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AVAILABILITY OF INFECTIVE LARVAE OF PARASITIC NEMATODES OF SHEEP GRAZING ON KIKUYU *(PENNISETUM CLANDESTINUM)* PASTURES IN THE WINTER RAINFALL AREA

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ABSTRACT

REINECKE, R. K., KIRKPATRICK, R., KRIEL, ANNA M. D. & FRANK, F., 1989. Availability of infective larvae of parasitic nematodes of sheep grazing on Kikuyu *(Pennisetum clandestinum)*, pastures in the winter rainfall area. *Onderstepoort Journal of Veterinary Research*, 56, 223–234 (1989).

Thirteen groups of 4 South African mutton Merinos grazed for 4 weeks with the flock on Kikuyu pastures and were slaughtered for total and differential worm counts at necropsy. Subsequently 12 groups of 8 week tracers grazed on the pastures and were killed for worm counts post mortem. The following were present in most sheep:

Teladorsagia (syn. *Ostertagia*) *circumcincta, Trichostrongylus axei, Trichostrongylus colubriformis, Dictyocaulus filaria* and *Oesophagostomum venulosum. Haemonchus contortus, Nematodirus spathiger* and *Trichuris skrjabini* were less frequently recovered.

Optimal conditions for infestation of grazing sheep occurred from June (late autumn)—October (spring) when mean temperatures in any 4 week period were <20 °C and a total of >40 mm of rain fell on 8 or more separate days. When the mean temperatures exceeded 20 °C pastures were safe, sheep acquiring < 1 000 worms in 4 weeks.

INTRODUCTION

Reinecke, Kirkpatrick, Swart, Kriel & Frank (1987) studied the helminth parasites of a flock of South African mutton Merinos grazing on Kikuyu *(Pennisetum clandestinum)* pastures at Elsenburg Agriculture Research Station near Stellenbosch in the winter rainfall region. That experiment involved the regular slaughter of 4 (or more) flock sheep every 4 weeks for 2 years from April 1982–March 1984. Sheep started dying from helminthosis in July and deaths continued at an alarming rate throughout spring and summer of 1983. The entire flock was dosed with a half dose (22 mg/kg) thiabendazole (thibenzole Logos) on 13 April 1983 to prevent further deaths. *Trichostrongylus* and *Teladorsagia* (syn. *Ostertagia*) were the major genera, reaching a peak in March 1983 of 67 128–124 753 worms, with a mean of 88 763. It was thought that a total rainfall of 102 mm in spring (1982) and 104 mm in summer 1983 respectively, were the cause of the marked accumulation of infective larvae on the herbage, translated into massive worm burdens in the grazing flock.

The present experiments with 4-week tracers were conducted during the period 20 December 1983–18 December 1984 (overlapping our previous trials by 3 months, December 1983–March 1984). Subsequently, trials with 8-week tracers commenced on 20 November 1984 for another year, finishing on 19 November 1985.

The object of these trials was to establish which climatic conditions in the winter rainfall area were optimal for the development of infective nematode larvae so that these data could be used to predict acquisition of infestation by sheep grazing on Kikuyu pastures and possibly, other improved pastures in this area.

MATERIALS AND METHODS

Site

The present trial was carried out at Elsenburg and the site and rainfall distribution have been described (Reinecke *et al.*, 1987).

TABLE 1 Rotation of Kikuyu *(Pennisetum clandestinum)* pastures and number of sheep on pastures at Elsenburg. W1 is 2,2 ha and W2 is 2,3 ha in extent

Pasture	Date	No. of Sheep
W1	1983-12-10–1984-01-17	71
W2	1984-01-18–1984-02-14	67
W1	1984-02-15–1984-03-06	63
W2	1984-03-07–1984-11-23	47
W1	1984-11-24–1985-01-22	35
W2	1985-01-23–1985-06-03	64
W1	1985-06-04–1985-06-13	76
W2	1985-06-14–1985-07-22	72
W1	1985-07-23–1985-08-08	72
W2	1985-08-09–1985-10-11	68
W1	1985-10-12–1985-11-08	59
W2	1985-11-09–1985-12-28	55

Sheep and Grazing (Table 1)

Thirty-five–76 S.A. mutton Merinos grazed alternately on 2 Kikuyu pastures: W1 (2,2 ha) and W2 (2,3 ha in extent).

Irrigation

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

(1) Once in December 1983,
(2) Once in January 1984,
(3) Once in February 1984.

At no other time were any pastures irrigated.

Tracer sheep

Two trials with weaned Merinos were carried out, as follows:

(1) *Four-week tracers:* On 20 December 1983 4 sheep from the flock were each dosed *per os* with ivermectin (Ivomec Logos) at 0,2 mg/kg live mass, returned to the flock and killed 4 weeks later on 17 January 1984 for differential worm counts post mortem. A further 4 sheep selected from the same flock were dosed on 17 January and killed 4 weeks later. This process was repeated until the final group was slaughtered on 18 December 1984.

(2) *Eight-week tracers:* On 20 November 1984 the first group of 4 sheep in the second trial were dosed with ivermectin at the same rate as the first trial and killed 8 weeks later on 15 January

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TABLE 2 Four week tracers. Nematodes consistently recovered and total helminth worm burdens of tracer sheep grazing at Elsenburg Experimental Station 4 weeks after being dosed with invermectin at 0,2 mg/kg

Group	Sheep No.	Date dosed	Date killed	*Dictyocaulus filaria* * L_3	*Dictyocaulus filaria* ** 5	*Haemonchus contortus* L_3	*Haemonchus contortus* *** L_4	*Haemonchus contortus* **** A	*Nematodirus spathiger* L_3	*Nematodirus spathiger* L_4	*Nematodirus spathiger* A	*Oesophagostomum venulosum* L_3	*Oesophagostomum venulosum* L_4	*Oesophagostomum venulosum* A	*Teladorsagia circumcincta* L_3	*Teladorsagia circumcincta* L_4	*Teladorsagia circumcincta* A	*Trichostrongylus axei* L_3	*Trichostrongylus axei* L_4	*Trichostrongylus axei* A	*Trichostrongylus colubriformis* L_3	*Trichostrongylus colubriformis* L_4	*Trichostrongylus colubriformis* A	Other helminths listed in Table 3	Total
		1983	1984																						
01	01	20 Dec.	17 Jan.	0	1	0	0	50	0	0	80	0	0	0	0	0	10	0	0	0	0	0	11	0	152
	02	" "	" "	0	0	0	0	20	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	50
	03	" "	" "	0	8	0	0	40	0	0	20	0	0	0	0	0	10	0	0	4	0	0	0	10	92
	04	" "	" "	0	4	0	0	376	0	0	40	0	0	0	0	0	52	0	0	0	0	0	0	52	524
02	05	17 Jan.	14 Feb.	0	0	0	0	290	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	2	302
	06	" "	" "	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	1	21	42
	07	" "	" "	0	0	0	0	30	0	0	10	0	0	0	0	0	30	0	0	0	0	0	0	3	73
	08	" "	" "	0	0	0	0	10	0	0	100	0	0	0	0	0	30	0	0	0	0	0	0	11	151
03	09	14 Feb.	12 Mar.	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	1	11
	10	" "	" "	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	11	" "	" "	3	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	13
	12	" "	" "	5	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	8
04	13	12 Mar.	10 Apr.	0	0	0	38	20	0	0	0	0	0	0	0	237	27	188	0	0	0	153	53	18	734
	14	" "	" "	33	0	3	390	343	0	152	0	0	0	0	0	38	143	2	0	0	5	0	164	15	1 288
	15	" "	" "	0	45	0	0	568	0	10	0	0	0	0	0	0	52	0	0	10	0	0	70	94	849
	16	" "	" "	0	0	0	0	0	0	54	0	0	0	0	10	0	0	0	0	0	0	160	66	1	291
05	17	10 Apr.	8 May	0	22	0	0	78	0	0	0	8	0	0	0	550	273	0	0	46	2	0	560	86	1 617
	18	" "	" "	0	24	0	25	0	0	0	0	0	0	13	152	16	0	203	16	0	10	3	430	1	893
	19	" "	" "	0	0	0	0	0	0	0	0	0	0	0	730	6	0	6	0	0	10	0	0	4	756
	20	" "	" "	12	11	0	0	0	0	0	0	0	1	3	336	0	10	222	0	54	0	103	305	141	1 198
06	21	8 May	6 Jun.	0	0	0	0	0	0	0	0	2	0	0	0	183	37	1	0	140	0	0	232	1	595
	22	" "	" "	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	342	343
	23	" "	" "	4	1	0	0	70	0	55	28	0	0	0	0	0	0	11	0	110	0	0	579	4	862
	24	" "	" "	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	102	21	127
07	25	6 Jun.	3 Jul.	4	0	0	0	0	160	0	0	7	0	0	10	0	0	0	0	0	0	0	0	1	182
	26	" "	" "	0	0	0	0	0	0	0	0	0	4	0	87	0	0	0	0	0	0	22	6	1	120
	27	" "	" "	3	0	0	0	0	10	40	0	2	1	4	832	346	0	688	0	0	18	0	0	1	1 945
	28	" "	" "	26	7	0	0	0	0	0	0	10	0	2	0	1 904	0	9	0	0	12	0	237	3	2 210

TABLE 2 Four week tracers. Nematodes consistently recovered and total helminth worm burdens of tracer sheep grazing at Elsenburg Experimental Station 4 weeks after being dosed with invermectin at 0,2 mg/kg (*continued*)

Group	Sheep No.	Date dosed	Date killed	*Dictyocaulus filaria*		*Haemonchus contortus*			*Nematodirus spathiger*			*Oesophagostomum venulosum*			*Teladorsagia circumcincta*			*Trichostrongylus axei*			*Trichostrongylus colubriformis*			Other helminths listed in Table 3	Total
				*	**	***	****																			
				L_3	5	L_3	L_4	A	L_3	L_4	A	L_3	L_4	A	L_3	L_4	A	L_3	L_4	A	L_3	L_4	A		
08	29	3 Jul.	31 Jul.	29	0	0	0	0	50	32	0	0	0	0	15	10	0	0	0	0	0	0	0	0	136
	30	" "	" "	8	6	0	0	0	0	45	0	0	2	0	3	0	0	202	0	0	37	0	545	1	849
	31	" "	" "	0	0	0	0	0	0	0	0	26	1	6	1 693	847	0	0	0	50	45	0	150	1	8 819
	32	" "	" "	2	0	0	0	0	0	30	0	4	2	0	88	40	0	0	0	0	10	0	0	0	176
09	33	31 Jul.	28 Aug.	41	0	0	0	0	0	0	0	0	8	0	20	0	0	30	0	0	7	0	0	1	107
	34	" "	" "	0	0	0	0	0	0	0	0	15	0	0	476	420	0	0	317	0	4	36	0	20	1 288
	35	" "	" "	0	117	0	0	0	0	0	0	0	7	0	818	73	400	512	0	0	2	0	0	1	1 930
	36	" "	" "	18	5	0	0	0	0	0	0	1	0	0	0	0	0	410	0	0	133	0	0	4	571
10	37	28 Aug.	25 Sep.	0	25	0	0	0	0	0	0	0	0	0	0	0	254	0	0	0	160	0	0	2	441
	38	" "	" "	0	22	2	0	0	2	0	0	18	0	0	94	0	0	129	0	0	71	0	0	7	345
	39	" "	" "	0	16	0	0	0	0	0	0	0	0	0	1	0	0	253	0	0	4	0	0	1	275
	40	" "	" "	0	8	8	0	0	87	34	0	3	0	0	102	401	0	0	0	0	0	0	0	0	643
11	41	25 Sep.	23 Oct.	0	10	0	50	0	0	0	0	43	0	0	1 207	0	0	603	0	32	1 461	0	551	0	3 957
	42	" "	" "	0	30	0	2	0	0	0	0	33	0	0	106	408	0	0	0	0	325	257	1 936	18	3 115
	43	" "	" "	0	87	0	0	0	0	0	0	24	12	0	1 768	318	0	0	0	0	30	0	1 244	10	3 493
	44	" "	" "	0	134	0	0	0	90	438	0	23	0	0	230	0	0	60	0	0	30	0	0	30	1 035
12	45	23 Oct.	20 Nov.	0	62	217	24	0	0	0	0	60	0	0	270	0	0	0	0	0	0	0	0	0	633
	46	" "	" "	0	6	0	0	0	0	0	0	1	4	2	102	110	31	0	0	3	0	1	0	1	261
	47	" "	" "	0	0	456	270	20	0	0	0	0	0	0	3	20	0	0	0	0	0	0	0	1	770
	48	" "	" "	0	5	0	0	0	0	0	0	0	0	0	0	12	0	0	0	20	36	63	454	33	623
13	49	20 Nov.	18 Dec.	0	11	0	0	0	0	0	0	0	0	0	69	20	10	0	0	0	9	0	0	5	124
	50	" "	" "	0	7	4	0	10	0	0	0	11	0	0	55	69	0	0	0	0	0	0	0	0	156
	51	" "	" "	0	5	0	30	0	0	0	0	40	0	0	100	20	0	0	0	0	0	67	0	5	267
	52	" "	" "	0	13	19	0	22	0	38	0	11	0	0	89	0	22	0	0	0	75	0	0	7	266

* L_3 = 3rd stage larva
** 5 = 5th stage
*** L_4 = 4th stage larva
**** A = Adult

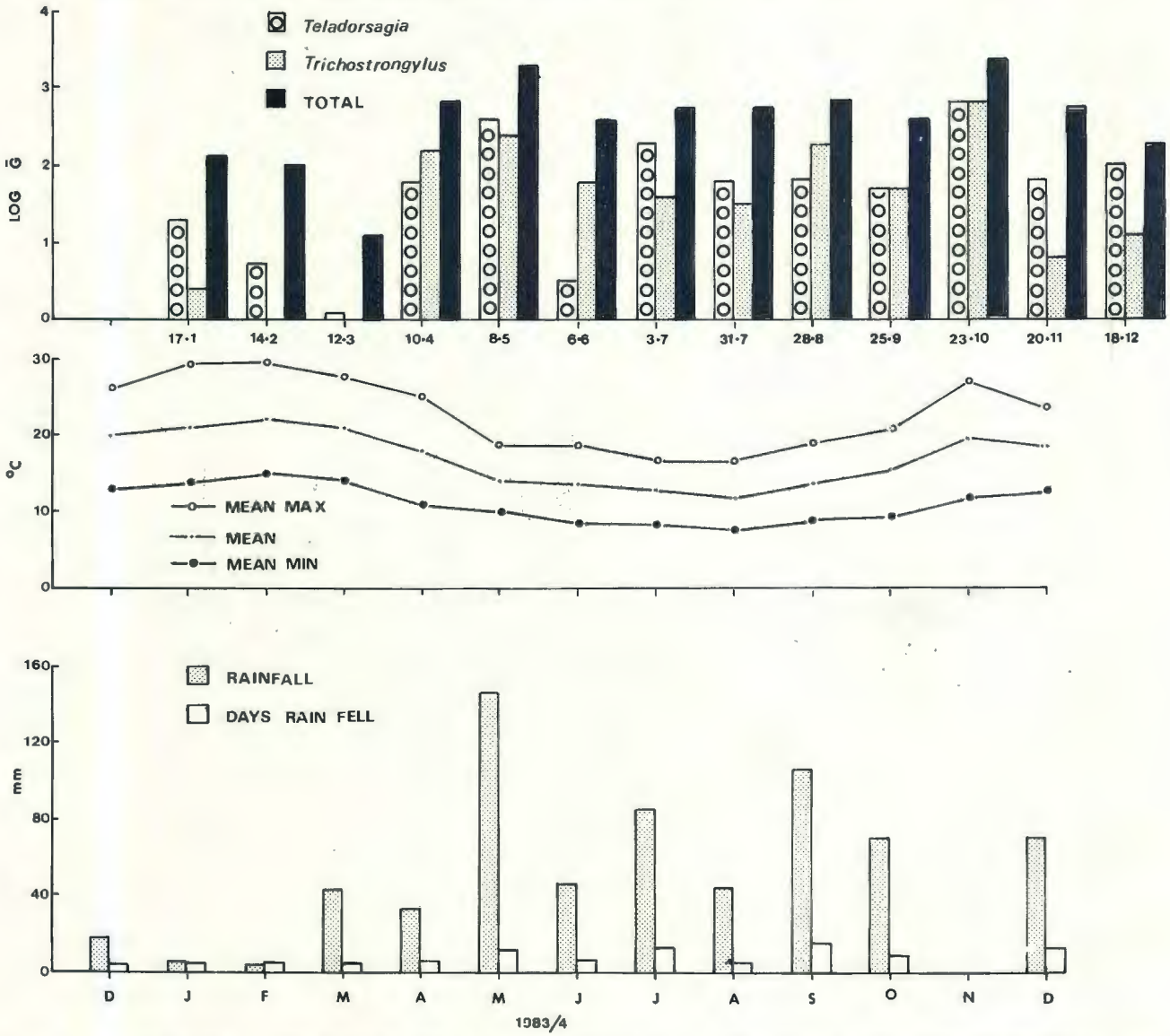

FIG. 1 Variations in the log of the geometric mean (Log $\overline{G}$) of *Teladorsagia, Trichostrongylus* and total worm burdens acquired by 4 tracer sheep grazing for successive period of 4 weeks on Kikuyu pasture at Elsenburg

1985 for worm counts post mortem. The second group of 4 sheep were dosed on 18 December 1984 and killed 8 weeks later, on 12 February 1985. This process was repeated, a group of sheep being dosed with invermectin and killed 8 weeks later, overlapping the grazing period of the previous group until the final group was killed on 19 November 1985. Sheep 88, killed on 26 August 1985, was not examined for helminths at necropsy.

Other routine procedures

Supplementary feed, lick, sheep, necropsy, worm counting and identification, climatic observations, etc., were similar to those described by Reinecke *et al.*, (1987).

Graphs

Data were summarised in Tables 2–5. The log of the geometric means of the worm counts were estimated and illustrated in graphs (Fig. 1 and 2).

Statistical Analyses

Helminth worm counts of the 52 sheep in the first trial and 47 sheep in the second trials were compared by the Kruskal-Wallis test ($P<0,05$) described by Siegel (1956).

RESULTS

Climate (Fig. 1 and 2, Table 6)

Fluctuations in monthly temperatures and rainfall are illustrated in Fig. 1 and 2. In Table 6 the total rainfall, days on which rain fell and mean temperatures for the period the tracers were on pasture are summarized.

Four-week tracers (Fig. 1)

In the dry, hot summer of 1984 worm burdens fell, almost disappearing in March (1–13 worms Table 2). Rainfall increased in autumn and winter, accounting to some extent for the rise in worm counts which fell in September before reaching a peak in October. The entire flock grazed in Paddock W2 from 7 March–23 November, also contributing to the increased number of infective larvae (L_3) on the pasture, resulting in high worm burdens in October. No rain fell in November, which may have been responsible for the marked decrease of infestation.

TABLE 3 Four week tracers 1983/84. Helminths and *Oestrus ovis* occasionally recovered from tracers grazing for 4 weeks at Elsenburg after being dosed with invermectin at 0,2 mg/kg body mass

Sheep No.	*Avitellina*	*Chabertia ovina*	*Muellerius capillaris*	*Teladorsagia trifurcata*	*Strongyloides papillosis*	*Thysanezia giardi*	*Trichostrongylus falculatus*	*Trichostrongylus rugatus*	*Trichuris skrjabini*		Total	*Oestrus ovis*	
		L_4	L_1	A	A		A	A	L_4	A		L_2	L_3
2	0	0	0	0	0	0	0	0	0	0	0	0	2
3	0	0	0	10	0	0	0	0	0	0	10	0	0
4	0	0	0	52	0	0	0	0	0	0	52	2	0
5	0	0	0	0	0	0	0	0	0	2	2	0	0
6	0	0	0	20	0	0	0	0	0	1	21	0	1
7	0	0	0	0	0	0	0	0	0	3	3	0	2
8	0	0	0	0	0	0	0	0	0	11	11	0	0
9	1	0	0	0	0	0	0	0	0	0	1	0	0
11	0	0	0	0	0	0	0	0	0	0	0	2	0
13	0	0	0	0	0	0	0	0	0	18*	18	0	0
14	1	0	0	0	0	0	0	0	3	11	15	0	0
15	3	0	0	0	0	0	0	0	4	87	94	0	0
16	1	0	0	0	0	0	0	0	0	0	1	0	0
17	1	0	0	59	0	0	0	0	0	26	86	0	2
18	1	0	0	0	0	0	0	0	0	1	2	0	0
19	1	0	2	0	0	0	0	0	0	1	4	0	0
20	1	0	0	0	140	0	0	0	0	0	141	0	0
21	1	0	0	0	0	0	0	0	0	0	1	0	1
22	0	0	0	0	342	0	0	0	0	0	342	0	0
23	1	1	0	0	2	0	0	0	0	0	4	0	0
24	1	0	0	0	0	0	20	0	0	0	21	0	0
25	1	0	0	0	0	0	0	0	0	0	1	0	0
26	1	0	0	0	0	0	0	0	0	0	1	0	2
27	1	0	0	0	0	0	0	0	0	0	1	0	0
28	1	0	0	0	0	0	0	0	0	2	3	0	0
30	1	0	0	0	0	0	0	0	0	0	1	0	1
31	1	0	0	0	0	0	0	0	0	0	1	0	0
33	1	0	0	0	0	0	0	0	0	0	1	0	1
34	1	0	19	0	0	0	0	0	0	0	20	0	1
35	1	0	0	0	0	0	0	0	0	0	1	0	1
36	0	0	4	0	0	0	0	0	0	0	4	0	0
37	1	0	0	0	0	0	0	0	0	1	2	0	1
38	0	3	4	0	0	0	0	0	0	0	7	0	0
39	1	0	0	0	0	0	0	0	0	0	1	0	1
41	0	0	0	0	0	0	0	0	0	0	0	0	2
42	0	0	0	0	0	0	0	0	0	18	18	0	1
43	0	0	0	0	0	1	0	0	3	6	10	0	1
44	0	0	0	0	0	0	0	0	0	30	30	0	1
46	0	0	0	0	0	0	0	0	1	0	1	0	1
47	1	0	0	0	0	0	0	0	0	0	1	0	1
48	0	0	0	10	0	0	0	10	0	13	33	0	1
49	0	0	5	0	0	0	0	0	0	0	5	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0	1
51	0	0	0	0	0	0	0	0	5	0	5	0	1
52	0	0	0	0	0	0	0	0	0	7	7	0	9

* Including 2 Adult *Trichuris ovis*

Major genera (Fig. 1 and 2, Tables 2 and 3)

Teladorsagia *spp.*

This genus accounted for most of the worms present, *Teladorsagia circumcincta* being dominant and *Teladorsagia trifurcata* only occurring in 5 sheep, in numbers ranging from 10–52.

Trichostrongylus *spp. (Fig. 2)*

Initially this genus was present in small numbers until October when 2 out of the 4 sheep killed had more *Trichostrongylus* than *Teladorsagia. Trichostrongylus colubriformis* was dominant with *T. axei* only present in 23 sheep, mainly as 3rd stage larvae (L_3). *Trichostrongylus falculatus* (20 adults) and *Trichostrongylus rugatus* (10 adults) were only present in 2 sheep (Table 3).

Dictyocaulus filaria

Although present in 37 of 52 sheep slaughtered, very few worms were recovered, ranging from 1–137, either as L_3 in the wall of the ileum or caecum or as fifth stages in the lungs. In summer only 5 out of 12 sheep were positive, but from April–December, 32 out of 40 sheep killed were infested.

Haemonchus contortus *(Table 2)*

In summer 7 out of 12 and in autumn 6 out of 12 sheep killed were positive, reaching a peak in April. Sixteen tracers were negative in winter and 7 out of 12 sheep were positive in spring, burdens ranging from 2–746 worms.

Nematodirus spathiger *(Table 2)*

In summer 10 out of 12, in autumn 4 out of 12, in

TABLE 4 Eight week tracers. Nematodes consistently present and total helminth worm burdens of tracer sheep grazing at Elsenburg Experimental Station 8 weeks after being treated with ivermectin at 0,2 mg/kg

Group	Sheep No.	Date dosed	Date killed	*Dictyocaulus filaria*		*Haemonchus contortus*			*Nematodirus spathiger*			*Oesophagostomum venulosum*			*Teladorsagia circumcincta*			*Trichostrongylus axei*			*Trichostrongylus colubriformis*			Other helminths listed in Table 4	Total
				L_3	5	L_3	L_4	A	L_3	L_4	A	L_3	L_4	A	L_3	L_4	A	L_3	L_4	A	L_3	L_4	A		
		1984	1985																						
14	53	20 Nov.	15 Jan.	0	5	1 444	12	0	0	80	0	12	0	3	233	0	0	0	0	0	4	0	80	2	1 875
	54	" "	" "	0	3	20	0	269	22	24	0	4	3	0	259	169	185	80	0	34	0	0	0	34	1 106
	55	" "	" "	0	0	0	0	0	0	0	0	0	9	3	350	143	0	0	0	0	40	0	0	0	545
	56	" "	" "	0	8	0	0	0	4	0	2	5	0	3	325	162	80	0	0	0	40	80	240	0	949
15	57	18 Dec.	12 Feb.	0	6	127	0	2 364	0	7	0	0	0	3	190	52	310	127	6	441	0	0	1 895	1 630	7 158
	58	" "	" "	81	0	200	0	1 501	0	4	0	0	0	(1)7	999	160	1 199	532	222	1 207	36	286	214	143	6 791
	59	" "	" "	0	48	947	0	5 524	0	24	49	0	0	9	1 518	2 093	1 723	4	1	3	76	98	1	765	12 883
	60	" "	" "	0	135	0	0	1 489	0	0	0	11	0	3	193	385	87	193	0	159	5	0	780	28	3 468
		1985																							
16	61	15 Jan.	12 Mar.	0	2	64	0	744	0	164	49	0	0	3	8	22	1	137	0	31	0	0	17	31	1 277
	62	" "	" "	0	3	2	99	0	0	58	0	38	0	0	98	221	49	8	0	247	31	12	134	3	1 003
	63	" "	" "	0	3	0	50	177	0	96	24	0	21	1	7	0	328	0	0	0	0	0	0	25	732
	64	" "	" "	0	2	0	0	216	0	0	0	0	7	5	24	259	863	0	0	179	0	0	474	132	2 161
17	65	12 Feb.	19 Apr.	11	16	0	0	2 603	40	0	0	0	88	17	1 851	24	2 169	2 085	0	2 778	527	316	4 764	116	17 405
	66	" "	" "	4	0	375	747	5 217	0	0	0	18	0	2	1 192	0	0	0	0	0	31	62	31	3	7 682
	67	" "	" "	0	7	0	770	3 746	0	118	0	1	0	18	391	231	309	0	0	0	0	0	48	158	5 797
	68	" "	" "	0	12	192	1 832	492	31	235	174	5	0	3	245	289	96	0	0	386	15	0	0	6	4 013
18	69	12 Mar.	07 May	0	1	0	0	0	0	14	0	4	0	1	544	869	0	14	0	14	0	0	0	2	1 463
	70	" "	" "	0	14	163	870	4 591	80	749	0	20	0	2	33	0	0	0	0	0	23	3	5	1	6 554
	71	" "	" "	0	2	102	285	102	13	91	0	2	0	0	135	288	0	0	0	0	0	0	0	2	1·022
	72	" "	" "	0	3	162	918	0	0	0	0	1	1	1	25	35	0	0	0	0	0	0	0	0	1 146
19	73	19 Apr.	04 Jun.	0	0	11	73	486	96	225	354	0	0	3	57	0	5	15	0	0	32	0	483	0	1 840
	74	" "	" "	0	1	492	375	74	69	519	0	80	0	6	208	22	150	0	0	0	0	0	35	7	2 038
	75	" "	" "	0	4	12	500	2 618	0	197	0	0	0	1	393	142	700	0	0	0	0	7	0	62	4 636
	76	" "	" "	0	14	103	362	0	0	0	0	0	2	2	103	249	103	0	0	0	5	0	138	157	1 238
20	77	07 May	02 Jul.	0	0	42	127	0	0	0	0	2	0	0	0	9	0	84	254	1 408	2	443	623	634	3 628
	78	" "	" "	0	0	0	0	0	0	0	0	6	0	1	0	0	0	343	433	2 088	3	0	1	27	2 902
	79	" "	" "	0	2	0	0	0	0	0	0	2	0	1	10	286	0	0	67	468	0	0	0	0	836
	80	" "	" "	0	42	0	0	0	0	556	0	0	17	10	344	4 226	1 344	258	2 426	16 602	0	0	0	18	25 843

TABLE 4 Eight week tracers. Nematodes consistently present and total helminth worm burdens of tracer sheep grazing at Elsenburg Experimental Station 8 weeks after being treated with ivermectin at 0,2 mg/kg (*continued*)

Group	Sheep No.	Date dosed	Date killed	*Dictyocaulus filaria*		*Haemonchus contortus*			*Nematodirus spathiger*			*Oesophagostomum venulosum*			*Teladorsagia circumcincta*			*Trichostrongylus axei*			*Trichostrongylus colubriformis*			Other helminths listed in Table 4	Total
				L_3	5	L_3	L_4	A	L_3	L_4	A	L_3	L_4	A	L_3	L_4	A	L_3	L_4	A	L_3	L_4	A		
21	81	04 Jun.	30 Jul.	0	24	0	287	0	0	0	0	0	14	15	1 013	1 766	317	646	12	1 372	0	0	110	22	5 598
	82	" "	" "	0	4	0	693	0	0	0	0	0	12	1	0	1 387	1 141	7	2 505	7 713	0	0	2	42	13 507
	83	" "	" "	0	0	0	0	0	0	0	0	0	7	51	0	5 601	944	0	2 814	37 588	0	664	6 063	2 541	57 273
	84	" "	" "	0	1	0	0	0	20	20	0	0	0	0	0	0	0	274	1 368	1 778	0	3	0	0	3 464
22	85	02 Jul.	26 Aug.	0	3	0	0	1 038	0	0	127	0	1	17	10	689	1 630	148	74	360	1	0	602	490	5 190
	86	" "	" "	0	3	18	35	474	0	280	0	0	3	13	18	35	65	0	0	0	1	0	0	11	956
	87	" "	" "	0	1	0	10	207	0	67	67	0	4	99	39	21	36	37	4	53	0	0	0	28	673
	88	" "	" "	—	Not examined		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
23	89	30 Jul.	24 Sep.	0	5	0	103	227	0	80	20	2	0	4	0	37	822	0	0	79	1	0	3	90	1 473
	90	" "	" "	0	2	349	276	214	0	43	0	0	0	91	71	103	568	0	0	0	12	7	5	172	1 913
	91	" "	" "	0	0	0	12	273	0	130	0	0	0	8	3	0	34	0	0	0	0	0	0	12	472
	92	" "	" "	0	0	0	0	219	0	40	0	3	5	6	7	23	46	2	0	1	2	0	0	12	366
24	93	26 Aug.	22 Oct.	0	9	0	10	40	0	0	0	0	1	4	5	0	0	22	40	100	0	0	7 281	370	7 882
	94	" "	" "	0	0	120	0	7	0	31	0	0	5	4	0	200	32	0	80	64	0	0	170	1 900	2 613
	95	" "	" "	33	3	0	43	3 792	0	0	0	0	16	16	0	85	1 896	0	342	455	209	0	0	226	7 116
	96	" "	" "	0	0	2	20	19	0	0	0	0	0	0	214	23	0	0	0	99	0	0	93	0	470
25	97	24 Sep.	19 Nov.	0	0	0	0	303	0	0	836	0	0	6	0	0	107	0	0	0	0	0	513	96	1 861
	98	" "	" "	0	0	0	0	28	0	0	0	0	0	1	0	0	55	0	0	27	0	0	0	93	204
	99	" "	" "	0	0	0	0	377	0	116	0	0	0	7	482	0	203	0	193	0	0	29	14	26	1 447
	100	" "	" "	0	0	0	0	137	0	10	0	0	0	0	0	0	1 823	0	0	0	0	0	130	36	2 136

(1) 1 *O. venulosum* plus 6 *Oesophagostomum columbianum*

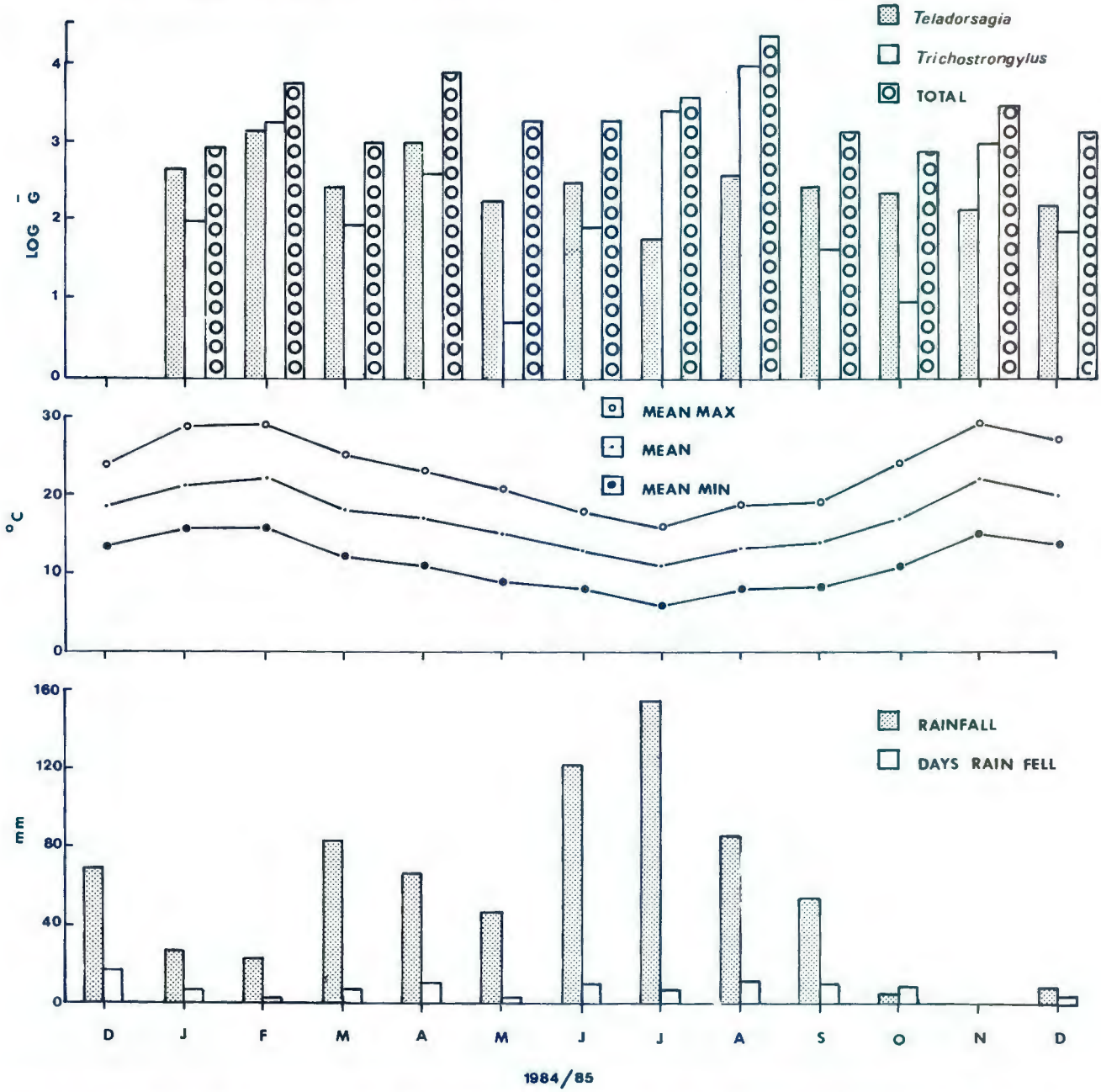

FIG. 2 Eight-week tracers. Variations in the log of the geometric mean (Log $\bar{G}$) of *Teladorsagia, Trichostrongylus* and total worm burdens acquired by 4 tracer sheep grazing for successive periods of 8 weeks on Kikuyu pastures at Elsenburg

winter 6 out of 16 and in spring 2 out of 12 tracers, were infested with 2–160 worms only.

Oesophagostomum venulosum *(Table 2)*

This species was absent in summer, present in 4, 13 and 9 tracers in autumn, winter and spring respectively, only 2–33 worms being present.

Species occasionally recovered (Table 3)

The following were recovered in the numbers of animals shown:

Avitellina	22
Chavertia ovina L_4	2
Muellerius capilaris L_1	4
Strongyloides papillosus	2
Trichuris skrjabini	16
Trichuris ovis	2

Oestrus ovis *(Table 3)*

Second instar were present in 2 and third instar in 22 sheep respectively. In summer 5, in autumn 2, winter 7 and spring 10 sheep respectively were infested.

Eight-week tracers (Table 4 and 5, Fig. 2 and 3)

Climate (Table 6)

The rainfall in the summer of 1985 was 141,2 mm and remained at a high level throughout autumn and winter but the spring was drier than that of the previous year. Moreover, in 1985 the flock was moved more frequently between W1 and W2 (Table 1), one of the reasons being that the sheep formed paths in the water-logged paddock and only by moving them could this be prevented.

Total worm burdens (Table 4, Fig. 2)

Sheep killed on 30 July 1985 (Group 21) had a

TABLE 5 Eight week tracers 1984/85. Helminths and *Oestrus ovis* occasionally recovered from tracers grazing for 8 weeks at Elsenburg after being dosed with ivermectin at 0,2 mg/kg

Sheep No.	*Avitellina*	*Chabertia ovina*		*Moniezia expansa*	*Muellerius capillaris*	*Nematodirus filicollis*	*Teladorsagia trifurcata*	*Paramphistomum*	*Strongyloides papillosus*	*Thysanezia giardi*	*Trichostrongylus rugatus*	*Trichuris skrjabini*		Unidentified nematodes	Total	*Oestrus ovis*
		L_4	A		L_1	A	A	A	A		A	L_4	A	A		L_3
53	1	0	0	0	1	0	0	0	0	0	0	0	0	0	2	1
54	0	0	0	0	0	0	34	0	0	0	0	0	0	0	34	1
56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
57	0	0	0	0	1 418	0	112	0	0	0	90	8	2	0	1 630	0
58	0	2	0	0	0	0	0	0	0	0	133	0	8	0	143	3
59	0	3	0	0	0	0	760	0	0	0	0	0	2	0	765	0
60	0	1	0	0	10	0	17	0	0	0	0	0	0	0	28	0
61	0	0	0	0	0	0	31	0	0	0	0	0	0	0	31	0
62	0	0	0	0	0	0	0	0	3	0	0	0	0	0	3	2
63	0	0	0	0	0	0	25	0	0	0	0	0	0	0	25	6
64	0	0	0	0	0	0	129	2	0	0	0	0	1	0	132	0
65	0	1	0	0	106	0	0	0	0	0	0	0	9	0	116	0
66	1	1	0	0	0	0	0	0	0	1	0	0	0	1	3	0
67	1	0	0	0	0	0	154	0	0	0	0	0	3	0	158	0
68	0	0	0	0	0	0	0	0	0	0	0	0	6	0	6	0
69	0	0	1	1	0	0	0	0	0	0	0	0	0	0	2	0
70	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
71	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2	0
73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
74	1	0	1	0	5	0	0	0	0	0	0	0	0	0	7	0
75	0	0	0	0	0	0	62	0	0	0	0	0	0	0	62	0
76	0	0	0	0	156	0	0	0	0	0	0	0	1	0	157	0
77	1	0	0	0	632	0	0	0	0	0	0	1	0	0	634	0
78	1	0	2	0	20	0	0	0	0	0	0	4	0	0	27	1
80	0	0	0	0	8	0	0	0	0	0	0	0	10	0	18	0
81	1	0	1	0	17	0	0	0	0	0	0	2	1	0	22	0
82	1	0	0	0	0	0	32	0	0	0	0	0	9	0	42	0
83	1	0	2	0	1 876	0	933	0	0	0	664	0	65	0	3 541	0
85	1	0	2	0	0	0	486	0	0	0	0	1	0	0	490	0
86	1	0	0	0	0	0	0	0	10	0	0	0	0	0	11	0
87	0	1	5	0	0	0	0	16	0	0	0	0	6	0	28	0
89	2	1	2	0	0	0	85	0	0	0	0	0	0	0	90	0
90	0	0	0	0	0	0	172	0	0	0	0	0	0	0	172	0
91	1	0	0	0	0	0	11	0	0	0	0	0	0	0	12	0
92	0	0	0	0	0	0	12	0	0	0	0	0	0	0	12	0
93	0	4	5	0	276	74	0	0	0	0	6	0	*5	0	370	0
94	0	0	0	0	0	0	0	0	0	0	0	0	0	1 900	1 900	0
95	0	0	0	0	0	0	211	0	0	0	0	0	0	15	226	0
97	0	0	0	0	24	51	21	0	0	0	0	0	0	0	96	0
98	0	0	0	0	27	0	0	66	0	0	0	0	0	0	93	0
99	0	0	0	0	16	0	0	0	0	0	0	0	0	10	26	0
100	0	0	0	0	25	0	0	0	0	0	0	0	0	11	36	0

* Including 1 *Trichuris ovis*

geometric mean (G) of 11 072, with minor peaks when the G mean was > 1 000 worms in February, April and October.

Major genera (Tables 4 and 5, Fig. 2)

Teladorsagia

All 47 tracers were infested and this genus was the major contributor to the peak in February, second only to *Trichostrongylus axei* in October.

Trichostrongylus *(Tables 4 and 5, Fig. 2)*

Trichostrongylus axei

This species was dominant in July.

Trichostrongylus colubriformis

In October this species reached its peak.

Nematodirus spathiger *(Table 4)*

From January–June 18 out of 24 tracers were infested, reaching a peak in April.

Oesophagostomum venulosum *(Table 4)*

Forty-four out of 47 animals had 1–115 worms. All sheep were infested in summer and 11 out of 12 animals in autumn, compared with the 4-week tracers killed in the previous year, when there were none in summer and only 4 out of 12 sheep were infested in autumn.

Dictyocaulus filaria *(Table 4)*

Thirty-four tracers had from 1–135 worms.

Helminths occasionally recovered (Table 5)

Avitellina

Fourteen animals were infested, only 1 with 2 worms and the others with a single parasite, most of them occurring the autumn or winter.

Chabertia ovina

Fourteen animals either had adult worms or L_4 or both, in numbers ranging from 1–5.

Moniezia expansa

A single animal had a single parasite in May.

TABLE 6 Four and 8 week tracers. The period each group spent on pastures, the total rainfall, days on which rain fell and mean temperatures recorded during the respective periods each group of tracer sheep grazed at Elsenburg

Group	Period on pastures	Total rainfall mm	Days on which rain fell	Mean temperatures °C
	4-week tracers			
01	20 Dec. '83–17 Jan. '84	6,6	Dec. 24; Jan. 11;	21,9
02	17 Jan. –14 Feb.	5,3	Jan. 30; Feb. 6, 7;	21,8
03	14 Feb. –12 Mar.	29,0	Mar. 1, 10, 11;	22,1
04	12 Mar. –10 Apr.	14,9	Mar. 19, 25;	20,0
05	10 Apr. –08 May	65,3	Apr. 12, 14, 17, 25, 26, 30; May 5, 6, 8;	15,4
06	08 May –06 Jun.	126,2	May 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 20; June 3, 4;	14,5
07	06 Jun. –03 Jul.	44,7	Jun. 10, 18, 19, 28, 29, 30; Jul. 1, 2, 3;	12,6
08	03 Jul. –31 Jul.	79,9	Jul. 3, 4, 5, 11, 12, 13, 17, 18, 19, 26, 31;	12,3
09	31 Jul. –28 Aug.	44,4	Jul. 31; Aug. 2, 3, 4, 5, 12, 13, 24;	12,8
10	28 Aug. –25 Sep.	103,6	Sep. 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 16, 18, 24, 25;	13,5
11	25 Sep. –23 Oct.	70,9	Sep. 25, 30; Oct. 5, 6, 8, 18;	16,2
12	23 Oct. –20 Nov.	3,2	Oct. 28, 31;	19,4
13	20 Nov. –18 Dec.	54,4	Dec. 1, 2, 3, 4, 5, 17, 18;	17,6
	8-week tracers			
14	20 Nov. '84–15 Jan. '84	89,2	Dec. 1, 2, 3, 4, 5, 17, 18, 19, 20, 23, 24, 27; Jan. 3, 6, 7, 13, 14;	19,5
15	18 Dec. '84–12 Feb. '85	57,5	Jan. 7, 13, 14, 16; Feb. 6, 7;	21,4
16	15 Jan. –12 Mar.	62,1	Jan. 16, 17; Feb. 6, 7, 28; Mar. 1, 2, 3;	21,7
17	12 Feb. –19 Apr.	119,9	Feb. 28; Mar. 1, 2, 3, 14, 15, 18, 22; Apr. 2, 5, 6, 8, 17;	19,7
18	12 Mar. –07 May	120,9	Mar. 14, 15, 18, 22; Apr. 2, 5, 6, 8, 17, 21, 22, 23, 27, 30;	17,9
19	19 Apr. –04 Jun.	88,3	Apr. 21, 22, 23, 27, 30; May 20, 21, 22, 27;	15,4
20	07 May –02 Jul.	171,5	May 20, 21, 22, 27; Jun. 10, 11, 12, 13, 15, 18, 21, 22, 24, 27;	14,3
21	04 Jun. –30 Jul.	279,6	Jun. 10, 11, 12, 13, 15, 18, 21, 22, 24, 27; Jul, 4, 5, 7, 8, 10, 11, 25;	12,4
22	02 Jul. –20 Aug.	225,0	Jul. 4, 5, 7, 8, 10, 11, 25, 31; Aug. 1, 2, 3, 5, 6, 8, 9, 10, 11, 18;	11,7
23	30 Jul. –24 Sep.	152,0	Jul. 31; Aug. 1, 2, 3, 5, 6, 8, 9, 10, 11, 18, 21, 22, 23; Sep. 5, 9, 10, 11, 12, 18, 23, 24;	13,8
24	26 Aug. –22 Oct.	60,0	Sep. 5, 9, 10, 11, 12, 18, 23, 24, 29; Oct. 3, 4, 11, 12, 14, 22;	16,6
25	24 Sep. –19 Nov.	13,8	Sep. 24, 29; Oct. 2, 3, 4, 11, 12, 14, 22, 27;	18,3

TABLE 7 A statistical comparison of the total worm counts in 2 groups of 4-week tracers in 1983/84 with a single group of 8-week tracers in 1984/85 using the Kruskal-Wallis test (P<0,05)

4-week tracers			8-week tracers	
Period on pastures	Group		Group	Period on pastures
20 Dec. 1983–14 Feb. 1984	01 & 02	<	15	18 Dec. 1984–12 Feb. 1985
1984				1985
17 Jan.–12 Mar.	02 & 03	<	16	15 Jan.–12 Mar.
14 Feb.–10 Apr.	03 & 04	<	17	12 Feb.–19 Apr.
12 Mar.–08 May	04 & 05	NS*	18	12 Mar.–07 May
10 Apr.–06 Jun.	05 & 06	<	19	19 Apr.–04 Jun.
08 May –03 Jul.	06 & 07	<	20	07 May –02 Jul.
06 Jun.–31 Jul.	07 & 08	NS	21	04 Jun.–30 Jul.
03 Jul.–28 Aug.	08 & 09	NS	22	02 Jul.–26 Aug.
31 Jul.–25 Sep.	09 & 10	NS	23	30 Jul.–24 Sep.
28 Aug.–23 Oct.	10 & 11	NS	24	26 Aug.–22 Oct.
25 Sep.–20 Nov.	11 & 12	NS	25	24 Sep.–19 Nov.

*NS = not significant

Muellerius capillaris

Only L_1 were recovered from 15 sheep, ranging from 1–1 876.

Nematodirus filicollis

Only 2 sheep were infested with 74 and 51 worms in the spring.

Teladorsagia trifurcata

Eighteen sheep were infested, numbers ranging from 11–933 adults.

Paramphistomum

Two sheep had 16 and 66 parasites respectively.

Strongyloides papillosus

Only 2 sheep were infested with 3 and 10 worms respectively.

Thysaniezia giardi

A single sheep had a single parasite.

Trichostrongylus rugatus

Four sheep were infested, adult worms ranging from 6–664.

Trichuris *spp.*

Only 18 sheep had *Trichuris skrjabini,* numbers ranging from 1–65 worms and 1 sheep had a single *Trichuris ovis.*

Unidentified nematodes

Unfortunately some specimens were counted but not identified and are included under this heading. Four sheep had 1–15 nematodes and in one other there were 1 900 parasites.

O. ovis

Third stage instar were present in 9 sheep, ranging from 1–6, which were erratically recovered from January–July and then disappeared.

TABLE 8 The G mean worm burdens of 2 groups (Group 03 and 04) of 4-week tracers and 2 groups (Group 16 and 17) of 8-week tracers grazing on Kikuyu pasture at Elsenburg in summer

Group	Period on pasture	*Haem-onchus*	*Nemat-odirus*	*Telador-sagia*	*Tricho-strongylus*	Total
	4-week tracers	1984				
03	14/02–12/03	0*	4	0*	0*	7*
04	12/03–10/04	8*	20	45*	178*	668*
	8-week tracers	1985				
16	15/01–12/03	129*	49	339*	100	1 023*
17	12/02–19/04	3 548*	46	1 259*	398*	7 079*

* Significant difference between groups $P<0,05$

Comparison of 4-week with 8-week tracers (Table 7)

Worm data of 2 successive groups of 4-week tracers (Groups 01 and 02) acquired infestation from 20 December 1983–14 February 1984. In the following year 1 group of 8-week tracers (Group 15) grazed from 18 December 1984–12 February 1985. We compared total worm counts of Groups 01 and 02 (4-week tracers) with those of Group 15 (8-week tracers) grazing these pastures for the same period the following year, using the Kruskal-Wallis test ($P<0,05$). Other groups of 4- and 8-week tracers were compared and the statistical differences are summarized in Table 7. Infective larvae were significantly less throughout the summer of 1983/84, most of autumn and early winter of 1984, when compared with the following summer (1984/85) and autumn (1985). From June–November there was no significant difference between 4- and 8-week tracers in successive years.

DISCUSSION

Temperature (Table 6)

Once the mean temperature exceeded 20 °C there were very few available infective larvae on the herbage. While Group 03 grazed the mean temperature was 22,1 falling to 20 °C when Group 04 was on pastures (Table 6). Similarly, in the following year the mean temperatures were 21,7 and 19,7 °C (Groups 16 and 17, 8-week tracers 1985, Table 6). The G mean worm burdens of *Haemonchus, Nematodirus, Teladorsagia, Trichostrongylus* and the total worm burdens of these respective groups of tracers are compared in Table 8. Pastures were safe if the temperature exceeded 21 °C and even 8 weeks' exposure only resulted in grazing animals acquiring a G mean of 1 203 worms (Group 16, Table 8).

Reinecke *et al.* 1987 slaughtered 10 flock sheep grazing with the tracers in the present experiments on the same pastures at Elsenburg. These animals also had low burdens and we erroneously concluded that it was the drought and not the high temperatures that killed infective larvae on the pasture. Muller (1968) working at Outeniqua (George) in the southern Cape, concluded that mean monthly mean temperatures exceeding 20 °C in December and January were responsible for the lowest worm burdens of any tracers killed in his experiments, which is confirmed in the present trials. Anderson (1972) stated that larvae disappeared from pasture when mean temperatures exceeded 15,5 °C. The present trials do not confirm this lower temperature as the threshhold for larval survival.

Rainfall (Table 6, Fig. 1 and 2)

During the summer and in November 1984 only 3,2–29,0 mm rain fell on either 2 or 3 days during the 4 week period tracers grazed. This possibly accounted not only for the low worm burdens but also for the absence of more than one genus in 2, 3 or even all 4 tracers killed (Groups 01–03 and 12, Table 2). In spring the following year the last group of 8-week tracers were on pasture, when rain of 13,8 mm was recorded, distributed over 10 days (Table 6), which may have been responsible for the absence of *D. filaria* and low worm burdens of *Trichostrongylus* in Group 15 (Table 4).

Rainfall from June–November of 10 mm, falling on 2 or more days per week, was optimal for *Teladorsagia, Trichostrongylus, Oesophagostomum* and *Dictyocaulus* but did not apply to *Haemonchus, Nematodirus* nor *Trichuris*. The latter 3 were only present in less than half the 4-week tracers and during the rainy season, either disappeared in autumn and winter, or were recovered erratically in small numbers (Table 2 and 3).

In the 8-week tracers the percentage of sheep infested with the different genera, in decending order, varied as follows:

Teladorsagia	95,7 %
Oesophagostomum	93,6 %
Trichostrongylus	85,0 %
Haemonchus	74,5 %
Dictyocaulus	72,0 %
Nematodirus	66,0 %
Trichuris	36,2 %

Levine (1968) has reviewed the bionomics of the free-living stages of the common nematode parasites of ruminants. Soulsby (1982) states that *Haemonchus contortus* and *Oesophagostomum columbianum* are hot climate parasites, while *Trichostrongylus, Teladorsagia* and *Oesophagostomum venulosum* predominate in warm climates. It is generally accepted that *Trichostrongylus, Teladorsagia* and *Oesophagostomum venulosum* are winter rainfall parasites but observations on *Dictyocaulus filaria* consistently present in 8-week tracers in the present trial, is probably a new finding. We feel it might be confined to Kikuyu pastures at Elsenburg because we have not encountered it on spray-irrigated grass/legume pastures (Reinecke, unpublished observations), nor on dry-land lucerne alternating with wheat stubble in the winter rainfall area (Louw, 1989; Reinecke, 1989; Reinecke & Louw, 1989 a, b,).

Haemonchus is common on spray-irrigated grass/legume pastures in the winter rainfall areas and Muller (1968) found it at Outeniqua. It is entirely absent on dry-land lucerne or wheat stubble (Louw, 1989; Reinecke, 1989; Reinecke & Louw, 1989 a, b). Although *Haemonchus* was fairly common on Kikuyu pastures (Reinecke *et al.*, 1987) and in the

present trails it tended to be more common in summer, there was no seasonal incidence. *Nematodirus* and *Trichuris* were of minor importance in these trials. If *Haemonchus, Nematodirus* and *Trichuris* are excluded, the following postulate is proposed to define the optimal climatic conditions on Kikuyu pastures in the winter rainfall area, for available infective larvae of:

(1) *Teladorsagia (T. circumcincta, T. trifurcata)*
(2) *Trichostrongylus (T. axei, T. colubriformis)*
(3) *Oesophagostomum venulosum* and
(4) *Dictyocaulus filaria*

From May or June–October, i.e. late autumn—spring, mean temperatures ranging from 11–19 °C and well distributed rain on 8 or more days, exceeding 40 mm per month, is optimal for the 4 genera. Mean temperatures exceeding 20 °C are fatal and even flood irrigation of Kikuyu is unable to counteract the desiccation of the free-living states of these parasites.

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