CHAPTER 1: INTRODUCTION

Nearly all cattle are infected with coccidia, but only a limited number suffer from coccidiosis. The disease occurs mainly in young animals, indicating that immunity may play a role in the protection of older animals. Occasionally it may occur in calves over 6 months of age or even in adult cattle (Joyner, Norton, Davies and Watkins 1966). The two most common factors that precipitate coccidiosis are (1) a severely contaminated environment and (2) stress-related relaxation of immunity (Schillhorn van Veen 1986).

Coccidiosis is particularly a problem of confined animals. Intensive animal husbandry practices have increased the problem of coccidiosis. Coccidiosis affects over 50% of cattle, sheep and goats and is considered the fifth most important bovine disease in the USA (Schillhorn van Veen 1986).

Many cattle are subclinically infected resulting in considerable economic losses. Subclinically infected animals appear normal outwardly, but suffer from reduced feed consumption, feed conversion and growth performance. The severity of the infection is related to the number of ingested oocysts.

In the USA 2-3 million cattle are treated annually for clinical coccidiosis. Depending upon other conditions, as many as one in five of these animals die (Fox 1985).

Economic losses from coccidiosis due to mortality, poor performance, cost of treatment and prevention may be considerable, especially in stud farms and calf-rearing systems. Coccidiosis costs cattle ranchers more than $400 million annually in lost profits due to reduced feed efficiency, slower weight gain and increased susceptibility to other diseases. This can set back calves' growth by as much as two months (Thomas 1994).

1.1 JUSTIFICATION

Literature review

Bovine coccidia are protozoan parasites of the genus *Eimeria*. The parasites, which are host specific, belong to the order Eucoccidiorida of the phylum Apicomplexa. In this order merogony is a feature and the cycle involves both sexual and asexual phases (Levine 1985). Coccidia are mainly found in intestinal epithelial cells, although some species attack the liver and other organs (Fox 1985).

Susceptible animals are infected when they ingest contaminated feed or water, graze contaminated pasture or lick a soiled hair coat. The parasites reach the intestine and multiply in the intestinal cells, destroying the gut lining and releasing thousands of oocysts. These oocysts pass out with faeces to further contaminate soil, feed, water, bedding, etc., and repeat the cycle.

a) Life cycle

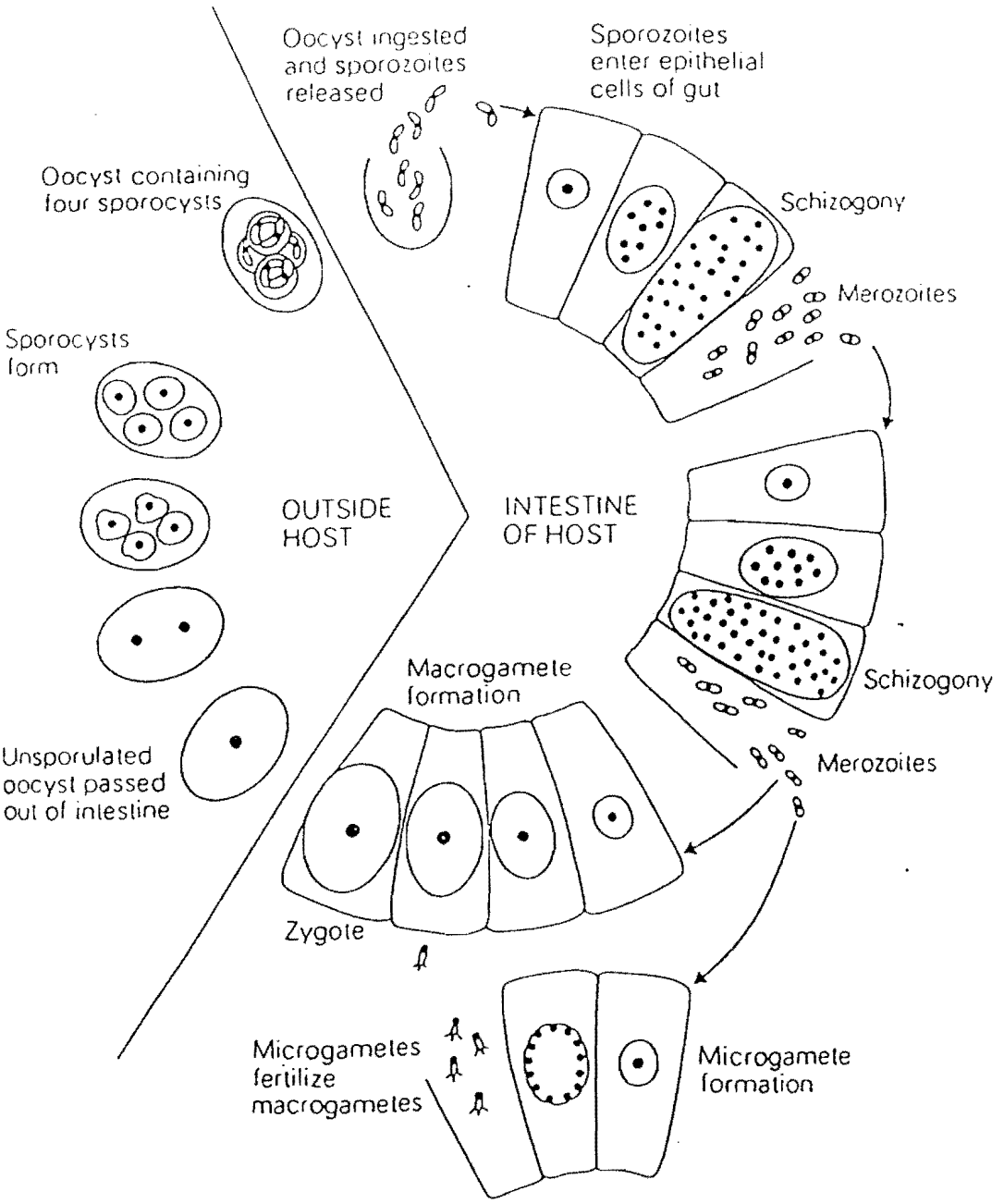
The life cycle is initiated after the host has ingested sporulated oocysts (Fig. 1). In the host the sporozoites are released and invade appropriate host cells. In the host cell each sporozoite forms a meront, which undergoes merogony to form merozoites. When mature the merozoites escape from the meront, penetrate other host cells, and begin another generation of merogony. Merogony continues for a specific number of generations depending on the coccidial species. Finally gamogony occurs with microgametes and macrogametes being formed. Syngamy occurs within the cell hosting the macrogamete and a zygote is formed. A membrane wall forms around the zygote to form an oocyst. Host cells containing the oocysts rupture and the oocysts are excreted together with faeces to the external environment.

At the appropriate temperature and humidity, the oocyst cytoplasm divides to form four sporocysts, each with two sporozoites. The time required for sporulation depends on the species of coccidia and the temperature of the environment. Only sporulated oocysts are infective to cattle.

b) Clinical signs

Clinical coccidiosis in cattle is usually deceptive. Signs are often not apparent until 3-8 weeks after initial infection (Fox 1985). Observation of one clinical case in a population indicates oocyst cycling in other animals in the population (Fox 1985). In mild cases of

Fig. 1 Life cycle of a typical *Eimeria* (Cox 1994)



infection, the animals have diarrhoea with little or no blood in their faeces and they may be anorexic and listless for a day or so. In severe cases, the faeces are fluid and bloody and may contain mucus and strands of intestinal mucosa. The animals become emaciated, dehydrated, weak and listless. They have rough hair coats, drooping ears and sunken eyes. Death may occur in severe cases owing to the disease or later owing to secondary infections, especially bacterial enteritis or pneumonia (Ernst and Benz 1986).

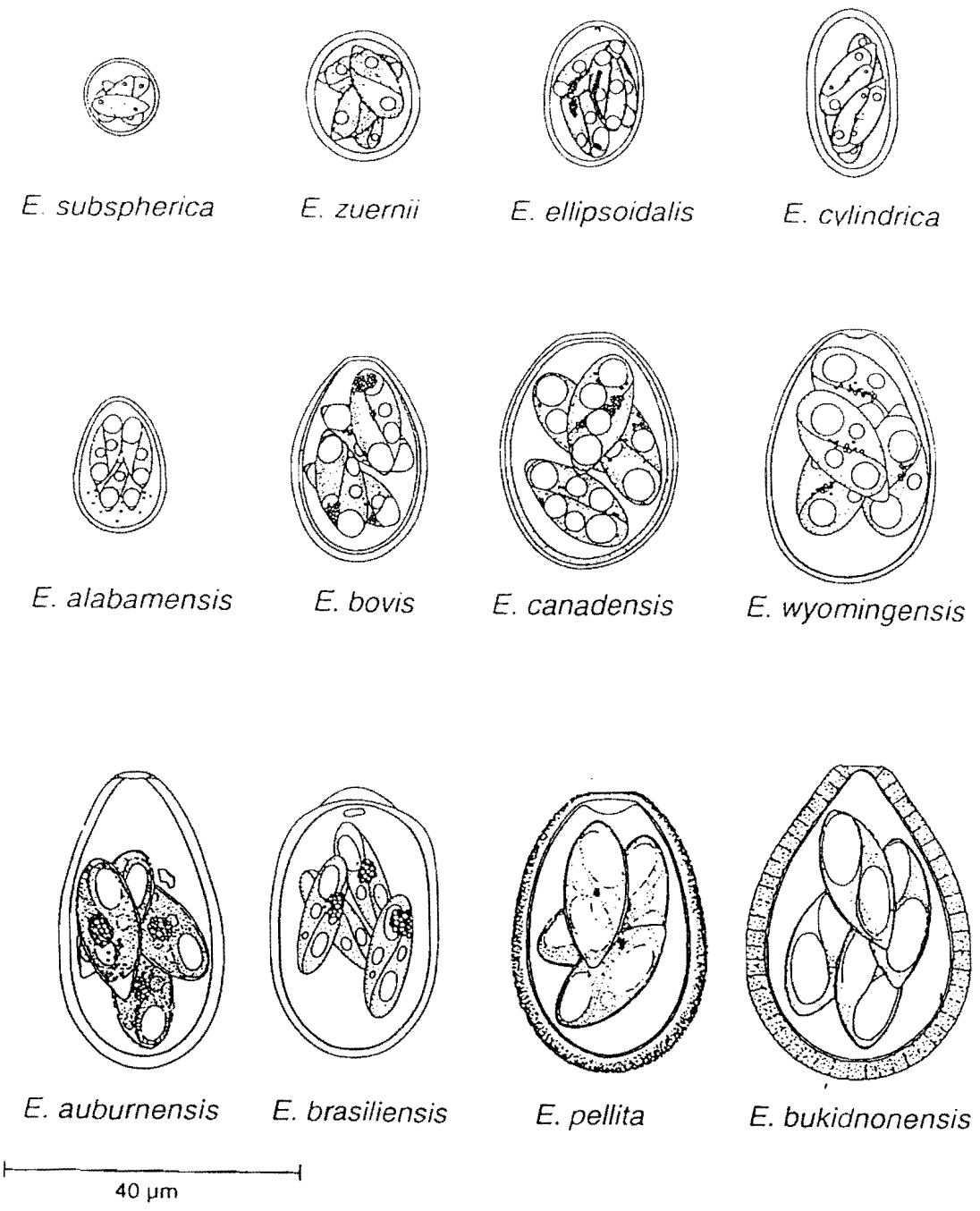
c) Diagnosis

Diarrhoea and the presence of oocysts in the faeces are not reliable indicators of clinical disease. Other important causes of diarrhoea in bovines in South Africa include acute and chronic salmonellosis, colibacillosis, chronic bovine viral diarrhoea, malnutrition, or gastrointestinal helminthosis. Coccidiosis can exist concurrently with any of these conditions (Oetjen 1993). Diagnosis of coccidiosis should be based on the history of the cattle population, presence of clinical signs, the abundance of oocysts of veterinary important species and the occurrence of intestinal lesions at necropsy.

d) *Eimeria* species

At least 13 *Eimeria* species are known to infect cattle (Levine and Ivens 1967). Fig 2 illustrates sporulated *Eimeria* oocysts of most of the documented species. The structural characteristics used in identification include oocyst shape and size; the

Fig. 2 Sporulated oocysts of some *Eimeria* species from cattle (Levine and Ivens 1967)



presence of a micropyle or micropylar cap; number of layers in the oocysts wall; size, shape and arrangement of sporocysts; and the presence or absence and size and appearance of oocyst or sporocyst residua (Levine 1985). The following morphological descriptions of *Eimeria* oocysts are from Levine (1985).

Oocysts of *E. bovis* are variable in shape, being ovoid, short ovoid or subellipsoidal and measure 26-32 x 17-23 μm. Oocysts appear in the faeces 16-21 days after ingestion. Sporulation time is 2-3 days under favourable conditions. Although this species is pathogenic, Ernst, Ciordia and Stuedemann (1984) reported that *E. bovis* oocysts could be present in large numbers in the faeces in the absence of clinical disease.

Oocysts of *E. zuernii* are also variable in shape, being subpherical, subovoid, ovoid, or sometimes ellipsoidal. They measure 12-29 x 10-21 μm and lack a micropyle. The prepatent period is 15-17 days. According to Fitzgerald (1975) this species is by far the most important species involved in clinical coccidiosis. *E. zuernii* appears to cause coccidiosis more frequently in older animals than does *E. bovis* and is generally more commonly seen in the disease known as "winter coccidiosis" which occurs during or following cold or stormy weather in the winter months (Speer 1999). Sporulation time is 2-10 days under favourable conditions.

E. alabamensis has oocysts that are usually ovoid and appear pale yellow. They measure 13-25 x 11-17 μm and lack a micropyle. Oocysts appear in faeces 6-8 days after infection. Sporulation takes 4-8 days under favourable conditions. Although

Levine (1985) reported that *E. alabamensis* was non-pathogenic, in the USA the species was shown to be pathogenic to calves under experimental conditions, but was not thought to be involved significantly in naturally acquired clinical coccidiosis (Davis, Boughton and Bowman 1955). In contrast in Germany coccidiosis due to *E. alabamensis* was reported to be a clinical problem in grazing calves (Grafner, Graubmann, Kron, Muller, Daetz, Plotner and Benda 1982). Svensson, Hooshmand-Rad, Pehrson, Tornquist and Uggla (1993) also reported that in Sweden coccidiosis due to overwintered oocysts of *E. alabamensis* may be a considerable clinical problem for young calves on pastures.

Oocysts of *E. ellipsoidalis* are ellipsoid, but they are sometimes ovoid or cylindrical, and measure 12-32 x 10-29 µm and lack a micropyle. Oocysts appear in faeces 8-13 days after ingestion of the oocysts. Sporulation takes 3 days under favourable conditions. This species is mildly to moderately pathogenic. It is also one of the frequently recorded species in prevalence studies of *Eimeria* oocysts.

Oocysts of *E. auburnensis* are ovoid and flattened at the small end. They measure 32-46 x 19-30 µm. The prepatent period is 16-24 days. Sporulation time is 2-3 days under favourable conditions. This species is moderately pathogenic.

Oocysts of *E. bukidnonensis* are piriform and measure 34-64 x 21-41 µm, with a yellowish brown, punctate, radially striated 2-layered wall. Sporulation takes 4-55 days under favourable conditions. This species is probably nonpathogenic.

Oocysts of *E. canadensis* are ovoid or ellipsoidal and measure 28-39 x 20-29 µm. This species is slightly pathogenic.

Oocysts of *E. cylindrica* are ellipsoidal and measure 16-34 x 12-19 µm, with a colourless smooth 1-layered wall. The prepatent period is 10 days. This species is slightly pathogenic.

Oocysts of *E. illinoisensis* are ellipsoidal or slightly ovoid and measure 24-30 x 19-23 µm, with a smooth, colourless 1-layered wall. This species is not common.

Oocysts of *E. subspherica* are spherical to subspherical and measure 9-14 x 8-13 µm, without a micropyle. The prepatent period is 7-18 days. Sporulation time is 4-5 days.

Oocysts of *E. pellita* are ovoid and measure 32-42 x 22-27 µm, with a 2-layered wall. The sporulation time is 10-12 days. This species is uncommon.

Oocysts of *E. brasiliensis* are ellipsoidal but sometimes slightly ovoid and measure 31-49 x 21-33 µm, with a generally smooth, brownish yellow 2-layered wall. Sporulation time is 6-14 days.

Oocysts of *E. wyomingensis* are ovoid, yellowish brown and measure 36-46 x 26-32 µm. The sporulation time is 3-7 days and the prepatent period is 13-15 days. This species is uncommon.

The occurrence and abundance of coccidial species in cattle have been studied in various parts of the world. In papers reviewed for this study, the authors identified between 7 and 13 species of *Eimeria*. Kasim and Al-Shawa (1985) identified 7 species in Saudi Arabia and Oda and Nishida (1989) identified 11 in Japan. The studies conducted in Africa are of importance to this study. A study conducted by Majoro (1980) in Nigeria reported 9 species, *E. bovis* and *E. auburnensis* being most frequently identified. In Kenya, Munyua and Ngotho (1989) identified 8 species, the commonly recorded ones being *E. bovis* and *E. zuernii*.

1.2 Problem

Information on the *Eimeria* species that occur in cattle under different management systems is still lacking in South Africa. This is information that is crucial to the management and control of coccidiosis in South Africa.

1.3 Benefits of the Research

The study was expected to provide baseline data on the *Eimeria* species that occur at the three studied localities. This information will help interested scientists in the field

and provide information important to the local farming communities and the agricultural industry to assist in implementing effective management and control measures against coccidiosis.

1.4 Objectives

The objectives of the study were (i) to identify the *Eimeria* species that occur in cattle at the three localities (ii) to assess the infection levels of *Eimeria* species in cattle at the three localities (iii) to determine at the two localities with similar management systems, the more susceptible breed.

CHAPTER2: MATERIALS AND METHODS

2.1 Model system and justification

Three locations were used for this study for sample collection. Faecal samples were collected monthly from November 1997 to November 1998, in order to evaluate seasonal fluctuations in infection levels. Seasons were differentiated into wet and dry. Wet season were those months when there was rainfall and dry season were those months when there was no rainfall (Figs. 3-5); these seasons therefore differed at the three localities. The thirteenth month was included to see if results would resemble those of the first month. Age was taken into account by separate analysis of the results from young (< 12 months) and adult (> 24 months) animals. In consultation with a statistician it was decided that for the results to be statistically valid at least 15 samples for each age group per locality were needed. In most cases at least 25 samples were collected for each age group at each sampling.

a) Mallesons

Latitude: 25'45° South

Longitude: 28'16° East

Summer rainfall area.

This locality was an intensively managed farm. The owners followed strict programs of proper nutrition, vaccination and grouping strategies. More than 500 Ayrshires were kept on this farm for the purpose of milk production. Frieslands were kept on the farm but were rarely used. Suckling calves (younger than 3 months) were kept in individual pens or stalls that were roofed and had cement floors. These pens were cleaned on a daily basis. Weaned calves, sub-adults and adults were grouped according to age and kept in separate kraals. All the animals on the farm were pen fed although they sometimes grazed the little grass that grew inside the kraals. Fresh water was pumped from a reservoir into drinking troughs for the animals. In this way a strict management program for controlling and preventing coccidiosis was followed by way of feeding practices and grouping strategies. Anti-coccidial drugs were only given to the animals when necessary. This is a summer rainfall area (Fig.3).

b) Pienaars River

Latitude 25'27° South

Longitude 28'24° East

Summer rainfall area.

This locality was situated 126 km north of the Veterinary Faculty at Onderstepoort. The farm was a Nguni stud farm. Over 150 indigenous-breed animals including

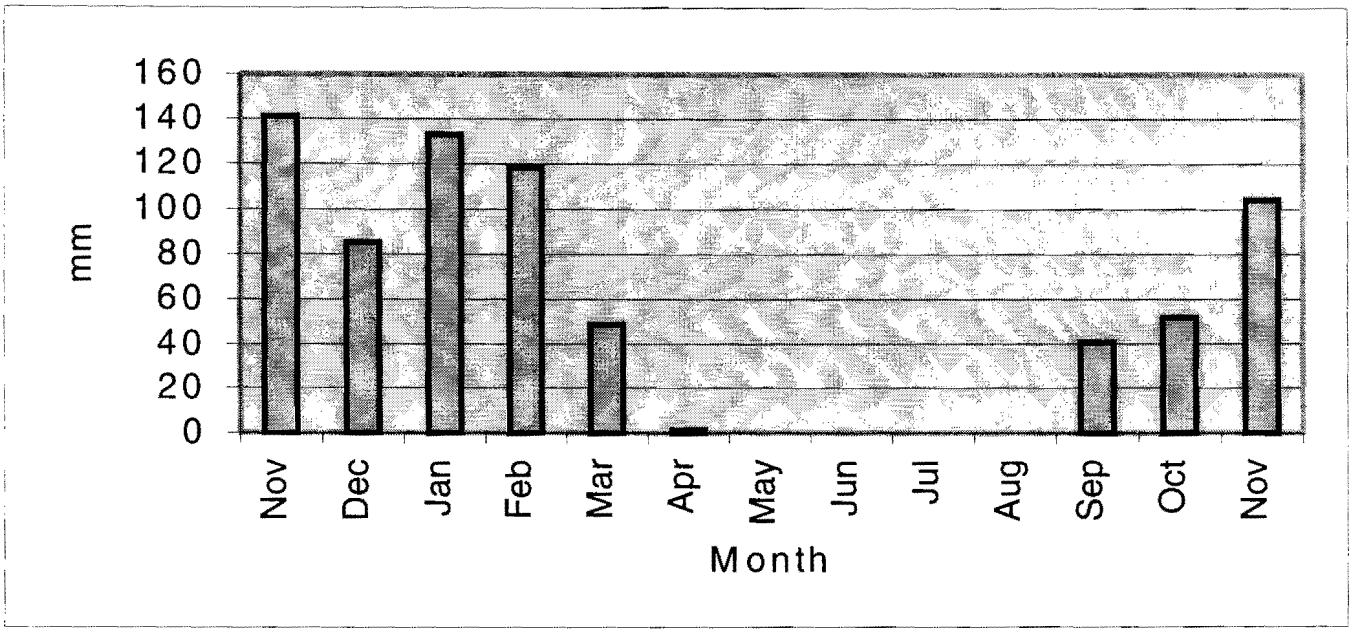


Fig. 3: Monthly rainfall (in mm) recorded at Mallesons, November 1997 to November 1998.

calves, subadults and adults were kept on this farm. Bulls were put to individual herds of cows only during the summer months. Calves were left to run with their dams until weaned at three months. The animals were occasionally dipped against ecto-parasites. A veterinarian was called to the farm whenever there was a need and to vaccinate, mainly against heartwater.

The animals were kept in camps and both young and older animals were allowed to mix freely. No grouping strategies or any other measures to curb coccidiosis were employed. Although the manager of the farm did practise pasture rotation, this was solely for the re-growth of grass in vacant camps. This locality was relatively hot and dry and it was noted that the Ngunis were also browsers of acacia tree leaves. No supplementary feeding was provided and water was available from water troughs and sometimes pools of rainwater on the ground. No anti-coccidial drugs were given to the animals even when there were calves with obvious signs of diarrhoea. This is a summer rainfall area (Fig. 4).

c). Kaalplaas

Latitude 25'39° South

Longitude 28'11°East

Summer rainfall area.

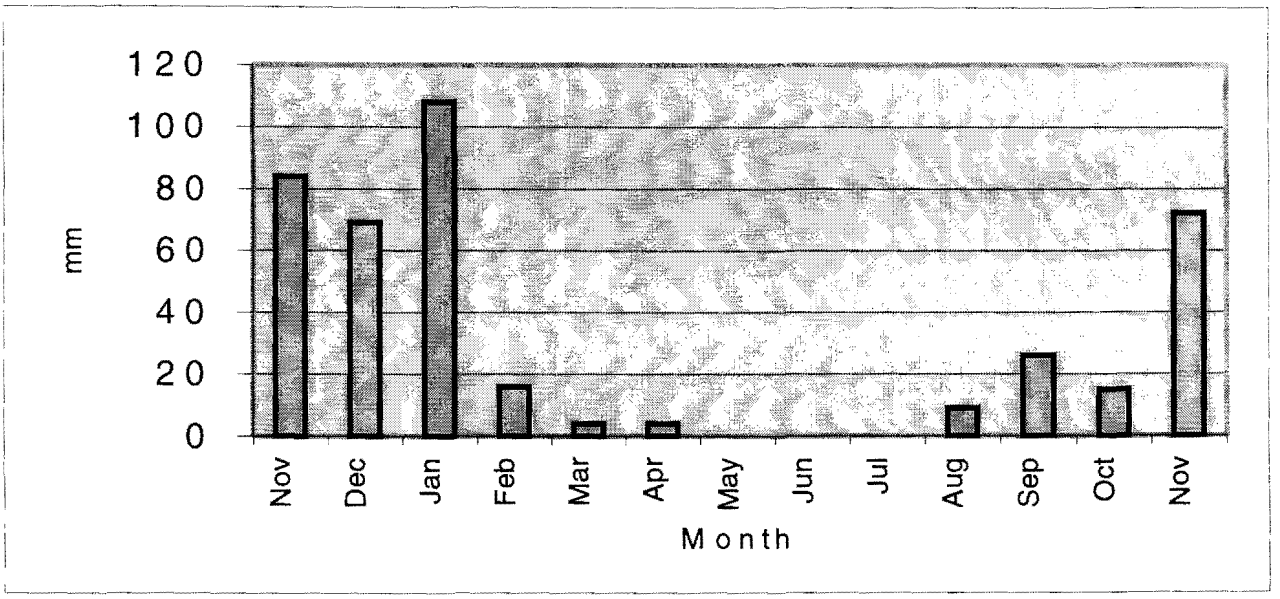


Fig. 4: monthly rainfall (in mm) recorded at Pienaars River, November 1997 to November 1998.

The third locality was 5 km from the Veterinary Faculty at Onderstepoort. Bonsmara cattle and Nguni bulls were kept on this farm for breeding F1 generation calves. The Nguni bulls were put to the Bonsmara cows at the beginning of January. The calves were left to run with their dams until weaned at three months. After weaning the calves were removed from the dams and kept with older calves in separate camps. These animals were dipped if necessary and the manager had a vaccination program. Only Bonsmara cows and F1 crosses were sampled. There were no set procedures for the prevention and control of coccidiosis and no drugs had ever been given to the animals to prevent coccidiosis.

At any time there were more than 100 Bonsmaras and 60 F1 crosses on the farm. These were allowed to graze in the camps and no supplementary feeding was given. Water was available in the camps in troughs fed from a reservoir, although it was noted that the animals did sometimes drink rainwater from pools on the ground. This is a summer rainfall area (Fig. 5).

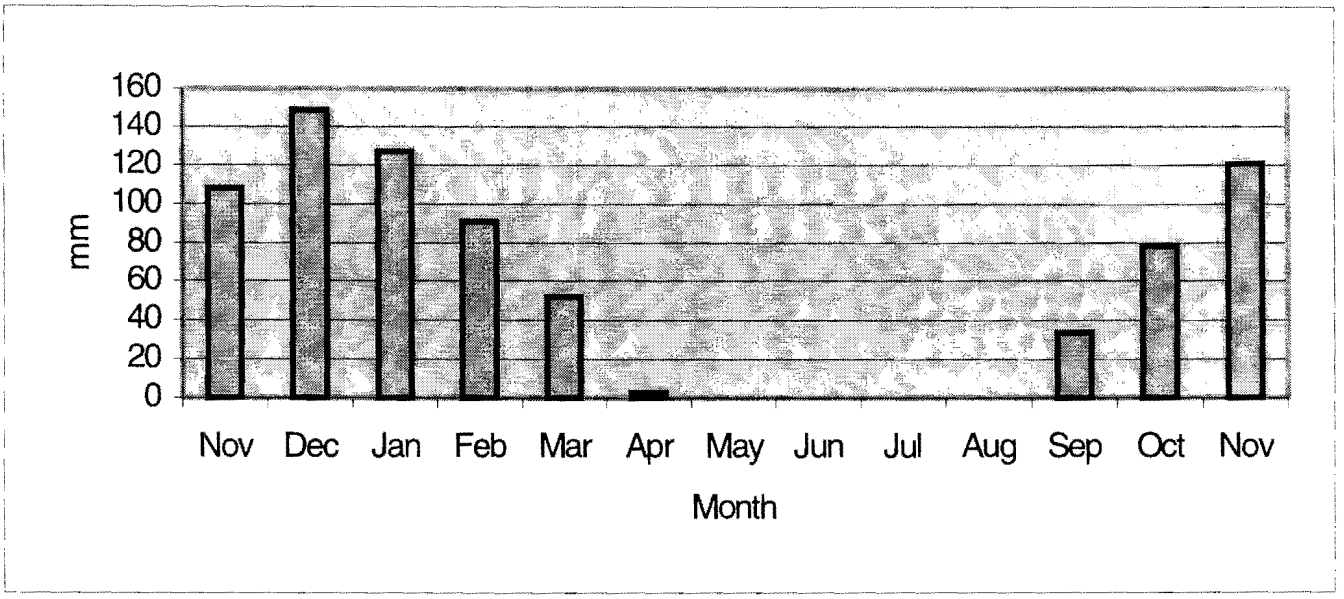


Fig. 5: Monthly rainfall (in mm) recorded at Kaalplaas, November 1997 to November 1998.

2.2 Experimental design

a) Mallesons

At least 25 adult animals and at least 25 calves were randomly selected at each sampling. Different animals were used during each visit. Faecal sampling was done from November 1997 to November 1998. Visits were made during the third week of each month.

b) Pienaars River

At least 25 adult and 25 calf faecal samples were collected from randomly selected Nguni adults and calves. Visits to this site were made during the third week of each month for a period of thirteen months.

c) Kaalplaas

At least 25 Bonsmara adults and 25 F1 cross calves were randomly selected and sampled for specimens. This locality was visited every third week of the month for thirteen months.

2.3 Experimental procedures

At Malleson's farm both adults and calves were observed at each sampling and freshly voided faeces were picked up. This was due to the fact that the management was not in favour of driving the animals into crushpens for they wanted minimal stress to the animals. At Pienaars River and Kaalplaas randomly selected animals were driven into crushpens for faecal sampling. Faecal specimens were collected manually from the rectum using examination gloves. Samples were individually marked and stored in a cooler box.

2.4 Observations and analytical procedures

Collected specimens were transported to the Protozoology Laboratory at the Onderstepoort Veterinary Faculty on the day of collection and stored in the refrigerator at 4°C until processed. The modified McMaster technique (Reinecke 1983) was used to determine the oocysts per gram (OPG) of faeces. From each sample 4g was required and this was put in a plastic cup and weighed on an electric scale. The 4g of faeces were finely crushed with a wooden spatula and then thoroughly mixed with 56ml of a 40% sugar solution.

Three chambers of 2 McMaster slides were filled with the mixed solution using a wide-mouthed pipette and a rubber bulb. The slides were left for five minutes to allow oocysts to rise to the top for easier examination. The oocysts in each chamber were

then counted under the 10 x magnification of the microscope. OPG was calculated by multiplying the total number of oocysts by 200 and dividing by 6.

Samples with an OPG of at least 2000 were allowed to sporulate for species identification. Faeces remaining after OPG determinations were crushed and mixed thoroughly with a 2.5% potassium dichromate solution. The mixture was strained through thick gauze to remove coarse plant matter, poured in thin layers into petri dishes and left to sporulate for 10-14 days at room temperature.

After sporulation, the potassium dichromate faecal solution was centrifuged in a test tube at 3000 revolutions per minute for five minutes. The supernatant was decanted and the sediment put into a faecalyser tube. A 40% sugar solution was poured into the faecalyser tube until a meniscus formed. A cover slip was placed on top of the faecalyser tube, which was allowed to stand for ten minutes. The cover slip was carefully lifted and placed on a microscope slide, for microscopic examination. The first 100 oocysts were identified using 40 x magnification and a calibrated micrometer. Oocysts identification was done by measuring and identifying individual characteristics of each species as described by Levine (1985).

2.5 Data analysis

All stored and recorded data were analysed in conjunction with statisticians from the Department of Information Technology (Ms. Rina Owen) and Department of Statistics (Prof. Deon van Zyl) of the University of Pretoria. The statistical package SAS

(institute Inc., SAS/stat. users guide, version 6, 4th edition, Cary, NC: SAS Institute Inc) was used for analyses. This package included General Linear Modelling (GLM), paired comparisons and the chi-square test. Descriptive and comparative calculations were made. Descriptive statistics included the determination of means, standard deviations, minimum and maximum values. The comparative analysis included the chi-square test and the GLM for the analyses of variance.

CHAPTER 3: RESULTS

3.1 Introduction

A total of 1936 faecal samples were collected and analysed: 661 samples from Mallesons, 637 from Pienaars River and 638 from Kaalplaas. Of the 978 specimens from adults, 18% were positive for *Eimeria* oocysts, while 70% of 958 specimens from calves were positive for *Eimeria* oocysts.

3.2 Comparing general values for adults and calves at Mallesons, Pienaars River and Kaalplaas

Table 1 gives the percentage of positive faecal specimens from sampled animals in the three localities. There were significant differences between the three localities (χ^2=96.8; p=0.001).

The percentage of positive faecal specimens from adults in the three localities, respectively, is shown in Table 2. The differences between the three localities were significant (χ^2=55.4; p=0.001).

The percentage of positive faecal specimens from calves in the three localities, respectively, is shown in Table 3. The differences between the three localities were significant (χ^2=130.9; p=0.001).

Table 1: The percentage of faecal specimens from adult cattle and calves positive for *Eimeria* oocysts in the three localities from November 1997 to November 1998. The figures for November 1997 to October 1998 are shown in brackets.

	Mallesons	Pienaars River	Kaalplaas
No. collected	661 (608)	637 (587)	638 (588)
No. positives	189 (167)	334 (311)	317 (297)
% positives	28.6 % (27.5%)	52.4% (52.9%)	49.6% (50.5%)

Table 2: The percentage of faecal specimens from adult cattle positive for *Eimeria* oocysts collected in the three localities from November 1997 to November 1998. The figures for November 1997 to October 1998 are shown in brackets.

	Mallesons	Pienaars River	Kaalplaas
No. collected	339 (311)	332 (297)	317 (292)
No positive	28 (21)	90 (85)	57 (53)
% positive	8.3% (6.8%)	27.9% (28.6%)	17.9% (18.2%)

Table 3: The percentage of faecal specimens from calves positive for *Eimeria* oocysts collected in the three localities from November 1997 to November 1998. The figures for November 1997 to October 1998 are given in brackets.

	Mallesons	Pienaars River	Kaalplaas
No. collected	332 (297)	315 (290)	321 (296)
No. positives	161 (146)	244 (226)	260 (244)
% positives	50% (49.1%)	77.5% (77.9%)	81% (82.4%)

3.2.1 General values per locality

Mallesons

The means, standard deviations and maximum OPG's for the 13-month sampling period are shown in Table 4. The number and percentage of specimens from adults and calves, respectively, falling within specific OPG ranges are shown in Table 5. Table 6 represents the number and percentages of specimens from adults and calves falling within specific OPG ranges for the 12-month sampling period. There were significant differences in levels of positive specimens for the 12-month sampling period from the two age groups (χ^2=138.5; p=0.001).

Pienaars River

Table 7 represents the mean and maximum OPG as well as standard deviation for adults and calves at this locality. All values are given as counted in the first part of the table and only values under 100 000+ are given in the second part of the table. The number and percentage of specimens from adults and calves falling within specific OPG ranges are given in Table 8.

Results were broken down into three categories for the 12-month sampling period (Table 9). There were significant differences in levels of positive specimens between the two age groups (χ^2=143.2; p=0.001).

Table 4: Mean and maximum oocysts per gram of faeces (OPG), as well as standard deviation (SD) for adults and calves at Mallesons (November 1997-November 1998).

	Adults	Calves
Mean OPG	4.7	176.3
SD	25.2	861.6
Maximum OPG	366	14 200

Table 5: The number and percentage of specimens from adults and calves at Mallesons falling within specific OPG ranges (November 1997-November 1998).

	Adults	Calves
No. examined	336	322
0	311 (92.6%)	161 (50%)
1-49	16 (4.8%)	49 (15.2%)
50-499	5 (2%)	78 (27.6%)
500-999	4 (0.7%)	23 (3.8%)
1000-4999	-	10 (3.1%)
10 000-49 000	-	1 (0.3%)

Table 6: The number and percentage of adults and calves at Mallesons for the 12-month sampling period (November 1997-October 1998) falling within specific OPG ranges.

	Adults	Calves
No. examined	311	297
0	290 (93.3%)	151 (50.8%)
1-499	21 (6.8%)	127 (42.8%)
500+	-	19 (6.4%)

Table 7: Mean and maximum oocysts per gram of faeces (OPG), as well as standard deviation (SD) for adults and calves at Pienaars River (November 1997-November 1998). All values are given as counted in the first part of the table and only values under 100 000+ are given in the second part.

	Adults	Calves
All values		
Mean OPG	48.5	1586.9
SD	260.4	12256.4
Maximum OPG	2800	191 000
Excluding 100 000+		
Mean OPG	-	983.7
SD	-	5975.9
Maximum OPG	-	99 500

Table 8: The number and percentage of adults and calves at Pienaars River falling within specific OPG ranges (November 1997-November1998).

	Adults	Calves
No. examined	322	315
0	232 (72.0%)	71 (22.6%)
1 - 49	40 (12.4%)	31 (9.9%)
50 – 499	40 (14.5%)	123 (43.2%)
500-999	7 (0.1%)	49 (10.8%)
1000 - 4999	3 (0.9%)	32 (10.2%)
5000 - 9999	-	3 (1%)
10 000 - 49 000	-	4 (1.3%)
50 000 - 99 999	-	1 (0.3%)
100 000+	-	1 (0.3%)

Table 9: The number and percentage of specimens from adults and calves at Pienaars River for the 12-month sampling period (November 1997-October 1998) falling within specific OPG ranges.

	Adults	Calves
No examined	297	290
0	212 (71.4%)	64 (22.1%)
1-499	80 (26.9%)	154 (53.1%)
500+	5 (1.7%)	72 (24.8%)

Kaalplaas

For the 13-month sampling period, the means and the maximum OPG of faeces, as well as standard deviation for specimens from adults and calves are represented by Table 10. Table 11 represents the numbers and percentages of specimens from adults and calves falling within specific OPG ranges.

Table 12 represents the number and percentage of specimens from adults and calves for the twelve-month sampling period falling within specific OPG ranges. There were significant differences in the levels of positive specimens from adults and calves at this locality (χ^2=242.9; p=0.001).

3.2.2 Comparative analysis of values for Mallesons, Pienaars River and Kaalplaas: Adults (general values)

The numbers and percentages of specimens from adults at the three localities falling within specific OPG ranges (Tables 6, 9 and 12) were compared; the differences were significant (χ^2=55.4; p=0.001).

Calves

The numbers and percentages of specimens from calves at the three localities falling within specific OPG ranges (Tables 6, 9 and 12) were compared; the differences were significant (χ^2=130.9; p=0.001).

Table 10: Mean and maximum oocysts per gram (OPG) of faeces, as well as standard deviation (SD) for adults and calves at Kaalplaas (November 1997-November 1998).

	Adults	Calves
Mean OPG	8.9	1304.3
SD	21.8	5638.1
Maximum OPG	133	85466

Table 11: The number and percentage of specimens from adults and calves at Kaalplaas falling within specific OPG ranges (November 1997-November 1998).

	Adults	Calves
No. examined	317	321
0	260 (82%)	61 (19%)
1 – 49	37 (11.7%)	23 (7.2%)
50 – 499	16 (6.1%)	110 (37.7%)
500-999	4 (0.2)	61 (15.6%)
1000 – 4999	-	54 (16.8%)
5000 – 9999	-	5 (1.6%)
10 000 – 49 000	-	6 (1.9%)
50 000 – 99 999	-	1 (0.3%)

Table 12: The number and percentage of specimens from adults and calves at Kaalplaas for the 12-month sampling period (November 1997-October 1998) falling within specific OPG ranges.

	Adults	Calves
No examined	292	296
0	239 (81.9%)	52 (17.6%)
1-499	53 (18.2%)	133 (44.9%)
500+	-	111 (37.5%)

3.3 Comparing Mallesons, Pienaars River and Kaalplaas: monthly values.

Adults

Table 13 represents the mean monthly OPG values of specimens from adults at the three localities.

Calves

Table 14 represents the mean monthly OPG values of specimens from calves at the three localities.

3.3.1 Comparative analysis: Mallesons, Pienaars River and Kaalplaas: monthly values

Adults

Table 15 represents the monthly occurrence of positive specimens from adult cattle at the three localities for the 12-month sampling period. The months differed significantly at all three localities: Mallesons (χ^2=40.4; p=0.001), Pienaars River (χ^2=29.4; p=0.002) and Kaalplaas (χ^2=48.9; p=0.001).

Calves

Table 16 represents the monthly occurrence of positive specimens from calves at

Table 13: The mean monthly OPG values of specimens from adult cattle at the three localities.

	Mallesons	Pienaars River	Kaalplaas
Nov 1997	31.8	22.1	9.2
Dec	0	13.2	13.3
Jan 1998	1.3	15.9	5.3
Feb	9.8	75.4	0
Mar	1.3	126.5	11.9
Apr	1.3	25.2	4.0
May	0.9	283.0	1.3
Jun	2.6	10.6	3.9
Jul	0	16.5	8.0
Aug	0	2.6	15.8
Sep	0	21.2	10.6
Oct	5.1	15.9	23.4
Nov	7.9	9.2	6.6

Table 14: The mean monthly OPG values of specimens from calves at the three localities.

	Mallesons	Pienaars River	Kaalplaas
Nov 1997	205.8	1429.2	2542.1
Dec	199.9	225.0	719.3
Jan 1998	0	143.2	461.9
Feb	30.2	73.1	349.3
Mar	184.8	931.8	874.3
Apr	146.4	12938.4	341.0
May	345.1	2098.3	9349.3
Jun	42.4	38.6	1049.7
Jul	26.5	898.4	349.1
Aug	90.5	555.7	414.4
Sep	19.9	717.0	186.7
Oct	59.8	210.5	385.1
Nov	931.8	205.1	182.5

Table 15: Monthly occurrence of positive specimens from adult cattle at the three localities for the 12-month period (November 1997-October 1998).

	Mallesons	Pienaars River	Kaalplaas
Nov	8/25	8/24	5/25
Dec	0/31	7/25	4/25
Jan	1/25	8/25	2/25
Feb	4/27	10/25	0/18
Mar	1/25	9/25	6/25
Apr	1/25	6/25	3/25
May	1/26	15/24	1/25
Jun	1/25	2/25	2/25
Jul	0/26	6/24	2/25
Aug	0/25	1/25	8/25
Sep	0/25	7/25	5/25
Oct	4/26	6/25	15/24

Table 16: Monthly occurrence of positive specimens from calves at the three localities for the 12-month period (November 1997-October 1998).

	Mallesons	Pienaars River	Kaalplaas
Nov	19/25	15/17	22/22
Dec	5/20	19/25	19/22
Jan	0/25	22/23	25/25
Feb	14/23	18/25	22/31
Mar	14/29	16/25	17/21
Apr	17/25	23/25	17/25
May	18/25	25/25	25/25
Jun	14/25	7/25	21/25
Jul	8/25	19/25	19/25
Aug	11/25	23/25	21/25
Sep	8/25	24/25	16/25
Oct	18/25	15/25	20/25

the three localities for the 12-month sampling period. There were significant differences between the months at all three localities: Mallesons (χ^2=57.9; p=0.001), Pienaars River (χ^2=67.2; p=0.001) and Kaalplaas (χ^2=28.7; p=0.002).

3.3.2 Comparative analysis: November 1997 and November 1998

Table 17 represents the mean OPG's and standard deviations for specimens from adults and calves collected in November 1997 and November 1998. There were significant differences between the two months (F=8.4; p = 0.004). The above information was broken up to compare the months for each locality. Table 18 represents the mean OPG's and standard deviations for specimens at the three localities for the two months. There were significant differences between the two months at all localities (F=7.9; p=0.0005).

3.4 Comparative analysis of oocyst counts per season.

3.4.1 Dry and wet season

Table 19 represents values for a direct comparison of adult specimens at Mallesons for the dry and wet season. Counts during the wet season were significantly higher than during the dry season (χ^2=6.6; p=0.01). Table 20 represents values for a direct comparison of calf specimens at Mallesons for the dry and wet season. There were no significant differences between the seasons (χ^2=2.7; p=0.259).

Table 17: Mean oocysts per gram of faeces (OPG) and standard deviation (SD) for specimens from adults and calves at the three localities (lumped), for November 1997 and November 1998.

	Adults		Calves	
	Nov 97	Nov 98	Nov 97	Nov 98
No. specimens	74	75	64	75
Mean OPG	21	7	1333.9	489.7
SD	52	19	2456.9	1681.9

Table18: Mean oocysts per gram of faeces (OPG) and standard deviation (SD) for specimens from adults and calves from the three localities (lumped), for November 1997 and November 1998.

	No. of specimens	Mean	SD
Mallesons			
Nov 97	50	118.8	221.9
Nov 98	50	469.9	2046.5
Pienaars River			
Nov 97	41	605.5	1408.5
Nov 98	50	107.2	272.6
Kaalplaas			
Nov 97	47	1194.9	2677.5
Nov 98	50	94.5	246.1

Table 19: Number and percentage of specimens from adult cattle at Mallesons falling within specific OPG ranges for the dry and wet seasons.

OPG range	Dry	Wet
No. collected	127	184
0	124 (97.6%)	166 (90.2%)
1-499	3 (2.4%)	18 (9.8%)

Table 20: Number and percentage of specimens from calves at Mallesons falling within specific OPG ranges for the dry and wet seasons.

OPG ranges	Dry	Wet
No. collected	125	172
0	57 (45.6%)	94 (54.7%)
1-499	58 (46.4%)	69 (40.1%)
500+	10 (8%)	9 (5.2%)

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Table 21 represents values for a direct comparison of adult specimens at Pienaars River for the dry and wet season. There were no significant differences between the seasons (χ^2=1.1; p=0.558). Table 22 represents values for a direct comparison of calf specimens for the dry and wet season. Counts during the wet season were significantly higher than during the dry season (χ^2=11.1; p=0.004).

Table 23 represents values for a direct comparison of specimens from adults for the dry and wet seasons at Kaalplaas. Counts during the wet season were significantly higher than during the dry season (χ^2=4.2; p= 0.04). Table 24 represents values for a direct comparison of specimens from calves for the dry and wet seasons. There were no significant differences between the seasons (χ^2=3.4; p=0.17)

3.5 The identification of *Eimeria* species

Identification of species depended on samples that had OPG's of ≥ 2000. Only three samples for adults at Pienaars River met this criterion. All three samples were positive for *E. bovis*, two for *E. alabamensis* and one for *E. zuernii.* None of the adults from the other two localities had OPG's of over 2000, hence no species identification was done from those groups.

Most *Eimeria* species were identified from the calves. Thirty-eight specimens from Kaalplaas, 20 from Pienaars River and 4 from Mallesons were examined after sporulation. Table 25 represents the number and percentage of calf faecal samples positive for various *Eimeria* species.

Table 21: Number and percentage of specimens from adult cattle at Pienaars River falling within specific OPG ranges for the dry and wet seasons.

OPG ranges	Dry	Wet
No. collected	148	149
0	109 (73.6%)	103 (69.1%)
1-499	36 (24.3%)	44 (29.5%)
500+	3 (2%)	2 (1.3%)

Table 22: Number and percentage of specimens from calves at Pienaars River falling within specific OPG ranges for the dry and wet seasons.

OPG range	Dry	Wet
No. collected	150	140
0	37 (24.7%)	27 (19.3%)
1-499	66 (44%)	88 (62.9%)
500+	47 (31.3%)	25 (17.9%)

Table 23: Number and percentage of specimens from adult cattle at Kaalplaas falling within specific OPG ranges for the dry and wet seasons.

OPG ranges	Dry	Wet
No. collected	125	167
0	109 (87.2%)	130 (77.8%)
1-499	16 (12.8%)	37 (22.2%)

Table 24: Number and percentage of specimens from calves at Kaalplaas falling within specific OPG ranges for the dry and wet seasons.

OPG ranges	Dry	Wet
No. collected	125	171
0	22 (17.6%)	30 (17.5%)
1-499	49 (39.2%)	84 (49.1%)
500+	54 (43.2%)	57 (33.3%)

Table 25: The number of calf specimens positive for *Eimeria* species at the three localities. Species identification was done only from specimens with OPG's > 2000. From Mallesons n=4; Pienaars River n=20; Kaalplaas n=38.

Eimeria spp	Mallesons No. positives	Pienaars. River No. positives	Kaalplaas No. positives
E. zuernii	4/4	14/20	34/38
E. bovis		13/20	32/38
E. ellipsoidalis	4/4	9/20	26/38
E. pellita	1/4		10/38
E alabamensis	2/4	2/20	9/38
E. subspherica	1/4		6/38
E. brasiliensis	1/4		6/38
E. auburnensis		8/20	5/38
E. canadensis	1/4		4/38
E. bukidnonensis			4/38
E. cylindrica	3/4	2/20	2/38
E. illinoisensis			1/38

3.6 Comparative analysis of species abundance at the three localities from specimens with OPG's > 2000.

Also included in Table 25, are figures for the abundance of *Eimeria* species with a high prevalence and of veterinary importance at the three localities. There were significant differences in the abundance of *E. bovis* (χ^2=35.1; p= 0.001), *E. alabamensis* (χ^2=12.1; p=0.002), *E. zuernii* (χ^2=33.8; p=0.001) and *E. ellipsoidalis* (χ^2=25.4; p=0.001). Other species with high incidence rates of occurrence are discussed in the next chapter..

CHAPTER 4: DISCUSSION

4.1 Prevalence of *Eimeria* oocysts in faecal samples: general.

Overall, Pienaars River had the highest prevalence (52%) of positive specimens, followed closely by Kaalplaas (50%). The prevalence at Mallesons (27%) was significantly lower. This could be due to the fact that animals were kept under different conditions where at Mallesons they were pen fed and at the other two localities they were on pastures.

The overall pattern is repeated among adults, with a prevalence of 29% at Pienaars River, followed by 18% at Kaalplaas and only 6% at Mallesons. Not only was the prevalence higher at Pienaars River, but the mean OPG was also relatively higher than at the other two localities (Tables 4, 7 and 10).

The highest OPG in adults (2800) was also at Pienaars River. The highest OPG at Mallesons was 366 and at Kaalplaas it was 133. Only 1.7% of specimens at Pienaars River had OPG's > 500 whereas none of adult specimens at the other two localities had OPG's > 500. The low coccidia counts in the adult specimens are understandable, as coccidiosis is generally a disease of young animals (Levine 1973). Zimmerman and Hubbard (1961) and Ward, Ferguson and Parkhurst (1979) also reported *Eimeria* to be primarily calf parasites with adult animals being the usual source of infection. It should also be noted that animals develop age-related

immunity to the coccidian parasites in the environment and without further stressors will maintain this immunity through continuous exposure. It does not, however, eliminate infection but decreases the rate of coccidial reproduction in the intestinal tract (Smith & Sherman 1994).

As expected, prevalence of infection was higher in calves than in adults. Among calves the general pattern of prevalence was repeated, except that the order of the highest two was reversed. The highest prevalence was at Kaalplaas (82%), followed by Pienaars River (77%) and Mallesons (49%). Calf specimens at Kaaplaas also had the highest OPG counts when counts of > 100 000 were excluded (Tables 4, 7 and 10).

Mallesons calves had the least positive specimens and low OPG counts because of proper management and feeding practices followed by the owners, whereas at the other two localities the animals were put on pastures and were susceptible to picking up infections from a contaminated environment. The findings at Mallesons were interesting since coccidiosis is most commonly seen in housed or confined animals. It was also important to note that the problem of coccidiosis can be brought under control merely by proper management.

A majority of calves at Mallesons (42.8%) had low OPG counts ranging between 1-499 and only 6.4% had OPG > 500 (Table 6). The highest OPG value in Mallesons was 14 200 in November 1998, and that was suprising from this locality taking into account the management practices.

A high percentage (53.1%) of calves at Pienaars River had low OPG counts falling between 1-499 and only 24.8% had OPG's > 500 (Table 9). Only 2.9% of calves had high OPG counts of ≥ 5000 (Table 8). An extremely high OPG value was found only in one animal (191 000), in April 1998. There were no clinical symptoms in this animal. It was important to take note of animals with high OPG values since Boughton (1945) reported that faecal oocyst counts of 5000 to 10 000 indicated a severe level of infection. Horton-Smith (1958) stated that counts above 5000 OPG are indicative of clinical coccidiosis in naturally infected cattle. Kennedy and Kralka (1987) reported that clinical coccidiosis occurred only when *E. zuernii* was found in conjunction with *E. bovis*.

On the contrary Ernst, Ciordia and Stuedemann (1984) reported that the greatest number of *E. bovis* in a calf on pasture was 45 800 OPG. The faeces of this animal were mildly diarrhoeic with no blood or tissue present. Nyberg, Helfer and Knapp (1967) reported that of 36 dairy calves with OPG ≥ 5000 of *E. bovis* or *E. zuernii*, 21 had normally formed faeces, 9 had loose or scouring faeces, and the consistency of 6 animal's faeces was unknown. Fitzgerald (1962) reported that in naturally infected Hereford calves, severe clinical coccidiosis was seen only when *E. zuernii* oocysts were discharged at the rate of 100 000 or more.

Ernst and Benz (1981) recommended that diagnosis of clinical cases of bovine coccidiosis should be based on the presence of signs of disease, the presence in the faeces of oocysts of *E. bovis* and/ or *E. zuernii*, and the clinical history of the individual animal and herd. From the above observation it is important to note that

high numbers of coccidia alone without the presence of the two species and just the presence of *E. bovis* and *E. zuernii* does not necessarily indicate clinical disease.

A high percentage (44.9%) of calves at Kaalplaas had low OPG counts ranging between 1-499 and only 37.5% had OPG's > 500 (Table 12). Only 3.8% had high OPG counts of ≥ 5000 (Table 11). The highest OPG value (85 466) was in May 1998 and this was found only in one animal during the sampling period. The high prevalence of infected animals at Pienaars River and Kaalplaas was unexpected since the animals were not confined. However outbreaks of coccidiosis have been reported in animals on range, especially in dry years when they concentrate around watering points; this congregation not only enhances contamination of water and soil but causes stress that may affect the resistance of the animals (Schillhorn van Veen 1986)

Mallesons

This locality yielded the fewest positive specimens. The management followed a strict program by way of feeding and grouping strategies. New-born dairy calves were given colostrum and after being removed from their dams, they were housed in walled, roofed buildings and individual pens. Only after weaning, usually at three months, were the animals grouped according to age in kraals. The number of calves in a single kraal ranged from 5 to 10. Adults at this locality were also grouped according to age in bigger kraals and in larger numbers. All the animals

were fed concentrates and hay and since they were not grazing this lessened the chances of the animals picking up infections from the ground.

The mean OPG of the adults was very low (4.7) and almost all of the specimens were negative for coccidia (93.3%). These results illustrate that the management system must be effective in controlling and preventing coccidiosis. Only 6.8% of specimens were found to be positive with OPG counts ranging between 1-499.

The highest monthly OPG's were found during the rainy season, which may indicate that the animals were ingesting more viable oocysts when it was wet and humid. Statistical analysis for comparing the months showed that there were significant differences in the number of positive adult specimens on a monthly basis with more specimens being positive during the rainy season. The highest monthly OPG of 32 and the highest number of positive specimens (8) were in November 1997, the highest rainfall month during the study.

It was observed that the animals tended to roll in the muddy pools of rainy water and afterwards cluster together in the shade of trees to avoid the flies that are in abundance on dairy farms during the wet summer season. The animals tended to rub against each other and sometimes lick each other's soiled coat, increasing the chances of coccidial transmission.

Almost half of the calf specimens (49%) were found to be positive for coccidia. Comparisons between adult and calf specimens showed that there were significant

differences between the age groups. Only one animal had an OPG count of more than 10 000, a high majority (42.8%) had OPG counts ranging between 1-499. None of the animals with high OPG counts were ever treated for clinical coccidiosis. It is also important to note that the ingestion of large numbers of sporulated oocysts does not always result in disease (Davis and Bowman 1957; Marquardt 1962). The animals were asymptomatic, except for the watery stools. All the calves in this locality had watery stools, probably because of the diet.

No clinical case of coccidiosis was observed during sampling. Positive faecal samples were found throughout the monthly sampling period except in January 1998, when all the examined faecal samples were negative. This finding was rather suprising as it was during the rainy season. Due to the fact that sampling was done after four weeks it could be that oocyst excretion was missed owing to the intervals between consecutive samples.

The highest number of positive specimens was found during the first month of sampling. Thereafter, the number of positive specimens declined from 19 to 5 in December and to zero in January. There were positive specimens for the rest of the months with the second highest number of positive specimens being in May and October (Table 16). The monthly mean OPG's followed an erratic pattern with the second highest mean in May and the highest in November 1998. The high monthly OPG in May for this locality was probably due to stress associated with weaning, regrouping, and the changes in environmental conditions. May signifies the beginning of winter and temperatures tend to be low, especially at night. There

seemed to be a similarity with the other two localities for the month of May, where the mean monthly OPG's were relatively high. Statistical analysis showed that there were significant differences amongst calf specimens at the three localities with calves in this locality having the fewest positive specimens. This can be attributed to the management way of grouping and feeding strategies.

Pienaars River

Animals at this locality were kept on natural pasture in large fenced camps. They were left to graze and no supplementary feeding was provided. Adults at this locality had the highest number of positive specimens (28.6%) compared to the other localities. The differences were significant. Two samples only had OPG > 2000 and they were sporulated for species identification. The two OPG counts were 2366 in March 1998 and 2800 in May 1998, respectively.

The mean OPG was 48.5, which signified that a majority of specimens had either low counts or were negative. As the maximum OPG count occurred at the beginning of winter, it may be that the animal was stressed

The mean monthly OPG's were erratic with the lowest monthly mean of 2.6 in August and the highest of 283.0 in May. The high monthly mean in May signified that the animals must have been stressed since it was the onset of winter and viable oocysts might have been on the ground after the rainy season.

Calves at this locality ranked second in the percentage (77.9%) of positive specimens amongst the three localities, with a maximum OPG count of 191 000 recorded in April 1998. The animals sampled during this visit had recently been weaned and the stresses associated with weaning must have made the calves susceptible to infections.

Parker and Jones (1987) reported that there was an increase in both the number of calves shedding oocysts, and in faecal oocyst counts 3-5 weeks after weaning. Since the calves had been running with their dams before weaning it would be proper to assume that the dams must have been the source of infection. They further reported that calves herded with their dams would have experienced infections and developed immunity by the weaning age of 4-5 months and that calves at weaning were found to be shedding small numbers of oocysts of nine *Eimeria* species, and that it was suspected that disease followed the immuno-suppressive effects of weaning.

Kaalplaas

Animals at this locality were kept on natural pasture in large fenced camps. No supplementary feeding was provided. Age-related immunity to coccidia in adults seemed to be effective as shown by only 18.2% of adult cattle specimens that were found to be positive for coccidial oocysts. No adult specimens were sporulated as OPG counts were too low. The highest OPG count in the adults was 866 in October 1998, which was the onset of the rainy season. This was also the month with the

highest number of positive specimens (15) indicating that the animals were probably picking up overwintered oocysts. The mean monthly OPG's were erratic with the lowest monthly mean of 0 in February and the highest of 23.4 in October. The mean OPG's of the adults were generally very low signifying low counts of coccidia that are generally associated with adult animals. High rainfall months in summer did not seem to affect levels of coccidia infections in adults.

Calves in this locality had the highest number of positive specimens (82.4%). It is suspected that rainfall might have contributed to this figure since Kaalplaas received more rainfall than Pienaars River. The highest OPG count of 85466 was recorded in May and all sampled calf specimens (25) were found to be positive (Table 18). The high figures in May correlate with the high figures at Pienaars River during the same time.

As the animals had been recently weaned, stresses associated with post weaning and harsh environmental conditions including dietary changes, weaning stress and immuno-suppression made the calves susceptible to coccidial infections as stated by Parker and Jones (1987).

Not only were there a high number of positive specimens at this locality, but 3.8% calf specimens had OPG's > 5000. Speer (1999) reported that few OPG in faeces indicate only low-grade of infection; 50 to 100 OPG in faeces, a moderate infection; and 100 to 1000 OPG in faeces, a high-grade coccidial infection and disease.

However, due to the different prepatent periods of *Eimeria* species, the fact that during the patent period there are low and high peaks of OPG counts and the fact that by the time oocysts are observed there has already been damage in the animal, different categories of OPG counts may or may not indicate different levels of infection. Different categories of OPG's in relation to levels of infection and disease may only apply to certain *Eimeria* species.

Our argument is supported by the fact that no diseased animals were observed, in spite of the fact that a number of specimens had OPG's > 5000. Hence the argument that OPG's > 5000 indicate clinical disease might be questionable.

There were significant differences in the levels of positive specimens between adults and calves at this locality. This is in line with the fact that coccidia are usually important in calves of < 1 year old.

4.1.1 Comparative analysis of breeds

Only adult Ngunis at Pienaars River and Bonsmaras at Kaalplaas were compared, since they were kept under the same conditions and management systems. The prevalence of *Eimeria* oocysts in Nguni adults was significantly higher than in Bonsmara adults (Table 2). The mean OPG of Nguni adults specimens was also 5 times higher than in Bonsmaras (Table 7 and 10), indicating that not only were most Nguni specimens positive, they also had higher coccidial counts.

There might be differences in the breeds, resulting in Ngunis been more susceptible to coccidial infections or Bonsmaras may be more resistant to *Eimeria* parasites.

It should be noted that confounding factors other than breed susceptibility might have influenced these findings, e.g. locality, time of sampling, environmental conditions and the general state of the herd.

Speer (1999) reported that there were differences in geographical distribution of *Eimeria* species infecting cattle, hence locality might have influenced these findings.

Sampling was done at 4-week intervals and oocysts shedding might have occurred between samplings.

Wet and humid conditions influence the survival of oocysts on the ground and it is important that conditions are favourable for the oocysts to sporulate.

Stress results in immuno-suppression in animals and coccidia are opportunistic parasites that multiply quickly in stressed animals.

The prevalence of oocysts in F1 generation calves at Kaalplaas was significantly higher than in Nguni calves at Pienaars River. The mean OPG of calves at Kaalplaas was also higher than at Pienaars River if values excluding 100 000 were ignored (Table 7 and 10). The findings for the adults and calves seem to be contradictory as it would be expected that indigenous breeds would be more

resistant than exotic breeds, however the same confounding factors mentioned above might have played a role.

4.1.2 Comparative analysis of November 1997 and November 1998

The two months were compared to see if there would be similar results in levels of infections at the three localities. The mean OPG of specimens from adults for November 1997 was three times higher than that of November 1998. A similar situation was also found with the calves. The relatively higher rainfall in November 1997 correlates with higher counts of coccidia. Coccidial oocysts develop fast and survive well in moist areas (Schillhorn van Veen 1986). The means for each locality were also compared. The animals had more oocyst output during the first November, except at Mallesons where the mean for the second November was higher than the first (Table 19). Since Mallesons is an intensively managed farm it is possible to find stressed animals at any time and there should not be a pattern in oocyst shedding.

4.1.3 Comparative analysis of seasonal oocyst shedding

Dry and wet seasons were compared to determine if there were any significant differences in the numbers of positive specimens at each locality for each age group. Statistical analysis showed that there were significant differences in numbers of infected animals during the two seasons for adults at Mallesons. The mean monthly OPG's were relatively higher during the rainy months (Table 15).

Adult animals were shedding more *Eimeria* oocysts during the wet season. As stated above coccidial oocyst need moisture to survive and to be viable and it is expected that more animals will be infected during the wet season.

Overwintered oocysts could also be playing a role in increasing the number of viable oocysts on the ground. There were no significant differences for the calves in Mallesons for the dry and wet season, although the mean monthly OPG's were relatively higher during the rainy months (Table 16).

There were no significant differences in the number of infected animals during the two seasons at Pienaars River. The wetter conditions during the rainy months did not significantly affect numbers of infected animals.

Numbers of positive calf specimens at Pienaars River were found to be significantly different between the two seasons. A majority of calf specimens were found to be positive during the wet season, although the mean monthly OPG's indicate that high oocyst numbers were shed during the dry season because of stresses associated with harsher environmental conditions.

There were significant differences in adult specimens positive for *Eimeria* at Kaalplaas during the two seasons. A majority of adult specimens were positive during the wet season. The mean monthly OPG's were erratic and the highest number of infected animals in a single month was in the rainy season (Table 17).

Calf specimens were found not to be significantly different during the two seasons, although the mean monthly OPG's were higher during the dry season, probably because of stresses associated with harsher environmental conditions.

4.2 *Eimeria* species present in faecal samples

Mallesons

Species were identified from sporulated specimens. The prevalent species in this locality were *E. zuernii and E. ellipsoidalis* (Table 25). It is still not clearly understood why certain species of *Eimeria* are always dominant in numbers, especially since the most pathogenic species are usually the most frequently recorded.

Pienaars River

Only two adult faecal samples were sporulated. Both samples were positive for *E. bovis* and *E. alabamensis*. Also found in one sample were *E. zuernii* and *E auburnensis*. No clinical symptoms were observed from the sampled adults.

Six species of coccidia were identified from calves at this locality (Table 25). A number of calves had mixed infections of *E. zuernii* and *E. bovis* and high OPG's of ≥ 5000, without showing clinical disease, except for watery stools. *E. bovis and E. zuernii* were dominant over other species in numbers.

Kaalplaas

No faecal samples from adults were sporulated because of low OPG's. Twelve species were identified from calf faecal samples. The two pathogenic species *E. bovis* and *E. zuernii* dominated in numbers over other less pathogenic species (Table 25), although no clinical cases were encountered. Most of the sporulated specimens had mixed infections.

4.3 Prevalence of veterinary important species

In outbreaks of coccidiosis, the most frequent seen coccidian oocysts are usually those of *E. bovis* and *E. zuernii,* followed by *E.auburnensis*, and *E. ellipsoidalis* (Speer 1999). The two most abundant species from sporulated specimens at Mallesons were *E. zuernii* and *E.ellipsoidalis* (Table 29). The most prevalent species from sporulated specimens at Pienaars River were *E. bovis*, *E. zuernii* and *E. ellipsoidalis*. Munyua and Ngotho (1989) reported that the same species were the most prevalent *Eimeria* species in cattle in Kenya. Chibunda, Muhairwa, Kambarage, Mtambo, Kusiluka and Kazwala (1996) reported similar findings in dairy cattle farms in Tanzania. The most prevalent species from sporulated specimens at Kaalplaas were *E. zuernii, E. bovis, E. ellipsoidalis* and *E. alabamensis*. A number of authors, (Majoro 1980; Kasim and Al-Shawa 1984; Oda and Nishida 1989) reported either *E. bovis* and/or *E. zuernii* and/or *E. ellipsoidalis* to be the most prevalent species in their respective studies. Parker and Jones (1987) found that oocysts of the recognised pathogens *E. bovis, E. ellipsoidalis* and *E. zuernii* were

usually the earliest and commonly shed species in the first eight months of unweaned calves on pastures. They also found that this species dominated subsequent oocyst production.

Conclusion

In the three studied localities, coccidiosis did not seem to be a serious problem, although animals with obvious signs of diarrhoea were observed. Also veterinary important *Eimeria* species were identified and relatively high oocysts counts were made.

The management system at Mallesons seemed to be effective in preventing coccidiosis especially since the animals were confined and the farm was intensively managed. Pathogenic *Eimeria* species, including *E. zuernii,* were also found in the calf population, but *E. bovis* was not recovered. Prompt removal of calves after birth from their dams, appropriate neonatal management and transfer to clean roofed pens were some of the ways that minimised the chances of coccidial infections at Mallesons. The fact that the animals were fed in feed bunks and had access to clean water contributed to low occurrence of coccidia. Hence this study has shown that strict programs of feeding and grouping strategies can be effective in preventing coccidiosis outbreaks on intensively managed farms.

Although outbreaks of coccidiosis have been reported in animals on pasture, it was not found to be a problem in animals at Pienaars River and Kaalplaas. Various stressors enhance multiplication of coccidia parasites and with species like *E. zuernii* and *E. bovis* circulating in the herds at the two localities, there is a potential danger of outbreaks.

Since calves are most susceptible, owners should adopt the principles of grouping strategies in camps and pasture management should also be an option. Pasture rotation with limited grazing times and frequent movement may be beneficial as time goes on, by reducing overall oocyst contamination and exposure (Oetjen 1993). It is also important to monitor animals during weaning, harsher environmental conditions or during times when animals are moved from one locality to another.

Although anti-coccidial drugs are available and can be used prophylactically before and during stressful periods, cost is always a consideration for farmers. An important difficulty with treatment of clinical coccidiosis is that signs of the disease do not appear until the life cycle of the parasite is almost completed or the gut is already severely damaged. Also the parasites have already passed through the endogenous stages against which anti-coccidial drugs are effective (Ernst and Benz 1986).

Hence by following simple cost-effective strategies of grouping and pasture rotation and by constant monitoring of the animals, animals may have minimal exposure to coccidial oocysts, stressors may be reduced and coccidiosis may never have to be a threat to the cattle farming community especially to resource-limited farmers.

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