Epidemiological studies of parasitic gastrointestinal nematodes, cestodes and coccidia infections in cattle in the highveld and lowveld communal grazing areas of Zimbabwe

D.M. PFUKENYI[1], S. MUKARATIRWA[2], A.L. WILLINGHAM[3] and J. MONRAD[3]

ABSTRACT

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Between January 1999 and December 2000 faecal samples from 16 264 cattle at 12 dipping sites in the highveld and nine in the lowveld communal grazing areas of Zimbabwe were examined for gastrointestinal (GI) nematode and cestodes eggs, and coccidia oocysts. Strongyle larvae were identified following culture of pooled faecal samples collected at monthly intervals. The effects of region, age, sex and season on the prevalence of GI nematodes, cestodes and coccidia were determined. Faecal egg and oocyst counts showed an overall prevalence of GI nematodes of 43 %, coccidia 19.8 % and cestodes 4.8 %. A significantly higher prevalence of infection with GI nematodes, cestodes and coccidia was recorded in calves ($P < 0.01$) than in adults. Pregnant and lactating cows had significantly higher prevalences than bulls, oxen and non-lactating (dry cows) ($P < 0.01$). The general trend of eggs per gram (epg) of faeces and oocysts per gram (opg) of faeces was associated with the rainfall pattern in the two regions, with high epg and opg being recorded during the wet months. The most prevalent genera of GI nematodes were *Cooperia, Haemonchus* and *Trichostrongylus* in that order. *Strongyloides papillosus* was found exclusively in calves. *Haemonchus* was significantly more prevalent during the wet season than the dry season ($P < 0.01$). In contrast, *Trichostrongylus* was present in significantly ($P < 0.01$) higher numbers during the dry months than the wet months, while *Cooperia* and *Oesophagostomum* revealed no significant differences between the wet and dry season. These findings are discussed with reference to their relevance for strategic control of GI parasites in cattle in communal grazing areas of Zimbabwe.

Keywords: Age distribution, cattle, cestodes, coccidia, communal grazing, epidemiology, gastrointestinal nematodes, seasonal occurence, Zimbabwe

INTRODUCTION

In rural Zimbabwe, cattle are grazed on communal pastures throughout the year. The animals do not receive any supplement (Pandey, Chitate & Nyanzunda 1993) and fodder shortage is usually a problem, even in the rainy season (Moyo, Bwangomoi, Hendrikx & Eysker 1996). Anthelmintic treatment of communal cattle is either non-existent or very occasional and irregular (Pandey *et al.* 1993). A combination of poor nutrition, communal grazing, high stocking rate and lack of anthelmintic medication may result in heavy worm burden in communally grazed cattle (Pandey *et al.* 1993).

There have been studies on internal parasites of cattle in the communal farming areas of Zimbabwe (Pandey 1989; Obwolo, Hill, Nyathi, Ogaa, Odiawo,

[1] Clinical Veterinary Studies, Faculty of Veterinary Science, University of Zimbabwe, P.O. Box MP167, Mt Pleasant, Harare, Zimbabwe. Email: dmpfukenyi@vet.uz.ac.zw

[2] Paraclinical Veterinary Studies, Faculty of Veterinary Science, University of Zimbabwe, P.O. Box MP167, Mt Pleasant, Harare, Zimbabwe

[3] Danish Centre for Experimental Parasitology, Dyrlaegevej 100, DK-1870, Frederiksberg C, Copenhagen, Denmark

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Llewelyn, Vickers & Moyo 1992; Pandey *et al.* 1993; Vassilev 1994, 1999; Moyo *et al.* 1996). These studies have shown that the predominant parasites in cattle were *Fasciola gigantica,* amphistomes, and strongylid nematodes, with coccidia, *Schistosoma mattheei, Moniezia* spp. and *Trichuris* spp. being less prevalent. However, all the earlier studies carried out in Zimbabwe concentrated on one agroclimatic region of the country, that is the highveld with the lowveld being completely neglected. The diverse agroclimatic conditions, animal husbandry practices and pasture management have been shown to largely determine the incidence and severity of various parasitic diseases in a region (Jithendran & Bhat 1999). Therefore, information on the epidemiological patterns of the parasitic diseases in different agroclimatic zones of the country would provide a basis for evolving strategic and tactical control of these parasitic diseases (Jithendran & Bhat 1999).

This study was carried out to determine the level of gastrointestinal nematodes, cestodes and coccidia infections of cattle in the highveld and lowveld communal farming areas of Zimbabwe, and to determine the effect of agroclimatic zones, age and season on the prevalence of gastrointestinal parasitism in order to form a basis for formulating strategies for parasite control.

MATERIALS AND METHODS

Study location

Based mainly on rainfall and temperature, Zimbabwe is divided into agro-ecological regions I, II, III, IV and V (Fig. 1). On the basis of altitude, the country is also divided into three major relief regions, the Highveld (1 200–2 000 m), Middleveld (900–1 200 m) and the Lowveld (below 900 m).

The rainy season is from November/December to March/April and the dry season occurs from April/May to October/November. The respective mean annual rainfall for regions I–III is 1 000 mm, 750–1 000 mm and 650–800 mm. Region IV receives low rainfall of 450–650 mm and is subject to periodic droughts. In region V, rainfall is very erratic and is less than 500 mm per annum.

Hills and valleys characterize the topography of the highveld in which streams and rivers are located. Dams, rivers and marshy areas which serve as common watering places for livestock are common in the area. In the lowveld, the topography is generally flat land, with man-made dams serving as watering points for livestock. Pastures in the communal grazing areas are composed of uncultivated grassland and scrub bush.

Seven districts were randomly selected within agro-ecological regions II and III (Highveld) and IV (Lowveld) (Fig. 1)—four from the Highveld and three from the Lowveld (Table 1).

Selection of study sites

Dip tanks were chosen as the study sites owing to the availability of handling animal facilities and access to larger populations of cattle. Three dip tanks were randomly selected from each district, giving a total of 21 study sites—12 from the Highveld and nine from the Lowveld (Table 1). In these areas cattle were dipped weekly during the rainy season and fortnightly during the dry season for the control of ticks.

Animals

Local indigenous cattle used in the study were Sanga type (a stabilized *Bos taurus* x *Bos indicus* cross), commonly known as “Mashona”. Cattle from each of the study sites were categorized into calves (less than 12 months old), weaners (1–2 years old) and adults (over 2 years old). Calves and weaners were further divided into males and females, and adults into dry, lactating and pregnant cows, oxen and bulls. Rectal faecal samples were collected from each category of cattle once every month. The survey covered the period from January 1999 to December 2000.

Parasitological analysis

Faecal samples were quantitatively examined for nematode, cestode eggs and coccidia oocysts by the modified McMaster technique (Ministry of Agriculture, Fisheries & Food 1986) on 4 g of faeces using saturated sodium chloride solution and each egg counted represented 50 eggs. The results were expressed as eggs per gram of faeces (epg) or oocysts per gram of faeces (opg).

Monthly, pooled faecal samples from each category of cattle for each dip tank were cultured for larval identification (Ministry of Agriculture, Fisheries & Food 1986). One hundred third-stage strongyle larvae (L_3) including *Strongyloides papillosus* larvae from each culture were identified for each animal category and dip tank. Levels of strongyle infections were classified into low, moderate and heavy based on epg.

TABLE 1 Study sites, cattle census and total samples collected in the highveld and lowveld communal grazing areas of Zimbabwe for the period January 1999 to December 2000

Region	District	Distance from nearest meteorological station (km)	Number of dip tanks surveyed	Cattle census	Total faecal samples collected
Lowveld	Zvishavane	12	3	20 175	2 116
	Mberengwa	14	3	30 649	3 174
	Plumtree	9	3	24 041	2 504
Highveld	Wedza	8	3	30 189	3 121
	Murewa	10	3	25 801	1 390
	Zvimba	13	3	12 339	1 242
	Mazowe	10	3	26 165	2 716

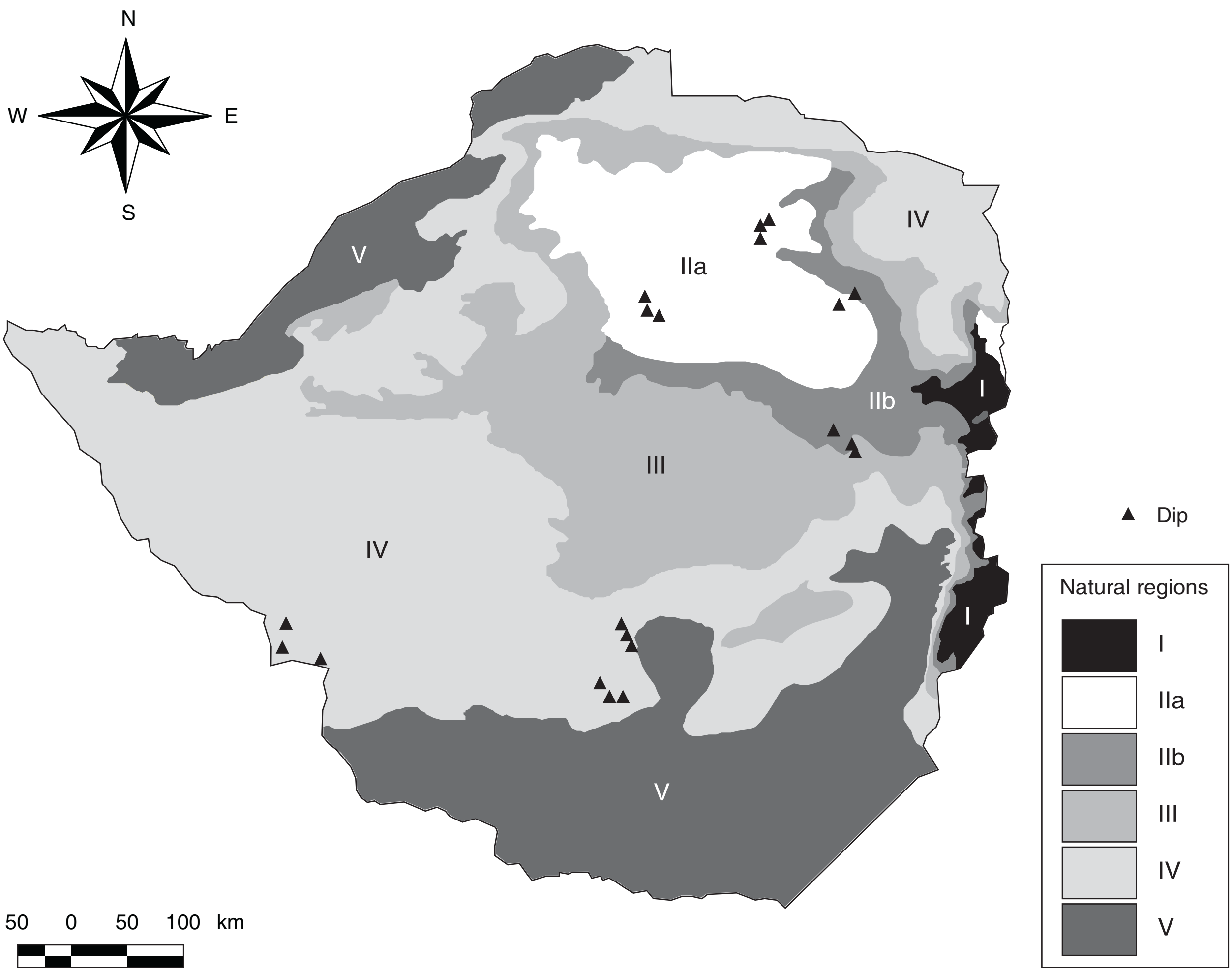

FIG. 1 Location of dips sampled in the different natural regions in the highveld and lowveld communal grazing areas of Zimbabwe

Meteorological data

Mean monthly temperatures and mean monthly rainfall data from the meteorological station nearest to each site were obtained from the recordings by the Department of Meteorology, Belvedere, Harare.

Statistical analysis

Faecal egg counts were logarithm-transformed [$\log_{10}$ (egg count + 1)] to stabilize the variance before analysis. The effect of age, sex, year, season and location on transformed egg counts was measured by the General Linear Model (GLM) in SPSS (version 8.0). Categories were generated as follows:

- Three for age (calves < 12 months old, weaners 1–2 years old and adults > 2 years old)
- Nine for sex (female calves, male calves, female weaners, male weaners, dry, lactating and pregnant cows, oxen and bulls)
- Two for season (wet, November to April and dry, May to October)
- Two for locations (highveld and lowveld).

Least Square Difference (LSD) was used as the post-hoc test to measure variances between different categories. Values of $P < 0.05$ were considered as significant. The correlation between egg counts and climatic factors (rainfall and temperature) was determined by a linear regression model.

RESULTS

The mean monthly temperature and rainfall during the period of study are presented in Fig. 2. Mean monthly rainfall was higher for the highveld region than the lowveld while mean monthly temperature was higher for the lowveld than the highveld. Except for these regional differences, weather values for each region were within the normal ranges.

Gastrointestinal nematodes

A total of 16 264 (calves 5 418, weaners 5 461 and adults 5 385) faecal samples was collected during the entire period of the study and 6 999 (43 %) of the samples were positive for strongyle eggs. For both agro-ecological regions the number of animals positive for strongyle eggs differed significantly between the 2 years, with the second year having a significantly higher prevalence ($P < 0.01$) than the first year (Table 2). For both years the highveld had a significantly higher prevalence ($P < 0.01$) than the lowveld (Table 2).

For both regions, there were significant differences in prevalence of strongyle infections among the age categories ($P < 0.001$) of the cattle, with calves having a higher prevalence than the weaners and adults—except for lactating cows on highveld in both years and on lowveld in Year 2 (Table 2). Lactating & pregnant cows had significantly higher prevalences ($P < 0.01$) than bulls, oxen and dry cows (Table 2).

FIG. 2 Mean monthly rainfall and temperature in the highveld and lowveld of Zimbabwe for the period January 1999 to December 2000

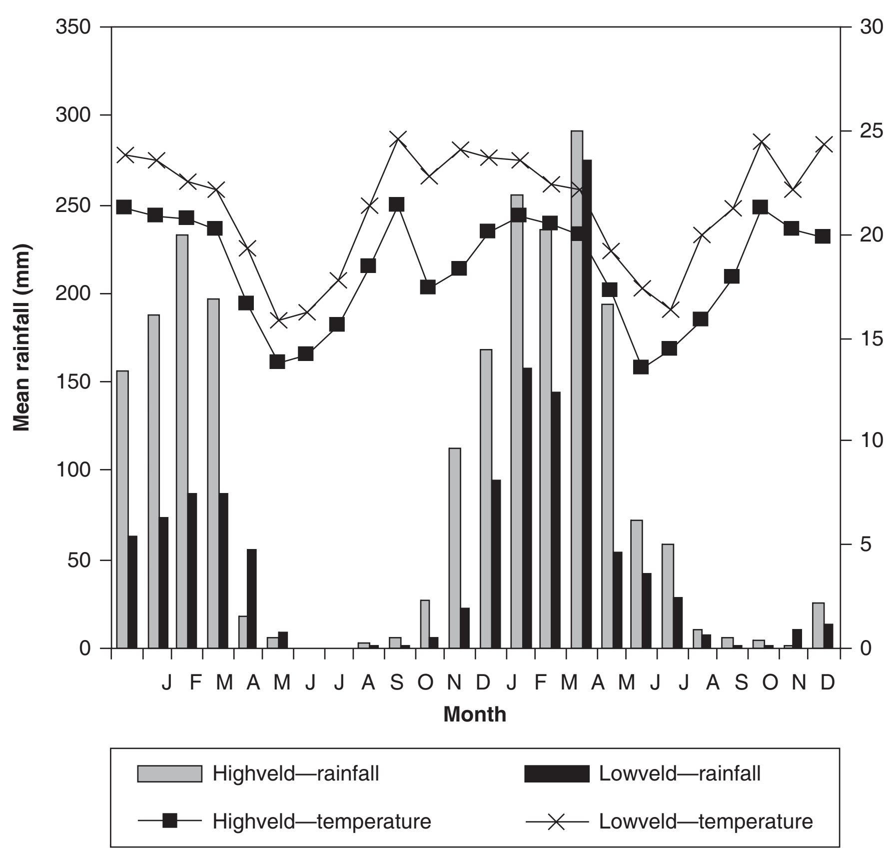

TABLE 2 Mean prevalence (%) of strongyles in the different categories of cattle by year, region and district in the highveld and lowveld communal grazing areas of Zimbabwe as from January 1999 to December 2000

Year	Region	Agro-ecological zone	District	+N	Animal category									Overall
					Calves		Weaners		Adult cows			Oxen	Bulls	
					Females	Males	Females	Males	Dry	Lactating	Pregnant			
Jan to Dec 1999	Highveld	II & III	Wedza	1 497	43.1	42.1	41.3	40.3	33.9	45.5	37.2	30.9	21.3	39.0
		II	Murewa	1 390	46.3	49.1	40.6	39.4	32.7	60.6	50.5	32.4	34.1	42.7
		II	Zvimba	842	53.6	47.6	41.8	48.5	10.6	48.5	34.0	21.1	24.1	40.1
		II	Mazowe	1 368	51.2	63.5	43.1	51.1	20.0	49.4	52.5	30.1	54.3	48.9
			Overall	**5 097**	**47.7^{a}**	**50.9^{a}**	**41.7^{b}**	**44.3^{b}**	**27.7^{c}**	**51.5^{e}**	**45.8^{f}**	**29.5^{c}**	**34.3^{d}**	**42.8^{aa}**
	Lowveld	IV	Zvishavane	1 354	45.8	44.2	34.2	35.8	17.6	47.4	31.1	24.6	23.8	36.4
		IV	Mberengwa	1 554	54.3	62.3	34.3	38.2	17.9	35.5	42.9	37.2	41.9	43.3
		IV	Plumtree	1 109	33.2	28.9	28.9	26.3	14.1	47.2	35.5	24.0	20.0	28.3
			Overall	**4 017**	**45.8^{a}**	**46.9^{a}**	**32.8^{e}**	**33.8^{e}**	**16.4^{b}**	**41.8^{d}**	**37.2^{d}**	**28.8^{c}**	**29.2^{c}**	**36.8^{bb}**
Jan to Dec 2000	Highveld	II & III	Wedza	1 624	56.1	55.9	49.0	45.3	35.2	65.1	52.2	36.5	34.4	48.8
		II	Murewa	–	–	–	–	–	–	–	–	–	–	–
		II	Zvimba	401	59.7	54.5	50.7	48.3	28.6	66.7	52.0	36.8	36.8	50.0
		II	Mazowe	1 348	56.3	57.1	46.3	50.7	41.7	64.9	43.1	35.8	50.0	50.3
			Overall	**3 373**	**56.6^{b}**	**56.2^{b}**	**48.1^{a}**	**47.6^{a}**	**35.5^{d}**	**65.2^{c}**	**47.5^{f}**	**36.2^{d}**	**40.0^{g}**	**49.5^{cc}**
	Lowveld	IV	Zvishavane	762	51.7	51.5	39.3	41.4	32.6	40.4	43.8	33.8	33.3	42.9
		IV	Mberengwa	1 620	53.1	54.8	44.9	45.4	28.8	52.0	46.7	44.3	25.9	47.3
		IV	Plumtree	1 395	45.8	45.8	38.3	40.8	25.0	56.1	46.0	31.9	29.5	41.0
			Overall	**3 777**	**50.2^{a}**	**50.6^{a}**	**41.5^{b}**	**42.8^{b}**	**28.1^{c}**	**51.0^{e}**	**46.0^{f}**	**37.2^{d}**	**28.9^{c}**	**44.1^{aa}**

Figures with a different superscript in a column or row under overall prevalence are significantly different at $P < 0.05$

+N = Total number of animals sampled

Overall, respectively 59 %, 35 % and 6 % of the faecal samples had low (< 200), moderate (200–700) and heavy (> 700) numbers of strongyle epg of faeces (Table 3). Over 6 % of female and male calves, and lactating and pregnant cows recorded heavy output of eggs compared to other categories of cattle.

There were significant differences in the prevalence at different seasons of the year ($P < 0.01$) with the wet season having a significantly higher prevalence than the dry season (Table 4). Faecal egg output occurred during all the months of the 2-year period study. The mean faecal egg output rose from November/December to April/May (Fig. 3). Mean faecal egg counts were significantly higher during the wet months ($P < 0.01$) than the dry months (Fig. 3). The mean monthly faecal count was significantly higher for the highveld ($P < 0.01$) than the lowveld (Fig. 3). For both regions, the mean monthly faecal egg count of calves during the wet months was significantly higher ($P < 0.01$) than that of weaners and adults (Fig. 3). Lactating and pregnant cows had a higher mean monthly faecal egg count than dry cows, bulls and oxen (Fig. 4).

The highest monthly egg count recorded during the period of study was 10 600 epg of faeces in a calf during the month of March 1999. The overall mean

TABLE 3 Levels of strongyle infections in various categories of cattle in the communal grazing areas of the highveld and lowveld for the period January 1999 to December 2000

Animal category	Low (epg < 200) Infected cattle (%)	Moderate (epg 200–700) Infected cattle (%)	Heavy (epg > 700) Infected cattle (%)
Female calves	56.3	36.1	7.6
Male calves	53.3	38.7	8.0
Female weaners	62.3	33.0	4.7
Male weaners	61.5	34.3	4.2
Dry cows	67.1	30.9	2.0
Lactating cows	58.8	33.4	7.8
Pregnant cows	50.9	40.7	6.8
Oxen	65.5	31.1	3.4
Bulls	70.9	25.8	3.3

TABLE 4 Seasonal mean prevalence (%) of strongyles in the different age categories of cattle by region and year in the highveld and lowveld communal grazing areas of Zimbabwe as from January 1999 to December 2000

Season	Region	Age group	Year 1 (Jan to Dec 1999)		Year 2 (Jan to Dec 2000)	
			*N	Mean prevalence (%)	+N	Mean prevalence (%)
Wet	Highveld	Calves	754	61.5	581	68.0
		Weaners	775	56.5	597	59.3
		Adults	759	47.8	571	55.3
		Overall	**2 288**	**55.3[a]**	**1 749**	**60.9[b]**
	Lowveld	Calves	656	55.6	604	62.7
		Weaners	669	41.1	594	51.5
		Adults	657	39.3	599	46.7
		Overall	**1 982**	**45.3[b]**	**1 797**	**53.7[c]**
Dry	Highveld	Calves	955	39.7	536	43.8
		Weaners	921	31.5	550	35.3
		Adults	933	26.8	538	32.7
		Overall	**2 809**	**32.7[c]**	**1 624**	**37.3[d]**
	Lowveld	Calves	671	37.2	661	39.2
		Weaners	695	25.8	659	33.5
		Adults	669	22.9	660	33.3
		Overall	**2 035**	**28.6[c]**	**1 980**	**35.4[d]**

Figures with a different superscript within a column or row under overall prevalence are significantly different at $P < 0.05$

+N = Total number of animals sampled

faecal egg count for positive animals combined was 269.4 and 221.5 for the highveld and lowveld, respectively, with the highveld having a significantly higher mean faecal egg count ($P < 0.01$) than the lowveld. Calves, weaners and adults had respective overall mean faecal egg count of 280.8, 226.4 and 227.5 with that of calves being significantly higher ($P < 0.01$) than that of weaners and adults. There was a positive correlation between the faecal egg counts and rainfall (r = 0.72).

Data from larval cultures indicated that the animals carried mixed parasite burdens. *Cooperia* (36.2 %), *Haemonchus* (28.4 %) and *Trichostrongylus* (23.7 %) were the most prevalent genera recorded. *Oesophagostomum* (9.6 %), *Strongyloides papillosus* (2.0 %) and *Bunostomum* (0.3 %) were less common. Only four calves and 39 adult animals were found positive for *Toxocara vitulorum* and *Trichuris,* respectively.

Table 5 shows the frequency of infective larvae (L_3) for the different genera of nematodes found on fae-

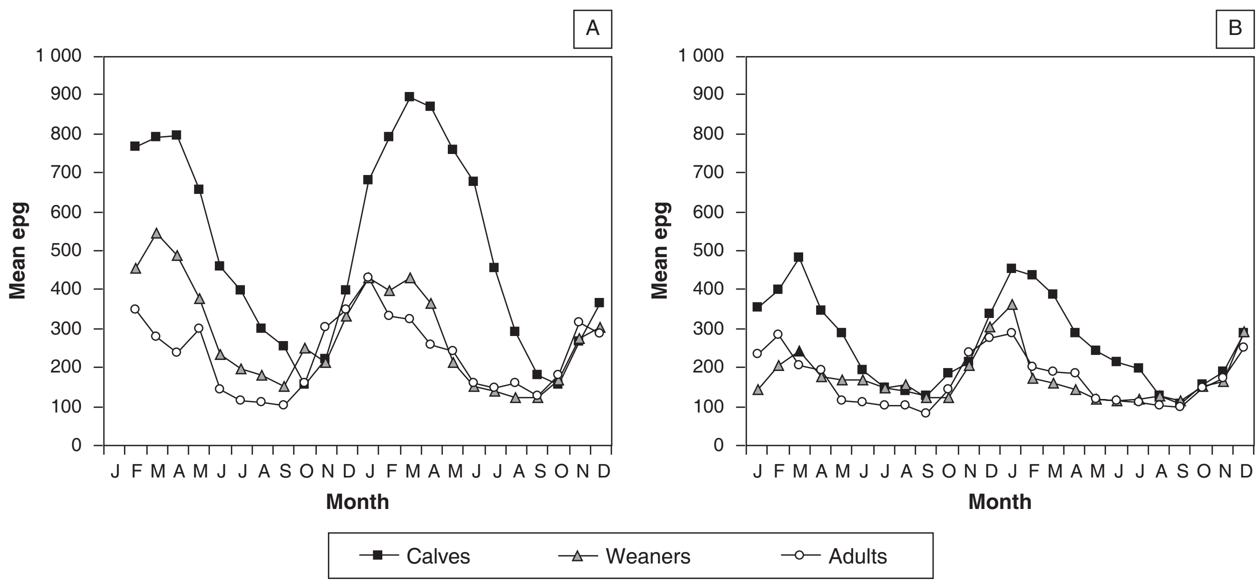

FIG. 3 Mean monthly strongyle faecal egg counts according to age in the (a) highveld and (b) lowveld for the period January 1999 to December 2000

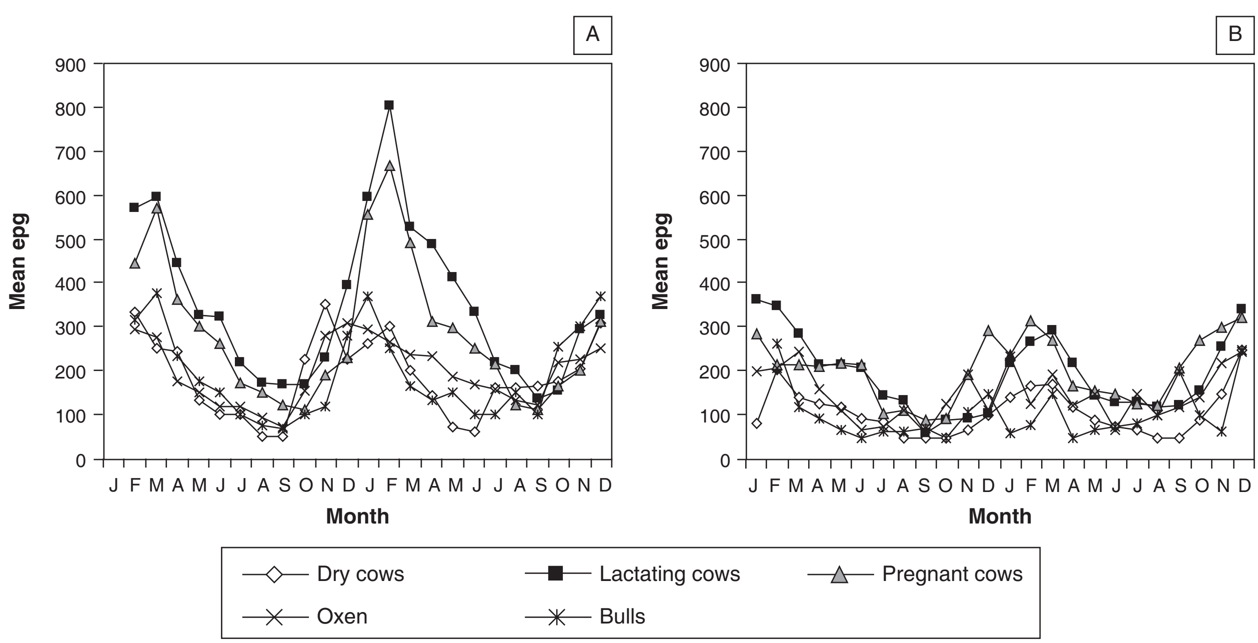

FIG. 4 Mean monthly strongyle faecal egg counts in adult cattle in the (a) highveld and (b) lowveld for the period January 1999 to December 2000

cal culture of pooled samples in calves, weaners and adults. *Strongyloides* were found in calves only. No clear age trend was detected in the frequency distribution of infective larvae of the other genera of nematodes. No significant difference in the frequency occurrence of *Cooperia* and *Oesophagostomum* was observed between the highveld and lowveld. *Haemonchus, Strongyloides* and *Bunostomum* had a significantly higher occurrence in the highveld ($P < 0.01$) than in the lowveld while *Trichostrongylus* had a significantly higher occurrence ($P < 0.01$) in the lowveld than the highveld.

The seasonal frequencies of different genera of GI nematodes found on faecal culture of pooled samples are shown in Fig. 5. For both regions, *Haemonchus* occurred significantly more during the wet months of the year ($P < 0.01$) than during the dry season. There was no significant difference in the occurrence of *Cooperia* between the wet and dry seasons except in the second year when the dry season had a significantly ($P < 0.01$) higher prevalence than the wet season. For both regions and years, *Trichostrongylus* was present in significantly higher numbers during the dry months ($P < 0.01$)

TABLE 5 Percent frequency of infective larvae (L_3) of different genera of nematodes found in faecal cultures of pooled samples of three categories of cattle in the highveld and lowveld of Zimbabwe (mean ± standard deviation) for the period January 1999 to December 2000

Region	Genus	Age group			Overall
		Calves	Weaners	Adults	
Highveld	*Cooperia*	32.0 ± 14.3	37.6 ± 13.2	38.0 ± 14.3	35.9^a ± 13.2
	Haemonchus	27.9 ± 13.2	31.2 ± 14.5	29.6 ± 16.6	29.6^a ± 14.8
	Trichostrongylus	23.3 ± 11.5	21.4 ± 12.7	21.9 ± 12.6	23.2^a ± 12.3
	Oesophagostomum	8.0 ± 10.0	9.4 ± 9.1	10.2 ± 11.7	9.2^a ± 10.3
	Strongyloides	8.4 ± 3.1	0	0	2.8^a ± 3.7
	Bunostomum	0.4 ± 1.0	0.4 ± 1.0	0.3 ± 0.9	0.4^a ± 1.0
Lowveld	*Cooperia*	36.3 ± 12.1	35.8 ± 13.3	37.5 ± 13.9	36.5^a ± 13.1
	Haemonchus	27.4 ± 12.6	25.7 ± 13.4	28.2 ± 13.2	27.1^b ± 13.1
	Trichostrongylus	24.8 ± 12.7	26.3 ± 12.2	24.2 ± 11.1	25.1^b ± 12.0
	Oesophagostomum	9.1 ± 8.2	10.5 ± 10.3	10.0 ± 9.0	9.9^a ± 9.2
	Strongyloides	2.2 ± 4.2	0	0	1.2^b ± 1.6
	Bunostomum	0.2 ± 1.4	0.2 ± 1.7	0.1 ± 2.5	0.2^b ± 1.4

Figures with a different superscript for the same species in a column are significantly different at $P < 0.05$

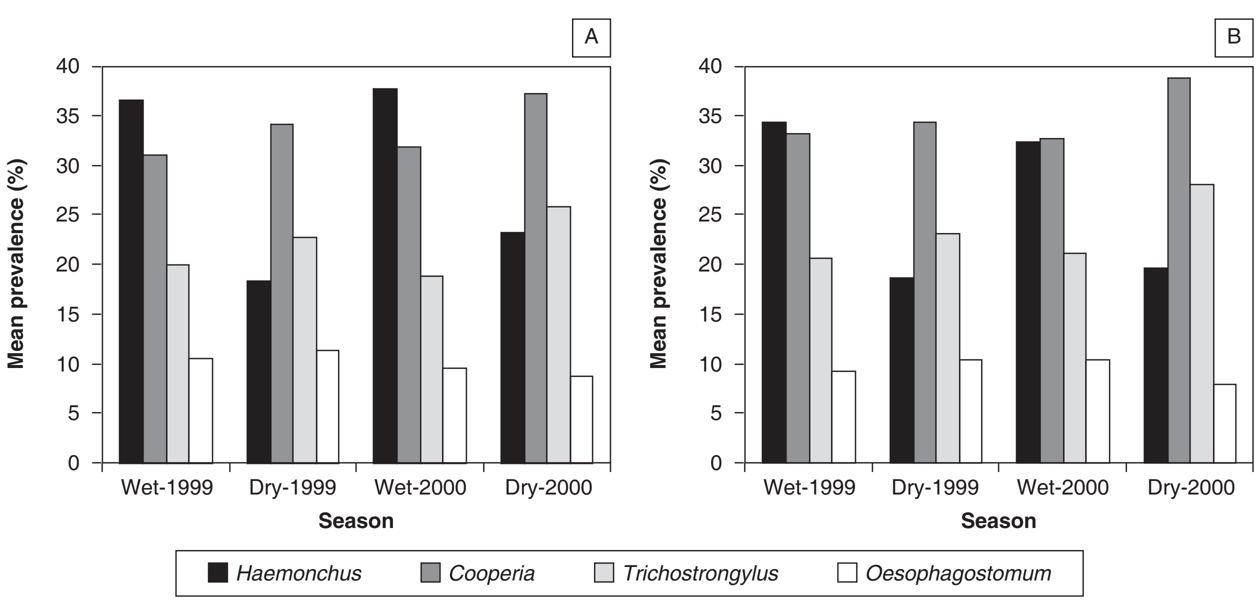

FIG. 5 Seasonal frequency (%) of infective larvae (L3) of strongyles in faecal cultures of pooled samples of communal grazing cattle in the (a) highveld and (b) lowveld of Zimbabwe for the period January 1999 to December 2000

TABLE 6 Mean prevalence (%) of coccidia oocysts in the different categories of cattle by year, region and district in the highveld and lowveld communal grazing areas of Zimbabwe as from January 1999 to December 2000

Year	Region	Agro-ecological Zone	District	$^{+}$N	Animal category									Overall
					Calves		Weaners		Adult cows			Oxen	Bulls	
					Females	Males	Females	Males	Dry	Lactating	Pregnant			
Jan to Dec 1999	Highveld	II & III	Wedza	1 497	28.5	25.2	19.7	18.2	13.7	14.0	20.0	7.2	12.8	19.4
		II	Murewa	1 390	27.9	23.9	20.1	16.9	13.3	16.1	22.7	12.4	4.5	17.5
		II	Zvimba	842	31.2	33.8	24.2	20.8	16.7	11.3	15.2	18.9	6.9	23.5
		II	Mazowe	1 368	27.2	24.5	15.1	16.6	4.0	6.4	16.9	13.3	17.4	17.8
			Overall	**5 097**	**28.4^{a}**	**26.1^{a}**	**19.4^{b}**	**17.8^{b}**	**13.4^{c}**	**11.3^{e}**	**19.0^{b}**	**12.1^{c}**	**12.0^{c}**	**19.7^{aa}**
	Lowveld	IV	Zvishavane	1 354	25.4	25.0	17.2	14.3	2.2	12.5	15.4	1.4	18.2	16.5
		IV	Mberengwa	1 554	14.1	12.5	10.6	10.1	13.6	6.0	6.3	7.9	13.8	10.7
		IV	Plumtree	1 109	12.7	11.0	10.2	7.6	4.8	3.0	3.7	5.8	6.6	8.5
			Overall	**4 017**	**15.7^{b}**	**14.7^{b}**	**11.7^{c}**	**10.1^{c}**	**7.1^{d}**	**6.0^{d}**	**7.3^{d}**	**5.7^{d}**	**11.8^{c}**	**11.1^{bb}**
Jan to Dec 2000	Highveld	II & III	Wedza	1 624	44.7	44.9	23.7	20.4	28.6	31.1	29.1	21.5	23.4	30.8
		II	Murewa	–	–	–	–	–	–	–	–	–	–	–
		II	Zvimba	401	20.9	33.3	19.2	15.0	17.9	12.0	8.3	7.9	26.3	19.3
		II	Mazowe	1 348	39.6	37.2	21.7	26.6	22.2	19.5	21.6	17.9	28.6	27.6
			Overall	**3 373**	**39.8^{c}**	**40.4^{c}**	**22.3^{d}**	**22.0^{d}**	**25.4^{d}**	**23.1^{d}**	**23.2^{d}**	**18.6^{e}**	**25.6^{d}**	**28.1^{cc}**
	Lowveld	IV	Zvishavane	762	31.9	31.3	21.1	22.5	10.8	18.0	21.1	13.8	14.3	23.1
		IV	Mberengwa	1 620	27.4	28.9	15.9	21.6	16.7	10.9	8.2	17.5	16.3	20.0
		IV	Plumtree	1 395	32.6	24.9	19.3	19.2	13.0	16.1	9.4	17.6	8.6	20.6
			Overall	**3 777**	**30.4^{a}**	**28.6^{a}**	**18.5^{d}**	**21.2^{d}**	**13.5^{c}**	**14.5^{c}**	**12.6^{c}**	**16.3^{c}**	**13.3^{c}**	**21.2^{aa}**

Figures with a different superscript in a column or row under overall prevalence are significantly different at $P < 0.05$

$^{+}$N = Total number of animals sampled

TABLE 7 Seasonal mean prevalence (%) of coccidia oocysts in the different age categories of cattle by region and year in the highveld and lowveld communal grazing areas of Zimbabwe as from January 1999 to December 2000

Season	Region	Age group	Year 1 (Jan to Dec 1999)		Year 2 (Jan to Dec 2000)	
			*N	Mean prevalence (%)	+N	Mean prevalence (%)
Wet	Highveld	Calves	754	33.0	581	41.5
		Weaners	775	23.1	597	29.6
		Adults	759	15.4	571	26.6
		Overall	**2 288**	**23.8[a]**	**1 749**	**32.6[b]**
	Lowveld	Calves	656	18.2	604	36.0
		Weaners	669	13.3	594	22.7
		Adults	657	8.8	599	16.9
		Overall	**1 982**	**13.5[c]**	**1 797**	**25.2[d]**
Dry	Highveld	Calves	955	22.7	536	38.6
		Weaners	921	14.9	550	14.0
		Adults	933	11.3	538	17.7
		Overall	**2 809**	**16.3[b]**	**1 624**	**23.4[d]**
	Lowveld	Calves	671	12.4	661	23.2
		Weaners	695	8.8	659	17.0
		Adults	669	5.5	660	12.0
		Overall	**2 035**	**8.9[d]**	**1 980**	**17.4[a]**

Figures with a different superscript within a column or row under overall prevalence are significantly different at $P < 0.05$

+N = Total number of animals sampled

than the wet months while there was no significant difference in the occurrence of *Oesophagostomum* between the wet and dry seasons.

Coccidia

Overall, oocysts were recorded in 19.8 % of the samples with the highveld having a significantly higher prevalence ($P < 0.01$) than the lowveld. The prevalence differed significantly between the 2 years with the second year having a significantly higher prevalence ($P < 0.01$) than the first year (Table 6).

For both regions, there were significant differences in prevalence among the age categories ($P < 0.001$), with calves having a higher prevalence than the adults (Table 6). Calves had significantly ($P < 0.001$) higher opg of faeces than the adults.

The highest oocyst count recorded during the period of study was 29 400 opg of faeces in a calf in February 1999. Of the total animals infected, 5.6 % were shedding more than 1 000 opg, with 8.1 %, 2.6 % and 4.5 % of infected calves, weaners and adults shedding more than 1 000 opg, respectively. During the wet season the prevalence was significantly higher ($P < 0.01$) than during the dry season (Table 7). Mean faecal oocyst counts were similarly significantly higher during the wet months than the dry months.

Cestodes

The only recorded cestode spp. was *Moniezia benedeni* and 4.8 % of the samples were positive for it. There was no significant difference in number of animals positive for cestodes between the two regions. The wet season had a significantly higher prevalence ($P < 0.01$) than the dry season. However, in the lowveld there was no significant difference between the two seasons in the second year.

DISCUSSION

Gastrointestinal nematodes

The present study clearly demonstrated the effect of age on the occurrence of GI nematodes with the prevalence being highest in animals aged less than 12 months and lowest in adult cattle. This conforms to earlier reports (Anene, Onyekwodiri, Chime & Anika 1994; Vassilev 1994, 1999; Waruiru, Kyvsgaard, Thamsborg, Nansen, Bogh, Munyua & Gathuma 2000), which showed that the susceptibility and pathogenicity of nematode infections were greater in young animals than in mature animals.

During lactation, and sometimes during late pregnancy, the immune response of the host to gastrointestinal nematodes is partially suppressed leading to an increase in the population of worms and at the same time the fecundity of female worms in previously immune hosts may also increase to approach that of worms in fully susceptible animals (Connan 1976). The present data and earlier reports (Borgsteede 1978; Hammerberg & Lamm 1980) revealed higher prevalence and egg counts of nematodes in lactating and pregnant cows compared to dry cows, bulls and oxen. Hence, lactating and pregnant cows might serve as a source of pasture contamination.

When cattle graze on natural pasture, climate plays an important role in the transmission of worms (Gatongi, Gathuma & Munyua 1987). From this study and earlier studies (Anene *et al.* 1994; Moyo *et al.* 1996; Lima 1998; Dreyer, Fourie & Kok 1999; Jithendran & Bhat 1999) the effect of climate on the prevalence of GI nematodes was evident. The overall prevalence and egg counts of nematodes were related to the climatic conditions (rainfall and temperature) (Fig. 2). During the wet months (December to March), rainfall and temperature were probably more favourable for the development and survival of the pre-parasitic stages (Durie 1961), leading to increased availability of infective larvae on the pasture. This resulted in an increase in egg counts with peaks between February and April. During the dry season pasture larval counts were reported to be low in communal grazing areas of Zimbabwe (Moyo *et al.* 1996). Hence, the decline in egg counts and prevalence during the dry months may be attributed to the lack of rainfall, a condition unfavourable for the development of eggs to infective larvae.

The spectrum of strongyles encountered in cattle in the present study has previously been reported in Zimbabwe (Pandey *et al.* 1993; Vassilev 1994, 1999; Moyo *et al.* 1996) and elsewhere in Africa (Anene *et al.* 1994; Ndao, Pandey, Zinsstag & Pfister 1995; Waruiru, Thamsborg, Nansen, Kyvsgaard, Bogh, Munyua & Gathuma 2001). The predominance of *Cooperia* spp. agrees with earlier reports in Zimbabwe (Pandey *et al.* 1993; Moyo *et al.* 1996; Vassilev 1999). The pathogenic effects of *Cooperia* spp. are not well known, but species from this genus are reported not to be as pathogenic as other genera like *Haemonchus* and *Trichostrongylus* (Vassilev 1999) and are not generally considered to be of great importance in terms of production losses (Bianchin & Honer 1987). Anderson, Armour, Jarrett, Jennings, Ritchie & Urquhart (1965) reported no evidence of pathogenicity of *C. punctata* in cattle in Northern Nigeria. However, Becklund (1962), Herlich (1962) and Henderson & Kelly (1978), considered large numbers of *Cooperia* spp. to be potentially pathogenic in susceptible calves. Alicata & Lynd (1961) found that calves given 250 000 *C. punctata* infective larvae developed clinical signs of helminthosis, but added that individual calves varied in their reaction. Owen & Talbot (1983) found massive burdens of *C. punctata* in dead weaners and were of the opinion that they were an important factor in at least accelerating their deaths. The high numbers of *Cooperia* spp. found in the present study could probably affect productivity especially during the dry season when pastures are poor and scanty.

In Brazil, the highest number of *Cooperia* L_3 was observed during the rainy season (Lima 1998). However, transmission occurred even in the dry season despite the relatively low rainfall during that period and the data indicated that *Cooperia* L_3 were more resistant to heat and dryness and had a better ability to migrate than other nematode species (Lima 1998). Similar observations have been reported by Reinecke (1960) and Durie (1962). Results of the present study also indicated that *Cooperia* L_3 were probably more resistant to adverse conditions of heat and dryness as high numbers were observed during both the wet and dry seasons.

Haemonchus spp. were second in prevalence after *Cooperia*. The genus is reported as a cause of primary disease, particularly in young animals (Vassilev 1999). High numbers of *Haemonchus* spp. have been obtained from cattle during the wet season (Vassilev 1994; Ndao *et al.* 1995; Lima 1998). The present data indicated significantly higher prevalence of *Haemonchus* spp. during the wet months of the year than during the dry season. During the wet season, temperature and rainfall in the survey areas were probably more suitable for the development and survival of the free-living stages of *Haemonchus* spp. than during the dry season. Another reason for the low prevalence of *Haemonchus* spp. during the dry season may be the occurrence of hypobiosis shown to occur in the highveld area of Zimbabwe during the same period of the year (Moyo *et al.* 1996).

Trichostrongylus species were also prevalent and their role in parasitic gastroenteritis is reported to be only additive to *Haemonchus* spp. (Vassilev 1999). In Brazil, *Trichostrongylus* spp. were more frequently observed during the dry season when temperatures were lower than during the rainy season (Lima

1998). It has been reported that lower temperature is required for the development of the free-living stages of this genus (Williams & Mayhew 1967). Higher monthly percent frequency of infective larvae of *Trichostrongylus* spp. were observed during the cold dry months (May to August). These findings are corroborative evidence of lower temperatures as a requirement for the development of the free-living stages of this genus.

Low numbers of *Oesophagostomum* spp. were observed during the present study and no seasonal trends were obtained for this genus. In Colombia, small numbers of *Oesophagostomum* spp. were observed in calves and this was attributed to the relatively long life cycle and low resistance to desiccation of the pre-infective stages of this genus (Rivera, Parra, Garcia & Ayeardi 1983), which account for the low prevalence noted during the present study. In Brazil, *Oesophagostomum* spp. were also present in low numbers in most months of the year, but large numbers were observed occasionally during the rainy season (Lima 1998).

Strongyloides spp. have been reported to be common in calves only (Moyo *et al.* 1996; Lima 1998; Vassilev 1999; Waruiru *et al.* 2000). Egg counts of *Strongyloides* spp. in calves were observed to diminish with increasing age of the calves with low levels reached when calves were 6 to 8 months of age (Rivera *et al.* 1983; Lima 1998). The present study indicated the presence of *Strongyloides* spp. in calves only.

Bunostomum spp. were found at low levels but they probably do not affect productivity. Infection with *Bunostomum* spp. under extensive range-type operations with low animal density is reported to be greatly reduced since the parasite's larvae do not migrate from faeces, but penetrate the host's skin (Rivera *et al.* 1983) which probably accounted for the low prevalence noted in the present study. The prevalence of *Bunostomum* spp. has been reported to be high during the wet season (Owen & Talbot 1983) and similar observations were made during the present study. Lee, Armour & Ross (1960) observed that rainfall is the most important element controlling the development of this parasite.

Toxocara vitulorum is an infrequent parasite under extensive conditions (Bianchin & Honer 1987). During the present study only four calves and 39 animals were found positive for *T. vitulorum* and *Trichuris*, respectively. Hence, both parasites are probably of little significance in the health of cattle in the study area. However, on effluent-irrigated pastures on one farm in Harare, Zimbabwe, a high prevalence of *T. vitulorum* in calves has been reported (Pandey, Hill, Hensman & Baragwanath 1990). An enquiry (Pandey *et al.* 1990) to several nearby farms on traditional pasture management revealed that none had experienced *T. vitulorum* infection. Pandey *et al.* (1990) concluded that it would appear that *T. vitulorum* infection is focal in nature and the high prevalence noted on the studied farm could probably due to the unique system of farm management resulting in persistent moist/wet pastures.

Coccidia

During the present study, a significantly higher proportion of calves were infected with coccidia than adult cattle. This agrees with earlier reports from Kenya (Munyua & Ngotho 1990; Waruiru, Mbuthia & Kimoro 1993; Waruiru *et al.* 2000), Nigeria (Anene *et al.* 1994), South Africa (Matjila & Penzhorn 2002), India (Jithendran & Bhat 1999) and the Netherlands (Cornelissen, Verstegen, Van den Brand, Perie, Eysker, Lam & Pijpers 1995). In cattle, clinical coccidiosis occurs mainly in young animals (Munyua & Ngotho 1990). During the present study, no clinical cases were observed in young or adult animals, but the results showed that calves are the major source of pasture contamination.

During the rainy season, high humidity and moderate temperature are factors that facilitate the survival and sporulation of the oocysts (Troncy 1989). Results of the present study showed seasonal variation in the prevalence of coccidia, with the prevalence and level of infection being higher during the rainy season than the dry season.

Cestodes

In Colombia, Rivera *et al.* (1983) observed that egg counts from *Moniezia* spp. increased with the calves' age peaking at 8–10 months of age and thereafter diminished considerably after 1 year of age. The present study indicated that the prevalence of *M. benedeni* was low and mainly in young animals. A significantly higher prevalence of this parasite was recorded during the rainy season which agrees with earlier reports (Negesse 1994; Vassilev 1994).

The present data revealed that the wet months (December to March) were the highest risk for occurrence of gastrointestinal parasites while young animals had the highest risk of infection. A broad-spectrum anthelmintic administered during January/February will control immature and mature forms of the GI nematodes. In July/August, a broad-spectrum anthelmintic should be administered and provided it is effective against arrested larvae, it will have an extended effect against *Haemonchus* spp., *Cooperia* spp. and *Trichostrongylus* spp. If infection with *Haemonchus* spp. is particularly severe during the rainy season, treatments with narrow-spectrum anthelmintics effective against this species should be administered.

Magaya, Mukaratirwa, Mutisi, Kyvsgaard & Thamsborg (2000) examined the effects of treatment with Fenbendazole Slow-Release bolus on the productivity of indigenous cattle on communal pastures in Sanyati area, Zimbabwe. Faecal worm egg counts were found to be significantly lower in the bolus treated group than in the control group. More studies on the use of controlled slow release systems in the communal farming areas of Zimbabwe should be assessed. These systems would probably be of importance especially during the rainy season. Conder, Rooney, Illyes, Keller, Meinert & Logan (1998) demonstrated that topical application of doramectin significantly reduced faecal egg counts by 99.9 % in treated cattle compared to controls. They expressed the view that doramectin in a pour-on formulation should provide a useful new treatment for controlling nematode parasites in cattle. The use of pour-on methods need assessment in Zimbabwe and would probably be effective in communal grazing areas.

However, whatever control strategy is employed, it is imperative that it should be village-based as cattle in communal areas are grazed together and there is no benefit for only a few to carry out the recommended control measures. The anthelmintic treatment should be organized and preferably done at the same time within a village.

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