Onderstepoort J. vet Res., 51, 33–39 (1984)

STUDIES ON *HAEMONCHUS CONTORTUS*. X. THE EFFECT OF *TRICHOSTRONGYLUS AXEI* IN MERINOS ON ARTIFICIAL PASTURES

R. K. REINECKE[1], I. L. DE VILLIERS[1] and GERDA JOUBERT[2]

ABSTRACT

REINECKE, R. K., DE VILLIERS, I. L & JOUBERT, GERDA, 1984. Studies on *Haemonchus contortus*. X. The effect of *Trichostrongylus axei* in Merinos on artificial pasture. *Onderstepoort Journal of Veterinary Research*, 51, 33–39 (1984).

A recently established *Eragrostis curvula* pasture 1,1 ha in size at Hennops River in the Transvaal Highveld was contaminated from 6 October 1976 until 20 May 1977 by 30 weaned Merinos, each infested with 7 000 infective larvae of *H. contortus*. On 2 November 1976 3 groups of weaned Merinos and again on 10 January 1977 a further group of Merinos were infested with 40 000 infective larvae of *Trichostrongylus axei*. From 19 November a single group of sheep, predosed with *T. axei*, and a control group grazed with the seeders for 8 weeks. After 6 weeks another group of sheep dosed with *T. axei* grazed with them, thus ensuring a 2-week overlap. This continued until autumn, when the last groups were removed. Efficacy against challenge reached Class C (>50 % effective against total worm burdens of *H. contortus* in >50 % of sheep) in early summer and autumn, but only reached significant levels of either P<0,01 or P<0,05 in summer. Peak worm burdens in controls were recorded in early autumn.

INTRODUCTION

Horak (1980) and Horak & Louw (1977) carried out extensive trials on irrigated pastures on an experimental farm at Hennops River in the Transvaal Highveld. Tracers, placed on these pastures at regular intervals from October 1968 to May 1973, acquired worm burdens of *Haemonchus contortus* considerably in excess of those reported on natural pastures at Tonteldoos in the eastern Highveld (Horak, 1978).

The present trial was an attempt to protect Merinos against challenge with *H. contortus* acquired naturally on artificial pastures on the same farm by predosing them with *Trichostrongylus axei*.

MATERIALS AND METHODS

Sheep

A flock of 251 5-month-old weaned Merino wethers was purchased, transferred to the University of Pretoria's (UP) Experimental Farm, treated with anthelmintics, ear-tagged and vaccinated with bluetongue, quarter evil and enterotoxaemia vaccines on Day −58. One hundred and three sheep were set aside for the trial at Hennops River and the balance were used in another trial on the UP Experimental Farm.

The experimental design is summarized in Table 1.

Seeders

Each of 10 sheep was given 7 000 infective larvae of *H. contortus* on Day −51, another 10 sheep were similarly dosed on Day −44 and a further 10 on Day −37 respectively.

Controls and groups dosed with T. axei

Groups HI and HII consisted of 12 sheep each, and HIII of 13 sheep. On day −44 each sheep was dosed with 40 000 infective larvae of *T. axei*. The 36 undosed controls were divided into 3 equal groups, Groups H1, H2 and H3.

On day +47 a further 25 Merinos of the same age arrived at the UP Experimental Farm, were ear-tagged, treated with mebendazole and vaccinated with bluetongue and enterotoxaemia vaccine. On Day +52 these were divided into 12 undosed controls (Group H4) and 13 sheep (Group HIV) were each dosed with 40 000 infective larvae of *T. axei*. Neither controls nor sheep dosed with *T. axei* grazed until the allocated periods mentioned in Table 1 but remained in concrete-floored kraals which were swept daily with brooms and cleaned with a cold water hose. All the sheep were kept in these pens from 15h00 overnight until 09h00 the following morning. Chaffed lucerne, hay and water *ad lib.* were provided in steel troughs in the pens.

Grazing

A newly established *Eragrostis curvula* paddock (1,1 ha) at Hennops River (25°50'S; 27°58'E; alt. ± 1 280 m) was used. From Day −37 (13 October 1976) the seeders were placed on the pasture and grazed there every day until Group H4 and Group HIV were removed from the pasture on Day +180 (May 20, 1977), when the seeders were returned to the UP Experimental Farm.

At first the seeders contaminated the entire pasture, but on Day 0 the camp was divided into 4 equal strips with Bonox fencing, each covering an area approximately 100 × 25m. Thereafter, all the sheep grazed in the first of the strips until the vegetation had been depleted and were then moved to an adjacent strip until the entire camp had been grazed. Thereafter they were transferred to the first strip and the process was repeated.

Irrigation

In months when less than 60 mm of rain was recorded, the pastures were spray-irrigated to provide precipitation in excess of 60 mm/month (Table 4).

The control groups (Groups H1, H2 and H3) and the *T. axei* groups (Groups HI, HII and HIII) were transferred to Hennops River on Day 0 and Groups H4, and HIV on Day +56.

Exposure to infestation and slaughter

The various groups grazed with the seeders on the pasture every day from 09h00 to 15h00 as indicated in Table 1.

Groups H4 and HIV grazed on infested pasture for 54 days. All the other groups grazed on pastures for 56 days. Grazing was arranged so that there was an overlap of 14 days between successive groups. Three to 5 days after removal from grazing half of each group was slaughtered and the balance 14 or 15 days later. Worms were recovered as described by Reinecke (1973).

Faecal worm egg counts

Faeces were collected from each "seeder" from Day −9 (10 November) every week for the duration of the experiment. Once either egg counts exceeded 30 000 epg or sheep were very anaemic, ½ of the therapeutic dose of thiabendazole or mebendazole was administered. This was necessary once only in 19 sheep and twice in 1 sheep.

[1] Faculty of Veterinary Science, University of Pretoria, P.O. Box 12580, Onderstepoort 0110

[2] 359 Cliff Avenue, Waterkloof Ridge 0181

Received 25 November 1983—Editor

TABLE 1 Hennops River (H) Experimental design showing the days on which weaned Merino sheep were divided into groups and dosed either with infective larvae of *H. contortus* (seeders) or of *T. axei* and placed on artificial pasture with worm-free controls

Day	
−60	251 Merino wethers 5 months of age arrive at the University of Pretoria's (UP) Experimental Farm on 20 September and were housed in concrete-floored pens
−58	Flock treated with mebendazole at 18 mg/kg, vaccinated against enterotoxaemia and bluetongue, ear-marked and 103 sheep selected for this trial
−51	7 000 infective larvae of *H. contortus* dosed to each of 10 sheep (seeders)
−44	7 000 infective larvae of *H. contortus* dosed to each of 10 sheep (seeders). 40 000 infective larvae of *T. axei* dosed to each of 37 sheep in Groups HI, HII and HIII
−37	7 000 infective larvae of *H. contortus* dosed to each of 10 sheep (seeders). Thirty seeders transferred to Hennops River and placed on artificial pastures from 09h00–15h00 and housed in worm-free concrete-floored kraals from 15h00 overnight until 09h00 the following day
0	19 November 1976. Each of 36 sheep in Groups HI, HII and HIII and a further 36 undosed controls: Groups H1, H2 and H3 transferred to worm-free kraals at Hennops River. Group HI (controls) and Group HII (*T. axei*) placed on artificial pastures
+42	Groups H2 (controls) and HII (*T. axei*) placed on artificial pastures
+47	25 sheep arrived from Amersfoort, treated, vaccinated against enterotoxaemia, bluetongue and ear-tagged and housed in worm-free kraals
+52	Each of 13 sheep dosed with 40 000 infective larvae of *T. axei* (Group HIV)
+56	Groups H1 (controls) and HI (*T. axei*) removed from pastures
+59	Half of Groups H1 (controls) and HI (*T. axei*) slaughtered
+73	Balance of Groups H1 (controls) and HI (*T. axei*) slaughtered
+84	Groups H3 (controls) and HIII (*T. axei*) placed on pastures
+98	Groups H2 (controls) and HII (*T. axei*) removed from pastures
+101	Half of Groups H2 (controls) and HII (*T. axei*) slaughtered
+115	Balance of Groups H2 (controls) and HII (*T. axei*) slaughtered
+126	Groups H4 (controls) and HIV (*T. axei*) placed on pasture
+140	Groups H3 (controls) and HIII (*T. axei*) removed from pasture
+143	Half of Group 3 (controls) and 7 sheep in Group III (*T. axei*) slaughtered
+157	Balance of Groups 3 (controls) and III (*T. axei*) slaughtered
+180	Groups 4 (controls) and IV (*T. axei*) removed from pastures
+185	Half of Group 4 (controls) and 7 sheep in Group IV (*T. axei*) slaughtered
+198	6 June 1977, Balance of Group 4 (controls) and IV (*T. axei*) slaughtered

Analysis of data

The square roots of the mean faecal worm egg counts and the range (i.e. the upper and lower limits) were estimated. The weekly variation is depicted graphically in Fig. 1.

Total and differential worm counts were ranked and either analysed by the non-parametric method NPM (Clark, cited by Reinecke, 1973) or by the Mann-Whitney U test (Siegel, 1956).

RESULTS

Seeders

Fluctuations in worm egg counts are illustrated in Fig. 1. The highest egg count of 74 800 eggs per gram (epg) in Sheep 169 was recorded on 25 November 1976 (Day +7). Mean egg counts fluctuated and fell gradually until mid February, then rose steadily to a minor peak in early March 1977 as a result of good rains in February (201 mm) (Table 4). Thereafter egg counts slowly fell to stabilize in April and May (Fig 1). It is clear that pastures were being continually contaminated with eggs of *H. contortus* at a high level throughout the experimental period.

Controls and groups predosed with T. axei

The number of worms recovered at necropsy are summarized in Table 2. Sheep 187 in Group H1 died on Day +20, but no worms were counted post-mortem. The mean total worm burdens of *H. contortus* and the percentage of the total worm load retarded as 4th stage larvae (L_4) for the various groups are summarized in Table 3.

Despite the high rate of contamination by the seeders (Fig. 2), initial pasture infestation was very low from November–January, but rose slowly in February to show an almost fivefold increase from February to early April (Groups H3 and HIII). It then tapered off rapidly to a low level in May.

Until the end of February, L_4 of *H. contortus* formed <10 % of the total worm burden. As the worm burdens increased in the autumn, L_4 represesented 78,6 % and 79,2 % of Group H3 and H4, and 72,0 % and 72,5 % of Group HIII and HIV respectively.

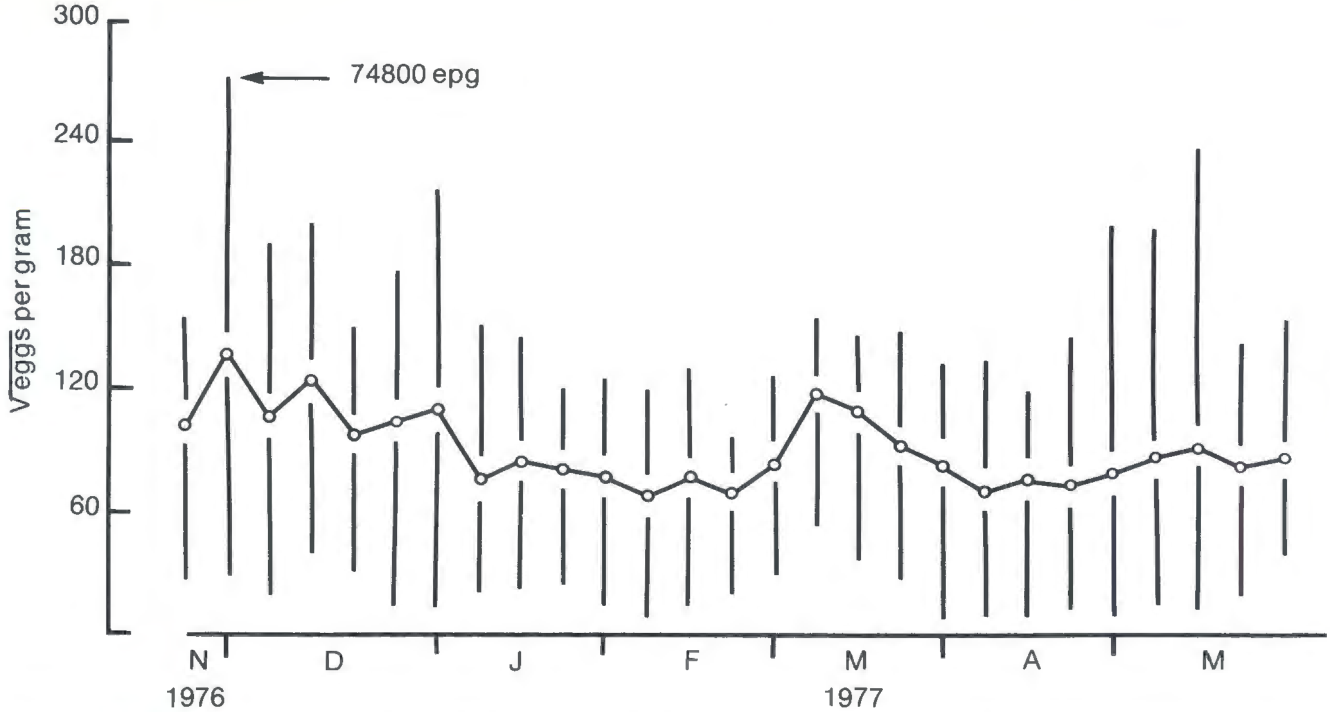

FIG. 1. Variations in the faecal worm, egg counts (epg) of the seeders. The meanj, upper and lower limit are converted to the square root of the eggs per gram

TABLE 2 Improved pastures: worms recovered at necropsy

Group H1 Controls

Sheep No.	Date slaughtered	*H. contortus* Stage of development				*T. axei* Stage of development				Total
		L_4(1)	5(2)	A(3)	Total	L_3	L_4	5	A	
11	17 Jan	1	51	324	376	0	0	0	20	20
*33	17 Jan	0	35	307	342	0	0	0	103	103
55	17 Jan	2	61	914	977	0	0	0	0	0
*79	17 Jan	0	38	234	272	0	0	0	30	30
*105	17 Jan	0	35	281	316	0	0	0	0	0
125	17 Jan	0	0	47	47	0	0	0	121	121
21	31 Jan	1	1	737	739	0	0	0	14	14
*43	31 Jan	2	30	322	354	0	0	0	4	4
71	31 Jan	0	0	523	523	0	0	0	3 840	3 840
97	31 Jan	5	30	145	180	0	0	0	13	13
113	31 Jan	0	10	150	160	0	0	0	30	30
145	31 Jan	1	33	342	376	0	0	0	35	35

5 & A Median 347 × 0,5 = 173,5   348 5 × 0,5 = 174

Group H1 40 000 L_3 of *T. axei* on Day −44

Sheep No.	Date slaughtered	*H. contortus* Stage of development				*T. axei* Stage of development				Total
		L_4(1)	5(2)	A(3)	Total	L_3	L_4	5	A	
5	17 Jan	0	20	20	40	0	10	0	11 890	11 900
*42	17 Jan	0	11	151	162	0	10	0	10 470	10 480
76	17 Jan	20	1	264	285	30	0	0	21 480	21 510
117	17 Jan	18	141	493	652	0	0	0	8 280	8 280
*161	17 Jan	0	0	162	162	0	0	0	26 585	26 585
230	17 Jan	0	20	56	76	30	0	20	9 540	9 590
*23	31 Jan	0	10	154	164	140	0	0	12 320	12 460
61	31 Jan	0	0	608	608	3	0	0	15 140	15 143
95	31 Jan	0	0	64	64	20	0	0	7 550	7 570
141	31 Jan	0	0	10	10	0	0	0	21 910	21 910
223	31 Jan	6	0	10	16	10	0	0	20 692	20 702

3/11 >173 C   3/11 >174 C

(1) Fourth stage
(2) Fifth stage
(3) Adults
* An additional 1/10 aliquot counted

TABLE 2 (contd.)

Group H2 Controls

Sheep No.	Date slaughtered	*H. contortus* Stage of development				*T. axei* Stage of development				Total
		L_4	5	A	Total	L_3	L_4	5	A	
147	28 Feb	112	171	1 519	1 802	0	0	0	160	160
167	28 Feb	243	344	1 465	2 052	0	0	0	42	42
181	28 Feb	295	180	2 272	2 747	0	0	0	27	27
*191	28 Feb	248	338	2 684	3 270	0	0	0	71	71
205	28 Feb	172	202	2 757	3 131	0	0	0	24	24
227	28 Feb	648	644	1 842	3 134	0	24	20	30	74
159	14 Mar	61	101	1 437	1 599	0	0	0	89	89
173	14 Mar	270	50	2 371	2 691	0	0	0	46	46
185	14 Mar	318	90	2 700	3 108	0	0	0	80	80
199	14 Mar	152	130	2 404	2 686	0	0	0	19	19
211	14 Mar	86	101	1 541	1 728	0	0	0	42	42
235	14 Mar	10	70	1 525	1 605	0	0	0	25	25

Median 2 436   2 689

× 0,5 = 1218   × 0,5 = 1344,5

Group HII 40 000 L_3 of *T. axei* on Day −44

Sheep No.	Date slaughtered	*H. contortus* Stage of development				*T. axei* Stage of development				Total
		L_4	5	A	Total	L_3	L_4	5	A	
10	28 Feb	142	316	580	1 038	0	20	0	16 500	16 520
**51	28 Feb	305	260	1 183	1 748	0	44	0	6 473	6 517
**83	28 Feb	122	602	961	1 685	0	0	0	13 610	13 610
127	28 Feb	202	461	252	915	0	39	0	19 975	20 014
175	28 Feb	52	151	143	346	0	10	0	17 450	17 460
213	28 Feb	80	217	1 783	2 080	0	30	0	9 160	9 190
26	14 Mar	187	145	1 747	2 079	0	0	0	38 610	38 610
68	14 Mar	230	79	1 784	2 093	40	0	0	14 960	15 000
102	14 Mar	12	11	40	63	0	0	0	18 363	18 363
150	14 Mar	13	32	370	415	10	0	0	8 102	8 112
194	14 Mar	65	19	2 734	2 818	0	0	0	8 200	8 200
232	14 Mar	20	0	280	300	0	0	0	8 047	8 047

* Including 18 L_3 of *H. contortus* $P<0,01$ $P<0,01$

** An additional $^1/_{10}$ aliquot counted

Group H3 Controls

Sheep No.	Date slaughtered	*H. contortus* Stage of development				*T. axei* Stage of development				Total
		L_4	5	A	Total	L_3	L_4	5	A	
4	12 Apr	1 693	238	2 528	4 459	0	0	0	71	71
18	12 Apr	14 281	433	223	14 937	0	0	0	61	61
46	12 Apr	11 856	693	101	12 650	0	0	0	44	44
62	12 Apr	16 220	2 900	1 070	20 190	660	0	0	290	950
86	12 Apr	1 350	520	340	2 210	0	0	0	30	30
114	12 Apr	2 817	202	991	4 010	0	0	0	42	42
12	25 Apr	1 965	1 642	3 000	6 607	0	272	60	815	1 147
*30	25 Apr	24 290	1 164	874	26 328	0	0	0	118	118
54	25 Apr	4 278	3 008	3 764	11 050	0	20	0	368	388
*78	25 Apr	3 812	571	1 289	5 672	0	0	30	226	256
100	25 Apr	11 687	1 100	385	13 172	0	2 467	70	501	3 038
152	25 Apr	19 220	2 101	1 688	23 009	0	0	0	682	682

Median 1949   11850

× 0,5 = 975   × 0,5 = 5925

Group HIII 40'000 L_3 of *T. axei* on Day −44

Sheep No.	Date slaughtered	*H. contortus* Stage of development				*T. axei* Stage of development				Total
		L_4	5	A	Total	L_3	L_4	5	A	
35	12 Apr	2 890	252	1 726	4 868	0	0	0	25 020	25 020
70	12 Apr	7 140	0	0	7 140	0	0	90	16 100	16 190
110	12 Apr	110	1	10	121	0	0	0	29 570	29 570
178	12 Apr	6 080	20	0	6 100	0	0	40	22 350	22 390
222	12 Apr	6 230	30	120	6 380	921	0	0	21 600	22 521
*239	12 Apr	14 566	408	289	15 263	0	3 354	150	20 860	24 364
246	12 Apr	6 700	0	0	6 700	0	0	0	14 460	14 460
57	25 Apr	3 004	1 032	9 109	13 145	0	0	0	11 082	11 082
88	25 Apr	669	11	10	690	0	80	60	5 132	5 272
137	25 Apr	829	60	11	900	0	0	0	11 453	11 453
197	25 Apr	1 651	830	2 780	5 261	0	0	0	5 440	5 440
237	25 Apr	2 680	2	24	2 706	180	0	90	17 750	18 020
241	25 Apr	6 037	4 572	1 521	12 130	0	53	0	2 086	2 139

* An additional $^1/_{10}$ aliquot counted   4/13>975 C $P<0,05$

TABLE 2 (contd.)
Group H4 Controls

Sheep No.	Date slaughtered	*H. contortus* Stage of development				*T. axei* Stage of development				Total
		L_4	5	A	Total	L_3	L_4	5	A	
254	23 May	2 205	0	1	2 206	0	16	0	138	154
257	6 June	4 870	101	1 412	6 383	0	75	3	673	751
260	23 May	2 373	30	614	3 017	0	140	0	221	361
265	6 June	993	10	941	1 944	0	0	0	88	88
269	23 May	943	0	586	1 529	0	0	0	174	174
*272	6 June	2 148	21	591	2 760	0	0	8	307	315
274	23 May	173	34	173	380	2	0	0	69	71
278	6 June	7 523	65	1 990	9 578	0	0	0	119	119
*282	23 May	2 284	60	404	2 748	0	42	0	282	324
286	6 June	5 313	70	460	5 843	0	0	0	232	232
288	23 May	3 515	0	745	4 260	0	0	0	167	167
290	6 June	882	2	350	1 234	0	0	0	107	107

5 & A Median 599 × 0,4 = 239,6   2754 6 × 0,5 = 1377

Group H IV 40 000 L_3 of *T. axei* on day +52

Sheep No.	Date slaughtered	*H. contortus* Stage of development				*T. axei* Stage of development				Total
		L_4	5	A	Total	L_3	L_4	5	A	
252	23 May	1 151	11	128	1 290	260	80	0	27 913	28 253
256	6 June	1 103	141	1 273	2 517	0	0	0	3 587	3 587
259	23 May	**0	0	0	0	340	80	0	4 945	5 365
*262	6 June	455	30	120	605	175	0	3	28 999	29 177
264	23 May	0	0	0	0	70	2	0	23 281	23 353
268	6 June	581	0	50	631	21	41	0	61 000	61 062
275	23 May	1 278	0	130	1 408	150	0	0	37 172	37 322
279	6 June	644	0	50	694	0	0	0	24 521	24 521
*281	23 May	316	21	269	606	79	0	0	40 210	40 289
283	6 June	1 568	101	576	2 245	1 288	40	0	24 652	25 980
285	23 May	0	0	10	10	120	0	0	26	146
287	6 June	387	30	80	497	0	320	0	24 451	24 771
*289	23 May	1 064	11	173	1 248	120	30	0	6 016	6 166

3/13 > 239 B   3/13 > 1377 C

* An additional 1/10 aliquot counted
** Including 80 L_3

Efficacy of groups dosed with T. axei

Worm burdens on controls and in groups predosed with *T. axei* are listed in Table 2, together with the results analysed by the NPM or Mann Whitney U test. Total worm burdens of *H. contortus* in groups predosed with *T. axei* were significantly less in Group HII ($P<0,01$) and in Group III ($P<0,05$) but rose to Class C (>50 % effective in >50 % of sheep) in Groups I and IV respectively. The highest efficacy was recorded against 5th stages and adults in Group IV, when it rose to >60 % in >60 % of sheep (Class B). This group grazed on infested pastures from 25 March–20 May.

The monthly rainfall and supplementary spray irrigation figures are recorded in Table 4. The dry months were January, April and May, during which an additional 20–50 mm of moisture was supplied by irrigation.

TABLE 3 The percentage of L_4 of *H. contortus* expressed as a percentage of the mean total worm burdens

Group	Period on grazing	*H. contortus* Mean total worm burden	L_4%
H1 HI	19 November 1976 –14 January 1977	401 203	0,2 2,0
H2 HII	31 December 1976 –25 February 1977	2 463 1 298	8,8 9,2
H3 HIII	11 February –8 April	12 023 6 261	78,6 72,0
H4 HIV	25 March –20 May	3 490 907	79,2 72,5

TABLE 4 Rainfall and irrigation on *Eragrostis curvula* grazing at Hennops River

Month and year	Rainfall (mm)	Irrigation (mm)
October 1976	93	0
November 1976	65,5	0
December 1976	60	0
January 1977	25,5	40
February 1977	201	0
March 1977	110,5	0
April 1977	50	20
May 1977	11	50

TABLE 5 The mean monthly total worm burdens L_4 expressed as a percentage of the total worm burdens of 127 tracer lambs which grazed on improved pastures at Hennops River from October 1968–May 1973 (Horak & Louw, 1977)

Month	Total No. of sheep slaughtered	*H. contortus* Mean total worm burden	L_4 %
January	9	696	43,8
February	10	1 168	65,2
March	10	1 003	61,6
April	13	3 840	92,5
May	13	4 127	92,9
June	10	720	95,6
July	10	198	92,1
August	8	238	82,6
September	8	33	60,8
October	10	32	75,2
November	13	137	10,1
December	13	462	36,6

DISCUSSION

Horak & Louw (1977) grazed 2–3 "tracers" for periods of 33 days on improved pastures on the same farm used in the present trials.

TABLE 6 A comparison of estimated mean total worm burdens on data from Horak & Louw (1977) compared with data from controls in the present trials

Group	Estimated mean total worm burden based on data from Horak & Louw (1977)	Actual mean worm burdens in the controls in the present trials
H1	772	401
H2	1 530	2 463
H3	2 453	12 023
H4	6 160	3 490

The pastures in their experiment were spray-irrigated on 2–4 occasions each month, approximately 37 mm of water being supplied on each occasion. When no rain was recorded from June to August or September, they were irrigated on 3 or 4 occasions (111–148 mm), and even from December to March, when it rained every month, pastures were irrigated at least twice (2 × 37 = 74 mm). This irrigation was considerably in excess of the 20–50 mm applied in dry months in the present trials.

The lambs in the trials of Horak & Louw (1977) grazed from 07h00–17h00 every day, i.e. for 10 h/day for 33 days, or 330 h. The sheep in our trials only grazed from 09h00–15h00 every day, i.e. for 6 h/day for either 54 days or 324 h (Groups 4 and IV) or for 56 days or 336 h (Groups 1 and I; 2 and II and 3 and III). There was almost no difference in the actual times spent on pastures. However, it has been shown that indirect light encourages migration on to herbage, but in bright sunlight larvae migrate to the humus layer or "mat" on the ground surface and are thus less available to grazing sheep (Crofton, 1948). Since this occurs only in the presence of moisture, the earlier grazing from 07h00–09h00 and in the late afternoon from 15h00–17h00, particularly in the autumn, provides the necessary periods of indirect light. Indirect light plus additional irrigation would suggest that the pastures in the trials reported on by Horak & Louw (1977) were considerably more favourable for infective larvae of *H. contortus* than the conditions in the present trials.

The controls of these trials (Table 3) are compared with the data summarized in Table 5 abstracted from Horak & Louw (1977). If the mean total worm burdens of each month in Table 5 are divided by 33, i.e. the number of days the sheep grazed, the mean number of infective larvae that were infective enough to develop to parasitic stages in the host are: November 4/day, December 14/day, January 21/day, February 35/day, March 30/day, April 116/day and May 125/day respectively.

The mean total worm burdens of the controls in the present trial are listed above. We have also indicated the exact period during which each group was on the pasture. By simple multiplication of figures extracted from Horak & Louw (1977), given above, estimates can be made of the worm burdens the sheep would have acquired. In Table 6 these estimates are compared with the actual worm burdens of the sheep in our trial.

Both the estimated and the actual worm burdens show a rise from Group H1 to H2. The fact that the mean worm burdens in the present trials, i.e. 2 463 in Group H2, exceed the estimate of 2 453 in Group H3 indicates a rapid build up of pasture infestation in our trails. There is a subsequent explosive increase in Group H3 followed by a dramatic fall in Group H4 in contrast with the marked increase between the estimated burdens in Group H3 and Group H4, based on Horak & Louw (1977).

A simple explanation for these differences is:

(i) In February 210 mm and in March 110,5 mm of rain was recorded, but rain plus irrigation was only 70 mm and 61 mm in April and May 1977 respectively in the present trials.

(ii) Horak & Louw (1977) recorded a major peak of 7 021 epg in March 1970, whereas in the present trials mean faecal worm egg counts ranged from 5 064–14 157 epg during the period Groups H3 and HIII were exposed to grazing.

(iii) In our trials the stocking rate was very high from 11–25 February, i.e. there were 54 sheep infested with *H. contortus* (30 seeders + 12 sheep in Group H2 and 12 in Group HII) and an additional 25 sheep (12 in Group H3 and 13 in Group HIII) making a total of 79 sheep/ha. After the removal of 24 sheep (12 in Group H2 and 12 in Group HII), the stocking rate fell to 55 sheep/ha, but for the last 5 of the 8 weeks the 25 sheep in Groups H3 and HIII acquired *H. contortus* and this also contributed to pasture contamination. By the time the last 25 sheep (12 in Group H4 and 13 in Group HIV) were added to those already on the pasture, boosting the numbers to 80 sheep/ha, half the pasture was so heavily overgrazed that it could no longer be used and grazing was limited to the other 0,5 ha for the balance of the trial.

In their trials Horak & Louw (1977) never reached the state of overgrazing on the grass clover pastures at Hennops River that we reached on the *E. curvula* pasture by the end of March 1977 in our trials. Their average stocking rate at Hennops River is 30 sheep/ha according to J. P. Louw (personal communication, 1981).

We deliberately set out to expose sheep in these trials to maximum challenge with *H. contortus* regardless of whether the pastures were abused by overcrowding. The efficacy of 40 000 infective larvae of *T. axei* in protecting sheep in Group HIII against 5th stage and adult *H. contortus* by >50 % in >50 % of sheep (Class C) and the significant reduction ($P<0,05$) in total worm burdens during this period of maximum challenge, confirm the favourable results in natural pastures at the UP Experimental Farm conducted at the same time (Reinecke, De Villiers & Brückner, 1984).

Efficacy in Group HIV improved to >60 % against 5th stage and adult *H. contortus in* >60 % of sheep and Class C against total worm burdens. This is interesting, because these animals were dosed with 40 000 infective larvae of *T. axei* on Day +52 and exposed to challenge on the grazing from Day +126–Day +180 or 74–128 days later (25 March to 20 May).

Reinecke, De Villiers & Brückner (1984) had similar results in UP Group IV predosed with *T. axei* which grazed on natural pastures. In their trial the latter group was >60 % effective against 5th stage, adult and total worm burdens of *H. contortus* in >60 % of sheep (Class B). This group had been dosed on Day 0 (November 2 1976) with *T. axei* and exposed to challenge for more than 7 months before being removed from pastures on 6 June 1977. It seems that the longer the sheep were exposed to *H. contortus* after dosing with *T. axei* the greater their resistance.

The present trial, however, shows that sheep dosed with *T. axei* in Group HIV are more efficient in resisting challenge in autumn (25 March–20 May) than in late summer and early autumn. This was the case in Group HIII when exposed to challenge from 14 February to 8 April. This raises the interesting possibility that predosing with *T. axei* in November may be followed by treatment with disophenol in January, a chemoprophylactic effective against *H. contortus* only. Disophenol still reaches Class C against challenge with *H. contortus* 3 months after treatment (Reinecke, Brückner & De Villiers, 1981).

ACKNOWLEDGEMENTS

We wish to thank MSD (SA Pty Ltd) for providing facilities and grazing at the Hennops River Research Centre and the University of Pretoria for financial assistance to complete these trials.

REFERENCES

CROFTON, H. D., 1948. The ecology of immature phases of Trichostrongyle nematodes. I. Vertical distribution of infective larvae of *Trichostrongylus retortaeformis* in relation to their habitat. *Parasitology*, 39, 17–25.

HORAK, I. G. & LOUW, J. P., 1977. Parasites of domestic and wild animals in South Africa. IV. Helminths in sheep on irrigated pasture on the Transvaal Highveld. *Onderstepoort Journal of Veterinary Research*, 44, 261–270.

HORAK, I. G., 1978. Parasites of domestic and wild animals in South Africa. V. Helminths in sheep on dryland pasture on the Transvaal Highveld. *Onderstepoort Journal of Veterinary Research*, 45, 1–6.

HORAK, I. G., 1980. The incidence of helminths in pigs, sheep, cattle, impala and blesbok in the Transvaal. Ph.D. Thesis, University of Natal, Pietermaritzburg.

REINECKE, R. K., 1973. The larval anthelmintic test in ruminants. *Technical Communication, Department of Agricultural Technical Services*, Republic of South Africa, No. 106.

REINECKE, R. K., BRÜCKNER, CHRISTEL & DE VILLIERS, I. L., 1981. A residual anthelmintic 2, 6-diiodo-4 nitrophenol (disophenol). Methods of testing its anthelmintic efficacy. *Journal of the South African Veterinary Medical Association*, 52, 195–200.

REINECKE, R. K., DE VILLIERS, I. L & BRÜCKNER, CHRISTEL, 1984. Studies on *Haemonchus contortus*. IX. The effect of *Trichostrongylus axei* in Merinos on natural pastures. *Onderstepoort Journal of Veterinary Research*, 51, 25–31.

SIEGEL, S., 1956. Non-parametric statistics for the behavioral sciences. New York: McGraw-Hill.