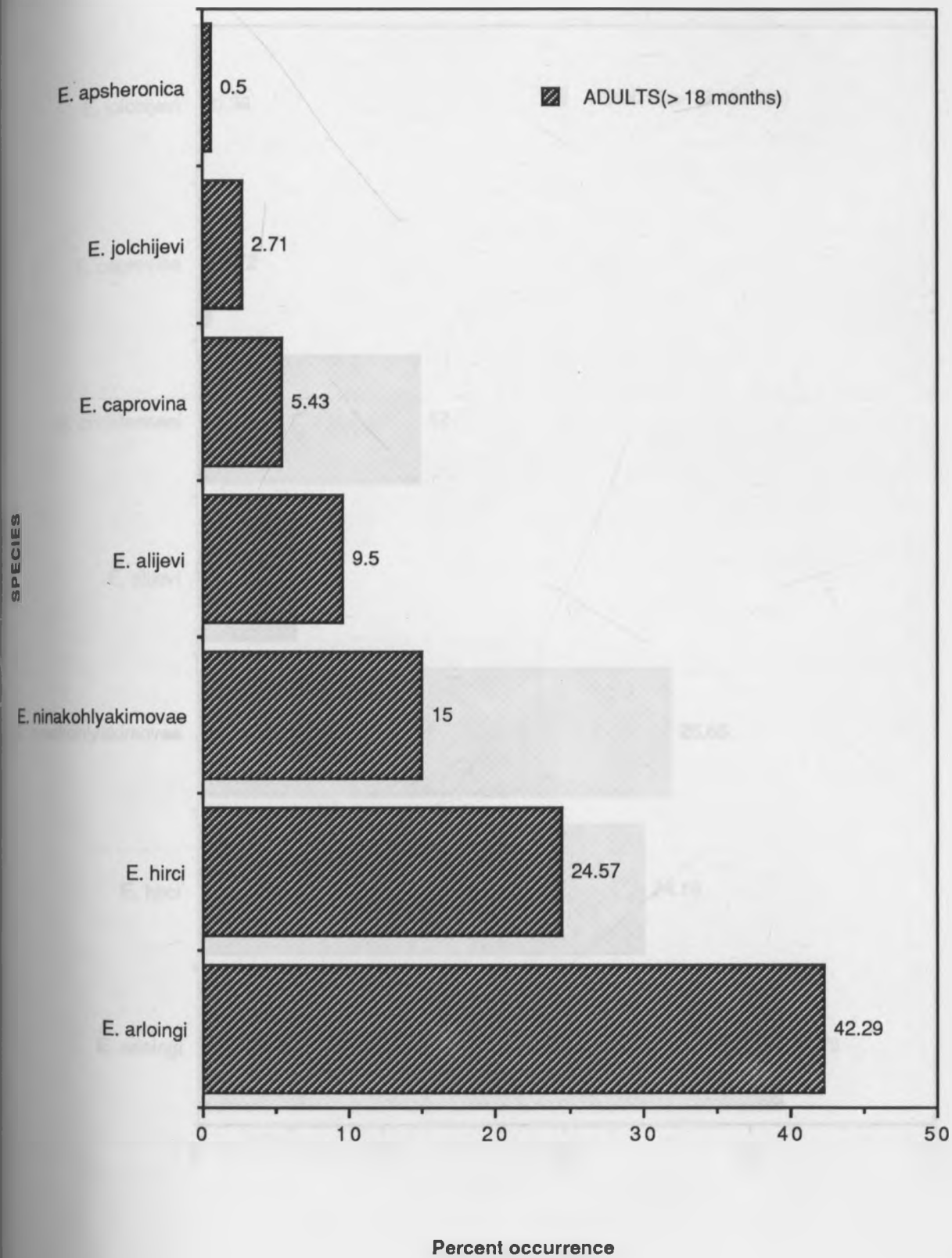


Fig. 14. Average percentages of Eimeria species at Kitengela

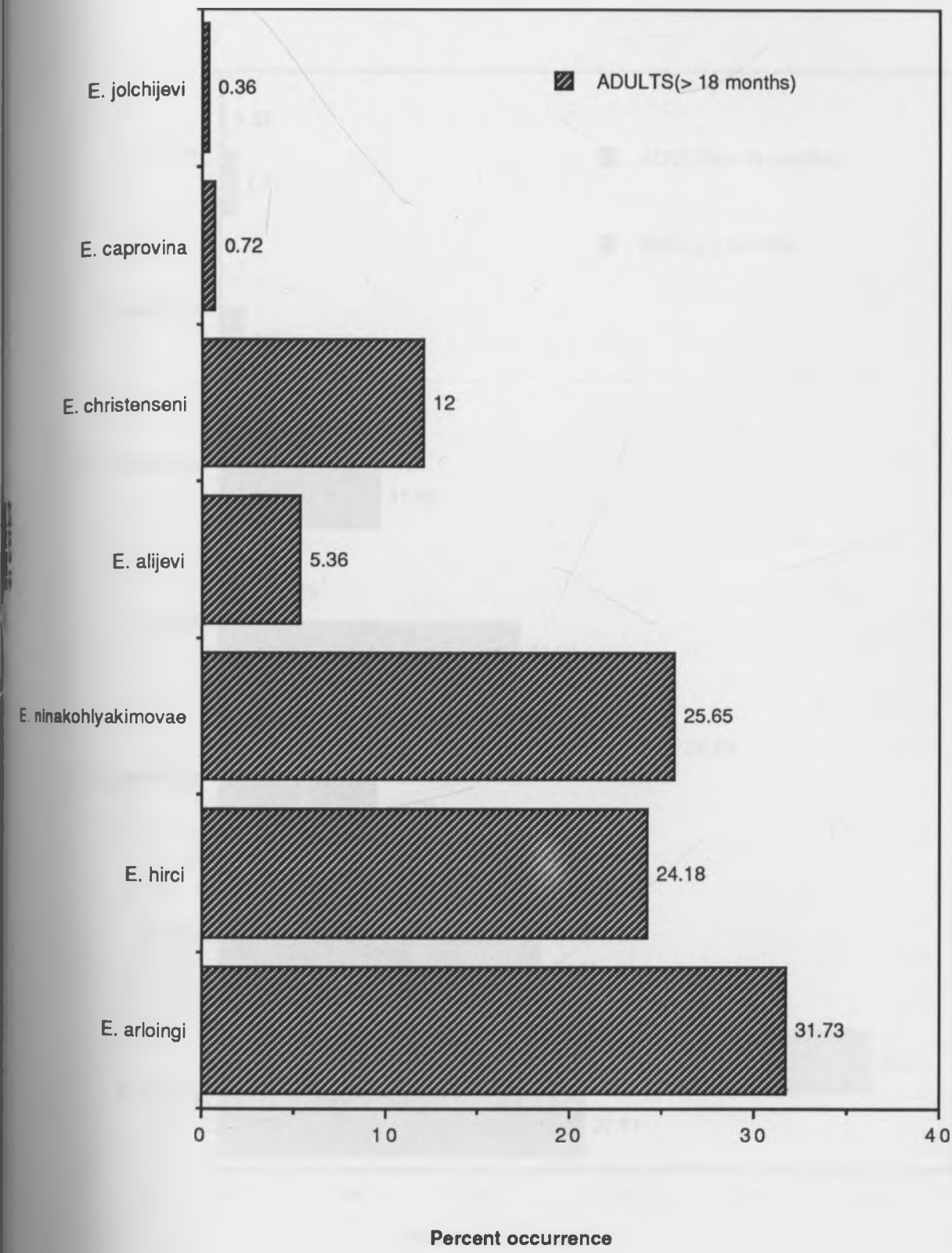


Fig. 15. Average percentages of Eimeria species at Embu

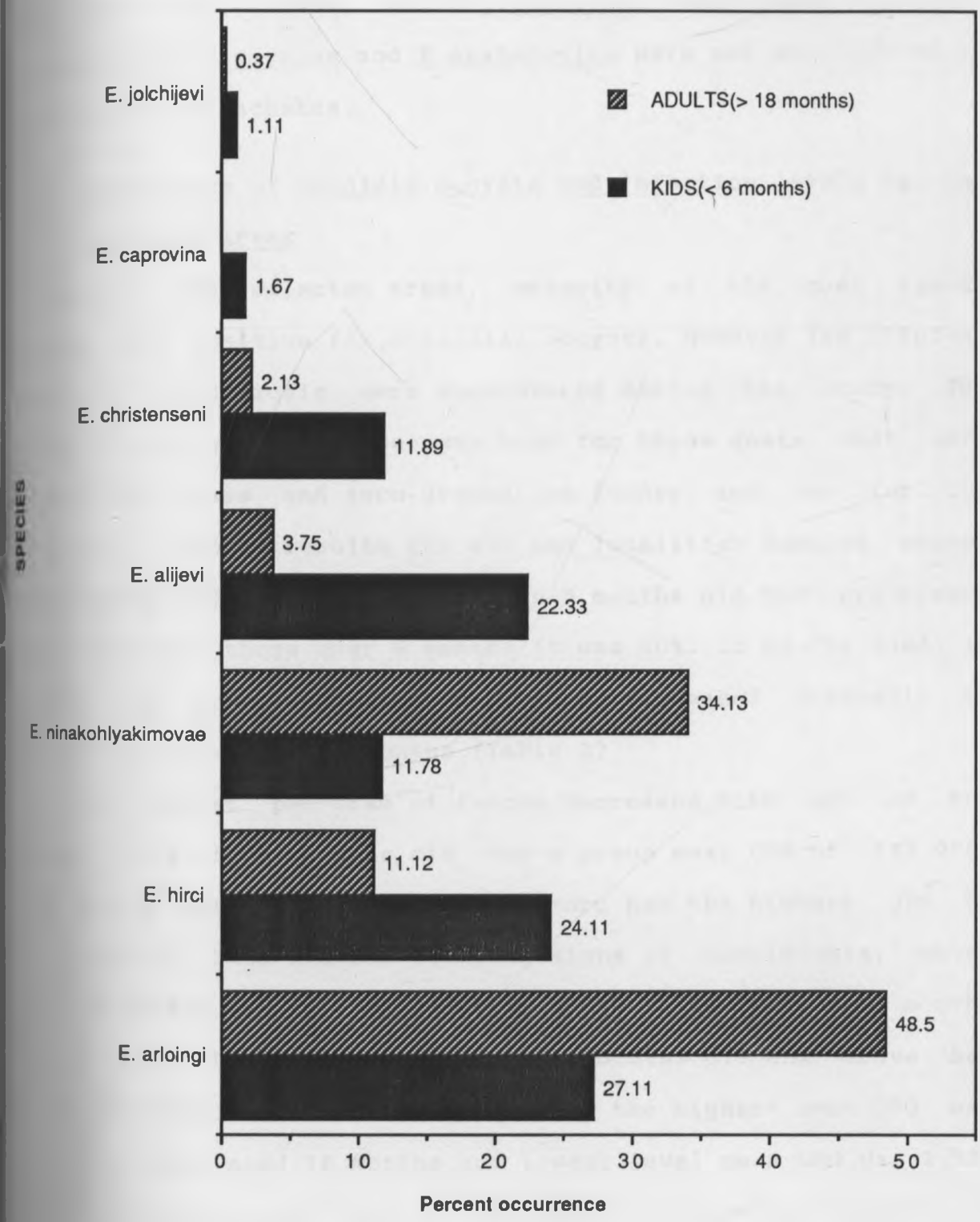


Fig. 16. Average percentages of Eimeria species at Naivasha

in goats at Naivasha.

From Machakos, samples were from adult goats only (Fig. 17). Six species of Eimeria were identified E.arloingi was the most prevalent (38.5%) while E.caprovina was least (1.75%). E.jolchijevi, E.caprina and E.apsheronica were not encountered in adult goats at Machakos.

4.3. Prevalence of coccidia oocysts and infection levels in the selected areas

In all the selected areas, majority of the goat faecal samples were positive for coccidian oocysts. However few clinical cases of coccidiosis were encountered during the study. The oocysts per gram of feaces was high for those goats that were grazed on grass and zero grazed on fodder and low for the browsers. Pooled results for all the localities sampled showed that, among kids that were less than 5 months old the prevalence was 100% while those over 6 months it was 80%. In adults aged 18 months the prevalence was 90 %, then decreased gradually to 86.21% in goats aged 48 months.(Table 2)

The oocyst per gram of feaces decreased with age of the goats. Kids of 2-3 months old had a group mean OPG of 152,970. One kid in this age group from Naromoru had the highest OPG of 1.5 million. This kid had clinical signs of coccidiosis, which were weakness, emaciation and diarrhoea. Those aged 4-5 months had a mean OPG of 49,680 while the 6 months old and above had 6,300 OPG (Table 2.). Among the adults, the highest mean OPG was 3,077 in those aged 18 months and lowest level mean OPG was 2,335 in the 48 months old. None of the adults was showing clinical

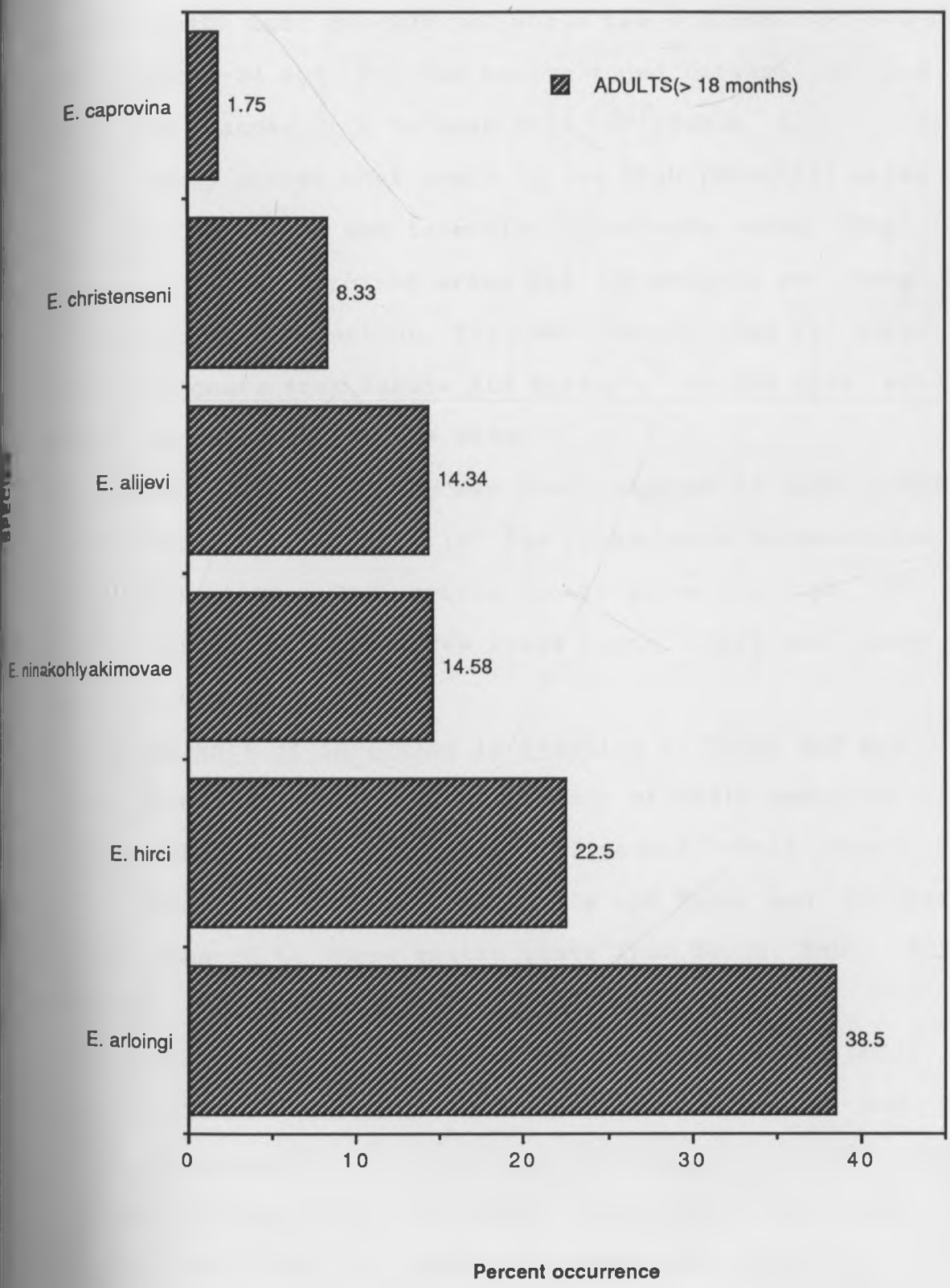


Fig. 17. Average percentages of Eimeria species at Machakos

signs of coccidiosis. The ranges followed the same pattern with kids of 2-3 months old having a an OPG range of 1,400-1,500,000, those 4-5 months had, 400-200,000 while the 6 months old and over ranged from 0-24,800. For the adults (aged between 18 and 48 months) the ranges were between 0-22,600 (Table 2).

This study showed that goats in the high potential areas had both high OPG values and infection prevalence rates (Fig. 18) while goats in the marginal areas had low oocysts per gram and low prevalence of infection. This was demonstrated by comparing the OPG's of goats from Kabete and Murang'a on one side against Kitengela and Machakos on the other.

In Naromoru where housing was poor compared to other areas the goats had high OPGs (Fig.18) The ranges were between 1400-1.5 million (Table 2). Zero grazed exotic goats had high OPG and infection prevalence than free range goats. This was shown by comparing Ngong and Naivasha.

4.4. Prevalence of infection in relation to breed and age.

The study showed that exotic breeds of adult goats had high OPG than the indigenous breeds. Indigenous adult goats from Murang'a Naromoru, Machakos, Kitengela and Thika had relatively low OPG compared to those exotic goats from Ngong, Embu, Kabete and Naivasha.

The young kids had the highest infection rate while the adults had the lowest. Kids less than 5 months of age had 100% infection rate while adults the infection rate was lower (Table 2). This showed that infection prevalence decreased with increasing age as did the number of oocyst per gram of

faeces (Table 2) The OPG was high in kids than in the adults (fig.18).

4.5. Significance of coccidiosis in the selected areas

Coccidiosis was significant in these areas. All the sampled goats were shedding Eimeria oocysts with some showing clinical coccidiosis as typified by a kid from Naromoru. No farm had any record of treatment or was taking prophylactic measures against the disease in goats. The goats studied had a fair general body condition except for the kids at Naromoru which were showing clinical signs of coccidiosis which were weak and emaciated.

OOCYSTS PER GRAM AND INFECTION PREVALENCE

BY AGE GROUP FROM SELECTED AREAS IN KENYA

LE 2

AREA	MEAN OPG	RANGE	AGE GROUP MEAN OPG	RANGE	INFECTED AGE GROUP N	%
MURANG'A	1700±624 n=3	1400-2400	152970	1400-	10	100
NAROMORU	304240 ± 668457 n=7	5400-1500000		1500000		
KABETE	49680± 79508 n=10	400-200,000	49680	400-200,000	10	100
NAIVASHA	6300±8411 n=10	0-24800	6300	0-24800	10	80
1.THIKA	2300±2572 n=19	0-6800	3077	0-22600	29	90.0
2.NAIVASHA	3855±3672 n=10	600-22600				
1.MACHAKOS	1883±1269 n=14	0-5400	2711			
2.NGONG	3130±256 n=21	0-13900		0-13900	50	89.29
3.NAROMORU	3320±1322 n=15	800-5600				
1.KABETE	3613±4503 n=10	0-12600	2651	0-12600	24	87.5
2.EMBU	1689±1091 n=14	0-3200				
1.KITE-NGELA	2670±5205 n=18	200-10,200	2335	0-10200	28	86.24
2.MURANG'A	2000±1411 n=10	0-5400				

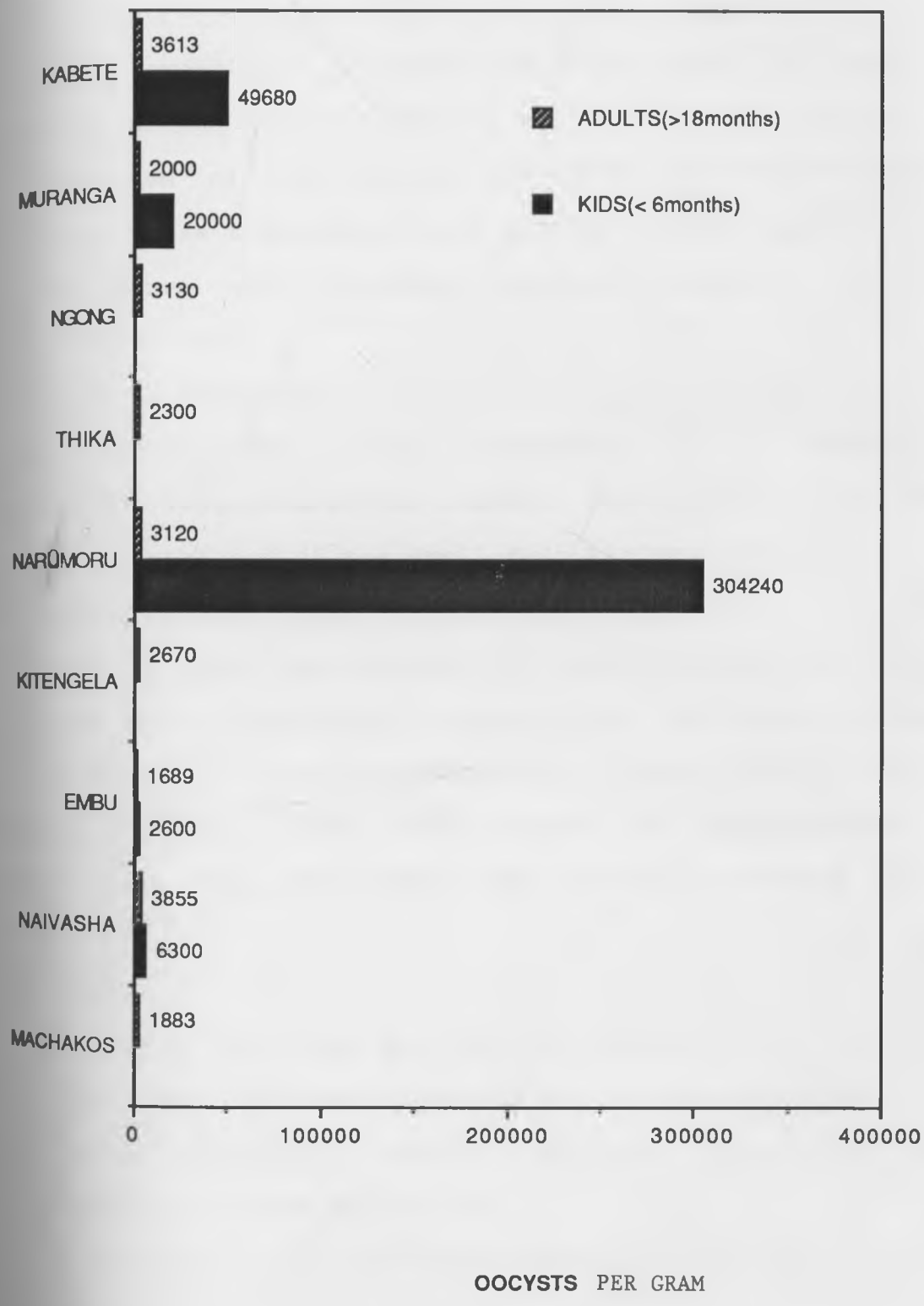


Fig.18 MEAN OOCYSTS PER GRAM FOR THE SELECTED AREAS IN KIDS AND ADULTS

PART II COCCIDIAL OOCYSTS:SEASONAL VARIATION,INFECTION LEVELS AND VARIOUS EIMERIA SPECIES IN GOATS OF VARIUOS AGES.

I.1 Introduction

This experiment concentrated on two farms at Ngong and Kitengela around Nairobi. The aim was to study the seasonal and the variation of mean oocysts per gram and various Eimeria species in these two farms over a period of three months.

The farms had different management systems breeds and weather conditions.

(a) Breeds of goats kept.

In Ngong, the flock consisted of a mixture of Anglonubians,Toggensburgs and Saanens. The Kitengela flock on the other hand consisted of the small East African goat breed.

(b) Feeding habits

Those at Ngong were grazers on extensive grassland composed of Kikuyu grass (Pennisetum clandestinum) and Rhodes grass.

The Kitengela flock were browsers on shrubs, small bushes and Themeda triandra grass. This flock was supplemented with mineral salt and commerical feeds especially during the dry season.

(c) Housing

At Ngong the goats were housed together in a wet soiled floor, the ventilation was poor and inadequate. There was a sharp urine odour especially on sunny mornings. The house had an accumulation of faeces and manure.

At Kitengela the goats were housed together in a spacious

wooden house covered with corrugated iron sheets. The house was erected in a large"boma" enclosure.

The ventilation was adequate. The house was swept daily and manure removed to a pile a distance from the house hence no accumulation of manure. The house was dry and had an outer chamber for busking during the day. The population density was low compared with the situation at Ngong.

(d) Care for the kids

At Ngong the kids accompanied their mothers once they were able to walk within one week after birth.

In Kitengela they were left in the boma and fed on concentrates until they were two months. They also fed on the shrubs in the"boma" enclosure.

(e) Treatment

At Ngong prophylactic treatment was not practiced, while at Kitengela this was practiced against helminthiasis. Drenching was done once every 3 months during the dry season and once a month for the rainy season.

The flock at Kitengela had a qualified technical assistant who visited the"boma" every morning to check for any sick animal. At Ngong only the herdsman checked on the goats.

3.2.2 Herd Structure of the Studied Animals

From each flock, 20 goats were randomly identified for faecal sample collection. The size of the flock from each station was 100 goats.

Ten kids (4 months old) and 10 adults (21 months old) were identified using numbered ear tags. Faecal sampling was done

weekly.

3.2.3. Methods of sampling:

The goats were sampled every Monday morning for 3 months from January to April 1989. The goats were sampled before going out for feeding. The goats were manually restrained by an assistant and the faecal samples were obtained per rectum using grooved index finger. About 6 grammes of faeces was obtained from each animal and put into labelled plastic cups with a record of age, ear tag number, breed, farm and general body condition.

The sample containers were corked after every animal was sampled and further details were recorded in a note book such as faecal consistency and presence of tape worm segments.

The samples were analysed as in part 1 to give the OPG and the species of Eimeria identified.

3.2.4. Statistical Analysis of the data

The statistical data analysis was carried out for Part II of the experiment to check whether the variation of various parameters studied was significant. The computer analysis was done using a users guide for least square computer programme by Harvey (1987), fixed models procedure. The fixed models were the sources of variation. Analysis of variance (ANOVA) was done and the graphs and ANOVA tables drawn out. From these significance of the variation were obtained. The significance levels considered were $P<0.01$ for the highly significant and $P<0.05$ significant.

The model for analysis was $y_{ij} = u + F_i + e_{ij}$

Where: F_i represents all fixed sets of effects (other than u)

such as discrete sets of cross-classified effects, interactions of discrete sets of effects, average or pooled partial regressions for continuous independent variables and individual class regressions for continuous independent variables. Var (e_{ij}) may be LO_{2e} (unweighted LS) or DO_{2e} (weighted LS) where D is a diagonal matrix.

CHAPTER FOUR: 4

PART II RESULTS

4.6.1 Eimeria species encountered in Ngong and Kitengela and their prevalence.

The results from Ngong are presented in Fig. 19 for both kids and adults . Seven species were identified in both groups of goats.

The most encountered species was E. arloingi with E. jolchijevi being the least. The overall prevalences were E. arloingi 44.96% E. hirci 20.28%, E. ninakohlyakimovae 14.85%, E. alijevi 17.50%, E. christenseni 1.11%, E. caprovina 0.63% and E. jolchijevi 0.67% (Table 3)

At Kitengela seven species were identified from both kids and adults (Fig. 20) .The prevalences of the species were E. arloingi 59.9%, E. hirci 14.53%, E. ninakohlyakimovae 12.65%, E. alijevi 7.64% E. christenseni 4.67%, E. caprovina 0.88% and E. jolchijevi 0.04%. E.caprovina and E.jolchijevi only occurred in kids. The most prevalent species was E.arloingi and while the least was E.jolchijevi. The variation of the species between the ages was not significant at both locations.

4.6.2 Weekly changes in oocyst output among goats at Ngong

The mean weekly OPG was high during the first 4 weeks of study in both adults and kids in Ngong and decreased gradually over the study period (Fig.21).The highest individual OPG count was encountered during the first week. The count was 193800 in a kid which had diarrhoea. Following the first month of study there was a dry spell of three weeks during which

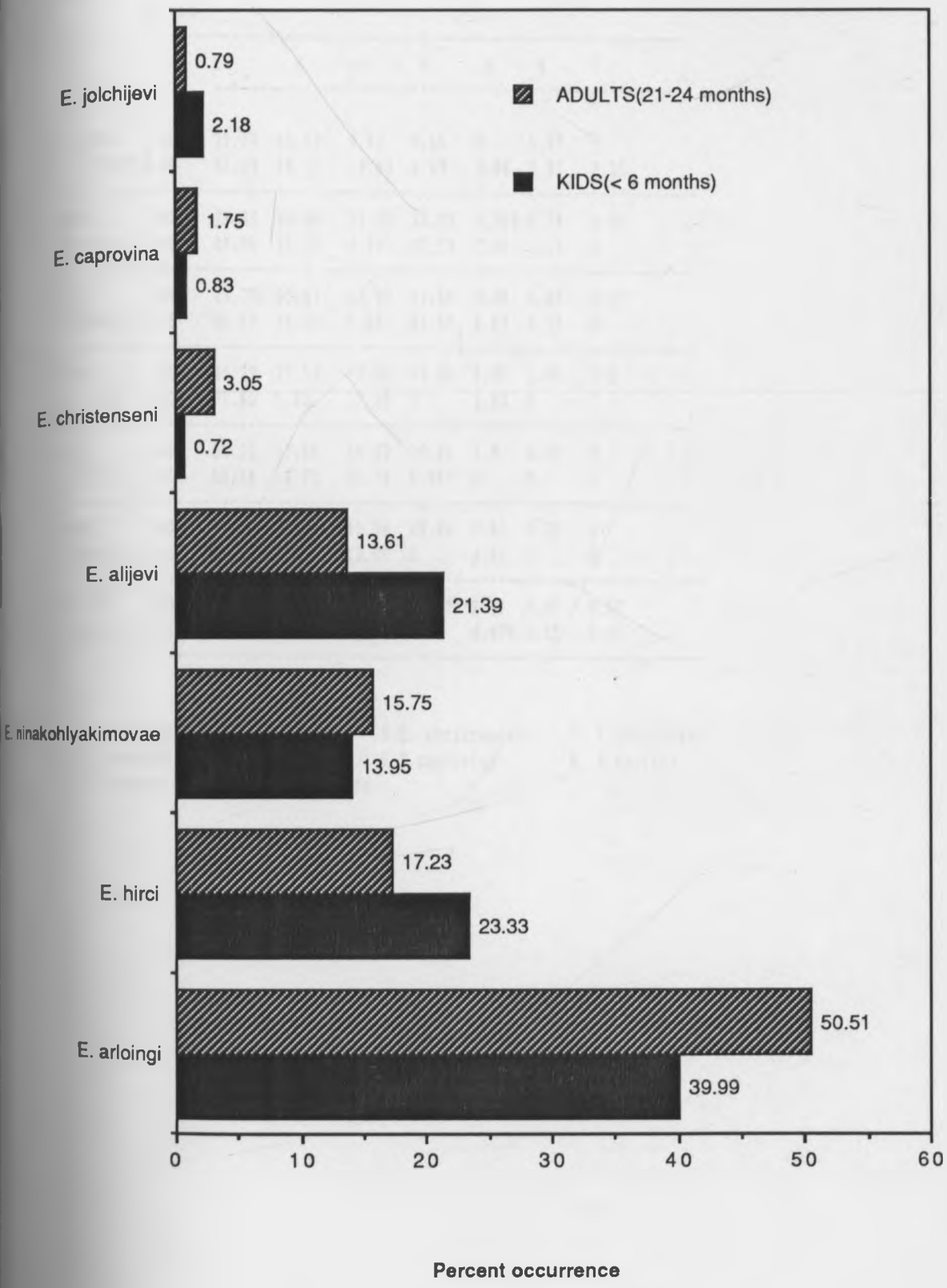


Fig. 19. Percentage occurrence of Eimeria species at Ngong over a period of 3 months

TABLE 4 : PREVALENCE OF SPECIES OF EIMERIA IN AGE GROUPS IN NGONG AND KITENGELA

AGE MON.	LOCATION	NUMBER OF SAM.	INDIVIDUAL SPECIES INDENTIFIED (PERCENT)*						
			1	2	3	4	5	6	7
4	1.NGONG	40	72.67	11.67	3.33	6.66	0	5.67	0
	2.KITENGELA	40	51.29	19.11	14.63	1.27	9.64	3.81	0.25
	NGONG	40	38.99	24.04	12.02	23.52	0.265	0.74	0.53
	KITENGELA	40	48.06	23.13	4.59	15.59	7.46	1.17	0
6	NGONG	40	43.73	23.47	10.27	21.65	0.38	0.23	0.27
	KITENGELA	36	58.63	11.65	3.89	22.67	2.83	0.33	0
21	NGONG	40	45.19	17.52	17.06	14.66	3.38	1.99	0.2
	KITENGELA	40	71.60	5.22	17.95	0	5.23	0	0
23	NGONG	40	55.23	17.66	14.62	10.21	1.9	0.38	0
	KITENGELA	40	58.24	12.71	22.74	6.31	0	0	0
33	NGONG	40	50.87	16.51	15.58	15.96	0.83	0.25	0
	KITENGELA	40	69.74	15.35	12.08	0	2.83	0	0
OVERALL PERCENT	NGONG	240	44.96	20.28	14.85	17.50	1.11	0.63	0.67
	KITENGELA	236	59.59	14.53	12.65	7.64	4.670	0.88	0.04

*KEY 1. E.arloingi 3. E.hirci 5.E. christenseni 7. E.jolchijevi
2. E.ninakohlya-komovae 4. E.alijevi 6.E.caprovina 8. E.caprina
9.E.apsheronica

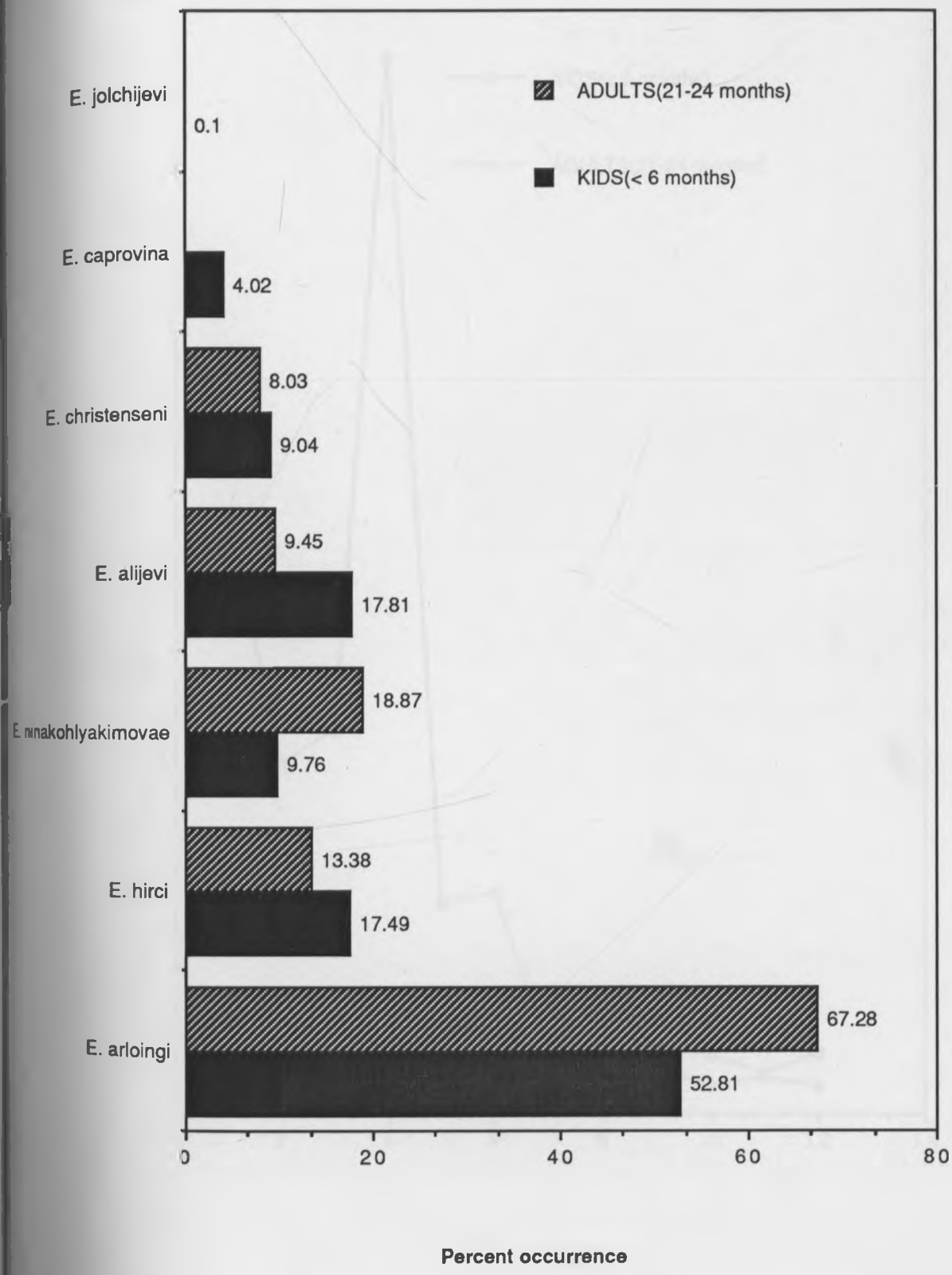


Fig. 20. Percentage occurrence of Eimeria species at Kitengela over a period of 3 months

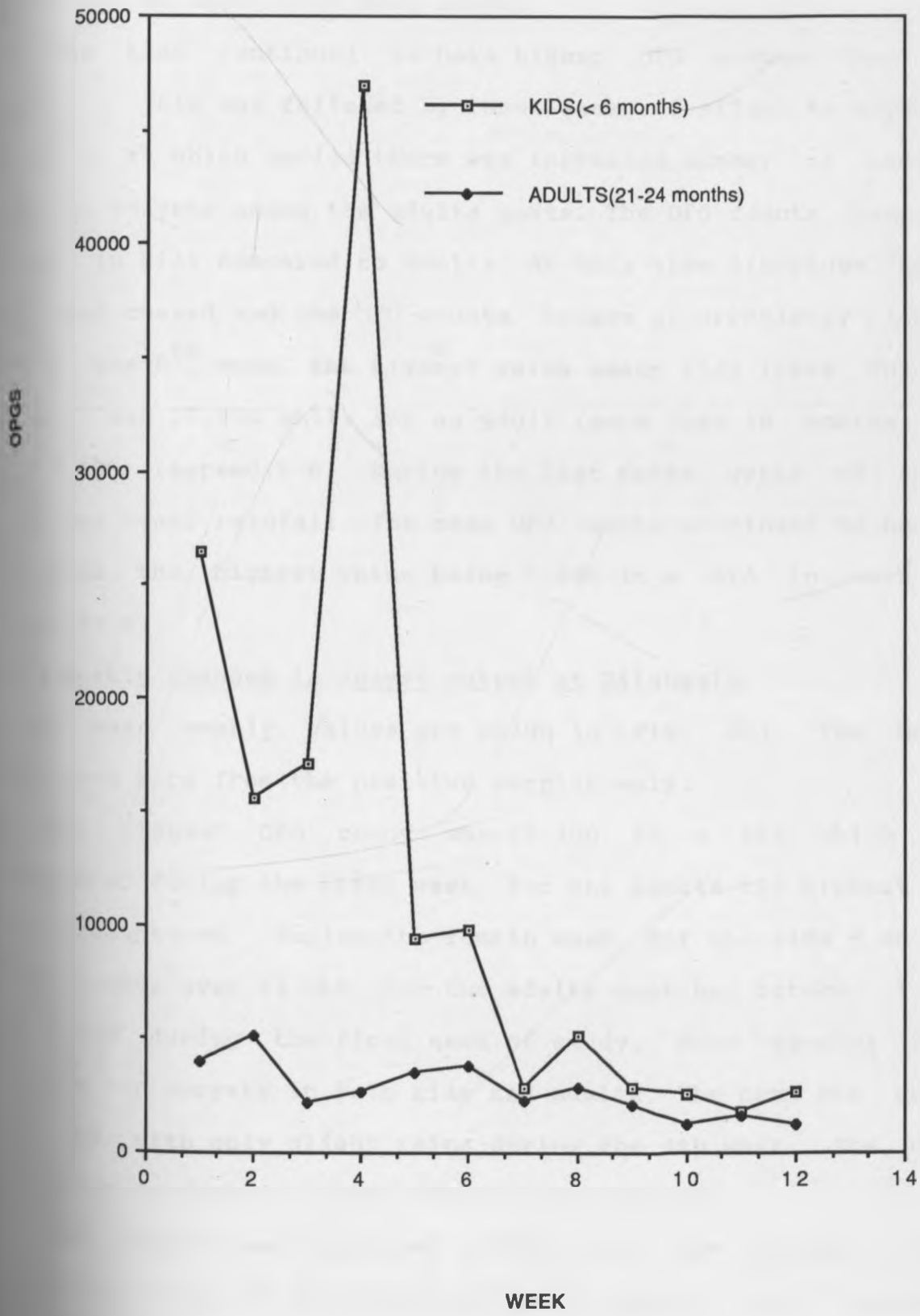


Fig. 21. Mean Weekly OPGS in kids and adults at Ngong

there was a progressive reduction in OPG count. The highest value during this period was 60,000 for a kid which had diarrhoea and 18,800 for an adult with soft faeces.

The kids continued to have higher OPG counts than the adults. This was followed by three weeks of slight to moderate rainfall at which period there was increased number of samples with no oocysts among the adults goats. The OPG counts remained higher in kids compared to adults. At this time diarrhoea among kids had ceased and the OPG counts became progressively lower. During the 8^{th} week, the highest value among kids (less than 6 months) was 17,400 while for an adult (more than 18 months) it was 9,000 (Appendix 6). During the last three weeks of study there was heavy rainfall. The mean OPG counts continued to become low with the highest value being 7,200 in a kid in week 10 (Appendix 6).

4.6.3 Weekly changes in oocyst output at Kitengela.

The mean weekly values are shown in (Fig. 22). The means considered were from the positive samples only.

The highest OPG count was 17,200 in a kid which was encountered during the first week. For the adults the highest was 6,800 encountered during the fourth week. For the kids 4 out of 10 had counts over 12,400. For the adults most had between 1,200 and 5,400 during the first week of study. Some samples were negative for oocysts in both kids and adults. The next six weeks were dry with only slight rains during the 4th week. The mean OPG values decreased slightly during the 2nd week.

The mean values increased slightly upto the 7th week. This was a reflection of individual OPG values which also increased

during the period reaching 10,200 oocysts per gram in one kid and 800 in an adult.

The ninth week was dry and OPGs were similar to those of the 7th week. The last three weeks were rainy with the heaviest rainfall during the 11th and 12th week. The mean OPG values decreased gradually. The highest count was 2000 in a kid while in an adult it was 1,200 during the last week. An average of 50% samples were negatives in kids while 40% samples were negative in adults. The mean weekly OPG was highest during the first week in kids and 4th week in adults. Consequently there was a general but fluctuent decrease in weekly mean OPG over the study period in Kitengela (Fig. 22) No goat in Kitengela showed clinical signs of coccidiosis.

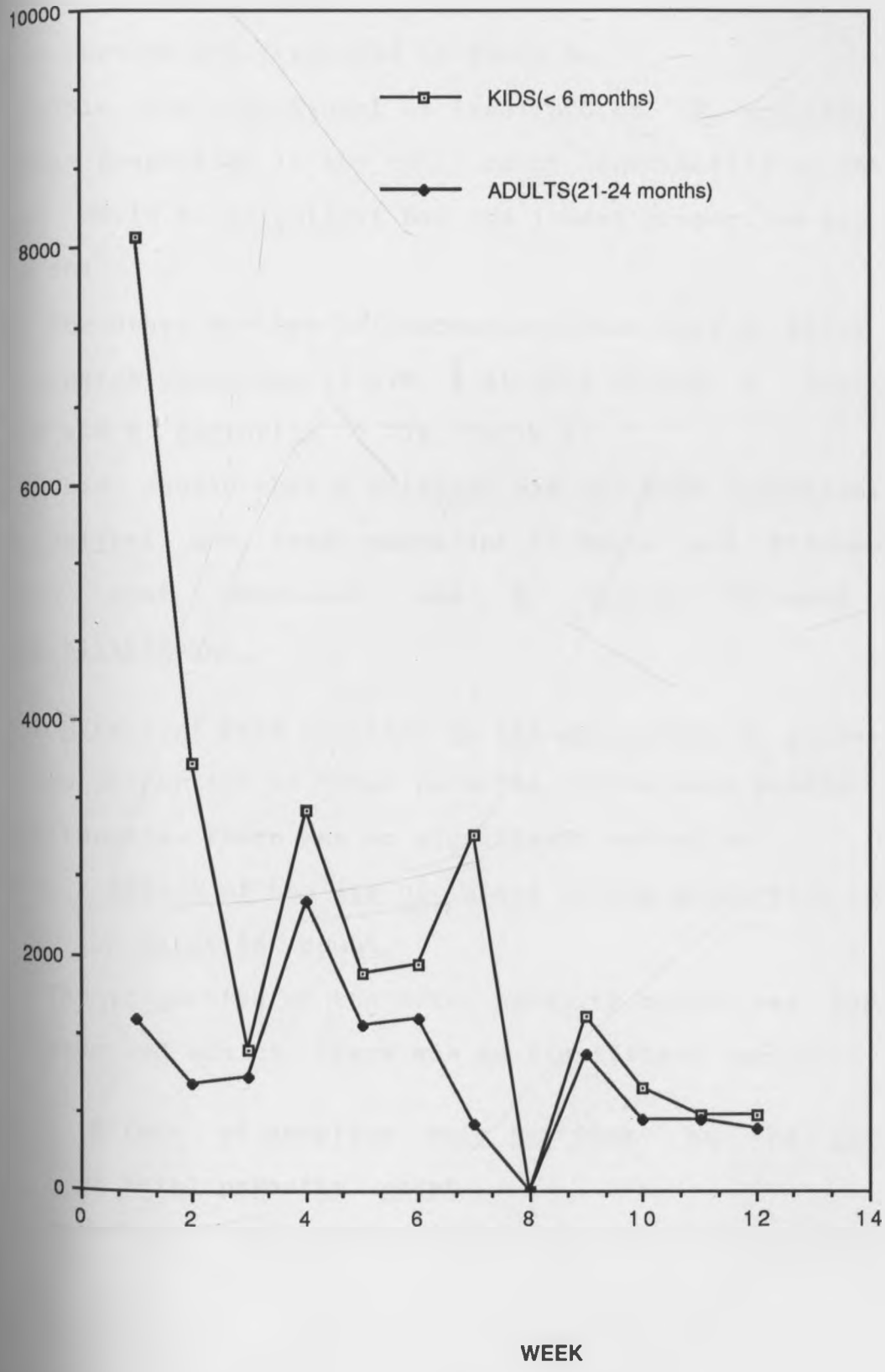


Fig. 22. Mean weekly OPGS in kids and adults at Kitengela

4.7. RESULTS OF STATISTICAL ANALYSIS.

4.7.1. Effect of species of parasites on the proportion of total parasite count.

These results are presented in Table 4.

This was significant at level $p<0.01$. E. arloingi had the highest proportion in the total count contributing 52.06% of the mean while E. jolchijevi had the lowest proportion with a mean of 0.50%.

The other species in decreasing order were E. hirci 17.38%, E. ninakohlyakimovae 13.67%, E.alijevi 12.63%, E. christenseni 2.98% and E. caprovina 0.77% (Table 5).

This showed that E arloingi was the most prevalent while E.jolchijevi was least prevalent in Ngong and Kitengela. The second most prevalent was E. hirci followed by E. ninakohlyakimovae.

4.7.2 Effect of Farm Location on the proportion of parasite count.

The proportion of total parasite counts were similar in Ngong and Kitengela. There was no significant variation.

4.7.3. Effect of the age of goats on the proportion of total parasite count.

The proportion of the total parasite counts was similar for both kids and adults. There was no significant variation.

4.7.4: Effect of sampling once per week on the proportion of total parasite count.

This was not significant at any level . Therefore the

TABLE 4 Analysis of Variance of proportion of Parasite in total count with location, age of animal, species of parasites and week of study in Ngong and Kitengela.

Source of variation	df	mean squares	f	prob
Location	1	0.14	$2x10_{-3}$	0.97
Age	1	0.92	$1.2x10_{-2}$	0.91
species of parasites	6	$1.48x10^{4}$	193.45	**0.01
Week of study	11	0.88	1.2x 10-2	1.00
ERROR	297	76.46		

Key
** P<0.01

TABLE 5. Least square means for variation proportion of parasites in total count with species of parasite

PARASITE	LEAST SQUARE MEANS ± S.E
1. E.arloingi	52.06 ± 1.29
2. E.hirci	17.38 ± 1.29
3. E.ninakohlya-kimovae	13.67 ± 1.32
4. E. alijevi	12.63 ± 1.29
5. E.christenseni	2.98 ± 1.33
6. E.caprovina	0.77 ± 1.29
7. E. jolchijevi	0.50 ± 1.31

proportion of total parasite count had no significant variation over the period of study.

4.7.5: Effect of location on the number per species counted.

This was significant at level $p<0.01$ (Table 6) Ngong had more number per species counted compared to Kitengela (Table 8) this showed that there were more parasites in Ngong than in Kitengela. Ngong had a mean of 22.18 while Kitengela had a mean of 11.51 per species counted.

4.7.6 Effect of species of parasite on number per species counted

This was significant at level $p<0.01$ (Table 6). Among the species encountered, E.arloingi had the highest number per species while E. jolchijevi had the lowest (Table 7). E.alijevi had the second highest number per species counted. The mean values were E.arloingi 50.45, E.alijevi 26.10, E. hirci 19.75, E ninakohlyakimovae 14.84, E. christenseni 5.57, E. caprovina 2.12 and E. jolchijevi 0.90 per sample.

This showed that E. arloingi was most abundant in numbers followed by E. alijevi (Table 7).

4.7.7: Effect of location on mean oocyst per gram (OPG).

This was significant at level $p<0.01$ (Table 9) Ngong Farm had a higher mean than Kitengela. The mean oocyst per gram of feaces in Ngong was 6850.50 $\pm$348.41 while in Kitengela it was 1516.32 $\pm$378.76. (Table 10). This showed that goats in Ngong had a higher mean oocyst per gram compared to those of Kitengela farm.

Table 6. Analysis of variance of number per species of Parasite counted with Location, species of parasite and week of study.

Source of variation	df	mean square	f	prob
Location	1	3.14x10	17.03	0.01
species of parasite	6	$5.7x10^3$	30.88	0.01**
week of study	11	93.76	0.51	0.89
ERROR	108	184.46		

Key
** P<0.01

Table 7. Least square means for variation of number per species counted with species of the parasite

PARASITE	LEAST SQUARE MEANS ± S.E
1. E.arloingi	50.45 ± 2.84
2. E.hirci	19.75 ± 2.91
3. E.ninakohya-kimovae	14.84 ± 3.06
4. E.alijevi	26.10 ± 3.16
5. E.christenseni	5.57 ± 3.37
6. E.caprovina	2.12 ± 3.62
7. E.jolchijevi	0.90 ± 4.29

Table 8. Least square means for variation of number per species counted with Location of farm

LOCATION	LEAST SQUARE MEAN S ± SE
Ngong	22.18 ± 1.60
Kitengela	11.51 ± 2.05

Table 9: Analysis of variance of mean OPG with Location species of parasites and week of study.

Source of variation	D.F.	Mean square	f	prop
Location	1	1.1×10^9	107.43	0.01**
species of parasite	6	0.00	0.00	0.99
week of study	11	2.13×10^8	20.84	0.01**
ERROR	142	1.02×10^7		

Key
** P<0.01

Table 10: Least square means for variation of mean OPG with Location of farm

LOCATION	LEAST SQUARE MEAN + SE
Ngong	6850.50 + 348.41
Kitengela	1516.32 + 378.76

4.7.8: Effect of week of study on mean oocyst per gram (OPG).

This was significant at level $p<0.01$ (Table 9). This showed that some weeks had higher mean oocyst per gram than others.

The highest mean OPG was encountered during the week 4 of the study while the lowest was during week 11 of the study (Table 11). The first four weeks of study had high mean oocysts per gram of faeces. The next three weeks had relatively lower mean oocysts per gram while the last four weeks had the lowest mean oocyst per gram.

4.7.9 Effect of species of Parasite on mean OPG.

This was not significant at any level (Table 9) Therefore there was no significant variation in mean oocyst per gram for the species encountered.

4.8. MEAN SIZES OF EIMERIA SPECIES IN NGONG AND KITENGELA

E. arloingi 28.91 X 20.23 microns

E. hirci 21.70 X 18.12 microns

E. ninakohlyakimovae 22.14 X 18.91 microns

E. alijevi 15.85 X 13.19 microns

E. christenseni 37.24 X 24.95 microns

E. caprovina 28.97 X 23.09 microns

E. jolchijevi 29.37X 21.98 x microns

Table 12 and 13)

Table 11: Least square means for variation of mean OPG with week of study.

WEEK	LEAST SQUARE MEAN ± SE
1.	10013.50 ± 853.42
2.	3429.00 ± 853.42
3.	5344.00 ± 853.42
4.	13833.00 ± 853.42
5.	4035.00 ± 853.42
6.	4222.50 ± 853.42
7.	2260.50 ± 853.42
8.	1322.91 ± 1234.05
9.	1906.50 ± 853.42
10.	1326.50 ± 853.42
11.	1239.00 ± 853.42
12.	1268.50 ± 853.42

Table 12: Least mean squares for variation of width of the parasite with the species of parasite

PARASITE	LEAST SQUARE MEANS ± S.E
1. E.arloingi	20.23 ± 0.14
2. E.hirci	18.12 ± 0.14
3. E.ninakohlya-kimovae	18.91 ± 0.15
4. E. alijevi	13.19 ± 0.16
5. E.christenseni	24.95 ± 0.17
6. E.caprovina	23.09 ± 0.18
7. E. jolchijevi	21.98 ± 0.22

Table 13: Least square means for variation of length of parasite with species parasite

PARASITE	LEAST SQUARE MEANS + S.E
1. E.arloingi	28.91 + 0.18
2. E.hirci	21.70 + 0.19
3. E.ninakohlya-kimovae	22.14 + 0.20
4. E. alijevi	15.85 + 0.20
5. E.christenseni	37.24 + 0.21
6. E.caprovina	28.97 + 0.23
7. E. jolchijevi	29.37 + 0.28

PART III. PATHOLOGY OF NATURAL EIMERIA INFECTIONS.

4.9.1 Introduction:

This part of the project was carried out to study the pathology caused by natural Eimeria infection in young kids and compare to the few available reports. The species of Eimeria causing the pathology were also identified.

4.9.2 MATERIALS AND METHODS

4.9.2.1. Kids and their management

Six kids aged between 1 and 4 weeks were purchased from small scale farmers around Ongata-Rongai Kajiado district and kept indoors in the animal compound.

They were fed on fresh cows milk for the first week during which time they were weaned to hay and concentrates.They had access to hay, concentrates and water ad libitum.

Faecal samples were collected from the rectum daily. Individual samples were analysed to give the oocysts per gram of faeces (OPG) and the Eimeria species infecting the individual kids. At least 40 sporulated oocysts were identified from every kid. This was done for three weeks and the values recorded for every kid.

4.9 2.2. Post mortem

After three weeks two kids died and a full postmortem was carried out. The other kids were euthanised one daily and postmortem carried out. Detailed examination was carried out on the intestinal tract from the duodenum to the rectum and also the mesenteric lymph nodes.

The macroscopic lesions such as oedema, congestion, haemorrhages, nodules and colour change were carefully noted in relation to their location, size and distribution through out the intestines and the mesenteric lymph nodes.

Histological samples were taken after every 30 centimetres starting from the duodenum up to the colon. Samples from each section of the intestines (duodenum, jejunum , ileum, caecum and colon) were fixed in 10% formalin. In cases where there were more lesions, more samples were taken. Samples of the mesenteric lymh nodes were also taken in all cases.

These samples were trimmed and processed for histology in paraffin wax. They were then sectioned at 5 microns and stained with haematoxylin and eosin (H&E). They were observed under a light microscope.

4.9.3 Results

All the kids were shedding Eimeria oocysts. The youngest kid (one week) had an OPG value of 50,000 while the oldest (4 weeks) had a value of 3,600 at the time of first sampling.

Over the period of study the OPG values decreased gradually and oocyst values are presented in Table 14 at two points in time, at the start and at their death.

Table 14 OOCYSTS VALUES FOR THE KIDS BEFORE AND AT DEATH.

KID NO.	Age at death and kind of death	OPG Values	
		Start	Death
21	3 Weeks-Euthanised	12,400	10,500
22	4 Weeks-Euthanised	30,300	20,500
23	3 Weeks-Natural	42,600	20,000
24	4 Weeks-Euthanised	3,600	3,200
25	3 Weeks-Natural	50,000	29,000

4.9.3.1. EIMERIA SPECIES INFECTING THE KIDS

All the kids were infected by a mixture of Eimeria species. 360 oocysts were considered.

Eimeria arloingi was the most prevalent species composing about 45% of all the species identified. The other species identified and their prevalences were E. ninakohlyakimovae 15%, E. hirci 15% E. alijevi 10%, E. christenseni 10%, and E. caprovina 3%. E. golchijevi, E. caprina and E. apsheronica composed about 2% of all the species identified in these kids.

4.9.3.2. MACROSCOPIC LESIONS

All the kids showed generalised congestion of the intestinal serosa. The congestion was more marked in the jejunum.

Mucosal haemmorrhages were found in the jejunum and ileum of one kid. They were more numerous in the jejunum.

Greyish-white nodular lesions were found in two kids. They were circumscribed and discrete. In one kid, the lesion was solitary in the jejunum and visible from the serosal surface. In the second kid these lesions were numerous. They were only visible on the mucosal surface. They were distributed from the duodenum up to the ileum.

These were more numerous in the jejunum where they appeared to fuse together. They were evenly distributed measuring about 1mm in diameter except in the ileum where they were fewer and larger measuring 5mm in diameter.

The mesenteric lymph nodes of two kids were slightly enlarged. There were no visible macroscopic lesions in the caecum and colon.

4.9.3.3. MICROSCOPIC LESIONS AND ENDOGENOUS STAGES

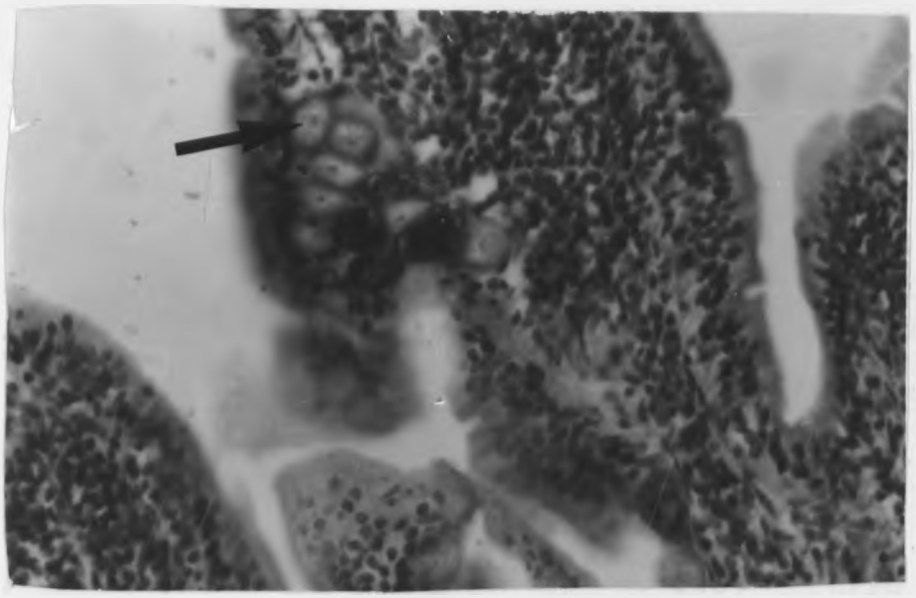
There was mild subacute enteritis which affected the whole of the small intestines from the duodenum up to the ileum and extended to affect part of the caecum and colon.

Marked congestion and submucosal oedema was also found particulary in the jejunum.

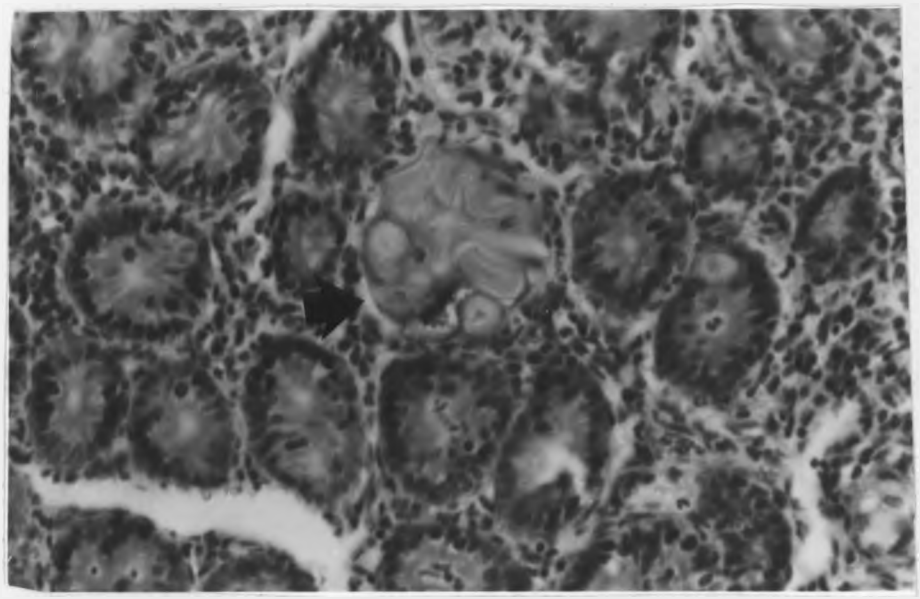
There was hypertrophy and hyperplasia of the mucosal glandular epithelial cells. Some of these were laden with macrogametes, microgametes and developing oocysts. These lesions were distributed from the duodenum up to the colon.

The macrogametes appeared as orange-red globular bodies (Fig.23a) packing the glandular cells and arranged as a chain of beads around the inner margin of the glandular epithelial cell. They were encountered through out the small intestines and part of the colon. The variation in their sizes ranged from 10-22.5 microns in length by 10-17.5 microns wide (average 14.68 X 12.27 microns) (n=42). The microgametes were fewer in number and were found in all the regions of the small intestine and colon. Their sizes ranged from 12.5 - 13.75 microns in length by 8.75-12.5 microns wide (average 13 X 10 microns) (n=15).

Developing oocysts were found in the duodenum ileum and colon (Fig. 23b). They had refractile eosinophilic walls with finely granular pinkish-blue contents. Like the macrogametes their sizes varied similarly in these regions from 15-27.5 microns (n=22) in length by 12.5-17.5 microns in width (average 20 X 13.4 microns). (Fig. 23b).



(a)



(b)

Fig.23: Histological section of intestines from goats naturally infected with coccidial oocysts showing (a) macrogametes and microgametes (arrow) and (b) developing oocysts (arrow) (H & E x 400)

Shortening of the villi occurred mainly in the jejunum and ileum while marked villi erosion occurred in the distal jejunum and ileum. One kid had submucosal haemorrhages accompanied by congestion in this region.

There was marked lymphocytic infiltration of the lamina propria which also involved few plasma cells and eosinophils. This infiltration affected whole small intestines and the colon.

In some sections of the mucosa of the caecum and colon there was erosion and destruction of the epithelial cells with polymorphonuclear leucocyte infiltration.

The greyish white nodular lesions were made up of hypertrophied glandular epithelial cells, fused villi, macrogametes and developing oocysts.

The peyers patches of the ileum of one kid were markedly enlarged. Among the kids with enlarged mesenteric lymph nodes the internodular trabeculae were not easily discernible.

CHAPTER 5: DISCUSSION

5.1 PART ONE: STUDIES IN SELECTED AREAS.

This study has shown that goats in Kenya shed coccidian oocysts and that parasites cause pathological lesions. This is in agreement with the findings of Mugera (1968) that coccidian parasites caused pathological lesions in Kenyan goat.

Kids had higher oocysts per gram of faeces which is in agreement with reports of other workers (Opoku -pare and Chineme,1979; Lima, 1980a; Lloyd and Soulsby, 1978; Vercruysse, 1982; Vujic and Ilic, 1985; Norton, 1986 and Kanyari, 1988b). The high oocyst counts from the young goats was consistent with the reported low degree of resistance that young animals have to coccidiosis (Hammond, 1964; Fayer, 1980).

This study has also shown that most Kenyan goats habour low levels of coccidia oocysts which they shed continously, this too has been reported (Opoku- pare and Chineme, 1979; Vercruysse, 1982; Norton, 1986; Magi *et al*. 1987; Kanyari, 1989; O'Callaghan, 1989).

Cases of clinical coccidiosis were encountered in kids at Maromoru farm. One kid had oocyst counts of up to 1.5 million per gram of faeces but in other areas no clinical cases were encountered. The shedding of the oocysts may be increased by change in the weather conditions, type of management, poor sanitation and hygiene, weaning stress, nutritional stress and presence of concurrent infection. These stress factors may also precipitate the clinical disease (Pellerdy, 1974; Opoku-pare and Chineme, 1979; Vercruysse, 1982; Norton, 1986). The oocyst count

also differed with management practices. This has also been reported by Opoku-pare and Chineme (1979) and Vercruysse (1982).

In some of the study areas, coccidiosis was not significant as a disease. This could have been due to good management and reduced stress to the animals, lack of concurrent infection. If the animals are protected from any stress or concurrent disease then coccidiosis will not be significant.

Samples in this study had multiple Eimeria species. This has also been reported by Pellerdy (1974), Opoku-pare and Chineme (1979) Lima (1980a), Vercruysee (1982) Sayin et al (1986) Hayat et al (1986), Norton (1986), Magi et al(1987), Guillous (1987) Kanyari (1988) and O'Callaghan (1989).

The most prevalent species was Eimeria arloingi. This has also been reported by Opoku-pare and Chineme (1979) in Nigeria, Lima (1980a) in U.S.A and Norton (1986) in S.E. England.

In this study the overall prevalence of E. arloingi was 37.67%, this compares with results of Opoku-pare and Chineme (1979) 58%, Lima (1980a) 98.8%, Norton (1986) 94% and O'Callaghan (1989) 81%.

Other species encountered in this study were E. ninakohlyakimovae , E. hirci , E. alijevi, E. christenseni, E. caprovina, E. jolchijevi , E. caprina and E. apsheronica . However their prevalence varied with location of farm and the age of the goats. They also varied with those reported by other workers in other parts of the world.

The sizes of these species and morphology were comparable to the descriptions given by Levine and Ivens (1970), Norton (1986)

and O'Callaghan (1989).

Other work in Africa was that of Vercruysee (1982) where species like E. crandallis, E.ahsata, E.faurei, E. parva and E.intricata were identified as species of goats. However, Norton (1986) revised the nomenclature of coccidia parasites in goats and sheep and concluded that E.crandallis in sheep is comparable to E. hirci in goats, E.ahsata in sheep is comparable to E. christenseni in goats, E. faurei to E.apsheronica and E.parva to E.alijevi. E. intricata has a large oocyst with a striated wall and is a sheep pathogen.

5.2. PART II STUDIES AT NGONG AND KITENGELA

Goat coccidia was prevalent in the two farms studied. kids were having higher oocyst counts than adults. A case of clinical coccidiosis was encountered in one kid having over 192,800 oocysts per gram at Ngong. Exotic breeds (Saanen and Toggenburgs) had higher oocysts per gram compared to indigenous (Small East African) in both adults and kids. This breed differences was also reported by Kanyari (1988b) that Anglonubians were shedding more oocysts than Saanens, Angora and British Alpine goats and O'Callaghan (1989) reported that domestic goats shed more oocysts than Feral ones.The breed differences are not yet explained.

Multiple infection was also the case in this study. Upto seven species were encountered per sample.

During the period of study E.arloingi was the most prevalent species in both farms. This was also reported by other researchers like Opoku-pare and Chineme, (1979), Lima, (1980a) and Norton, (1986). It was 44.5% at Ngong and 59.59% at Kitengela.

Other species encountered at Ngong were E.hirci, E.ninakohlyakimovea, E. alijevi, E.christenseni, E.caprovina, and E.lolchijevi. At Kitengela they were E.hirci, E. ninakohlyakimovae, E.alijevi, E. christenseni, E. caprovina. E. caprina and E.apsheronica were not encountered both at Ngong and Kitengela. These are rare species of Eimeria (Norton, 1986). The occurrence of the Eimeria species varied with location of farms. E. alijevi was more prevalent at Ngong while E.christenseni was more prevalent at Kitengela, the reason for

this difference is not known.

Regarding seasonal variation in the prevalence, there was no significant difference between the species of Eimeria, E.arloingi, remained the most prevalent species throughout the study period.

Vercruysse, (1982) observed no seasonal fluctuation in the prevalence of the coccidia in Senegal. His percentage prevalence of infection ranged from 74-95% while in this study the percentage prevalence ranged from 45-100%. His results were unexpected as climatic factors such as moisture, rainfall and temperature do influence coccidial infestations.
In this study these factors influenced coccidial infestation.

Goats at Ngong had higher mean oocysts counts than those at Kitengela. This was probably due to a combination of various factors; these being differences in breeds of goats kept there (Toggenburgs and Saanens for Ngong and Small East African goats for Kitengela), management practises, housing and enviromental condition.

All these factors were more favourable for oocyst development at Ngong hence high OPG than at Kitengela.. At Kitengela the goats were indigenous, housing was good, the enviroment was dry most of the weeks and they were browsers.

The proportion of individual Eimeria species per sample were the same for kids and adults and also for all weeks with no significant variation. The species were also the same for kids and adults with no significant variation. These agreed with observations of Vercruysse (1982). In his survey Norton (1986)

found E. arloingi to be predominant through out his survey. E. hirci was predominant in adults while E.christenseni was predominant in kids. This was also reported by Lima (1980a) and O'Callaghan (1989). In this survey there was no age predominance.

In terms of the number of each species counted and also oocyst per gram, this was higher in Ngong than in Kitengela. A possible explanation is that the factors mentioned above were more favourable for the oocysts development in Ngong.

The mean oocysts per gram varied with the weeks in both farms. It was high during the first weeks but the levels declined gradually. A possible explanation of the gradual decline in mean oocysts per gram is the age effect. Kids which contributed alot to the mean oocyst per gram were growing during the study period. Increase in age has been associated with increased immunity and resistance (Fayer, 1980) hence lowered oocyst per gram.

5.3. PART III PATHOLOGY OF NATURAL COCCIDIAL INFECTIONS.

Natural coccidial infections cause pathology in young kids as has been observed in this study. Greyish white nodular lesions found during this study have been reported by others like Levine et al. (1962) and Mugera (1968). These workers found numerous lesions in the duodenum and became progressively less posteriorly.

In this study these lesions were more numerous in the jejunum and fewer in both the duodenum and the ileum. This finding is in agreement with that of Opoku-pare and Chineme (1979) who reported numerous lesions in the jejunum and less in the ileum. They also found no macroscopic lesions in the duodenum unlike what was found in this study.

The microscopic lesions were distributed through out the small intestines, caecum and colon. However most lesions were concentrated in the small intestines. Some of the ealier workers like Opoku-pare and Chineme (1979) found no lesions in the caecum and colon.

Mature macrogametes and developing oocysts were encountered in caecum and colon. This has been reported by Norton (1986) where the caecum was thickened with congestion of the colon due to E. ninakohlyakimovae infection. Kanyari (1989) found for the first time giant first generation schizonts of E. apsheronica in the caecum of an experimentally infected goat.

Majority of the endogenous stages found in this study were macrogametes, which had a mean size of 14.68 X 12.27 microns. These sizes were in the ranges of those found by earlier workers

for various species of Eimeria. Sayin (1965) found macrogamates of E. ninakohlyakimovae to range in size from 9-18 x 13-17 microns while Sayin et al. (1966) found those of E. alijevi to range between 14-18 microns in length by 9-14 microns in width. Lima (1981) found macrogametes of E. Christenseni to range between 19-35 microns in length by 13-25 microns in width with a mean of 26 x 19 microns while Kanyari (1989) found that of E. apsheronica to be 24.7 x 18.5 microns. Few microgametes, developing and mature oocysts were also encountered.

No endogenous stages were seen in the mesenteric lymphodes in this study though this was reported by Pande and Bhatia (1967) in natural E. arloingi infection, Lima (1979b) in natural mixed E. arloingi, E. christenseni and E. crandallis infection while Kanyari (1989) reported them in an experimental E. apsheronica infection. A possible explanation in ths study is that the infection had progressed such that the stages had moved as merozoites to the intestines to develop to macrogametes and microgametes this being a natural infection.

CHAPTER 6. CONCLUSIONS

Kenyan goats habour and shed coccidia oocysts in variable numbers.The young goats shed more oocysts and are mainly the source of pasture contamination than the adults. Some of the young goats with OPG values of more than 190,000 were showing clinical signs of coccidiosis. The adults maintain low levels of oocyst output and act as carriers.

Though the goats appear healthy they usually habour large numbers of some of the pathogenic species like E. ninakohlyakimovae . Large oocyst counts do not necessarily mean clinical coccidiosis as some goats haboured high levels of upto 50,000 and looked healthy. The oocyst per gram varied with age being higher in young kids and low in adults due to development of immunity with age

Regarding seasons, goats habour and shed coccidia oocyst through out all the seasons in the areas studied. There was increased oocyst shedding during the rainy seasons due to increased survival of the oocyst and a decrease during the dry season due to their reduced survival.

Management practices were reflected in the oocysts counts especially housing. Goats housed in good sanitary conditions with constant removal of manure and faeces the counts were lower. This was because the oocysts which were shed in the faeces were prevented from accumulating, sporulating and being ingested in large numbers.

Grazing goats had higher oocyst counts than browsers. This was because the oocysts shed in the faeces usually sporulate at the ground and were likely to be picked by the grazers than

the browsers due to their feeding habits. This has been reported to be a contributing factor.

Those goats from high potential areas (with rainfall throughout the year) had higher oocyst counts than their counter parts from the marginal areas. This was due to favourable conditions for oocyst survival in the high potential areas than was the case in the marginal areas.

Eimeria arloingi was the predominant species through out the survey. The other species were E.hirci, E. ninakohlyakimovae, E. alijevi, E. christenseni, E.caprovina, E.jolchijevi, E.caprina, and E. apsheronica. Eimeria caprina and E. apsheronica were rare.

The prevalence of the individual species of Eimeria did not vary significantly with age and season (week of study) in Ngong and Kitengela farms covered in this study. Natural coccidial infections cause pathology in young kids. The pathologic lesions are distributed through out the intestinal tract but are most severe in the small intestines.

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APPENDICES

NDIX 1. SUMMARY OF VARIOUS PARAMETERS STUDIED IN THE SELECTED AREAS.

TION	NUMBER OF ANIMALS 1 ADULTS	2 KIDS	AGE (MON)	MEAN OPGS AND RANGE	COCCIDIAL OOCYSTS SPECIES	AVERAGE OOCYSTS SIZES OF INDIVIDUAL SPECIES (MICRONS)	RANGE OF SIZES OF INDIVIDUAL OOCYSTS(MICRON)
HE	10	10	1.36 2. 5	3613±4503 0-13900 49680±79508 1400-200, 000	E .arloingi	20.93±1.88x30.14±2.66 (n=56)	20-24x27-34
					E.ninakohly akimovae	20.94±1.24x23.35±0.93 (n=24)	20-24x22-24
					E.alijevi	13.17±1.59x16.5±2.02 (n=27)	12-16x12-18
					E.christen-seni	25.17±1.47x36.17±0.52 (n=8)	24-27x36-37
					E.hirci	19.71±2.14x23.71±1.80 (n=13)	16-24x20-27
					E.capr-ovina	24.33±0.58x29±2.65 (n=3)	24-25x27-32

ENDIX I CONTINUED

ANG'A	10	3	1.48	1.2000±1411 0-5400	1.E.arloingi	21.33±1.52x29.58±2.34	20-24x27-32
			2-3	2.1700±624 1200-2400	2.E.ninakonyl akimovae	20.83±1.34x23.17±1.34 (n=23)	20-24x20-24
					3.E hirci	18.29±1.38x22.29±1.38 (n=7)	16-20x20-24
					4. E.alijevi	14.4±67x17.2±1.1 (n=5)	12-18x16-18
					5.E.caprovina	21.67±1.9x27.5±3.20 (n=6)	20-24x26-18
					6.E.christen-seni	27 x 36 (n=1)	27-27x36-36

DIX 1 CONTINUED

21	-	24	3130±256	1.E.arloingi	21.42±1.62x29±1.46 (n=56)	20-24x27-32
			0-12600	2.E.ninakohy lakimovae	20.56±0.92x22.66±1.53 (n=29)	20-22x20-24
				3.E.hirci	19.93±1.15x22.67±1.71 (n=28)	18-22x20-24
				4.E.alijevi	15.75±0.71x17.75±0.71 (n=13)	14-16x16-18
				5.E.caprovina	22.33±1.97x25.33±2.66 (n=6)	20-24x36-38
				6.E.christen-	25±1.00x37.33±1.15 (n=5)	20-20x24-30
15	6	1.24 2.2-3	1.3320±1322 800-5600	1.E.ninakohy lakimovae	19.27±1.23x21.6±1.77 (n=65)	18-22x18-26
			2.304240±668 457	2.E.arloingi	20.50±0.88x28.75±1.62 (n=43)	20-22x26-32
			5400-1,500, 000	3.E.hirci	19.47±18x22.8±1.82 (n=14)	18-22x20-26
				4.E.alijevi	15.75±0.71x17.00±1.06 (n=11)	14-16x16-18
				5.E.christen- seni	24.71±0.49x36.86±1.07 (n=10)	24-25x36-38
				6.E.caprovina	23.57±0.53x29.43±1.51 (n=8)	23-24x28-32
				7.E.jolchi- jevi	22.5±0.71x29.00±1.41 (n=3)	22-23x28-32
				8.E.caprina	28±10x34±0 (n=1)	28-28x34-34
				9.E.apshero- nica	23±0x30±0 (n=1)	23-23x30-30

PENDIX 1 CONTINUED

THIKA	19 - 18	2300±2572	1.E.arloingi	20±00x26.91±2.26 (n=38)	20-20x24-30
		0-6800	2.E.ninakohy-lakimovae	19.56±0.88x21.33±1.41 (n=15)	18-20x20-24
			3.E.alijevi	14.83±17.00+0.89 (n=9)	14-16x16-18
			4.E.hirci	18.29±0.76x20.85±1.07 (n=7)	18-20x20-22
KITENGELA SHEEP & GOAT PROJECT	18 - 48	2670±5205	1.E.arloingi	21.43±1.45x29.43±1.45 (n=30)	20-24x28-32
		200-22600	2.E.hirci	18.40±1.26x21.6±2.07	16-20x18-24
			3.E.ninakohy	19.33±1.30x21.17±1.99	18-22x18-24
			4.E.alijevi	14.00±2.00x16.67±1.15 (n=8)	12-16x16-18
			5.E.caprovina	22.67±1.15x26.67±1.15 (n=6)	22-24x26-28
			6.E.jolchi-jevi	22.67±2.31x30.00±9.00 (n=3)	10-24x28-32
			7.E.apshero-nica	24.00±0.00x32.00±0.00 (n=1)	24-24x32-32

1.1

DIX 1 CONTINUED

U	14	36	1689±1091 0-3200	1.E.arloingi	20.29±0.73x29.14±1.29 (n=32)	20-22x28-32
STITUTE				2.E.ninakohy lakimovae	18.47±36x20.53±1.92 (n=24)	16-20x18-24
IC.				3.E.hirci	18.67±1.32x22.57±1.69 (n=23)	16-20x20-24
				4.E.christen-seni	25.25±0.89x37.13±0.83 (n=19)	24-27x36-38
				5.E.alijevi	15.14±1.57x17.43±0.99 (n=6)	12-16x16-18
				6.E.caprovina	24.00±10.0x26±0.0 (n=1)	24-24x26-26
				7.E.jolchi-jevi	20±0x26±0.0 (n=1)	20-20x26-26
VASHA GOAT	10	10	1.18	1.E.arloingi	20.59±0.94x28.94±1.52 (n=44)	20-22x27-32
			2.6300±8411 400-24800	2.E.hirci	18.77±1.22x23.05±1.00 (n=34)	16-20x22-24
				3.E.ninakohy lakimovae	19.33±1.19x22±1.66 (n=28)	18-22x20-24
				4.E.alijevi	15.14±1.95x16.86±1.07 (n=10)	12-18x16-18
				5.E.christen-seni	25.67±1.51x38.17±1.60 (n=6)	24-27x26-40
				6.E.jolchi-jevi	23.5±0.71x30.00±0.00 (n=3)	23-24x30-30
				7.E.caprovina	24±0.0x30.00±0.00 (n=1)	24-24x30-30

PENDIX 1 CONTINUED

MACHAKOS FARMERS TRAINING CENTRE	14 - 24	1883±1269 0-5400	1.E.arloingi	22.00±1.15x31.14±1.95 (n=24)	20-24x28-34
			2.E.hirci	19.20±1.11x22.0±2.00 (n=17)	18-20x20-24
			3.E.ninakohy lakimovae	19.33±1.15x22.67±2.3 (n=8)	18-20x20-24
			4.E.alijevi	16.0±0.0x18.00±0.00 (n=8)	16-16x18-18
			5.E.christen-seni	25.00±0.00x40.00±0.00 (n=4)	25-25x40-40
			6.E.caprovina	22.00±0.00x30.0±0.00 (n=2)	22-22x30-30

APPENDIX 2. NGONG GOVERMENT FARM - WEEKLY SUMMARY OF VARIOUS PARAMETERS
Week 1- Dry

NUMBER OF ANIMALS KIDS 1	ADULTS 2	AGE (MONTHS)	MEAN OPG STANDARD DEVIATION & RANGE	COCCIDIAL SPECIES ENCOUNTERED	MEAN SIZES AND STANDARD DEVIATION	RANGE OF SIZES OF OOCYSTS
10	10	4 21	1.26480 1800-193800	1.E.arloingi	20.3 x 29.04 ± ± 0.72 1.65	20-22x26-32 (n=49)
			2.4020± 3323 200-11000	2.E.hirci	18.00 x 22.74 ± ± 1.33 1.66	16-20x20-24 (n=29)
				3. E.ninakohy kimovae	19.41 x 21.88 ± ± 1.37 1.49	18-22x20-24 (n=27)
				4.E.alijevi	14.5 x 17.25 ± ± 0.93 1.04	14-16x16-18 (n=19)
				5.E.jolchi-jevi	22 x 29 ± ± 0.00 1.15	22-22x28-30 (n=7)
				6.E.christen-seni	24 x 36 ± ± 0.00 0.00	24-24x36-36 (n=2)
				7.E.caprovina	22 x 30 ± ± 0.00 0.00	22-22x30-30 (n=1)

endix 2 continued

2 RAINY

10	4	21	1.4040± 4750 1000-15600	1.E.arloingi	20.19 ± 0.60 x 28.67 ± 1.11	20-22x28-30 (n=48)
			2.50140-15000	2.E.hirci	18.86 ± 2.18 x 22.5 ± 2.50	16-22x18-27 (n=19)
				3.E.ninakohylakimovae	19.54 ± 1.66 x 22.77 ± 1.54	18-22x20-24 (n=17)
				4.E.alijevi	14.00 ± 1.63 x 15.50 ± 2.52	12-16x12-18 (n=11)
				5.E.caprovina	23.50 ± 0.71 x 29.00 ± 1.41	23-24x28-30 (n=5)
				6.E.jolchijevi	22.00 ± 0.00 x 31.00 ± 0.00	22-22x31-31 (n=4)
				7.E.christenseni	27.00 ± 0.00 x 38.00 ± 0.00	27-27x38-38 (n=2)

endix 2 continued

3 RAINY

10	4	21	1.17060± 36728	1.E.arloingi	20.21 x 29.11 ± 0.63 ± 1.79	20-22x27-32 (n=39)
			2.2140± 1500 200 - 4600	2.E.ninakohy lakimovae	19.00 x 21.57 ± 1.88 ± 1.60	16-22 x 20-24 (n=27)
				3.E.hirci	17.86 x 21.86 ± 1.83 ± 1.99	16-22x20-24 (n=23)
				4.E.alijevi	14.00 x 16.29 ± 1.63 ± 1.80	12-16x14-18 (n=21)
				5.E.christen-seni	25.00 x 36.00 ± 0.00 ± 0.00	25-5x36-36 (n=14)
				6.E.jolchijevi	22.5 x 30.00 ± 0.71 ± 0.00	23-23x30-30 (n=10)
				7.E.caprovina	24.00 x 30.00 ± 0.00 ± 0.00	24-24x30-30 (n=7)

ppendix 2 continued

EK 4 DRY

10	4	21	1.46960± 68209 2200 168800 2.2700 ± 2055 1000-6200	1.E.arloingi	20.09 x 28.39 ± 0.43 ± 1.16	20-22x27-30 (n=90)
				2.E.alijevi	14.0 x 15.54 ± 0.82 ± 1.20	12-16 x 12-16 (n=100)
				3.E.hirci	17.80 x 20.8 ± 1.48 ± 2.15	16-20x20-24 (n=18)
				4.E.ninakohylakimovae	19.33 x 21.55 ± 1.00 ± 2.40	18-20x18-24 (n=11)
				5.E.caprovina	23.30 x 29.00 ± 0.71 ± 0.58	23-24x28-30 (n=4)
				6.E.jolchijevi	23.00 x 30.67 ± 1.00 ± 0.58	22-24x30-31 (n=3)
				7.E.christenseni	27 x 38 ± 0.00 ± 0.00	27-27 x 38-38 (n=2)

ppendix 2 continued

EK 5 DRY

10	10	5	22	1.9400± 17880 1000- 60000	1.E.arloingi	20.00 ± 0.00 x 28.62 ± 1.17	20-20x27-30 (n=53)
				2.3500± 5489 400- 18800	2.E.alijevi	13.05 ± 0.15 x 15.68 ± 0.75	12-14x14-16 (n=58)
					3.E.hirci	17.89 ± 1.08 x 21.55 ± 2.12	16-20x18-24 (n=28)
					4.E.ninakohy-lakimovae	19.14 ± 1.07 x 20.57 ± 1.90	18-20x18-24 (n=8)
					5.E.christen-seni	27.0 ± 0.00 x 38.00 ± 0.00	27-27x38-38 (n=3)
					6.E.jolchijevi	22 ± 0.00 x 28.00 ± 0.00	22-22x28-28 (n=2)
					7.E.caprovina	23 ± 0.00 x 28 ± 0.00	23-23x28-28 (n=2)

ppendix 2 continued

X 6 DRY

10	5	22	1.9733± 13751 0- 39000	1.E.arloingi	20.17 ± 0.58 x 28.56 ± 1.41	20-22x27-32 (n=43)
			2.3778± 4166 0- 13600	2.E.hirci	17.73 ± 1.03 x 20.8 ± 1.97	16-20x18-24 (n=26)
				3.E.alijevi	13.85 ± 1.52 x 15.85 ± 0.99	12-16x14-18 (n=22)
				4.E.ninakohy-lakimovae	19.2 ± 1.47 x 22.27 ± 1.83	18-22x20-24 (n=20)
				5.E.caprovina	22.00 ± 2.83 x 28.5 ± 2.12	20-24x27-30 (n=3)

X 7 SLIGHT RAINFALL

10	5	22	1.2800± 2161 0-7200	1.E.arloingi	20.09 ± 0.44 x 28.29 ± 1.38	20-22x26-30 (n=59)
			2.2250± 1189 0-4000	2.E.hirci	17.85 ± 1.36 x 21.25 ± 1.61	16-20x20-24 (n=17)
				3.E.ninakohy-lakimovae	18.72 ± 1.35 x 22.00 ± 2.00	16-20x20-24 (n=14)
				4.E.alijevi	13.33 ± 1.63 x 16.33 ± 0.82	12-16x16-18 (n=12)
				5.E.jolchijevi	20.00 ± 0.00 x 26.00 ± 0.00	20-20x26-26 (n=3)
				6.E.christen-seni	25.00 ± 1.00 x 38.00 ± 2.00	24-26x36-40 (n=3)
				7.E.caprovina	22.00 ± 2.00 x 28.33 ± 1.53	20-24x27-30 (n=2)

ppendix 2 continued

8 MODERATE RAINFALL

10	6	23	1.5155± 5507	1.E.arloingi	20.48 ±0.87 X28.90±1.37	20-22x28-32 (n=68)
			0-18000 2.2825± 2772	2.E.hirci	17.22 ± 1.0 x 21.67 ± 1.71	16-18x20-24 (n=30)
			0-9000	3.E.ninakohylakimovae	18.00 ± 1.37 x 21.11 ± 1.41	16-20x20-24 (n=26)
				4.E.alijevi	13.6 ± 1.26 x 16.2 ± 1.14	12-16x14-18 (n=28)
				5.E.christenseni	24.5 ± 0.71 x 37.0 ± 1.41	24-25x36-38 (n=6)
				6.E.jolchijevi	22.0 ± 0.00 x 28.00 ± 0.00	22-22x28-28 (n=1)
				7.E.caprovina	23.00 ± 0.00 x 28 ± 0.00	23-23x28-28 (n=1)

pendix 2 continued

9 MODERATE RAINFALL

10	6	23	1.2875± 2541 0-9000	1.E.arloingi	20.31 ± 0.74 x 28.77 ± 1.36	20-22x26-30 (n=94)
			2.211 ± 2052 0-6600	2.E.hirci	17.85 ± 1.66 x 21.57 ± 2.38	16-20x18-24 (n=26)
				3.E.ninakohy-lakimovae	18.86 ± 1.51 x 21.86 ± 1.66	16-20x20-24 (n=20)
				4.E.alijevi	13.0 ± 1.09 x 15.67 ± 0.82	12-14x14-16 (n=6)

10 HEAVY RAINFALL

10	6	23	1.2560± 1938 800-7200	1.E.arloingi	20.35 ± 0.98 x 18.52 ± 1.83	20-24x26-32 (n=90)
			2.1280± 303 0-1600	2.E.hirci	17.4 ± 1.9 x 21.00 ± 1.41	16-20x20-24 (n=26)
				3.E.alijevi	12.4 ± 0.84 x 15.4 ± 1.35	12-14x12-16 (n=25)
				4.E.ninakohy-lakimovae	17.5 ± 1.77 x 20.00 ± 0.00	16-20x20-20 (n=12)
				5.E.jolchijevi	22.0 ± 0.00 x 31.00 ± 0.00	22-22x31-31 (n=5)

ppendix 2 continued

EK 11 HEAVY RAINFALL

10	10	7	24	1.1822 ± 1189 0-3600	1.E.arloingi	20.36 ± 0.79 x 29.45 ± 1.26	20-22x28-32 (n=60)
				2.1885± 1464 0-2000	2.E.alijevi	12.5 ± 0.89 x 14.63 ± 1.75	12-14x12-16 (n=48)
					3.E.hirci	17.11 ± 1.45 x 20.67 ± 1.41	16-20x20-24 (n=30)
					4.E.ninakohy-lakimovae	17.11 ± 1.76 x 20.00 ± 0.00	16-20x20-20 (n=27)

EK 12 HEAVY RAINFALL

10	10	7	24	1.2700± 2229 800-6800	1.E.arloingi	20.15 ± 0.54 x 28.81 ± 1.44	20-22x28-32 (n=78)
				2.1200± 1080 0-3600	2.E.alijevi	12.76 ± 1.34 x 15.52 ± 1.54	12-16x12-18 (n=62)
					3.E.hirci	17.38 x 21.88	16-20x20-24
						1.2 1.	86 (n=30)
					4.E.ninakohy-lakimovae	17.69 ± 1.38 x 20.62 ± 1.26	16-20x20-24 (n=24)
					5.E.caprovina	24 ± 0.00 x 30 ± 0.00	24-24x30-30 (n=7)
					6.E.christen-seni	24.5 ± 0.71 x 37.0 ± 1.41	24-25x36-38 (n=6)
					7.E.jolchijevi	22 ± 0.00 x 31.00 ± 0.00	22-22x31-31 (n=3)

NDIX 3. WEEKLY SUMMARY OF VARIOUS PARAMETERS STUDIED - KITENGELA SHEEP AND GOAT PROJECT

NUMBER OF IMALS D ADUL	AGE (MONTHS)	MEAN OPG STANDARD DEVIATION & RANGE	COCCIDIAL SPECIES ENCOUNTERED	MEAN SIZES AND STANDARD DEVIATION	RANGE OF SIZES OF OOCYSTS
10	4 21	1.8088± 5185 0-17200	1.E.arloingi	20.25±0.68x 28.75±1.18	20-22x27-30 (n=30)
		2.1466± 1549 0-5000	2.E.ninakohyla kimovae	19.64±0.81 x 21.82±1.89	18-20x20-24 (n=9)
			3.E.hirci	18.40±1.58 x 22.80±1.69	16-20x20-24 (n=5)
			4.E.christen-seni	25.33±1.37 x 36.67±1.03	24-27x36-38 (n=5)
			5.E.caprovina	23.50±0.58 x 29.00±1.15	23-24x28-30 (n=9)
			6.E.alijevi	14.00±1.79 x 16.67±1.03	12-16x16-18 (n=4)
X 2 DRY					
10	4 21	1.3622± 2318	1.E.arloingi	20.67±1.23 x 29.27±1.33	20-24x20-24 (n=39)
		0-7800 2.914±539 0-2000	2.E.ninakohy-lakimovae	19.14±1.07 x 22.29±1.80	18-20x20-24 (n=17)
			3.E.hirci	20.00±2.19 x 24.00±1.26	18-24x22-26 (n=14)
			4.E.christen-seni	24.75±0.50 x 38.00±1.63	24-25x36-40 (n=13)
			5.E.caprovina	24.00±0.00 x 30.00±0.00	24-24x30-30 (n=6)

Appendix 3 continued

EK 3 DRY

10	10	4	21	1.1200± 480 0-2000	1.E.arloingi	20.46±1.2 x 29.62±1.50	20-24x27-32 (n=33)
				2.975±328 0-1200	2.E.ninakohy-lakimovae	19.27±1.01 x 22.73±1.85	18-20x20-24 (n=19)
					3.E.hirci	19.0±1.07 x 23.0±1.51	18-20x20-24 (n=14)
					4.E.christen-seni	24.89±0.33 x 38.44±2.18	23-24x28-30 (n=2)
					5.E.caprovina	23.5±0.71 x 29.00±1.41	23-24x28-30 (n=20)
					6.E.jolchijevi	22.00±0.00x 30.00±0.00	22-22x30-30 (n=1)

EK 4 SLIGHT RAINFALL

10	10	5	22	1.2444± 2293 0-6200	1.E.arloingi	20.29±0.96 x 29.1±1.41	20-24x27-32 (n=27)
				2.3228± 2213 0-4800	2.E.hirci	19.40±0.97 x 22.8±1.40	18-20x20-24 (n=17)
					3.E.ninakohyla-kimovae	19.25 ±1.04 x 23.5±0.93	18-20x22-24 (n=9)
					4.E.christen-seni	25.00±0.00 x 38.80±1.79	25-25x36-40 (n=5)
					5.E.alijevi	14.00±0.00 x 16.00±0.00	14-14x16-16 (n=1)

ppendix 3 continued

X 5 DRY

0	10	5	22	1.1840± 2035 0-7400	1.E.arloingi	20.41±0.98 x 28.90±1.32 (n=67) 20-24x27-32
				2.1400± 1400	2.E.hirci	18.31±1.11 x 21.54±1.66 (n=26) 16-20x20-24
					3.E.alijevi	12.25±0.71 x 15.00±1.51 (n=43) 12-14x12-16
					4.E.ninakohy-lakimovae	19.11±1.05 x 23.11±1.05 (n=11) 18-20x22-24
					5.E.christen-seni	25.0±0.00 x 38.00±0.00 (n=4) 25-25x38-38

X 6 DRY

	10	5	22	1.914± 1918 0-5600	1.E.arloingi	20.31±0.75 x 28.92±1.32 (n=34) 20-22x28-32
				2.1467± 1330 0-3600	2.E.ninakohyla-kimovae	19.20±1.03 x 22.2±1.75 (n=22) 18-20x20-24
					3.E.hirci	18.29±1.38 x 20.86±1.07 (n=18) 16-20x20-22
					4.E.christen-seni	24.33±0.58 x 36.67±1.15 (n=12) 24-25x36-38
					5.E.alijevi	12.00±0.00 x 14.00±2.83 (n=9) 12-12x12-16

ppendix 3 continued

K 7 DRY

9	10	5	22	1.3025± 3504	1.E.arloingi	20.27±1.03 x 29.1±1.26	20-24x28-32 (n=56)
				567±150 0-800	2.E.hirci	18.86±1.57 x 21.71±1.80	16-20x20-24 (n=29)
					3.E.alijevi	13.00±1.67 x 16.33±0.82	12-16x16-18 (n=27)
					4.E.ninakohy-lakimovae	19.6±0.89 x 23.2±1.79	18-20x20-24 (n=8)
					5.E.christen seni	24.33±0.58 x 36.67±1.15	24-25x36-38 (n=5)
					6.E.caprovina	23.5±0.71 x 29 ±1.41	23-24x28-30 (n=3)

K 9 DRY

9	10	6	23	1.1160± 899 0-2600	1.E.arloingi	20.00±0.00 x 28.88±1.25	20-20x27-30 (n=31)
				2.1480± 996 0-2400	2.E.hirci	18.40±0.89 x 21.2 ±1.79	18-20x20-24 (n=17)
					3.E.alijevi	12.00±0.00 x 16.00±6.00	12-12x16-16 (n=15)
					4.E.ninakohyla-kimovae	18.00±0.00 x 22.67±2.31	18-18x20-24 (n=13)

Appendix 3 continued

EEK 10 MODERATE RAINFALL

9	10	6	23	1.867± 643 0-1600	1.E.arloingi	20.00±0.00 x 29.00±1.22	20-20x27-30 (n=27)
				2.600± 126 0-800	2.E.hirci	17.60±1.67 x 20.4±0.89	16-20x20-22 (n=13)
					3.E.alijevi	12.00±0.00 x 16.00±0.00	12-12x16-16 (n=9)
					4.E.ninakohyla-kimovae	20±0.00 x 24.00±0.00	20-20x24-24 (n=6)

EEK 11 HEAVY RAINFALL

9	10	6	23	1.600± 200 0-800	1.E.arloingi	20.00±0.00 x 28.63±1.19	20-20x27-30 (n=20)
				2.650± 661 0-1600	2.E.alijevi	12±0.00 x 16.00±0.00	12-12x16-16 (n=13)
					3.E.ninakohy-lakimovae	18.67± 0.15 x 22.67±2.31	18-20x2024 (n=11)
					4.E.hirci	17.00±1.41 x 20.00±0.00	16-18x20-20 (n=6)

pendix 3 continued

K 12 HEAVY RAINFALL

10	7	24	1.640± 780 0-2000	1.E.arloingi	20.71±1.49 x 29.64±1.45	20-24x27-32 (n=30)
			2.533± 577 0-1200	2.E.hirci	19.5±18.6 x 22.50±1.91	18-20x20-24 (n=12)
				3.E.christen-seni	24.29±0.49 36.28±1.38	24-25x34-38 (n=11)
				4.E.ninakohyla-kimovae	20.00±0.00 x 24.00±0.00	20-20x24-24 (n=5)
				5.E.caprovina	23.5±0.71 x 30.00±0.00	23-24x30-30 (n=3)

APPENDIX 4: NGONG FARM: MOST ENCOUNTERED EIMERIA SPECIES PER SAMPLE FOR 3 MONTHS

SAMPLE NO	WK 1	WK 2	WK 3	WK 4	WK 5	WK 6	WK 7	WK 8	WK 9	WK 10	WK 11	WK 12
4615	arloingi	arloingi	arloingi	arolingi	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi
4617	arloingi	arloingi	ninakohy-lakimovae	hirci	hirci	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi
4620	arloingi	arloingi	alijevi	arloingi	hirci	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi
3592	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi	NONE	hirci	alijevi	arloingi
4613	ninakohy-lakimovae	arloingi	arloingi	alijevi	alijevi	alijevi	arloingi	arloingi	arloingi	alijevi	arloingi	arloingi
4611	hirci	arloingi	arloingi	arloingi	alijevi	NONE	hirci	NONE	hirci	hirci	NONE	hirci
4624	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi
4623	arloingi	ninakohy-lakimovae	arloingi	arloingi	arloingi	arloingi	NONE	arloingi	arloingi	arloingi	arloingi	arloingi
4621	arloingi	arloingi	arloingi	alijevi	arloingi	hirci	arloingi	alijevi	arloingi	arloingi	arloingi	arloingi
4606	arloingi	arloingi	arloingi	hirci	hirci	hirci	arloingi	hirci	NONE	arloingi	arloingi	arloingi
A D U L T S												
3555	hirci	arloingi	arloingi	arloingi	arloingi	arloingi	NONE	hirci	hirci	arloingi	arloingi	arloingi
023	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi	NONE	NONE	arloingi	arloingi	NONE	arloingi
021	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi	NONE	arloingi	arloingi
4350	ninakohy-lakimovae	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi	NONE	arloingi	NONE
024	ninakohy-lakimovae	hirci	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi
4039	arloingi	arloingi	christe-nseni	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi	NONE	NONE	ninakohy-lakimovae
025	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi	NONE	arloingi	arloingi	NONE	arloingi
018	arloingi	arloingi	arloingi	alijevi	arloingi	arloingi	arloingi	arloingi	arloingi	NONE	arloingi	arloingi
3562	arloingi	hirci	alijevi	hirci	arloingi	arloingi	arloingi	arloingi	NONE	NONE	arloingi	NONE

APPENDIX 5: KITENGELA MOST ENCOUNTERED SPECIES OF EIMERIA PER SAMPLE FOR 3 MONTHS

SAMPLE NO	WK 1	WK 2	WK 3	WK 4	WK 5	WK 6	WK 7	WK 8	WK 9	WK 10	WK 11	WK 12
C 1145	*arloingi*	*arloingi*	*arloingi*	*arloingi*	arloingi	arloingi	arloingi	GOAT WERE NOT	NONE	NONE	NONE	arloingi
C 1141 1776	hirci	arloingi	ninakahy-lakimovae	arloingi	arloingi	NONE	NONE		NONE	NONE	NONE	NONE
C 1137	arloingi	arloingi	arloingi	hirci	hirci	hirci	hirci		alijevi	NONE	NONE	NONE
C 1139 173	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi	hirci		arloingi	arloingi	arloingi	arloingi
C 1146	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi		arloingi	arloingi	arloingi	arloingi
C 1136 1736	arloingi	arloingi	arloingi	arloingi	arloingi	NONE	arloingi		arloingi	NONE	NONE	arloingi
C 1147	arloingi	arloingi	arloingi	arloingi	arloingi		GOAT	DIED	AFTER ABDOMINAL TRAUMA			
C 1144	NONE	NONE	NONE	arloingi	arloingi	arloingi	arloingi	AVAILABLE SO NO SAMPLES SECURED	arloingi	arloingi	NONE	arolingi
C 1140 1775	hirci	hirci	arloingi	NONE	arloingi	christe-nseni	arloingi		NONE	NONE	NONE	NONE
C 1150	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi		arloingi	arloingi	arloingi	arloingi
C 1127 1754	arloingi	NONE	arloingi	arloingi	arloingi	NONE	NONE		NONE	NONE	NONE	NONE
C 1123	NONE	arloingi	arloingi	NONE	arloingi	NONE	NONE		NONE	NONE	NONE	NONE
C 1741	arloingi	arloingi	arloingi	NONE	arloingi	arloingi	arloingi		NONE	NONE	arloingi	NONE
C 1120	arloingi	arloingi	hirci	NONE	arloingi	NONE	arloingi		arloingi	arloingi	arloingi	NONE
C 1101	christe-nseni	NONE	arloingi	arloingi	arloingi	hirci	NONE		NONE	NONE	NONE	arloingi
C 1112	ninakohy-lakimovae	ninakohy-lakimovae	ninakohy-lakimovae	arloingi	arloingi	arloingi	arloingi		arloingi	NONE	NONE	arloingi
C 1107	ninakohy-lakimovae	ninakohy-lakimovae	ninakohy-lakimovae	ninakohy-lakimovae	arloingi	arloingi	arloingi		arloingi	arloingi	arloingi	NONE
C 1104	arloingi	arloingi	arloingi	arloingi	arloingi	NONE	NONE		arloingi	arloingi	NONE	NONE
C 1125	arloingi	NONE	NONE	arloingi	arloingi	arloingi	arloingi		arloingi	arloingi	NONE	arloingi
C 1132	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi	arloingi		NONE	arloingi	NONE	NONE

APPENDIX 6: WEEKLY OOCYSTS PER GRAM (OPG) NGONG COVERNMENT VET. FARM

SAMPLE NO	WK 1	WK 2	WK 3	WK 4	WK 5	WK 6	WK 7	WK 8	WK 9	WK 10	WK 11	WK 12
4615	15000	1000	2200	3000	5600	1600	800	1000	2200	1800	2400	1600
4617	19000	15600	8000	4400	6000	27400	7200	18000	9000	4400	1600	800
4620	193800	9400	4800	168800	4000	3200	2800	1800	1600	7200	7200	1800
3592	2000	1600	4200	3400	1200	4000	400	3400	0	800	400	1200
4613	1800	1400	120600	124800	60000	39000	2800	6000	3000	2800	1800	1200
4611	5200	2800	1400	2200	2000	0	3000	0	1400	1200	0	800
4624	4600	3200	7600	10400	5000	7200	3800	1600	1800	1400	400	6400
4623	7600	2600	1800	140000	6000	1600	0	600	1400	1200	600	6800
4621	13800	1000	18200	9800	3200	3200	4000	8600	2600	2200	3600	3200
4606	2000	1800	1800	2800	1000	400	400	5400	0	2600	3200	3200
MEAN	26480	4040	17060	46960	9400	9740	2800	5160	2780	2560	1830	2700
3555	4400	3200	3600	1000	1200	400	0	3400	600	1600	800	600
023	1100	2800	4600	2200	2800	600	0	0	3000	800	0	600
021	7400	15000	3400	5000	18800	4800	2200	9000	6600	0	4600	600
4350	200	3400	3200	1000	1400	0	800	800	600	0	1000	0
024	1200	2200	200	1000	3000	2400	1800	1400	800	1400	3000	6000
4039	2000	5400	600	3000	2000	400	1800	800	1200	0	0	2000
025	2800	3400	1000	5200	400	3000	3400	0	1200	1200	0	1000
018	600	2000	1000	1800	1000	2800	800	2600	1000	0	400	600
3562	3400	9600	1400	600	6000	4000	800	0	0	0	1600	0
[illegible]	6200	4400	2400	6200	2800	13600	3200	3800	4000	1600	[illegible]	2600

SAMPLE NO	WK 1	WK 2	WK 3	WK 4	WK 5	WK 6	WK 7	WK 8	WK 9	WK 10	WK 11	WK 12
C 1145	12400	2000	2000	1000	800	600	4200	GOATS	0	0	0	600
C 1141	2800	2000	800	600	1000	0	0		0	0	0	0
C 1137	12600	6000	1400	400	400	1400	1400		2600	0	0	0
C 1139	5400	3000	1000	400	1200	600	400		400	0	800	0
C 1146	17200	1800	1800	6200	2600	1400	10200		0	600	600	200
C 1147	2200	2000	1000	4800	1400	GOAT	DIED	AFTER	ABDOMINAL	TRAUMA		
C 1136	1200	2000	800	800	800	1400	600	WERE NOT AVAILABLE	1200	0	0	200
C 1144	0	0	0	4800	7400	3400	1000		1200	400	0	200
C 1140	6000	7800	600	0	1200	5600	5800		0	0	0	0
C 1150	13000	600	1400	3000	1000	400	600		400	1600	400	2000
MEAN	8090	3025	1200	2450	1780	1850	3025		1160	870	600	640
C 1127	1200	0	1200	3200	1200	0	0		0	0	0	0
C 1123	0	800	1200	0	200	0	0		0	0	-	0
C 1741	800	800	1000	0	600	400	600		0	0	200	0
C 1120	600	1200	1000	0	1200	0	400		400	600	600	0
C 1101	5400	0	1000	6800	5000	2400	0		0	600	0	200
C 1112	1200	600	1000	5000	0	400	400		400	0	200	200
C 1107	400	600	1200	1600	1000	3600	600		2000	800	1600	0
C 1104	1400	2000	0	1400	1400	0	0		2200	600	0	0
C 1125	1800	0	0	600	1200	1600	800		2400	400	0	1200
C 1132	400	400	200	4000	800	400	600		0	600	0	0
MEAN	1470	920	975	3230	1400	1470	570		1480	600	650	540

KIDS

ADULTS