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PARASITES IN SHEEP GRAZING ON KIKUYU *(PENNISETUM CLANDESTINUM)* PASTURES IN THE WINTER RAINFALL REGION

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ABSTRACT

REINECKE, R. K., KIRKPATRICK, R., SWART, LYDIA, KRIEL, ANNA M. D. & FRANK, F., 1987. Parasites in sheep grazing on Kikuyu *(Pennisetum clandestinum)* pastures in the winter-rainfall region. *Onderstepoort Journal of Veterinary Research*, 54, 27–38 (1987).

Regular worm counts were done post-mortem on sheep that had grazed on Kikuyu pastures at the Elsenburg Research Station near Stellenbosch, a winter rainfall region. Major species were *Trichostrongylus colubriformis, Trichostrongylus axei*, while *Ostertagia circumcincta* was usually present in large numbers.

Minor species were *Haemonchus contortus, Nematodirus spathiger, Dictyocaulus filaria, Oesophagostomum venulosum, Trichuris* spp., *Chabertia ovina* and larvae of the arthropod *Oestrus ovis*. *Muellerius capillaris* caused the formation of nodules in the lungs but were not counted.

The trial started in April 1982 and was concluded in March 1984. One hundred and four sheep died or were slaughtered and 99 were examined post-mortem during this period. Total worm burdens rose to a peak of 88 763 (range 67 281–124 735) worms in March 1983, i.e. sheep mortality was such that the flock had to be treated with an anthelmintic in April 1983 to prevent further losses.

Kikuyu pastures provide shade, form an excellent mat, the humus layer under the grass retains moisture and is an excellent incubator for preinfective larvae and a protector for infective larvae. If these qualities are combined with more than 100 mm of rain in spring and summer, Kikuyu pastures are a paradise for the free-living stages.

INTRODUCTION

The epizootiology of helminth parasites in sheep in the Southern Hemisphere has recently been correlated and summarized by Reinecke (1983). The only data for winter rainfall areas in this hemisphere were published by Anderson (1972; 1973) on work done in western Victoria, Australia.

The present paper reports on the helminth and arthropod parasite burdens on sheep grazing intensively on Kikuyu grass pastures at Elsenburg, near Stellenbosch, in the winter rainfall region.

MATERIALS AND METHODS

Elsenburg Agricultural Research Station is situated 33° 51′ S, 18° 50′ E, 177 m above sea level. The mean annual rainfall is 613,7 mm, 396,6 mm (64,4 %) falling during May to August and less than 22 mm per month in January and February respectively. Mean monthly maximum temperatures are 17,0 °C in July and 30,0 °C in February, and mean monthly minimum temperatures range from 7,0 °C in July and August to 14,9 °C in February, respectively.

Pastures

Sheep grazed 3 pastures alternately, as follows:

(1) W17, a mixture of Kikuyu *(Pennisetum clandestinum)* and grass clover, 2,6 ha in extent, from April–31 October 1982.

(2) W1, a Kikuyu pasture, 2,2 ha in extent, from 1 November 1982–22 August 1983.

(3) W2, a Kikuyu pasture, 2,3 ha in extent, from 23 August–13 October 1983.

(4) W1, from 14 October–8 December 1983.

(5) W2, from 9 December 1983–16 March 1984.

Irrigation

Flood irrigation at the rate of 1 404 kℓ per ha was applied to the adjacent pastures W1 and W2 in the very dry spring and summer as follows:

(1) Once in December 1983,

(2) Once in January 1984, and

(3) Once in February 1984.

At no other time were any pastures irrigated.

Supplementary feed

Throughout, feed comprised a mixture 1:1 of lucerne and oat hay, chopped in a hammermill, sieved through a 12,5 mm sieve and fed at the rate of 1 kg/sheep/day. The chopped hay was placed in hoppers for self-feeding.

Lick

From 8 March 1983 onwards the following lick was made available:

Salt (NaCl)	40 kg
Bone meal	35 kg
Molasses	15 kg
Dolomite agricultural lime	10 kg
Manganese sulphate	250 g
Copper sulphate	100 g
Cobalt chloride	1 g
Sodium selenite	1 g

Approximately 25 kg/month of this lick was consumed by the flock.

Sheep

Seventy-five South African mutton Merinos from Langewens and Elsenburg grazed on the pastures from April 1982–March 1984. They varied in age from yearling wethers to 19-month-old ewes and were lightly infested with *Ostertagia* spp. and *Trichostrongylus* spp. On 19 June, 13 Merino ewes and 17 wethers with a mixed infestation of *Chabertia ovina, Haemonchus contortus, Nematodirus* spp., *Oesophagostomum venulosum, Ostertagia* spp. and *Trichostrongylus* spp. were bought in the Swellendam district and placed on the pasture to contaminate it with a mixed infestation typical for this region. Sixteen lambs were born of the original Elsenburg flock in spring, but unfortunately they died within 4 months. In November 1983, a further 58 weaned mutton Merinos were added to the flock.

Slaughter and deaths

Four sheep were killed on 4 April 1982, and from 6 June 4 sheep were slaughtered every 4 weeks. In July, sheep started dying at pasture until treatment was given in April 1983. Sheep 45, which died, was included in the slaughter groups in 1982 and a further 12 sheep that died in slaughter groups in 1983. The entire flock was dosed with thiabendazole at 22 mg/kg (half dose) on 13 April

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TABLE 1 Worms recovered at necropsy at Elsenburg

Sheep No.	Date of slaughter or death	Nematodirus		Ostertagia			Trichostrongylus					
		L_4[(1)]	*N. spathiger*		*O. circumcincta*	*O. trifurcata*	L_4	*T. axei*	L_4	*T. colubriformis*	*T. falculatus*	*T. rugatus*
	1982											
1	6 Apr	0	620	859	1 130	0	0	528	0	1 841	0	525
2	6 Apr	0	130	187	895	147	90	120	56	670	0	0
3*	6 Apr											
4*	6 Apr											
5*	9 Jun											
6	9 Jun	0	2 407	13 901	705	1	0	494	0	7 865	0	0
7	9 Jun	0	6	579	785	0	8 591	1 701	170	2 749	0	0
8	9 Jun	21	3 712	23	459	0	1 210	728	70	3 722	0	0
9	9 Jun	0	54	10	160	0	1 400	80	20	656	0	0
10	8 Jul	0	2 889	6 372	3 392	0	0	3 038	350	11 566	0	0
11	8 Jul	447	588	2 444	7 170	876	1 463	457	2 684	10 012	434	2 354
12	8 Jul	40	423	157	1 800	478	1 305	717	0	5 282	0	0
13	8 Jul	0	0	1 021	2 406	0	970	310	200	6 772	0	154
14	8 Jul	87	2 280	934	1 243	0	1 394	1 515	817	6 273	0	570
15	9 Aug	942	10 848	6 385	4 972	0	0	1 607	3 298	13 560	0	11 572
16	9 Aug	62	1 838	1 700	664	0	23	5	512	2 911	664	115
17	9 Aug	365	3 127	702	743	328	1 311	1 364	1 664	22 051	0	1 251
18	9 Aug	0	0	205	942	0	470	1 034	150	4 685	0	167
19	1 Sep	0	0	245	477	213	326	995	378	11 891	0	880
20	1 Sep	0	1 052	1 317	1 562	237	183	327	1 920	16 176	0	789
21	1 Sep	100	0	1 517	3 597	360	583	1 522	301	13 005	0	1 178
22*	1 Sep											
23	28 Sep	1 030	813	195	512	497	110	57	5 177	27 727	0	406
24	28 Sep	0	0	65	970	291	136	147	30	3 918	0	88
25	28 Sep	1 125	0	7	331	48	6	189	382	18 336	0	91
26	28 Sep	0	0	0	3 041	698	370	980	4	13 562	0	729
27	28 Sep	0	0	184	1 424	0	248	10 791	4 128	54 487	0	7 200
28	27 Oct	0	0	0	44	0	0	218	0	13 405	0	964
29	27 Oct	4	1 136	285	2 440	0	1	7	340	34 665	0	10 222
30	27 Oct	0	11 606	69	0	0	150	899	12 786	28 075	0	3 873
31	27 Oct	0	0	56	761	0	0	2	1 060	2 127	0	0
32	24 Nov	67	0	0	452	126	2	353	83	71	0	0
33	24 Nov	36	0	0	192	319	4	16	124	140	0	0
34	24 Nov	0	0	47	1 852	463	0	1 318	275	15 041	0	2 493
35	24 Nov	95	0	0	1 547	360	55	1 305	1 154	20 076	0	2 038
36	22 Dec	560	6 278	54	964	42	150	167	2 000	14 283	0	2 092
37	22 Dec	0	0	360	467	633	655	2 122	202	15 504	0	594
38	22 Dec	594	9 287	0	1 582	0	117	7 816	2 851	34 124	0	5 160
39	22 Dec	0	449	63	3 896	0	500	3 147	91	23 649	0	2 290
40	22 Dec	140	0	280	2 087	0	3	5 163	140	19 563	0	1 253
45	22 Dec	0	0	1 904	1 115	984	1 055	1 862	7 886	29 501	554	1 631
	1983											
41	18 Jan	0	0	453	1 699	213	269	3 540	0	0	8	0
42	18 Jan	0	0	220	887	134	1	861	0	56	8	0
43	18 Jan	0	0	87	3 620	1 659	3	2 550	723	16 326	1 541	245
44	18 Jan	710	272	3 151	2 342	0	2	2 846	1 422	16 608	0	1 087
46	18 Jan	342	0	472	790	207	68	1 622	217	427	0	53
47	3 Jan	0	455	261	566	216	0	254	303	3 606	76	76
48	18 Jan	19	1 727	0	529	216	211	793	651	15 742	0	9
49	22 Jan	1 650	517	1 650	2 700	1 300	1 650	3 700	1 653	22 876	0	2 585
50	31 Jan	0	0	800	4 001	966	801	9 934	2 440	29 466	0	4 675
51	7 Feb	0	0	1 050	7 301	1 738	303	25 915	1 550	58 256	0	106
52	11 Feb	10	0	3 225	3 700	1 009	4 163	6 083	781	43 313	0	2 551
53	22 Feb	0	0	293	463	0	367	9 970	601	59 777	0	7 384
54	22 Feb	0	0	965	4 590	1 148	681	20 994	661	50 205	0	4 818
55	22 Feb	0	0	0	14 190	2 365	2 093	12 379	3 000	83 816	0	3 967
56	11 Mar	1 700	0	3 913	10 631	2 658	1 952	1 548	1 154	32 867	0	581
57	10 Apr	420	1	1	261	0	210	1 518	1 680	19 714	0	3 607
58	10 Apr	0	0	680	12 750	0	447	10 236	0	58 427	0	15 297
59*	10 Apr											
60	10 May[(2)]	60	0	10	10	0	38	10	0	13	0	0
61	10 May	0	0	0	2 842	598	0	1	0	2	0	0
62	10 May	53	0	0	2 668	359	0	0	107	995	0	148

(1) L_4 = 4th larval stage

(2) On 13 April each sheep was treated with Thiabendazole 22 mg/kg

* Carcasses putrified—no worms counted

Sheep No. EB	Date of slaughter or death	*Nematodirus*		*Ostertagia*			*Trichostrongylus*					
		L_4[1]	*N. spathiger*		*O. circumcincta*	*O. trifurcata*	L_4	*T. axei*	L_4	*T. colubriformis*	*T. falculatus*	*T. rugatus*
63	9 Jun	0	0	145	387	0	50	48	0	0	0	0
64	9 Jun	223	0	2 939	5 453	0	825	5 412	953	42 191	0	4 936
65	9 Jun	0	0	0	200	20	176	1 903	6 533	1 430	0	61
66	9 Jun	0	0	355	7 718	2 573	2 121	10 512	501	59 458	0	6 980
67	5 Jul	0	0	5 758	7 282	1 300	523[4]	251	40	523	22	0
68	5 Jul	0	0	0	0	0	88	1	0	0	0	0
69	5 Jul	0	0	56	1 736	64	31	0	50	30	0	0
70	5 Jul	15	0	125	11	0	156[5]	13 729	0	393	196	0
71	18 Jul	20	0	0	80	0	86	90	40	0	0	0
72	19 Jul	0	3 250	0	1 052	301	32	2 928	0	81 955	0	25 390
73	6 Aug	0	0	0	311	0	0	5 798	110	2 363	0	44
74	6 Aug	0	0	2 926	9 436	1 397	7 705	23 926	100	28 905	0	56
75	30 Aug	175	0	0	778	84	109	3 929	60	1 078	0	22
76	30 Aug	104	0	5	0	0	0	0	46	20	0	0
77	30 Aug	0	0	0	20	0	0	50	0	0	0	0
78	30 Aug	0	0	10	140	0	45	11 100	0	54	0	0
79	27 Sep	0	0	0	0	0	0	0	0	0	0	0
80	27 Sep	5	0	5	0	0	20	0	0	0	0	0
81	27 Sep	0	0	5	0	0	53	195	0	0	0	0
82	27 Sep	0	0	0	199	0	0	7 840	0	70	0	0
83	25 Oct	0	0	0	331	10	0	35	0	27	0	0
84	25 Oct	0	0	0	62	0	0	106	0	0	0	0
85	25 Oct	0	250	11	2 007	387	0	106	0	0	0	0
86	25 Oct	0	0	0	967	0	300	80	0	0	0	0
87	22 Nov	0	0	0	92	58	0	115	0	0	0	0
88	22 Nov	0	0	0	131	0	0	540	0	225	15	0
89	22 Nov	0	0	0	160	40	30	43	0	0	0	0
90[1]	22 Nov	0	0	5	321	17	15	153	0	5	0	0
91[2]	9 Dec	16	0	0	46	0	0	142	0	0	0	0
92	9 Dec	40	0	0	37	0	1	435	0	0	0	0
93	9 Dec	0	0	1	730	150	3	576	0	0	0	0
94	9 Dec	0	0	0	0	0	27	231	0	3	0	0
95	6 Mar	0	0	0	1 184	194	0	91	0	180	0	0
96	6 Mar	48	97	0	654	121	0	4	0	242	0	0
97	6 Mar	0	24	0	6 070	0	0	11 245	0	547	0	96
98	6 Mar	0	0	0	804	90	0	0	0	90	0	0
99	6 Mar	0	28	0	1 512	423	0	676	0	330	27	0
100[3]	6 Mar	0	0	0	3 947	654	0	5 823	0	0	0	0
101	6 Mar	0	170	0	90	45	0	55	0	0	0	0
102	6 Mar	0	0	0	414	85	0	0	0	0	0	0
103	6 Mar	60	150	20	56	0	0	11	20	60	0	0
104	6 Mar	0	1	0	664	180	0	46	0	64	0	0

(1) Sheep 90 had 643 *Strongyloides papillosus*
(2) Sheep 91 had 6 *S. papillosus*
(3) Sheep 100 had 718 *S. papillosus*
(4) Including 327 3rd stage larvae (L_3) *T. axei*
(5) Including 37 L_3 *T. axei*

1983 to prevent further deaths. Four sheep were slaughtered every 4 weeks thereafter until December 1983. On 6 March 1984, stray dogs attacked the flock, 10 sheep being either killed or mauled so badly that the survivors were slain for humanitarian reasons.

Necropsy

The head, left half of the skin and left limbs from the metacarpus and metatarsus to the hooves were placed in plastic bags, the mouths of which were tied off with string and labelled. The liver, trachea and lungs were likewise placed in labelled plastic bags. The gastro-intestinal tract was removed from the abdominal cavity and the mesenteric lymph nodes enucleated from the mesentry, the fat being completely removed. The lymph nodes were then cut into small slices with a bowel scissors and placed in a labelled bottle.

A double ligature was tied around the reticular-omasal juncture, the mesenteric fat being stripped from the abomasum and entire intestine. The reticulum and rumen were cut off from the rest of the gastro-intestinal tract between the double ligatures and these were then cut open for examination of the mucosa. *Paramphistomum* spp., if present, were removed. The abomasum and the rest of the intestinal tract were placed in a labelled plastic bag and tied off.

At the laboratory (Stellenbosch), the sliced lymph nodes were placed in physiological saline in bottles and incubated for 4 h at 37 °C in a water-bath, after which formalin was added to preserve them. All these specimens and those in plastic bags were placed in square plastic boxes (Tupperware) 30 × 30 × 10 cm in size and deep-frozen for 1 or 2 days at −6 °C. The specimens were then transferred to cardboard cartons lined with polystyrene strips and sent by air-freight and motor transport to Onderstepoort, where they were again deep-frozen until they could be examined.

The skin, wool and ears were removed from the head, the skull was sawn open along its length and the nasal cavities and sinuses examined, from which larvae of

TABLE 2 Worms and *Oestrus ovis* recovered at necropsy at Elsenburg

Sheep No.	Date of slaughter or death	*Chabertia ovina* L_4(3)	*Chabertia ovina*	*Dictyocaulus filaria* L_3	*Dictyocaulus filaria* 5(4)	*Dictyocaulus filaria*	*Haemonchus contortus* L_4	*Haemonchus contortus*	*Oesophagostomum venulosum* L_4	*Oesophagostomum venulosum*	*Trichuris* spp.	*Oestrus ovis* L_2(1)	*Oestrus ovis* L_3(2)
	1982												
1	6 Apr	0	0	138	0	1	0	40	0	4	19	0	1
2	6 Apr	0	0	25	0	0	10	50	0	0	30	0	0
3*	6 Apr												
4*	6 Apr												
5*	9 Jun												
6	9 Jun	0	4	127	0	45	1 019	481	10	50	36	0	12
7	9 Jun	0	1	62	0	6	0	0	0	32	4	0	20
8	9 Jun	0	1	164	0	7	0	0	10	83	25	0	0
9	9 Jun	0	0	30	0	0	0	0	0	3	0	0	5
10	8 Jul	0	2	9	0	0	0	0	624	202	9	0	1
11	8 Jul	0	0	63	4	5	0	0	90	43	6	0	0
12	8 Jul	0	0	270	7	53	40	0	0	43	13	0	10
13	8 Jul	0	0	426	0	47	0	0	60	72	31	0	1
14	8 Jul	0	0	487	0	79	0	0	60	7	9	0	3
15	9 Aug	0	0	50	0	130	0	0	240	333	18	0	0
16	9 Aug	0	0	119	0	119	0	0	260	284	47	0	1
17	9 Aug	0	4	3	3	7	443	356	31	71	0	0	0
18	9 Aug	0	0	45	0	14	0	28	5	88	37	0	5
19	1 Sep	0	4	27	11	94	99	0	2	208	10	0	3
20	1 Sep	0	0	7	9	141	320	0	10	0	11	0	0
21	1 Sep	0	0	25	30	73	0	0	62	638	148	0	0
22*													
23	28 Sep	0	0	0	346	363	93	0	870	469	75	0	0
24	28 Sep	0	0	12	0	9	65	0	0	5	0	0	0
25	28 Sep	0	0	60	13	2	0	0	110	3	0	0	0
26	28 Sep	0	0	3	82	35	0	6	110	129	0	0	0
27	28 Sep	0	0	12	356	126	0	0	0	0	0	0	0
28	27 Oct	0	3	25	0	1	360	0	20	5	0	0	0
29	27 Oct	0	0	106	0	324	85	0	50	1	0	0	2
30	27 Oct	0	0	23	2	12	914	0	10	276	0	0	1
31	27 Oct	0	0	0	1	0	0	0	0	1	0	0	0
32	24 Nov	0	0	1	0	3	0	50	0	3	0	0	0
33	24 Nov	0	0	0	10	24	0	319	10	3	1	0	6
34	24 Nov	0	0	0	27	1	0	203	2	22	6	0	1
35	24 Nov	0	0	5	1	2	0	203	60	54	27	0	1
36	22 Dec	0	0	1	5	6	0	120	40	134	0	0	1
37	22 Dec	0	0	0	0	0	94	40	0	2	0	0	0
38	22 Dec	0	0	0	4	6	0	50	60	390	82	0	0
39	22 Dec	0	0	2	20	12	0	440	69	127	51	11	8
40	22 Dec	0	0	0	17	21	0	737	70	112	4	12	527
45	17 Dec	0	0	0	16	27	134	566	0	1	25	0	0
	1983												
41	18 Jan	0	0	0	23	23	7	213	0	8	0	0	0
42	18 Jan	0	0	1	35	4	0	83	10	6	0	0	0
43	18 Jan	0	0	0	22	9	43	277	0	0	2	0	0
44	18 Jan	0	0	0	11	31	0	1 177	135	29	6	0	32
46	18 Jan	0	0	0	1	1	31	415	0	23	1	0	0
47	3 Jan	0	0	0	4	20	65	115	0	0	9	0	3
48	18 Jan	0	0	0	0	7	0	0	0	10	11	0	1
49	22 Jan	0	0	0	18	27	0	810	90	67	17	0	1
50	31 Jan	0	1	13	6	19	0	0	0	16	91	0	7
51	7 Feb	0	0	12	4	141	150	0	0	0	9	0	3
52	11 Feb	0	0	27	9	21	772	1 209	10	0	24	0	6
53	22 Feb	0	0	0	4	0	0	0	0	0	83	0	0
54	22 Feb	0	0	106	0	0	0	0	30	104	52	0	0
55	22 Feb	0	0	46	1	57	417	2 310	90	0	4	0	0
56	11 Mar	0	0	75	1	51	0	0	130	0	7	0	8
57	10 Apr	0	0	0	2	18	0	0	150	0	2	0	0
58	10 Apr	0	0	7	13	0	2 014	9 619	0	0	9	0	0
59*													
60	10 May	0	0	81	0	3	120	430	60	20	0	0	0
61	10 May	0	0	3	8	37	0	780	0	0	20	0	0
62	10 May	0	0	182	0	10	2	1 200	0	1	21	0	0

Sheep No.	Date of slaughter or death	*Chabertia ovina*		*Dictyocaulus filaria*			*Haemonchus contortus*		*Oesophagostomum venulosum*		*Trichuris* spp.	*Oestrus ovis*	
		L_4		L_3(3)	5(4)		L_4		L_4			L_2(1)	L_3(2)
63	9 June	0	0	0	5	0	328	435	50	30	1	0	0
64	9 June	0	0	3	0	0	0	2 683	10	359	138	0	1
65	9 June	0	0	99	0	0	20	70	0	140	0	0	0
66	9 June	0	0	26	11	3	195	337	0	25	1	0	0
67	5 Jul	0	0	7	0	0	1 322	2 534	20	6	0	0	0
68	5 Jul	0	0	70	6	2	370	0	0	0	0	0	4
69	5 Jul	0	0	0	0	0	870	210	0	4	0	0	0
70	5 Jul	0	0	17	11	0	0	0	0	1	0	0	0
71	18 Jul	0	0	0	0	0	40	0	0	0	0	0	0
72	19 Jul	0	0	153	28	17	0	0	0	0	74	0	0
73	6 Aug	0	0	43	4	2	170	0	0	0	6	0	0
74	6 Aug	0	0	44	2	126	464	127	10	2	12	0	1
75	30 Aug	0	0	46	5	3	672	0	0	0	0	0	0
76	30 Aug	0	0	17	16	1	0	0	0	0	0	0	0
77	30 Aug	0	0	62	8	11	0	0	0	0	0	0	0
78	30 Aug	0	0	4	0	0	0	40	0	0	0	0	0
79	27 Sep	0	0	74	0	0	0	0	0	0	0	0	0
80	27 Sep	0	0	0	0	0	0	0	0	0	0	0	0
81	27 Sep	0	0	3	0	1	0	0	0	0	0	0	1
82	27 Sep	0	0	3	0	0	0	1 062	0	62	11	0	0
83	25 Oct	0	0	2	6	0	0	20	0	0	0	0	0
84	25 Oct	0	0	0	1	0	0	62	0	0	0	0	2
85	25 Oct	0	0	0	15	1	200	0	0	0	0	0	0
86	25 Oct	0	0	2	10	2	0	193	0	0	0	0	0
87	22 Nov	0	6	0	0	0	0	35	0	1	0	0	0
88	22 Nov	0	0	29	0	0	0	16	0	0	0	0	3
89	22 Nov	0	4	3	0	0	0	107	0	7	0	0	3
90	22 Nov	40	2	0	0	0	0	51	0	23	1	0	0
91	9 Dec	0	1	24	0	1	0	40	10	0	0	0	0
92	9 Dec	0	1	0	0	0	0	239	0	0	0	0	0
93	9 Dec	0	0	0	0	0	0	30	0	0	0	0	0
94	9 Dec	0	18	14	0	0	0	0	0	2	1	0	4
	1984												
95	6 Mar	0	0	0	0	0	10	273	0	7	1	0	0
96	6 Mar	0	0	7	0	0	0	388	0	8	11	0	0
97	6 Mar	0	2	0	14	20	0	405	0	10	6	0	7
98	6 Mar	0	0	0	1	0	0	156	0	50	33	0	3
99	6 Mar	0	0	0	0	0	0	484	0	16	17	0	6
100	6 Mar	0	0	0	0	0	0	441	0	0	0	0	10
101	6 Mar	0	0	0	0	0	0	0	0	0	35	0	4
102	6 Mar	0	0	0	0	0	0	231	0	13	26	0	2
103	6 Mar	0	0	0	2	2	0	113	0	0	0	0	9
104	6 Mar	0	0	0	0	0	0	60	0	18	19	0	3

(1) L_2 = 2nd stage larvae
(2) L_3 = 3rd stage larvae
(3) L_4 = 4th stage larvae
(4) 5 = 5th stage
* = Carcass putrified—No worms counted

Oestrus ovis were extracted. All wool was cut off the hide and digested in KOH. The dissolved wool was then poured out and washed with water through sieves (38 μm apertures), and the residue on the sieve surfaces washed off into wide-mouthed jars and preserved in formalin. The hides and skin on the limbs were thoroughly scrubbed, using brushes with 20 mm long steel bristles, washed and sieved, and the residue on the sieve preserved in formalin.

Liver

Five–10-mm-thick slices of the entire liver were cut and any worms present expelled. The slices were placed in trays into physiological saline and incubated for 4 h in a water-bath at 37 °C. The fluid was then sieved (apertures 38 μm) and the residue on the sieve preserved in formalin.

Lymph nodes

The lymph nodes were removed from the saline, the fluid sieved (38 μm apertures) and the contents of the sieve preserved in formalin.

Lungs

Nodules caused by *Muelleris capillaris* were observed in the lung tissue. The lungs and bronchi were examined for *Dictyocaulus filaria*, as described by Reinecke (1973).

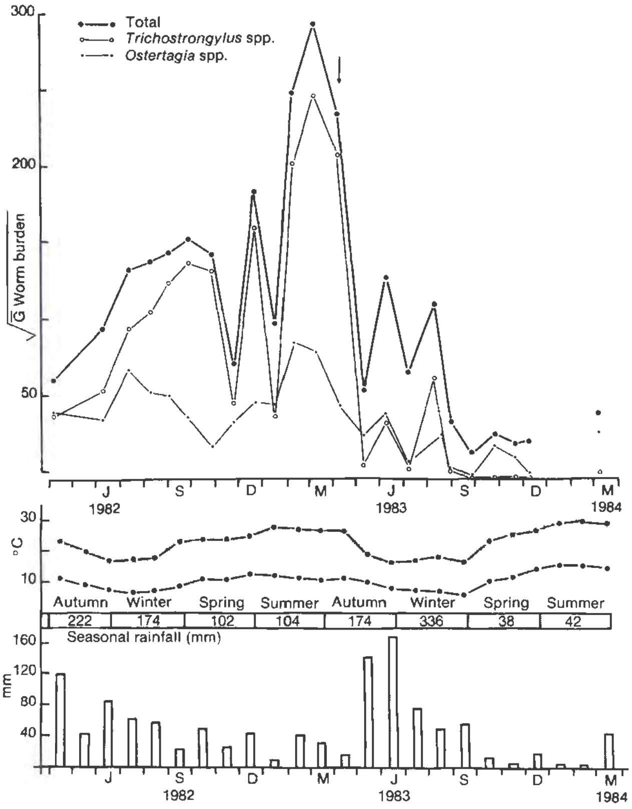

FIG 1 Variations in total worm burdens *Trichostrongylus* spp. and *Ostertagia* spp. at Elsenburg

Data converted to the square root of the geometric mean worm burden (√G)

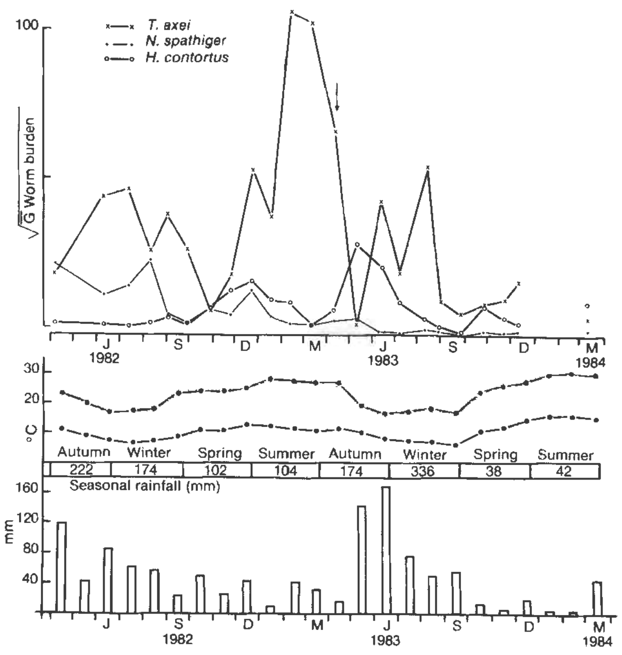

FIG 2 Variations in *T. axei, H. contortus* and *N. spathiger* worm burdens at Elsenburg

Abomasum and intestines

After thawing, worm recovery was undertaken, the technique used being that described by De Villiers, Liversidge & Reinecke (1985).

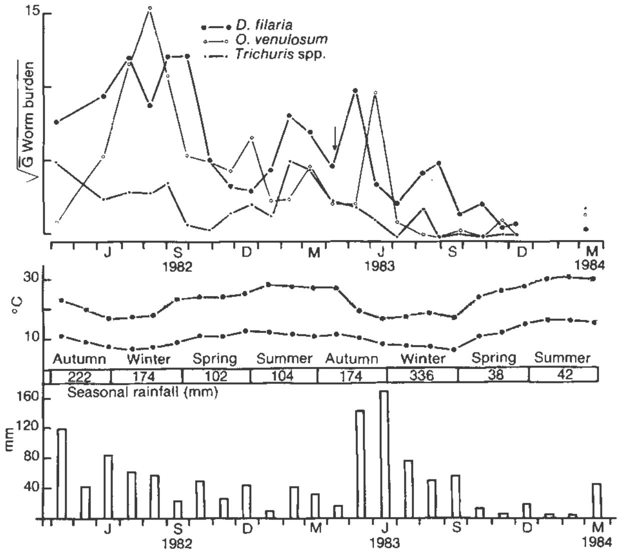

FIG 3 Variations in *D. filaria, O. venulosum* worm burdens and *Trichuris* spp. at Elsenburg

Worm counting and identification

All specimens were initially examined with a stereoscopic microscope. All the digested walls of the abomasum, small intestine, caecum and colon were examined, from which worms were removed, counted and preserved in formalin. A 1/10 aliquot of each ingesta of the abomasum, small intestine, caecum and colon was also examined. Worms present were counted and 100–120 were removed and transferred to specimen bottles (40 mℓ capacity) for subsequent identification on slides, with a laboratory microscope. The balance of the caecal and colonic ingesta (9/10) was macroscopically examined for helminths.

Identification of adult and larval stages was performed in accordance with procedures described by authors listed by Reinecke (1983).

Graphs

Data were summarized in tables and the mean worm counts estimated at each period of slaughter (Tables 1 & 2). The square roots of the geometric means ($\bar{G}$) were estimated and are illustrated in graphs (Fig. 1, 2 & 3).

Statistical analysis

Nematode worm counts of the 99 positive sheep were divided into 4 seasons, according to the date of slaughter or death, as follows:

Autumn: 20 March–20 June

Winter: 21 June–21 September

Spring: 22 September–21 December

Summer: 22 December–19 March

Data from the different seasons were compared by the Kruskal-Wallis test ($P < 0{,}05$) (Siegel, 1956) and, if differences were found to exist, Dunn's multiple comparison test was used to identify specific seasons which differed ($P < 0{,}10$) (Hollander & Wolfe, 1973).

Climate

Every day the maximum and minimum temperatures and rainfall at Elsenburg were recorded.

Period of this trial

The first and last sheep were killed on 5 April 1982 and 6 March 1984, respectively.

RESULTS

HELMINTHS

Total worm burdens (Fig. 1)

Worm counts rose steadily to October (1982), fluctuated until January (1983), and thereafter increased rapidly, rising to a peak in March, when sheep had 67 281–124 753 worms with a mean of 88 763. Sheep were dying at an alarming rate, and on 13 April were dosed with a half dose of thiabendazole (22 mg/kg) to prevent further mortalities. Worm counts fell after treatment, except that *Ostertagia* spp., *Dictyocaulus filaria* and *Haemonchus contortus* actually increased. However, reinfestation was rapid in June and August, fell in the dry spring until December 1983 and rose slightly in March 1984.

MAJOR GENERA

***Trichostrongylus* spp. (in the small intestine) (Table 1, Fig. 1)**

This genus was largely responsible for the fluctuations in the total worm burden, reaching peaks at the same time. *Trichostrongylus colubriformis* was by far the most dominant species, followed by *Trichostrongylus rugatus*, while *Trichostrongylus falcultatus* was not consistently diagnosed (Table 1).

***Ostertagia* spp. (Table 1, Fig. 2)**

In descending numerical order, species present were *Ostertagia circumcincta* and *Ostertagia trifurcata*. This genus had its first peak in July and then fell steadily until October 1982, rose slowly thereafter to January and then rapidly to February and March, and fell again in April. Minor peaks occurred in June, August and October 1983 and again in March 1984, when worm burdens of *O. circumcincta* ranged from 56–6 070 (mean 1 539).

***Trichostrongylus axei* (Table 1, Fig. 2)**

Minor peaks occurred in July, September and December 1982, with a marked rapid rise from January to February and March 1983. After treatment (April), counts fell but rose rapidly in June and August. From the end of August 1983, *T. axei* replaced *T. colubriformis* as the dominant species.

MINOR GENERA

***Nematodirus* spp. (Table 1, Fig. 2)**

Only 65 sheep were infested, and *Nematodirus spathiger* was the important species, *Nematodirus filicollis* being present in only 2 sheep. A peak in August was followed by fluctuating burdens until a further peak was reached in December 1982, after which there was a steady fall to a low level.

***Haemonchus contortus* (Table 2, Fig. 2)**

Of 99 positive sheep, only 64 had this species. Many sheep were negative or had low worm burdens in 1982. Only Sheep 6, which was killed on 9 June, had more than 1 000 worms. From January to June 1983, however, most sheep were infested and treatment in April had no effect on burdens, although a major peak was noted in May. Thereafter, counts fell, except for minor peaks in October 1983 and March 1984.

***Dictyocaulus filaria* (Table 2, Fig. 3)**

Counts of this species rose steadily until the end of September and then declined until December 1982. During 1983, peaks occurred in February, May and August. Many 3rd stage larvae were recovered from the digested gut wall of the caecum and colon, particularly in the autumn and winter.

***Oesophagostomum venulosum* (Table 2, Fig. 3)**

With the exception of peaks in August and December 1982 and June 1983, this species followed the same trends as *D. filaria*.

***Trichuris* spp. (Table 2, Fig. 3)**

Fifty-seven out of 99 sheep were infested with worms of this genus. The dominant species was *Trichuris skrjabini* followed by *Trichuris globulosa*. *T. ovis* was recovered in March 1984. Counts of this genus fell in winter, rising to a minor peak in September 1982, fluctuating thereafter to rise to a major peak in February 1983, falling steadily thereafter with a peak in August 1983 and again in March 1984.

Chabertia ovina

Worm burdens ranged from 1–42 in 15 sheep, and the rest were negative.

Muellerius capillaris

These thin worms are curled up and difficult to see. They occur in reddish mauve, greenish or grey nodules not more than 5 mm in diameter, and although the nodules were consistently present, there was no practical method of counting the worms within, without an impractical time-consuming dissection of each nodule to release the worms.

Cestodes and trematodes

Data are summarized in Table 3.

TABLE 3 Cestodes and trematodes recovered from sheep at necropsy

Sheep No.	*Moniezia expansa*	*Avitellina* spp.	Larvae of *Taenia hydatigena*	*Paramphistomum* spp.
42	+	–	–	–
45	+	–	–	–
47	+	–	–	–
49	+	–	–	–
56	+	–	–	–
61	Scolices not identified		–	–
63	–	+	–	–
64	+	–	–	–
65	–	+	–	–
67	–	+	–	9
68	–	+	–	346
69	Scolices not identified		–	–
70	–	+	–	–
71	–	+	–	–
76	–	–	–	2
84	–	–	–	104
89	–	–	+	–
90	–	+	–	3
91	–	–	+	–
92	–	+	–	–
94	–	+	–	1
101	–	+	–	–

Moniezia expansa were recovered in 6 sheep, *Avitellina* spp. in 10, unidentified scolices in 2 and larvae of *Taenia hydatigena* in 2 sheep, respectively. Except in Sheep 64 killed on 9 June 1983, *M. expansa* occurred in summer. *Avitellina* spp. was a winter and summer parasite, although it was found only in 1983 and 1984 during the latter half of the trial. *Paramphistomum* spp. was erratically present in 6 sheep from July 1983 to March 1984, and ranged from 2–346 parasites in the rumen and reticulum.

***Oestrus ovis* (Table 2)**

Only 43 sheep had larvae of *O. ovis*. The highest count of 539 2nd and 3rd stage larvae (Sheep 40) was recorded on 22 December 1982. Despite the most diligent search of digested wool specimens and scrapings of the hide, no other parasitic arthropods were recovered.

TABLE 4 Climatic data at Elsenburg

Month	Mean maximum temperature °C	Mean minimum temperature °C	Total rainfall mm
1982			
April	22,9 (24,4)	11,4 (11,7)	120,2 (52,0)
May	19,9 (19,9)	9,0 (9,4)	42,2 (83,1)
June	16,8 (17,9)	7,0 (8,2)	86,7 (90,1)
July	16,9 (17,0)	6,6 (7,0)	63,3 (90,2)
August	17,1 (17,1)	6,9 (7,0)	57,9 (90,3)
September	22,4 (19,3)	8,7 (7,8)	24,5 (46,3)
October	23,8 (22,2)	10,9 (9,4)	52,0 (36,9)
November	23,9 (24,9)	10,9 (11,7)	25,1 (31,3)
December	24,9 (26,7)	12,1 (13,3)	44,4 (24,5)
1983			
January	27,6 (28,0)	13,6 (14,1)	10,2 (21,1)
February	26,5 (29,0)	13,2 (14,5)	42,8 (16,3)
March	26,3 (27,4)	12,4 (13,2)	30,8 (19,4)
April	26,0 (24,4)	12,5 (11,7)	17,2 (52,0)
May	18,7 (19,9)	9,6 (9,4)	142,9 (83,1)
June	16,6 (17,9)	7,7 (8,2)	169,0 (90,1)
July	17,0 (17,0)	7,3 (7,0)	77,2 (90,2)
August	18,0 (17,1)	7,0 (7,0)	51,2 (90,3)
September	17,4 (19,3)	8,4 (7,8)	56,4 (46,3)
October	23,1 (22,2)	9,9 (9,4)	12,8 (36,9)
November	25,1 (24,9)	11,4 (11,7)	5,6 (31,3)
December	26,8 (26,7)	13,9 (13,3)	18,0 (24,5)
1984			
January	29,0 (28,0)	14,9 (14,1)	5,3 (21,1)
February	29,7 (29,0)	15,1 (14,5)	4,2 (16,3)
March	28,8 (27,4)	14,5 (13,2)	43,9 (19,4)

(1) Total rainfall 1 April 1982–31 March 1983 = 600,1 mm
1 April 1983–31 March 1984 = 603,7 mm

(2) Figures in parenthesis are the mean for 10 years

Rainfall and temperature

Data from April 1982–March 1984 are summarised in Table 4. The total rainfall for the 2 years of the trail, from 1 April 1982–31 March 1983, was 600,1 mm, and from 1 April 1983–31 March 1984 was 603,7 mm respectively. Despite this similarity, the seasonal distribution varied markedly.

	mm	mm
Autumn	1982–222,2	1983–173,9
Winter	1982–174,4	1983–336,3
Spring	1982–101,7	1983–37,7
Summer	1982/83–103,6	1983/84–41,6

The spring of 1983 and summer of 1983–1984 were very dry compared with the rainfall in the previous year.

The range of the monthly mean temperatures was:

	°C		°C
1982		1983	
Autumn	11,9–17,2	Autumn	12,2–19,3
Winter	11,8–15,6	Winter	12,2–12,9
Spring	17,4–18,5	Spring	16,5–20,4
1983		1984	
Summer	19,4–20,6	Summer	21,7–22,4

There was little difference between the mean monthly mean temperature in each season if that in 1982 is compared with the mean temperature in the following year.

Statistical analysis of seasonal worm burdens

With the exception of 5 sheep (Sheep 3, 4, 5, 22 and 59), in which worms were not counted because carcasses were putrified, results from the other 99 animals were divided into groups to coincide with the season in which they were killed or died, as follows:

TABLE 5 Dunn's multiple comparison test (Hollander & Wolf, 1973)

Seasons	Difference	Critical Value
Ostertagia spp.		
1982		
1 & 4	19,73	16,9934
1983		
5 & 7	15,00	13,7627
1982 + 1983		
2 & 7	42,56	31,5679
4 & 6	32,70	30,1847
4 & 7	47,26	27,7264
5 & 7	35,42	34,4434
T. colubriformis		
1982		
1 & 4	22,25	16,9934
1983		
5 & 7	19,65	13,7627
6 & 7	14,95	12,6137
1982 + 1983		
2 & 8	35,60	31,0169
3 & 6	31,54	27,8637
3 & 7	44,36	41,4916
3 & 8	40,86	30,1896
4 & 5	29,51	26,6404
4 & 6	36,26	26,1772
4 & 7	49,08	40,3784
4 & 8	45,58	28,6404
T. axei		
1982		
1 & 4	21,48	16,9934
2 & 4	14,15	13,3308
1983		
No significant difference		
1982 + 1983		
4 & 7	42,13	27,7264
4 & 8	41,56	32,0157
Total worm burdens		
1982		
1 & 4	24,55	16,9934
1983		
5 & 7	18,62	13,7627
1982 + 1983		
2 & 7	45,37	31,5679
3 & 7	46,26	30,2520
4 & 7	56,12	27,7264
4 & 8	42,90	32,0157
5 & 7	40,45	34,4434

(1) Only significant differences (P < 0,10) between seasons are listed

(2) Season 1 is autumn 1982 and season 8 summer 1983/84 (see text)

(3) Critical value = CV

Group No.	*Season*	*Sheep No.*	*No. of animals*
	1982		
1	Autumn	1,2,6–9	6
2	Winter	10–21	12
3	Spring	23–35 + 45	14
4	Summer 82/83	36–44, 46–56	20
	1983		
5	Autumn	57, 58, 60–66	9
6	Winter	67–78	12
7	Spring	79–94	16
8	Summer 83/84	95–104	10

Only 15 sheep had *Chabertia ovina*, and this species was therefore excluded from the analysis.

Kruskal-Wallis test (P < 0,05)

1982 (Groups 1–4)

Apart from *H. contortus* and *N. spathiger*, there was a significant difference between the seasons for all the other species and the total worm burdens.

TABLE 6 Significant results (P < 0,10) of Dunn's multiple comparison test at Elsenburg (continued)

Season	Difference	Critical Value
D. filaria		
1982		
2 & 3	14,49	14,3621
2 & 4	19,13	13,3308
1983		
5 & 8	17,81	15,1765
6 & 8	18,25	14,1428
1982 + 1983		
1 & 7	43,87	36,4650
1 & 8	53,70	39,3355
2 & 4	29,44	27,8144
2 & 7	54,66	29,0890
2 & 8	64,49	32,6153
3 & 7	32,23	27,8764
4 & 8	35,05	29,5016
6 & 8	35,91	32,6153
O. venulosum		
1982		
1 & 2	19,29	18,2539
1983		
5 & 6	16,20	14,5651
5 & 7	15,15	13,7627
1982 + 1983		
2 & 6	55,33	31,0974
2 & 7	53,57	29,0810
3 & 6	34,08	29,9662
3 & 7	32,32	27,8764
4 & 6	32,67	27,8144
4 & 7	30,91	25,5491
5 & 6	33,93	33,5891
5 & 7	32,17	31,7387
H. contortus		
1982	No significant differences	
1983		
5 & 6	14,89	14,5651
5 & 7	20,76	13,7627
1982 + 1983		
1 & 5	45,29	40,1466
2 & 5	50,12	33,5891
5 & 7	41,73	31,7387
N. spathiger		
1982	No significant differences	
1983	No significant differences	
1982 + 1983		
1 & 7	41,06	36,4650
2 & 7	37,81	29,0890
Trichuris spp.		
1982		
2 & 3	16,21	14,3621
1983		
5 & 6	14,93	14,5651
5 & 7	17,94	13,7627
7 & 8	16,52	13,3150
1982 + 1983		
1 & 7	39,61	36,4650
2 & 3	30,82	29,9662
2 & 6	35,87	31,0974
2 & 7	42,94	29,0890
4 & 7	33,36	25,5491
5 & 7	36,58	31,7387
7 & 8	34,14	30,7063

1983 (Groups 5–8)

Apart from *N. spathiger* and *T. axei*, all the other species and the total worm burdens had significant differences between the seasons.

1982 and 1983 combined (Groups 1–8)

There were significant differences between the seasons for all species and the total worm burdens.

Dunn's multiple comparison test

Results in which there was a significant difference (P < 0,10) are listed in Tables 5 & 6, and those where there was no significant differences are excluded. Seasons are synonymous with groups (see above) and, starting with autumn 1982, Group 1, extend through to summer 1984, Group 8.

There are certain common denominators in the results in Tables 5 & 6 and in Fig. 1–3, if the fluctuations in the figures are ignored.

Peak total worm burdens reached in summer 1982/83 were significantly higher than those in autumn 1982, due to the presence of *T. colubriformis* (including *T. falcultatus* and *T. rugatus*), *Ostertagia* spp. and *T. axei*, but are not reflected by Dunn's test when results are compared for the entire period of the trial 1982 and 1983 (Table 5).

In Autumn 1983 (Group 5), total worm burdens were significantly higher than those in the following spring (Group 7), and this difference was repeated if both years are combined (Table 5). This agrees with results for some genera and species (Tables 5 & 6) but not for others, and there were at least 2 possible reasons for these differences.

(1) *Ineffective treatment*

Thiabendazole dosed to the flock at 10 mg/kg (half dose) on 13 April 1983 had no effect on *H. contortus* and little effect on *O. venulosum, Ostertagia* spp. and *Trichuris* spp. and the rise in worm burdens was probably not influenced by the anthelmintic.

(2) *Rapid reinfestation*

After treatment, worm burdens of *T. colubriformis* and *T. axei* fell dramatically in May but recovered markedly in June to compensate for this fall, and partially, at least, account for the significantly higher worm burdens (P < 0,10) in autumn when compared with those of the following spring in 1983. This trend was not repeated when Dunn's multiple comparison test for both years (1982 and 1983) combined was carried out (Table 5).

DISCUSSION

Statistical differences

The flocks at the experimental stations, Elsenburg and Langewens, were treated regularly with anthelmintics for many years and this was reflected in the low worm burdens of the 6 sheep killed in April and June 1982 (Tables 1 & 2).

We introduced sheep with a mixed infestation, which were bought in Swellendam about 200 km from Elsenburg in the winter rainfall region. These animals contaminated the pasture and, in the wet winter (174,4 mm rain), spring (101,7) and summer (103,6 mm rain) which followed, worm burdens in the flock increased markedly (Fig. 1 & 2). In total worm burdens as well as in all major species, there were significant differences between the seasons in 1982 by the Kruskal-Wallis test (P < 0,05).

The data, when analysed by Dunn's multiple comparison test, show a significant difference between the autumn of 1982 and the summer of 1982/83 (P < 0,10) for all major species (Table 5).

In 1983, worm burdens in autumn were significantly higher than those in spring for *T. colubriformis* and *Ostertagia* spp. and for total worm burdens (P < 0,10 Table 5). In addition, there were significantly higher worm burdens for *T. colubriformis* in winter compared with

TABLE 7 Worm burdens from control groups in weaned Merinos grazing on natural pasture at the University of Pretoria (UP) Experimental Farm

No. of sheep	Control groups	Time on pasture (days)	Total worm burdens		
			L_L (1)	Median	L_U (2)
10	UP 4	220		Experiment 1: 1976/77	
	L_4 *H. contortus*		1 928	9 024	14 730
	5 (3) & A (4) *H. contortus*		70	760	5 811
	Total worm burdens		3 451	12 486	21 181
10	UP 1	114		Experiment 2: 1977/78	
	L_4 *H. contortus*		525	2 668	22 281
	5 & A *H. contortus*		5 562	8 821	11 591
	Total worm burdens		6 770	12 522	34 885
6	UP 7	127–167			
	L_4 *H. contortus*		2 356	5 824	11 685
	5 & A *H. contortus*		6 636	14 662	23 612
	Total worm burdens		13 109	25 483	42 846

(1) L_L = lower limit
(2) L_U = upper limit
(3) 5 = 5th stage
(4) A = adult

TABLE 8 Total rainfall and mean monthly maximum and minimum temperatures at the University of Pretoria Experimental Farm

Month	1976/77				1977/78			
	Total rainfall mm	Total No. of days rain fell	Mean maximum temperature °C	Mean minimum temperature °C	Total rainfall mm	Total No. of days rain fell	Mean maximum temperature °C	Mean minimum temperature °C
Sep	0	0	25,7	11,0	—	—	—	—
Oct	83,9	6	22,9	12,4	—	—	—	—
Nov	112,1	8	26,0	13,3	52,8	6	28,5	14,2
Dec	114,8	14	28,0	15,4	54,5	5	28,1	15,4
Jan	148,5	13	28,7	16,4	486,9	14	26,4	15,4
Feb	69,3	5	27,5	26,7	131,9	10	32,0	15,1
Mar	126,3	13	23,5	13,6	36,1	7	25,9	14,2
Apr	30,9	6	24,5	11,9	44,6	6	23,4	11,8
May	0	0	21,0	5,8	0	—	21,8	6,0
June	0	0	19,9	3,1	0,8	1	—	—

those in spring (Table 5). When data for *T. axei* were compared in 1983, however, there were no differences between seasons (from autumn 1983 to summer 1984).

Reason for this anomaly

T. axei, in common with the other species, found conditions in the hot, wet summer of 1982/83 optimal, peak worm burdens being recorded in February 1983 (6 083–25 915). After treatment (13 April), counts fell, only to recover in autumn and winter. *T. axei* was the dominant species in August and September and maintained this position in relation to the other *Trichostrongylus* spp. throughout the dry spring (1983) and summer (1984).

Ostertagia spp. were found in the wet autumn of 1983 in significantly higher numbers than in the dry spring, but surprisingly they retained their position in the arid summer of 1984, showing no significant difference in number from the previous autumn. It therefore more closely resembles *T. axei*, the other abomasal parasite, than the *Trichostrongylus* spp. in the small intestine.

Deaths and treatment

In these experiments, some sheep died and therefore were not slaughtered on a specific date. Moreover, the effect of treatment on other sheep was unknown. Both defects are freely admitted, but epidemiological facts overruled the requirements of statistical analysis.

Rainfall and temperature

Anderson (1972, 1973), using tracer lambs in trials in Victoria, Australia, concluded that infective larvae on pasture showed an accelerated mortality, with rising temperatures and falling humidity, and in spring and in the hot, dry summer months *Ostertagia* and *Trichostrongylus* larvae virtually disappear from the pasture. Prior to this, Muller (1968), working at Outeniqua, George (400 km from Elsenburg), found there is a negative correlation between the mean monthly temperature of 20 °C and the availability of larvae from October to March, and his tracer (indicator) lambs killed in December and January had the lowest worm burdens (320–1 609) of all lambs killed in his experiments. In the present trials, a monthly mean of 20 °C was exceeded in January and February of 1983 in the first summer, but in the late spring, December (20,4 °C) and summer 1984, mean monthly temperatures were 21,8 °C, 22,8 °C and 21,6 °C in January, February and March, respectively. In some respects, therefore, our data confirm those of Muller (1968) and Anderson (1972, 1973) that heat does not suit *Trichostrongylus* and *Ostertagia*. We differ from Muller (1968), however, in that in December (1960) 113,0 mm and January 55,6 mm of rain and 71,9–85,6 mm was recorded from February to April (1961) in Muller's trials, whereas in the present trials rainfall for this period, December 1982 to April 1983, ranged from 10,2 mm to 44,4 mm (Table 4), and sheep were dying of helminthosis. In the following spring and summer, the highest rainfall was recorded in March 1984 (43,9 mm), but was preceded by a very arid period from October–February, the monthly rainfall being 12,8, 5,6, 18,0, 5,3 and 4,2 mm, respectively.

Drought caused larval mortality of *Ostertagia* spp. and *Trichostrongylus* and not high temperatures.

Kikuyu pasture and helminths

Kikuyu pasture, *Pennisetum clandestinum*, has its origin in Kenya and takes its common name from the largest indigenous tribe there, the Kikuyu. It is probably the most popular lawn grass with gardeners and is the standard grass used for rugby and other playing fields in South Africa. It can withstand drought and heavy frost and grows rapidly with very little rain or irrigation. It is very succulent, has a high protein content and is an excellent grazing, both for sheep and cattle. It is usually green, forms an excellent mat and, apart from periods of drought, has humus layers on the surface. The soil under the grass is generally damp. It is an excellent incubator for preinfective larvae and a protector of infective larvae, providing shade and moisture for survival and migration. In fact, it is a paradise for the free-living larvae of parasitic nematodes. If these qualities are combined with good rains of 102 mm and 104 mm, with mean monthly temperatures ranging from 17–20 °C respectively in spring and summer of 1982 and 1983, the stage is set for an outbreak of helminthosis. This caused the deaths of 16 lambs and 13 sheep from helminthosis in the spring and summer of the present trials and probably was also responsible for the propagation of *Ostertagia* spp., *Trichostrongylus* spp. (of the small intestine) and *T. axei*, the winter rainfall parasites. These species survive well on the pasture and caused this outbreak of helminthosis in spring and summer.

Evans & Horak (1985, personal communication) carried out trials with cattle grazing on Kikuyu pastures at Alexandria near Port Elizabeth, one of the warmest areas in the R.S.A., where rain falls throughout the year. Infested cattle grazed on 4 ha and contaminated the pasture with the following nematode parasites:

Ostertagia ostertagi
Haemonchus placei
Trichostrongylus axei
Cooperia oncophora
Cooperia mcmasteri
Cooperia spatulata
Oesophagostomum radiatum
Oesophagostomum venulosum

and, to a lesser degree, with *Nematodirus helvetianus*.

Two tracer calves were placed on the pasture for 2 weeks, then removed, and one of them was killed immediately, the other 21 days later. Many thousands of worms, mostly *O. ostertagi*, were recovered, peak numbers of which, ranging from 166 000 (Day 21 tracer) to 286 400 (Day O tracer) were recorded in August.

Kikuyu pastures are obviously a very favourable environment for the free-living stages of cattle nematodes as well as those of sheep.

Natural pastures and H. contortus

In the summer rainfall areas of South Africa, *Haemonchus contortus* is by far the most dominant parasite. In this discussion, 2 experiments are reviewed to emphasise the importance of rainfall in the transmission of this parasite, (Reinecke, De Villiers & Brückner, 1984; Reinecke, De Villiers & Joubert, 1984).

At the University of Pretoria (UP) Experimental Farm, the experiments covered 2 successive years from spring to autumn. A camp, 17 ha in extent and comprising mixed natural grasses, was used, and these pastures were contaminated by 40 Merinos dosed with 7 000 infective larvae in the spring of 1976 and 30 Dorpers dosed with 5 000 infective larvae of *H. contortus* in the spring of 1977, respectively.

Experiment 1

Four groups of 12 or 13 weaned Merinos were predosed with 40 000 infective larvae on Day 0 (2 November 1976) and grazed on the contaminated pasture with groups, similar in size, of undosed controls. They were slaughtered at regular intervals throughout the summer and autumn (Reinecke, De Villiers & Brückner, 1984). In Table 7, the lower limit (L_L), upper limit (L_U) and median worm burdens of 4th stage larvae (L_4) of *H. contortus*, 5th stage and adult of this species and total worm burdens are listed. The details for *T. axei* are not given in Table 7 but form part of the total worm burdens. The L_4 of *H. contortus* represented 87,5 % of the worm burdens of this species in sheep that grazed on pasture for 220 days and were removed to pens prior to slaughter on 10 June 1977. Although the worm burdens of L_4 were fairly high, L_4 is not nearly as avid a blood-sucker as the 5th stage or adult *H. contortus*, and the sheep survived. Rainfall from the spring to the autumn was normal for the Highveld (Table 8).

Experiment 2

The original plan of this experiment called for the groups of sheep to be divided into 2 parts: Groups 1–6 were to be removed from the pasture in March and Groups 7–13 in August 1978. The 10 sheep in control Group 1 survived for 114 days on pasture until 17 March 1978. They had heavy worm burdens and 5th stage and adults represented nearly 70 % of the total, while the balance were L_4. They were on the brink of crisis, which occurred with Group 7, in which sheep developed severe helminthosis and had to be removed from the pasture 13–40 days later. They were slaughtered *in extremis*, and some of them even died on the pastures. The total number of *H. contortus* doubled, and L_4 represented only 32 % of this worm burden.

Very heavy rains were undoubtedly the cause of this outbreak of haemonchosis. It will be noted from the data summarized in Table 8 that both in January (486,9 mm) and February, rain fell on 14 and 10 separate days. The field was wet and remained wet for the entire summer. In addition, both the mean maximum and the mean minimum temperatures were, on average, 1 or 2 °C higher than during the same period the previous year. These hot, wet conditions are optimal for the free-living stages and they probably also accounted for the predominantly 5th stage and adult *H. contortus*. The combination was fatal and most sheep could not survive.

Except for some of the pioneer grasses such as *Cynodon dactylon*, which creeps over bare patches in overgrazed camps, in this trial, the pastures which the sheep grazed consisted of indigenous grass species that grow in pods separated by open spaces. Most of the grass in this pasture was *Eragrostis* spp. which stool. The stalks spread out at the top, grow rapidly in the summer and by February or March, when the plant has seeded, die off and the nutrient value decreases. If the rain stops, the veld dries rapidly and the micro-environment is less suitable for the pre-infective larvae and these die off on a large scale. The infective larvae, except the most hardy species, do not survive for any length of time.

In conclusion, Kikuyu grass pastures are a paradise for the free-living stages of all nematode species, whereas natural field grasses need a lot of rain (almost flood conditions) before these pastures become dangerous as a source of infestation.

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