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THE RELATION OF CLIMATE AND TOPOGRAPHY TO WORM EGG COUNTS OF GASTRO-INTESTINAL NEMATODES OF SHEEP IN THE EASTERN CAPE

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ABSTRACT

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Haemonchus, Trichostrongylus, Ostertagia and *Nematodirus* worm populations of sheep based on differential egg counts are considered in relation to climatological and topographical data. Late spring, summer and early autumn rainfalls are related to ground slope to assess wetness. Egg counts indicated that the estimated worm populations in animals in flat areas with low rainfall were as heavy as or heavier than in animals on steep hilly areas with a high rainfall. It is proposed that tactical anthelmintic treatment be based on the degree of wetness of the grazing or farm.

INTRODUCTION

The prevalence of the gastro-intestinal nematodes of sheep is dependent on a number of factors but the burdens of all worm species depend on the intake of infective larvae. The availability of infective larvae is influenced by various factors such as climate and season (Ollerenshaw, Graham & Smith, 1978), pasture management and grazing rotations (Armour, 1980; Morley & Donald, 1980) and general weather conditions (Thomas & Starr, 1978; Starr, 1981).

In the Eastern Cape and Karoo considerable work has been done on the seasonal incidence of gastro-intestinal nematodes in sheep based principally on worm counts at slaughter (Barrow, 1964); Reinecke, 1964; Rossiter, 1964; Viljoen, 1969).

In the present investigation, also carried out in the Eastern Cape and Karoo, differential egg counts were used to estimate the prevalence of *Haemonchus, Trichostrongylus, Ostertagia* and *Nematodirus* spp. Rainfall and ground slope were used to define the degree of wetness which was then correlated with the prevalence of gastro-intestinal nematodes.

MATERIALS AND METHODS

General

These observations were carried out on 9 properties for some 12 months at a time, from November 1978 to November 1981. The properties were situated about the Eastern Cape towns of Klipplaat, Jansenville, Pearston, Somerset East and Bedford—the area as a whole lying between 32°S and 33°S, 24°E and 27°E.

Experimental animals

Sixteen different groups of Merino sheep, 15 of which contained 128 sheep and one 120, mostly wethers, were used. At the commencement of each trial, the sheep in each group were numbered and individually mass measured and thereafter divided into 4 comparable groups based on mass, age and sex.

After the groups had been identified with colour tags, faecal samples were collected from 12 sheep in each of the 4 groups, collection being carried out in the same rank order for each group. Thereafter, the 4 groups of sheep that made up the group for each trial were treated with a commercially available anthelmintic. Four of the 16 trial groups were excepted; in 3 trials the sheep had been treated just before grouping and in one trial, made up of a group of spring lambs (Leeuwfontein 1979/80), treatment was considered unnecessary (see below). In one other trial (Cavers 1979/80), the anthelmintic treatment of the 4 groups was repeated, as the first administration was ineffective in reducing faecal egg counts.

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Follow-up anthelmintic treatments

Group 1 was left untreated for the duration of the investigation. All the egg count data from these animals were used in this investigation.

Groups 2 & 3 were treated with an anthelmintic according to rainfall. In the absence of a dangerous 8-week rainfall period (see terminology) they were left untreated. Only egg count data from the untreated Groups 2 & 3 were used in these calculations.

Group 4 were treated throughout the trail with an anthelmintic at approximately 4–6 week intervals. Egg count data *per se* from Group 4 were ignored.

Worm egg counts of each of the 4 groups were determined at 4–6 week intervals. The 12 sheep initially selected from the 32 or 30 sheep making up each group were used for this purpose, faecal samples from these 12 sheep being sub-grouped in set order, with 3 or 4 samples making up the sub-groups for examination. Egg counts and differential egg counts were carried out, *Nematodirus* eggs being counted separately.

Fifteen of the 16 trials were iniated in the spring/early summer period, namely, late September/early December, the other in mid-autumn, April. In the latter trial an initial anthelmintic treatment was regarded as unnecessary, as the sheep were lambs born in the immediate spring. All the trials were terminated in the spring following their inception.

No special grazing programmes were undertaken, the animals fitting into the farming process as convenient to the management.

Statistical analysis

Geometrical arrangement of worm egg count data, based on geometrical progression (first term/common ratio—16/2, i.e., 16, 32, 64, 128, 256 and 512), was used for chi-squared assessment of the combined, *Haemonchus, Trichostrongylus* and *Nematodirus* egg counts. *Ostertagia* counts were not assessed. The combined and *Haemonchus* counts were each grouped 5 times, as follows, $\geq 32/\leq 31$, $\geq 64/\leq 63$, $\geq 128/\leq 127$, $\geq 256/\leq 255$ and $\geq 512/\leq 511$, the *Trichostrongylus* counts were grouped 5 times $\geq 16/\leq 15$, $\geq 32/\leq 31$, $\geq 64/\leq 63$, $\geq 128/\leq 127$ and $\geq 256/\leq 255$ and the *Nematodirus* counts were grouped 3 times $\geq 16/\leq 15$, $\geq 32/\leq 31$ and $\geq 64/\leq 63$. The results of grouping the worm egg counts as recorded in Tables 1, 2, 3 and 4 are shown in Table 5; those of Table 1 in Section 1, Table 2 in Section 2, Table 3 in Section 3 and Table 4 in Section 4. For the purpose of grouping, the counts recorded on the day on which each trial was established were excluded from assessment. There were 2 exceptions, namely, Cavers 1979/80 and Leeuwfontein 1979/80.

With regard to Cavers 1979/80, Groups 1 and 2, Table 2, the initial counts and those of the following month were excluded, and in the case of Leeuwfontein 1979/80 Groups 1, 2 and 3, Table 2, the initial counts were not excluded (see Experimental animals).

Chi-squared assessments were effected on the geometrically grouped data as recorded in Table 5, Sections 1, 2, 3 & 4. As shown in Table 5, the geometrically grouped data from the 4 sections were, as convenient, vertically integrated for the purpose of assessment, i.e., Section 1 data/Section 2 data + Section 3 data + Section 4 data.

Terminology

A number of descriptive terms, mostly related to the climate and topography of the various properties under consideration, were drawn up and are listed in alphabetical and numerical order.

(a) "Adjusted rainfall precipitation figures" These figures were calculated for each property by reducing the amounts of the rainfall which occurred in the first quarter of each seasonal year (see f) by 7/8 and by adding the full amounts of subsequent rainfall to the 1/8 residues.

(b) "Mean annual rainfall figures" The figures for each property were calculated, where possible, from the rainfall data of the 5 preceding seasonal years, i.e., 1980/81 from 1975/76, 1976/77, 1977/78, 1978/79 and 1979/80.

(c) "Dangerous 8-week rainfall period" An 8-week rainfall period (see k), at least 5 weeks of which showed a minimum 4-week rainfall requirement (see d) and at least 7 showed a 4-week rainfall figure (see j) greater than zero.

(d) "Minimum 4-week rainfall requirement" This requirement related to a 4-week rainfall figure (see j) and, to warrant consideration, was regarded as the minimum amount of rain required to fall on a property over a 4-week period. The formula used, namely,

$$\frac{\textit{Mean annual rainfall (see b)} \times \textit{slope (see g)}}{52}$$

was adjusted upwards if required to a minimum of 32 mm (grassveld/Karoo veld/mixed grass and Karoo veld) and downwards to a maximum of 100 mm (grassveld) and 125 mm (Karoo veld/mixed grass and Karoo veld).

(e) "Moving 4-week rainfall figures" This term describes the successive measurements of rain as determined on successive Sundays by the 4-week rainfall figures (see j) for each preceding 28-day period.

(f) "Seasonal year" 1 July–30 June the following year.

(g) "Slope" The angle of upward inclination from the lowest to the highest point on the area under consideration as determined by means of contour maps and the mathematical formula:

$$\text{Tan}\ \theta = \frac{y}{x} \text{ (expressed in decimalized degrees/minutes)}$$

(h) "1/8 annual rainfall qualifying date", that is, the date on which the adjusted rainfall precipitation figure (see a) for a property surpassed the 1/8 mean annual rainfall figure (see i) for the seasonal year (see f) under consideration.

(i) "1/8 mean annual rainfall figure" This figure is calculated for each property by dividing the relevant mean annual figure (see b) by 8.

(j) "4-week rainfall figure" The total amount of rain measured over 4 weeks, and recorded on the Sunday at the end of the 28-day period under consideration.

(k) "8-week rainfall period" The 8-week period following and including, but not preceding, a week which showed a minimum 4-week rainfall requirement (see d). The period of assessment lay between the beginning of October or the 1/8 annual rainfall qualifying date (see h) (whichever was the latest, but excluding the week in which the 1/8 annual rainfall qualifying date fell) and the end of the following April.

Topographical considerations—slope calculations

On 5 properties a calculation of the slope from the lowest to the highest point of the property or grazing area was an adequate expression of the overall position. On one property which shed rainfall in 2 main directions, 2 slopes were calculated, while on 3 properties 3 slopes were determined. Mean values were utilized.

RESULTS

Moving 4-week rainfall figures pertaining to the trials are recorded (Fig. 1, 2, 3 & 4), as are faecal worm egg counts of Group 1 (Fig. 1, 2, 3 & 4, Tables 1, 2, 3 and 4). Faecal worm egg counts of Group 4 and Groups 2 and 3 are excluded, unless Groups 2 and 3 could be considered as supplementary to Group 1 (Tables 2, 3 and 4), as happened from time to time.

Mean undifferentiated faecal worm egg counts are shown as combined counts; mean *Haemonchus, Trichostrongylus* and *Ostertagia* egg counts are differentiated, the mean *Nematodirus* count is listed separately (Tables 1, 2, 3 and 4).

Where 2 dangerous 8-week rainfall periods occurred in the late spring and early autumn months (October/April), or a single dangerous 8-week rainfall period occurred in the late spring and summer months (October/March), combined egg counts in general showed one or more clear rises from late summer/early autumn through to the following spring (Fig. 1, Table 1 and Fig. 2, Table 2 respectively). Where one dangerous 8-week rainfall period occurred over the late summer and early autumn months (February/April), combined egg counts tended to increase the following spring, Shirlands (1979/80) being the only exception out of 5 trials (Fig. 3, Table 3). In the absence of a dangerous 8-week rainfall period in the late spring, summer or early autumn, combined counts remained low throughout the winter and early spring (Fig. 4, Table 4). This sequence of events was illustrated in different years on 2 properties, viz., Joubertskraal 1978/79, 1979/80, 1980/81 (Fig. 1, 2 & 3, Tables 1, 2 and 3) and Mount Pleasant 1980/81, 1979/80 (Fig. 3 & 4, Tables 3 and 4).

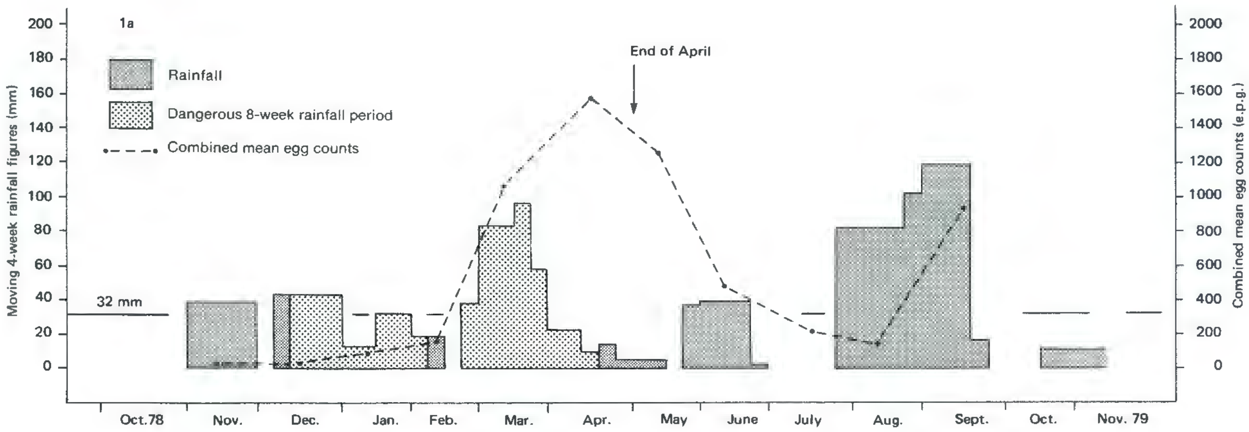

Fig. 1a Joubertskraal 1978/79
Slope 0,77°
Annual rainfall 449 mm
Minimum 4-week rainfall requirement 32 mm*
1/8 annual rainfall qualifying date 1978.12.08
Date of anthelmintic treatment 1978.11.17
Veld type Karoo
*minimum 4-week rainfall requirement adjusted upwards to 32 mm

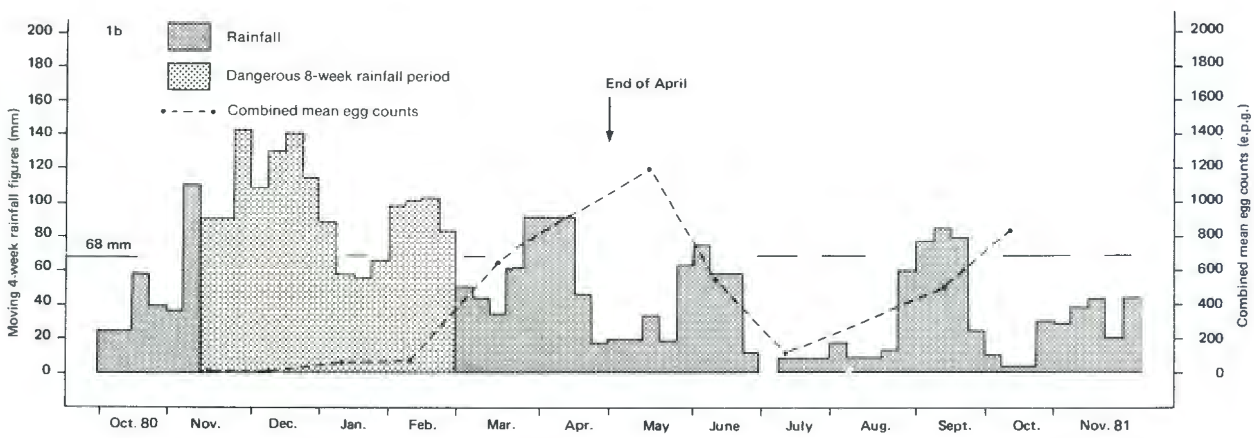

Fig. 1 b Cavers 1980/81
Slope 4,80°
Annual rainfall 732 mm
Minimum 4-week rainfall requirement 68 mm
1/8 annual rainfall qualifying date 1980.11.06
Date of anthelmintic treatment 1980.11.04
Veld type grass

FIG. 1 Moving 4-week rainfall figures of 2 properties with 2 dangerous 8-week rainfall periods before the end of April. Combined mean egg counts superimposed

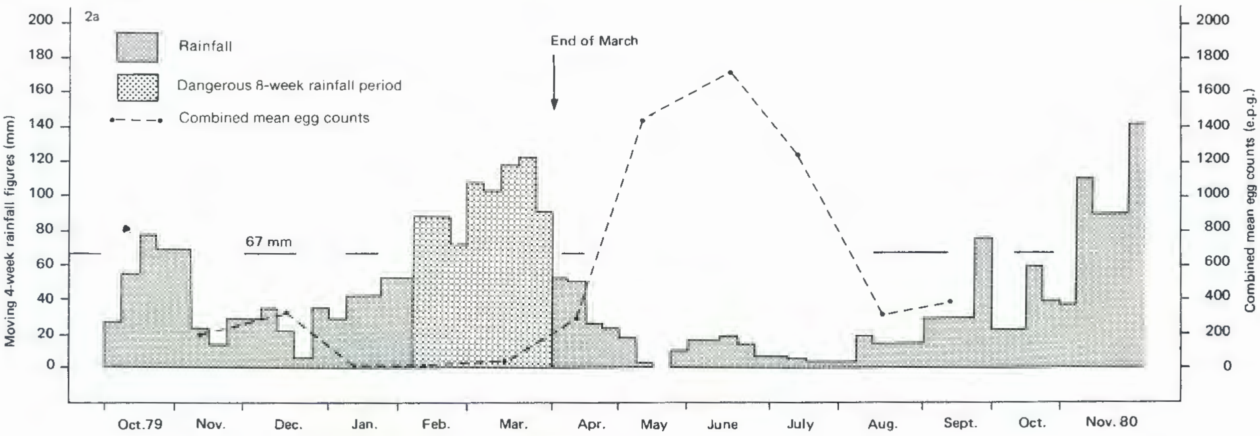

Fig. 2a Cavers 1979/80
Slope 4,80°
Annual rainfall 730 mm
Minimum 4-week rainfall requirement 67 mm
1/8 annual rainfall qualifying date 1979.10.19
Date of anthelmintic treatment 1979.11.08 and 1979.12.27
Veld type grass

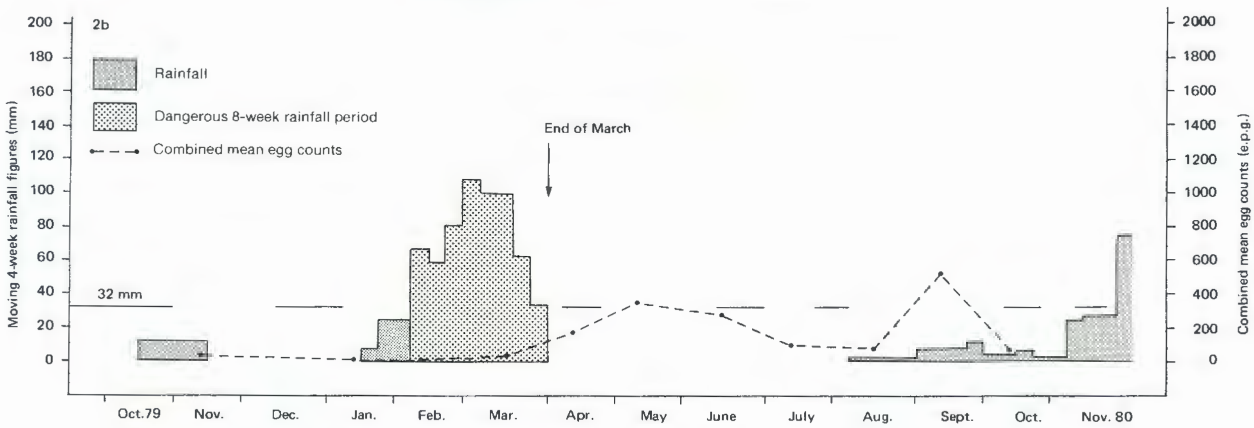

Fig. 2b Joubertskraal 1979/80
Slope 0,77°
Annual rainfall 370 mm
Minimum 4-week rainfall requirement 32 mm*
1/8 annual rainfall qualifying date 1980.01.22
Date of anthelmintic treatment 1979.11.27
Veld type Karoo
*minimum 4-week rainfall requirement adjusted upwards to 32 mm

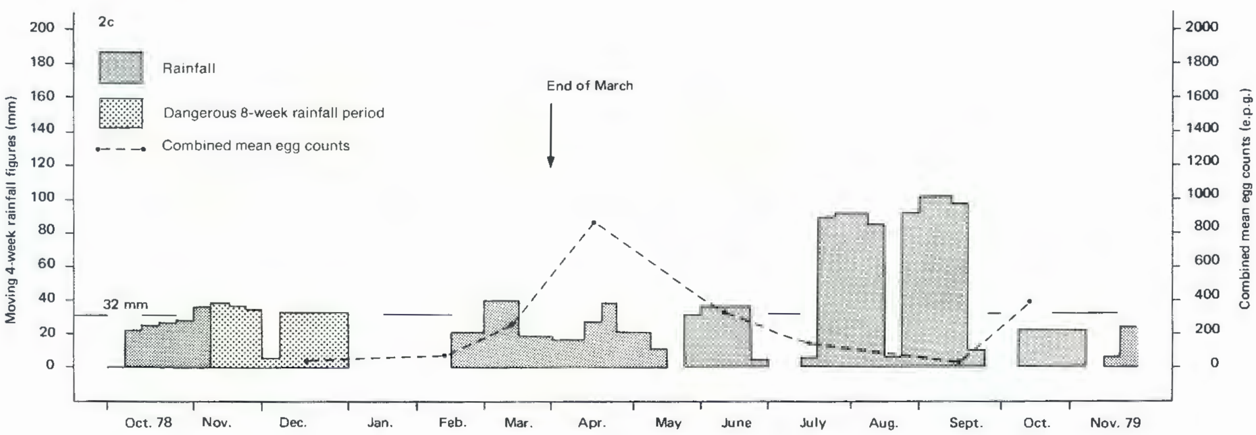

Fig. 2c Leeuwfontein 1978/79
Slope 0,42°
Annual rainfall 384 mm
Minimum 4-week rainfall requirement 32 mm*
1/8 annual rainfall qualifying date 1978.11.01
Date of anthelmintic treatment 1978.11.13
Veld type Karoo
*minimum 4-week rainfall requirement adjusted upwards to 32 mm

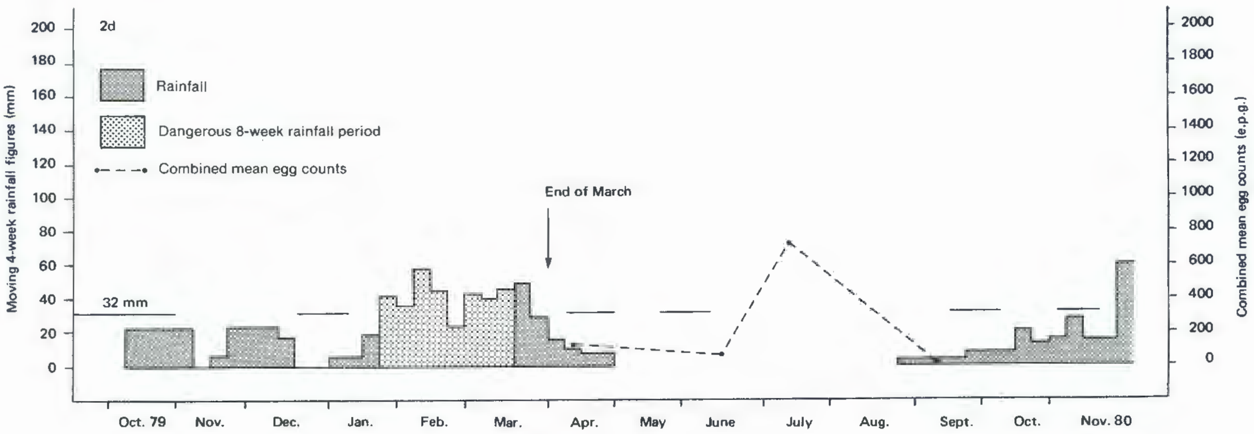

Fig. 2d Leeuwfontein 1979/80
Slope 0,42°
Annual rainfall 320 mm
Minimum 4-week rainfall requirement 32 mm*
1/8 annual rainfall qualifying date 1979.10.10
Date of anthelmintic treatment not applicable
Veld type Karoo
*minimum 4-week rainfall requirement adjusted upwards to 32 mm

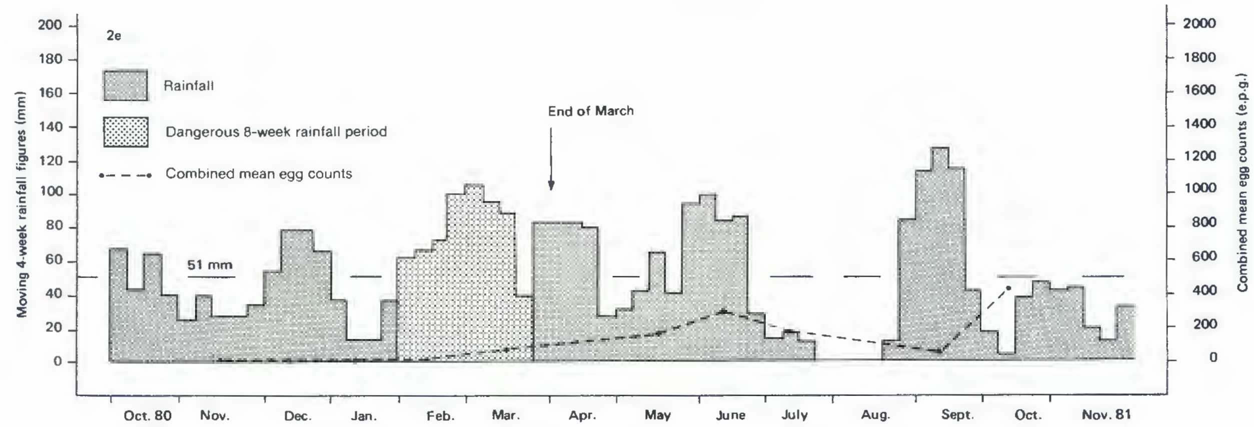

Fig. 2e Buffelskloof 1980/81
Slope 5,00°
Annual rainfall 535 mm
Minimum 4-week rainfall requirement 51 mm
1/8 annual rainfall qualifying date 1980.11.30
Date of anthelmintic treatment 1980.11.03
Veld type grass

FIG. 2 Moving 4-week rainfall figures of 4 properties with 1 dangerous 8-week rainfall period before the end of March. Combined mean egg counts superimposed

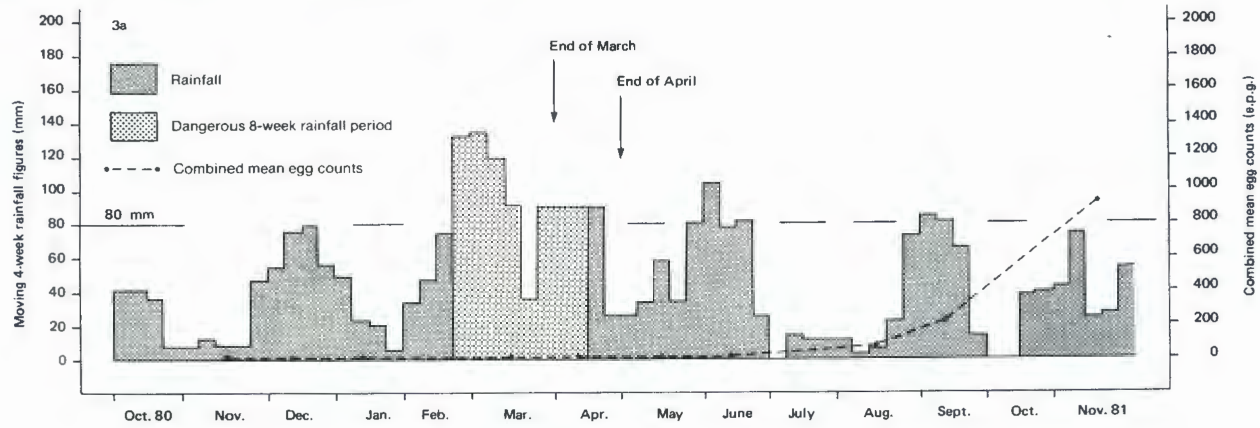

Fig. 3a Hyndhope 1980/81
Slope 8,12°
Annual rainfall 511 mm
Minimum 4-week rainfall requirement 80 mm
1/8 annual rainfall qualifying date 1980.12.01
Date of anthelmintic treatment 1980.11.11
Veld type grass

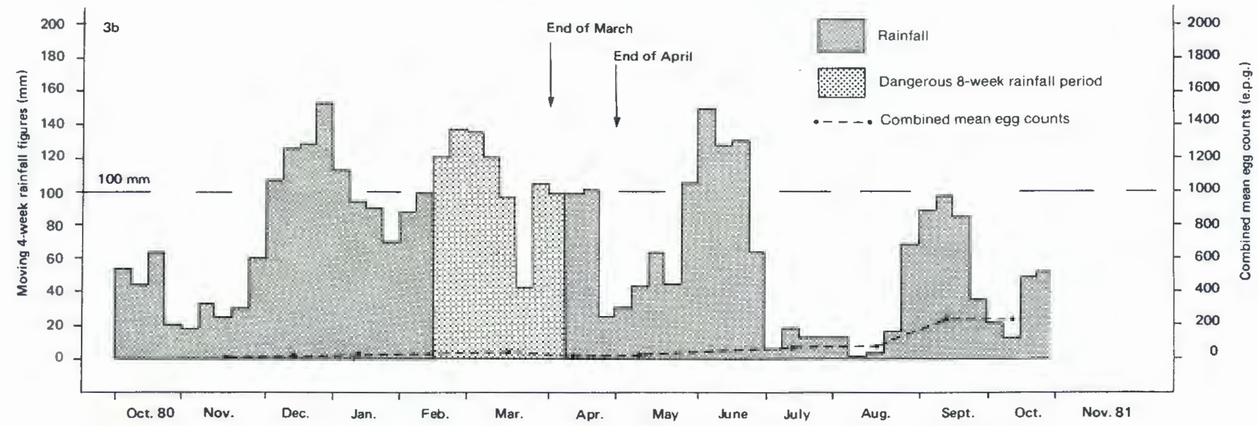

Fig. 3b Mount Pleasant 1980/81
Slope 7,57°
Annual rainfall 785 mm
Minimum 4-week rainfall requirement 100 mm*
1/8 annual rainfall qualifying date 1980.12.01
Date of anthelmintic treatment 1980.11.12
Veld type grass
*minimum 4-week rainfall requirement adjusted downwards to 100 mm

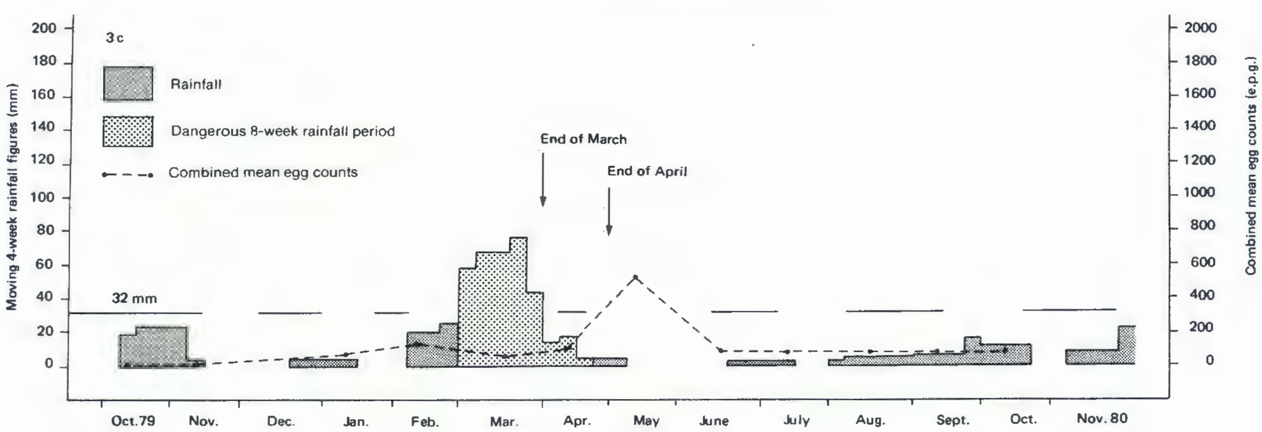

Fig. 3c Shirlands 1979/80
Slope 0,57°
Annual rainfall 303 mm
Minimum 4-week rainfall requirement 32 mm*
1/8 annual rainfall qualifying date 1979.12.21
Date of anthelmintic treatment 1979.10.23
Veld type Karoo
*minimum 4-week rainfall requirement adjusted upwards to 32 mm

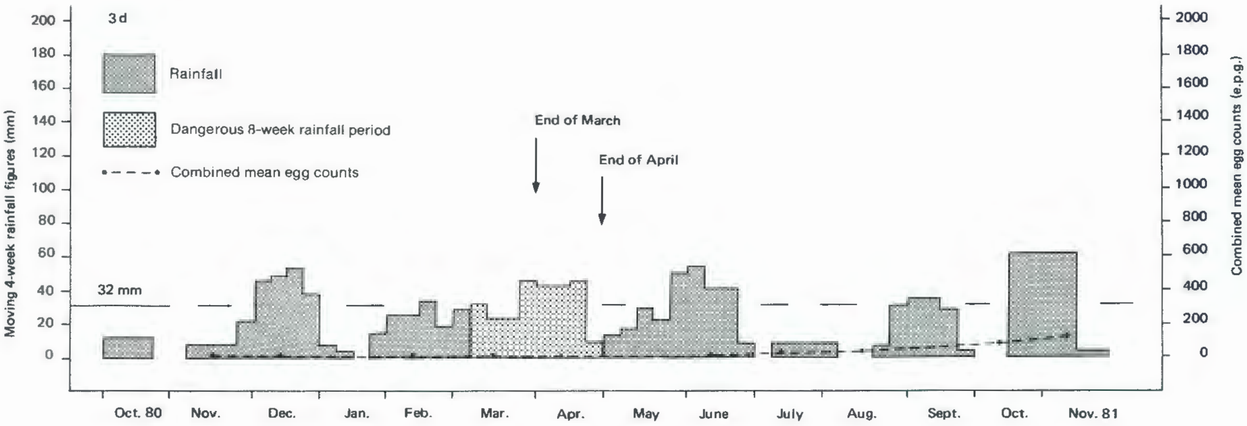

Fig. 3d Shirlands 1980/81
Slope 0,57°
Annual rainfall 304 mm
Minimum 4-week rainfall requirement 32 mm*
1/8 annual rainfall qualifying date 1980.12.01
Date of anthelmintic treatment 1980.11.19
Veld type Karoo
*minimum 4-week rainfall requirement adjusted upwards to 32 mm

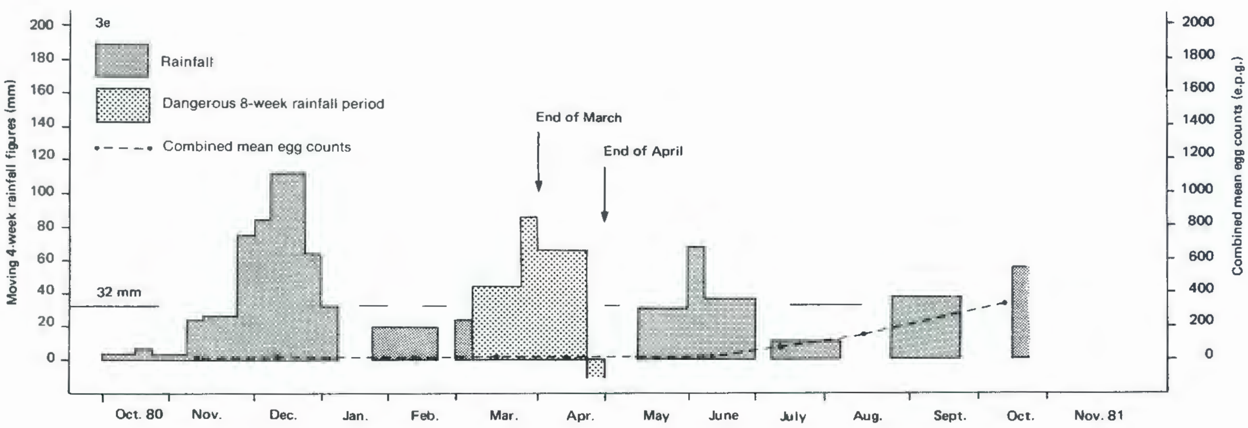

Fig. 3e Joubertskraal 1980/81
Slope 0,77°
Annual rainfall 392 mm
Minimum 4-week rainfall requirement 32 mm*
1/8 annual rainfall qualifying date 1980.11.28
Date of anthelmintic treatment 1980.11.10
Veld type Karoo
*minimum 4-week rainfall requirement adjusted upwards to 32 mm

FIG. 3 Moving 4-week rainfall figures of 4 properties with 1 dangerous 8-week rainfall period ending in April. Combined mean egg counts superimposed

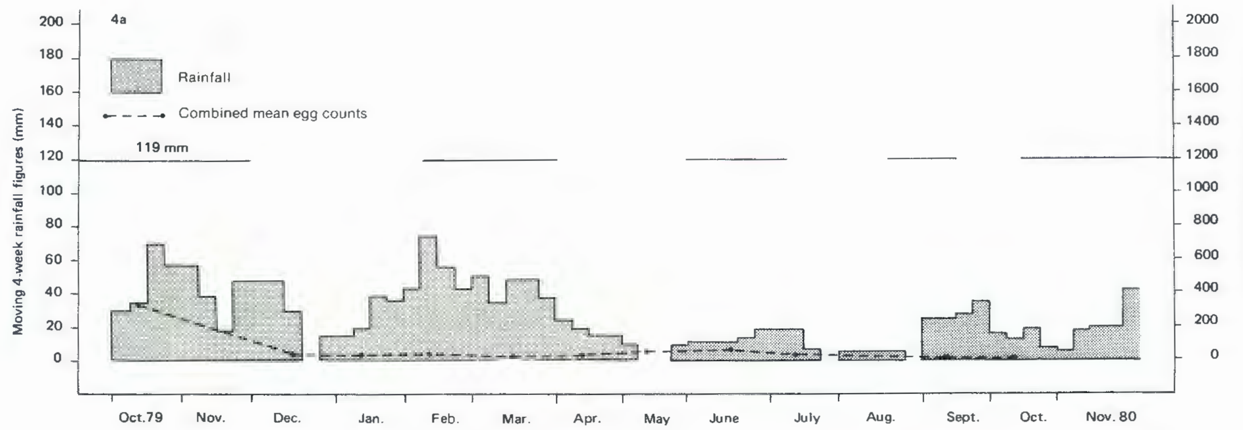

Fig. 4a Eildon 1979/80
Slope 11,58°
Annual rainfall 536 mm
Minimum 4-week rainfall requirement 119 mm
1/8 annual rainfall qualifying date 1979.10.18
Date of anthelmintic treatment 1979.10.31
Veld type mixed grass and Karoo

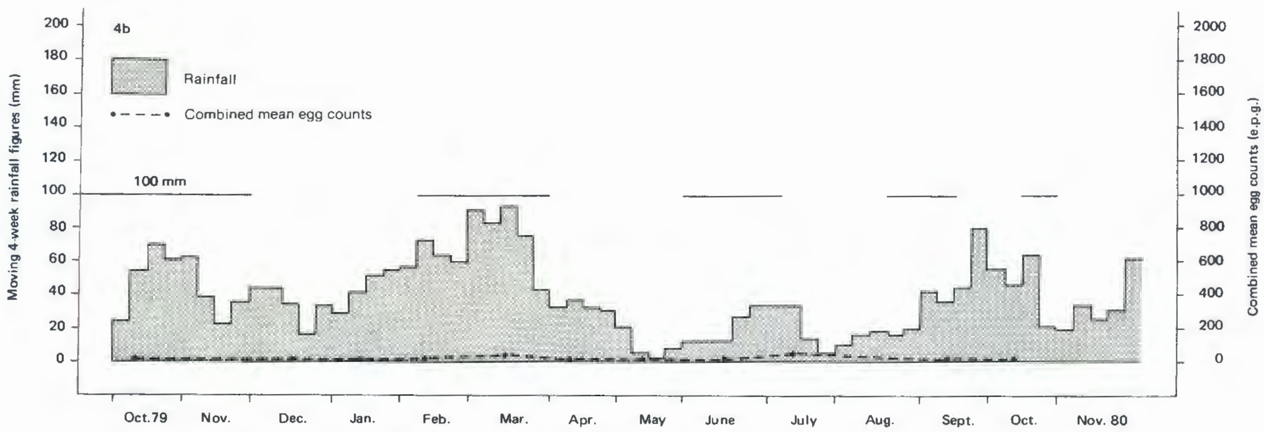

Fig. 4b Mount Pleasant 1979/80
Slope 7,57°
Annual rainfall 781 mm
Minimum 4-week rainfall requirement 100 mm*
1/8 annual rainfall qualifying date 1979.11.13
Date of anthelmintic treatment 1979.09.24
Veld type grass
*minimum 4-week rainfall requirement adjusted downwards to 100 mm

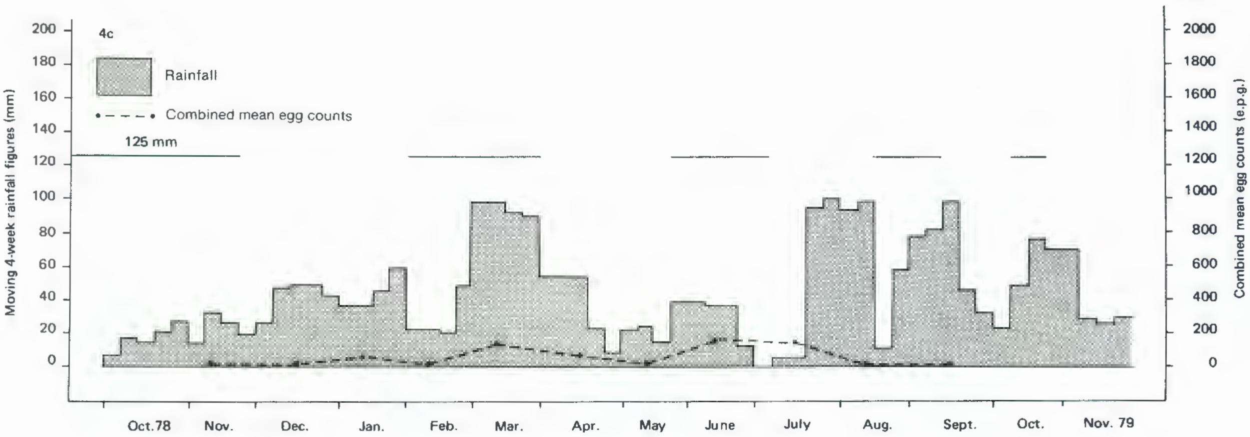

Fig. 4c Glen Cullen 1978/79
Slope 14,68°
Annual rainfall 714 mm
Minimum 4-week rainfall requirement 125 mm*
1/8 annual rainfall qualifying date 1978.12.10
Date of anthelmintic treatment 1978.09.30
Veld type mixed grass and Karoo
*minimum 4-week rainfall requirement adjusted downwards to 125 mm

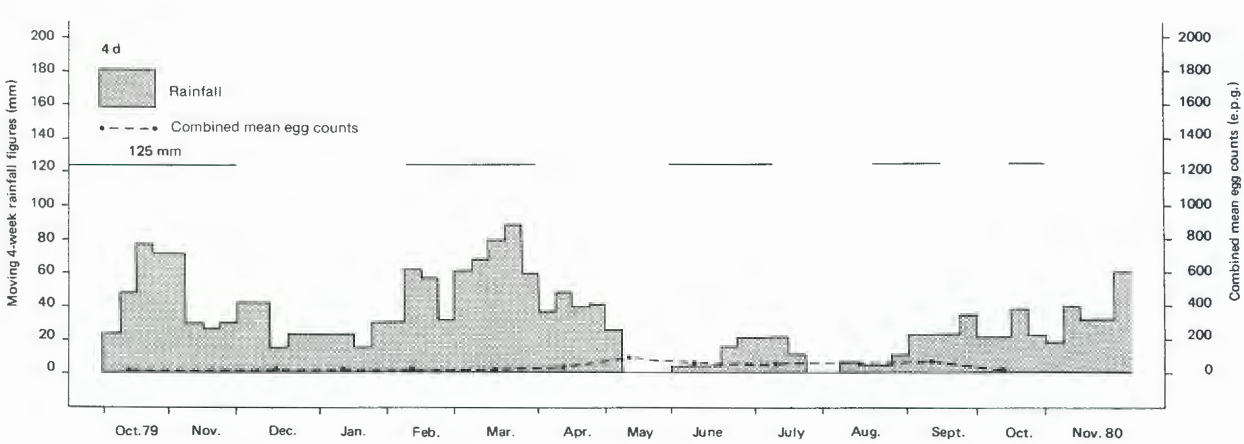

Fig. 4d Glen Cullen 1979/80
Slope 14,68°
Annual rainfall 595 mm
Minimum 4-week rainfall requirement 125 mm*
1/8 annual rainfall qualifying date 1979.10.18
Date of anthelmintic treatment 1979.10.30
Veld type mixed grass and Karoo
*minimum 4-week rainfall requirement adjusted downwards to 125 mm

FIG. 4 Moving 4-week rainfall figures of 3 properties with no dangerous 8-week rainfall period. Combined mean egg counts superimposed

TABLE 1 Mean egg count data (e.p.g.) of sheep, recorded on 2 properties on 2 occasions, with 2 dangerous 8-week rainfall periods observed by the end of April

Property/year	Egg counts	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
Joubertskraal (1978/79)	***Group 1***														
	Combined		17	17	100	167	1 067	1 583	1 250	483	217	150	900		
	Haemonchus		+	14	29	124	988	1 259	1 115	0	0	0	0		
	Trichostrongylus		+	3	65	38	63	324	135	476	217	145	843		
	Ostertagia		+	0	6	5	16	0	0	7	0	5	57		
	Nematodirus		0	0	33	33	33	17	0	0	17	0	0		
Cavers (1980/81)	***Group 1***														
	Combined		0	0	50	87	662	—	1 200	563	125	—	500	825	
	Haemonchus		0	0	50	75	628	—	1 181	543	119	—	488	825	
	Trichostrongylus		0	0	0	9	29	—	19	20	6	—	12	0	
	Ostertagia		0	0	0	3	5	—	0	0	0	—	0	0	
	Nematodirus		0	0	0	0	0	—	0	0	0	—	12	0	

\+ = Culture failure

TABLE 2 Mean egg count data (e.p.g.) of sheep, recorded on 4 properties on 5 occasions, with 1 dangerous 8-week rainfall period observed by the end of March

Property/year	Egg counts	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
Cavers (1979/80)	***Group 1***														
	Combined		188	325	0	0	63	300	1 438	1 725	1 237	312	388		
	Haemonchus		0	195	0	0	13	218	1 166	1 484	804	178	116		
	Trichostrongylus		133	125	0	0	44	80	261	241	399	117	258		
	Ostertagia		55	5	0	0	6	2	11	0	34	17	14		
	Nematodirus		0	0	0	13	0	0	0	0	0	0	0		
	Group 2														
	Combined		25	200	0	13	25	187	738	875	675	812	775		
	Haemonchus		0	78	0	0	3	154	564	550	309	562	436		
	Trichostrongylus		14	111	0	13	21	27	161	325	352	216	320		
	Ostertagia		11	11	0	0	1	6	13	0	14	34	19		
	Nematodirus		0	0	0	0	13	0	0	0	0	0	0		
Joubertskraal (1979/80)	***Group 1***														
	Combined		33	—	0	0	17	183	333	283	100	83	516	67	
	Haemonchus		0	—	0	0	4	55	37	79	22	13	287	33	
	Trichostrongylus		30	—	0	0	13	95	276	167	76	43	195	34	
	Ostertagia		3	—	0	0	0	33	20	37	2	27	34	0	
	Nematodirus		17	—	17	0	0	50	17	0	0	0	0	0	
Leeuwfontein (1978/79)	***Group 1***														
	Combined			13	—	75	250	875	—	300	138	—	13	388	
	Haemonchus			10	—	3	143	501	—	152	73	—	0	175	
	Trichostrongylus			3	—	56	106	374	—	148	65	—	13	213	
	Ostertagia			0	—	16	1	0	—	0	0	—	0	0	
	Nematodirus			13	—	100	113	13	—	0	0	—	13	0	
Leeuwfontein (1979/80)	***Group 1***														
	Combined							117	—	67	733	—	0		
	Haemonchus							110	—	41	421	—	0		
	Trichostrongylus							7	—	22	295	—	0		
	Ostertagia							0	—	4	17	—	0		
	Nematodirus							33	—	17	17	—	0		
	Group 2														
	Combined							33	—	133	417	—	0		
	Haemonchus							32	—	82	220	—	0		
	Trichostrongylus							1	—	40	176	—	0		
	Ostertagia							0	—	11	21	—	0		
	Nematodirus							0	—	33	17	—	0		
	Group 3														
	Combined							167	—	150	550	—	83		
	Haemonchus							131	—	123	348	—	39		
	Trichostrongylus							30	—	20	192	—	43		
	Ostertagia							6	—	7	10	—	1		
	Nematodirus							0	—	0	33	—	0		
Buffelskloof (1980/81)	***Group 1***														
	Combined		0	0	0	0	50	—	167	300	183	—	67	433	
	Haemonchus		0	0	0	0	50	—	167	300	183	—	67	433	
	Trichostrongylus		0	0	0	0	0	—	0	0	0	—	0	0	
	Ostertagia		0	0	0	0	0	—	0	0	0	—	0	0	
	Nematodirus		0	0	0	0	0	—	0	0	0	—	0	0	
	Group 2														
	Combined		0	17	0	0	67	—	117	150	50	—	600	117	
	Haemonchus		0	+	0	0	67	—	117	150	50	—	600	101	
	Trichostrongylus		0	+	0	0	0	—	0	0	0	—	0	16	
	Ostertagia		0	+	0	0	0	—	0	0	0	—	0	0	
	Nematodirus		0	0	0	0	0	—	17	0	0	—	0	0	
	Group 3														
	Combined		0	0	0	0	67	—	67	433	89	—	550	267	
	Haemonchus		0	0	0	0	67	—	67	433	89	—	550	267	
	Trichostrongylus		0	0	0	0	0	—	0	0	0	—	0	0	
	Ostertagia		0	0	0	0	0	—	0	0	0	—	0	0	
	Nematodirus		0	0	0	17	0	—	0	0	0	—	0	0	

TABLE 3 Mean egg count data (e.p.g.) of sheep, recorded on 4 properties on 5 occasions, with 1 dangerous 8-week rainfall period observed ending in April

Property/year	Egg counts	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
Hyndhope (1980/81)	***Group 1***														
	Combined		0	0	0	—	0	0	0	17	—	66	233	—	933
	Haemonchus		0	0	0	—	0	0	0	13	—	0	228	—	933
	Trichostrongylus		0	0	0	—	0	0	0	4	—	66	5	—	0
	Ostertagia		0	0	0	—	0	0	0	0	—	0	0	—	0
	Nematodirus		0	0	0	—	0	0	0	33	—	0	0	—	0
	Group 2														
	Combined		0	0	0	—	0	0	0	0	—	267	67	—	1 050
	Haemonchus		0	0	0	—	0	0	0	0	—	232	67	—	1 050
	Trichostrongylus		0	0	0	—	0	0	0	0	—	23	0	—	0
	Ostertagia		0	0	0	—	0	0	0	0	—	12	0	—	0
	Nematodirus		0	0	0	—	0	0	0	0	—	0	0	—	0
Mount Pleasant (1980/81)	***Group 1***														
	Combined		0	0	17	—	33	0	17	—	67	67	233	234	
	Haemonchus		0	0	0	—	23	0	+	—	+	67	233	227	
	Trichostrongylus		0	0	17	—	10	0	+	—	+	0	0	7	
	Ostertagia		0	0	0	—	0	0	+	—	+	0	0	0	
	Nematodirus		50	17	0	—	0	0	0	—	0	0	0	0	
	Group 2														
	Combined		0	0	17	—	0	33	33	—	50	50	183	100	
	Haemonchus		0	0	8	—	0	+	+	—	+	50	183	98	
	Trichostrongylus		0	0	9	—	0	+	+	—	+	0	0	2	
	Ostertagia		0	0	0	—	0	+	+	—	+	0	0	0	
	Nematodirus		67	0	0	—	150	0	0	—	0	33	0	0	
Shirlands (1979/80)	***Group 1***														
	Combined	17	17	—	50	133	50	83	533	83	84	67	83	83	
	Haemonchus	+	+	—	0	9	0	0	34	5	17	0	0	0	
	Trichostrongylus	+	+	—	50	124	50	41	446	69	67	67	83	83	
	Ostertagia	+	+	—	0	0	0	42	53	9	0	0	0	0	
	Nematodirus	33	0	—	17	0	17	0	0	0	17	17	0	0	
Shirlands (1980/81)	***Group 1***														
	Combined		0	0	—	0	0	0	—	0	17	33	—	83	117
	Haemonchus		0	0	—	0	0	0	—	0	+	0	—	0	0
	Trichostrongylus		0	0	—	0	0	0	—	0	+	33	—	55	87
	Ostertagia		0	0	—	0	0	0	—	0	+	0	—	28	30
	Nematodirus		0	0	—	0	0	0	—	0	0	83	—	17	17
Joubertskraal (1980/81)	***Group 1***														
	Combined		0	0	—	0	17	17	—	17	75	150	—	317	
	Haemonchus		0	0	—	0	+	13	—	17	75	75	—	107	
	Trichostrongylus		0	0	—	0	+	4	—	0	0	75	—	140	
	Ostertagia		0	0	—	0	+	0	—	0	0	0	—	70	
	Nematodirus		0	0	—	33	33	0	—	0	0	0	—	0	

TABLE 4 Mean egg count data (e.p.g.) of sheep, recorded on 3 properties on 4 occasions, with no dangerous 8-week rainfall period observed

Property/year	Egg counts	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
Eildon (1979/80)	***Group 1***														
	Combined	333	—	17	33	33	0	17	50	67	33	—	0	0	
	Haemonchus	0	—	0	0	0	0	8	10	17	0	—	0	0	
	Trichostrongylus	266	—	13	16	25	0	9	40	50	33	—	0	0	
	Ostertagia	67	—	4	17	8	0	0	0	0	0	—	0	0	
	Nematodirus	50	—	0	0	0	0	0	0	0	0	—	0	0	
	Group 2														
	Combined	250	—	167	17	33	17	17	67	17	0	—	0	0	
	Haemonchus	0	—	0	2	0	0	14	16	0	0	—	0	0	
	Trichostrongylus	219	—	143	10	33	3	3	51	17	0	—	0	0	
	Ostertagia	31	—	24	5	0	14	0	0	0	0	—	0	0	
	Nematodirus	17	—	0	0	0	0	0	0	0	0	—	0	0	
Mount Pleasant (1979/80)	***Group 1***														
	Combined	0	—	0	0	17	33	0	0	17	33	—	0	0	
	Haemonchus	0	—	0	0	0	0	0	0	0	0	—	0	0	
	Trichostrongylus	0	—	0	0	4	33	0	0	17	33	—	0	0	
	Ostertagia	0	—	0	0	13	0	0	0	0	0	—	0	0	
	Nematodirus	33	—	50	33	67	0	33	17	0	0	—	67	17	
	Group 2														
	Combined	0	—	0	17	0	33	17	0	0	17	—	0	17	
	Haemonchus	0	—	0	+	0	+	0	0	0	0	—	0	+	
	Trichostrongylus	0	—	0	+	0	+	15	0	0	17	—	0	+	
	Ostertagia	0	—	0	+	0	+	2	0	0	0	—	0	+	
	Nematodirus	17	—	33	0	0	0	0	33	0	0	—	17	0	
Glen Cullen (1978/79)	***Group 1***														
	Combined		0	0	50	33	150	67	17	167	133	17	0		
	Haemonchus		0	0	50	+	31	7	+	0	0	+	0		
	Trichostrongylus		0	0	0	+	104	27	+	84	125	+	0		
	Ostertagia		0	0	0	+	15	33	+	83	8	+	0		
	Nematodirus		33	117	83	117	50	0	17	33	0	0	0		
Glen Cullen (1979/80)	***Group 1***														
	Combined	17	—	17	0	17	0	33	83	50	50	—	67	17	
	Haemonchus	0	—	+	0	+	0	33	31	19	14	—	20	+	
	Trichostrongylus	11	—	+	0	+	0	0	44	25	32	—	44	+	
	Ostertagia	6	—	+	0	+	0	0	8	6	4	—	3	+	
	Nematodirus	183	—	0	0	17	0	0	83	0	17	—	50	17	
	Group 2														
	Combined	33	—	0	0	17	0	0	67	117	83	—	33	0	
	Haemonchus	0	—	0	0	+	0	0	25	39	20	—	6	0	
	Trichostrongylus	17	—	0	0	+	0	0	39	64	56	—	25	0	
	Ostertagia	16	—	0	0	+	0	0	3	14	7	—	2	0	
	Nematodirus	117	—	0	0	17	0	17	0	33	0	—	50	17	

TABLE 5 Chi-squared evaluation of combined, *Haemonchus*, *Trichostrongylus* and *Nematodirus* mean egg count data (e.p.g.) of sheep on 9 properties on 16 occasions**. The egg count data are in geometrical arrangement, first term/common ratio—16/2

Property/year	Mean egg count data (e.p.g.) in geometrical arrangement																	
	Combined					*Haemonchus*					*Trichostrongylus*					*Nematodirus*		
	≥512/≤511	≥256/≤255	≥128/≤127	≥64/≤63	≥32/≤31	≥512/≤511	≥256/≤255	≥128/≤127	≥64/≤63	≥32/≤31	≥256/≤255	≥128/≤127	≥64/≤63	≥32/≤31	≥16/≤15	≥64/≤63	≥32/≤31	≥16/≤15
Section 1 Joubertskraal—1978/79 Cavers—1980/81	8/11	10/9	13/6	16/3	17/2	7/12	8/11	8/11	11/8	12/7	3/16	6/13	7/12	9/10	12/7	0/19	3/16	5/14
χ^2 values* Section 1/2, 3 & 4						21,4												
Section 2 Cavers—1979/80 Joubertskraal—1979/80 Leeuwfontein—1978/79 Leeuwfontein—1979/80 Buffelskloof—1980/81	14/60	26/48	36/38	50/24	54/20	8/66	18/56	29/45	42/32	50/24	9/65	18/56	24/50	30/44	36/38	2/72	6/68	13/61
χ^2 values* Sections 1 & 2/3 & 4 Sections 1 & 2/3	23,6	43,0	44,7	40,0	22,0		33,2	14,2	19,5	26,7	12,9	26,9	14,0	6,8	7,9			
Section 3 Hyndhope—1980/81 Mount Pleasant—1980/81 Shirlands—1979/80 Shirlands—1980/81 Joubertskraal—1980/81	3/61	5/59	11/53	25/39	33/31	2/62	2/62	7/57	13/51	15/49	1/63	2/62	11/53	16/48	18/46	2/62	6/58	13/51
χ^2 values* Section 3/4 Sections 1, 2 & 3/4				7,0				6,0	13,5	9,0								8,8
Section 4 Eildon—1979/80 Mount Pleasant—1979/80 Glen Cullen—1978/79 Glen Cullen—1979/80	0/70	0/70	4/66	12/58	26/44	0/70	0/70	0/70	0/70	3/67	0/70	1/69	5/65	17/53	25/45	6/64	16/54	26/44

* χ^2 values—10,8(P<0,001); 6,6(P<0,01); 5,4(P<0,02): $\chi^2 = \frac{n(|ad - bc| - \frac{1}{2}n)^2}{(a+b)\ (c+d)\ (a+c)\ (b+d)}$

** Significant chi-square values are listed for those sets of data pertinent to this evaluation

Haemonchus and *Trichostrongylus* egg counts predominated and made up the greater part of the combined egg count. Both, as was the case with the combined egg count, were favourably influenced by wet circumstances during the late spring and summer months ($P<0,001$); wet circumstances in late summer and autumn months were of less consequence (Table 5: Sections 1 & 2/Sections 3 & 4, Sections 1 & 2/Section 3). Very wet summer circumstances, while of decided advantage to the *Haemonchus* counts ($P<0,001$), had no noticeable influence on the *Trichostrongylus* counts (Table 5: Section 1/Section 2, 3 & 4).

Although *Nematodirus* egg counts were low throughout, there were indications that the counts were favoured by dry conditions ($P<0,01$) (Table 5: Sections 1, 2 & 3/Section 4). *Ostertagia* counts were very low throughout the period of observation and no trends could be determined.

Discussion

A number of authors are of the opinion that there is little or no meaningful relationship between gastro-intestinal nematode burdens and faecal worm egg counts (Muller, 1961; 1968; Barrow, 1964). In this regard egg count levels can indeed be influenced by a number of factors, but especially by the seasonal inhibition of the 4th stage larvae of *Haemonchus contortus*. The phenomenon occurs from mid/late summer into winter and has been recorded by Muller (1968), Connan (1971), Blitz & Gibbs (1972), Michel (1974), Horak (1978), and Grant (1981). Infestations of the ensuing summer probably result from the eggs produced by the inhibited larvae after they have resumed development (Blitz & Gibbs, 1972; Barger & Le Jambre, 1979). Somewhat similar circumstances may obtain, although of lesser proportion, with regard to *Trichostrongylus* spp. (Muller, 1968; Ogunsusi & Eysker, 1979, Ogunsusi, 1979). Thus, while low egg counts, especially over late autumn and winter months, do not necessarily indicate low worm burdens, high egg counts in general indicate the presence of corresponding infestations.

Rainfall plays an important role in the development of gastro-intestinal nematodes. *Haemonchus contortus*, especially, flourished under wet summer conditions (Gordon, 1950; Reinecke, 1964; Ogunsusi, 1979; Grant, 1981). Wetness is difficult to determine without the use of fairly sophisticated equipment. Daily, weekly and monthly rainfall figures, which are easy to record, give no real indication of the wetness of an area, in that one heavy thunder-shower can raise these figures while overhead conditions remain bright and shiny for some considerable time. The 4-week rainfall figures and the dangerous 8-week rainfall period assessments did much to facilitate the evaluation of wetness. However, in the course of the work it became evident that rainfall which created a wet condition on one property made little impression on another. While vegetation and ground texture had a role to play in this regard, it seemed that ground slope played a more important role; consequently, the degree of slope on a property or grazing area was incorporated in the formula used to estimate the minimum 4-week rainfall requirement and, as relevant, the related dangerous 8-week rainfall period. Minimum 4-week rainfall figures for flat areas were adjusted upwards to 32 mm, as in such areas extremely low values resulted from the formula. For the opposite reason, figures from very hilly areas were adjusted downwards to 100 mm for grassveld and 125 mm for Karoo veld and mixed grassveld/Karoo veld. Actual minimum 4-week rainfall requirement estimates and dangerous 8-week rainfall period assessments were applied to the late spring, summer and early autumn, namely, between 1 October and 30 April the following year. These estimates were subject to the consideration that no measurements were authenticated until the 1/8 annual rainfall qualifying date had been determined. The 1/8 annual rainfall qualifying date was regarded as a useful indication of the condition of ground cover.

Once the several parameters were brought into use, the gastro-intestinal nematode populations indicated by egg count determinations fell into more defined order notwithstanding the great variation in climatic conditions observed on the 9 properties in the 3-year period under consideration. Irrespective of location and veld type, combined, *Haemonchus* and *Trichostrongylus* egg counts were, in general, favourably influenced by wet conditions over the late spring and summer months and, at the lowest level of assessment ($\geqslant 16/\leqslant 15$) *Nematodirus* counts appeared favoured by dry conditions (Table 5: combined, Sections 1 & 2/Sections 3 & 4; *Haemonchus*, Section 1/Sections 2, 3, & 4, Sections 1 & 2/Sections 3 & 4, Sections 1 & 2/Section 3; *Trichostrongylus*, Sections 1 & 2/Sections 3 & 4; *Nematodirus*, Sections 1, 2 & 3/Section 4).

By and large in any study of gastro-intestinal worm populations the question of preventive worm control becomes relevant. Despite the shortfalls of faecal worm egg counts and faecal cultures in the determination of *Haemonchus*, *Trichostrongylus*, *Ostertagia* and *Nematodirus* populations, the data recorded in this study indicate that, under veld conditions, tactical anthelmintic treatment is warranted a few weeks after a dangerous 8-week rainfall period.

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