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STUDIES ON *HAEMONCHUS CONTORTUS*. XII. EFFECT OF *TRICHOSTRONGYLUS AXEI* IN DORPER LAMBS ON NATURAL PASTURE LIGHTLY INFESTED WITH *H. CONTORTUS*

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ABSTRACT

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Weaned Dorper lambs on natural pasture were predosed with 40 000 infective larvae (L_3) of *Trichostrongylus axei*, irradiated (0,3 kGy) L_3 of *T. axei* or closantel at 10 mg/kg either in September or November 1978 and were compared with Merino yearlings predosed with 40 000 L_3 of *T. axei* in November 1977. The following summer (December–March) only 178,6 mm of rain fell and very few *H. contortus* were present on pastures. Artificial challenge with 20 000 L_3 of *Haemonchus contortus* with the local strain from the University of Pretoria's experimental farm was given 6–7 months after predosing with *T. axei*. When compared with the controls, significant reductions occurred only in Group 11 (*T. axei* irradiated at 0,3 kGy on Day +63) (P=0,025); Group 2 (*T. axei* on Day 0) (P = 0,003) and Group 4 (*T. axei* and closantel on Day 0) (P = 0,049). We concluded that predosing with *T. axei* was unsuccessful in Dorpers and Merinos artificially challenged 6–7 months later with *H. contortus*.

INTRODUCTION

Two field trials with Merinos on natural pastures at the University of Pretoria's (UP) experimental farm were carried out in successive years in 1976–1977 and 1977–1978 to monitor the effect of predosing sheep in late spring with *Trichostrongylus axei* on subsequent natural challenge with *Haemonchus contortus* (Reinecke, De Villiers & Brückner, 1984a; Reinecke, De Villiers & Joubert, 1984b). In the first trial an ovine strain of *T. axei* was used and sheep, dosed with 40 000 infective larvae of this species on 2 November 1976, withstood challenge for more than 6 months (Reinecke *et al.*, 1984a).

In the following year we dosed infective larvae of a bovine strain of *T. axei* either on 23 November 1977 or on 7 December. This was followed by heavy rains, when 709,4 mm of rain was recorded between 1 December 1977 and 31 March 1978, with 486,9 mm in January alone, the highest rainfall on record for that month. Although most of the sheep in the 1st experiment survived the massive challenge from *H. contortus* until slaughter either on 21 March or 4 April, many of those in the 2nd experiment died in autumn with the exception of one group which has received both 40 000 infective larvae of *T. axei* and an injection of a chemoprophylactic anthelmintic diiodinitrophenol (DNP) at 10 mg/kg on 7 December 1977 (Reinecke *et al.*, 1984b).

The objects of the present trial were to study: firstly, the effect of *T. axei* on Dorpers rather than Merinos; secondly, predosing in September compared with November; thirdly, using a chemoprophylactic closantel rather than DNP, and, fourthly, challenge with the local field strain of *H. contortus*. This strain, which had passaged itself for a year in Merinos at UP, replaced the laboratory strain maintained at Onderstepoort and used in previous experiments.

MATERIAL AND METHODS

Infective larvae

Larvae of *T. axei* were harvested from cultures prepared from sheep housed at the laboratory at Onderstepoort, while those of *H. contortus* came from Merinos that had grazed on the natural pastures for more than 1 year at UP. The latter were not pure cultures of *H. contortus*, but contained from 4–7 % infective larvae of *Trichostrongylus* spp.

Animals

On Day −38 120 Dorper weaners arrived from Olifantshoek. A further 25 Dorpers were purchased locally in the Pretoria district and arrived on the farm on Day −4.

The 32 Merino yearlings were survivors from the experiment of the previous summer. Details of ear-marking, vaccination and treatment are given in Table 1.

Seeders

On Day +21 14 Dorpers were each dosed with 2 000 infective larvae (L_3) of *H. contortus* (Table 1).

Grazing

All the sheep grazed on natural pasture in a camp 21 ha in extent from 07h00–15h00 every day. They slept in kraals overnight with ground and manure floors which were partly covered with tiled roofs.

Infestation

Dorpers

One hundred and twenty-nine Dorpers were divided into 2 groups as follows: 71 into 6 groups (Groups 1–6) on Day 0 (22 September), the balance of 58 into a further 5 groups (Groups 7–11) on Day +63 (24 November). Details of infestation with infective larvae of *T. axei* or with closantel at 10 mg/kg are summarized in Table 1.

Merinos

Thirty-two Merinos were divided into 3 groups. On Day +40 21 sheep (Groups 12 & 13) were each dosed with Fenbendazole* at 20 mg/kg, and on Day +47 22 Merinos (Groups 13 & 14) were each dosed with 40 000 L_3 of *T. axei* (Table 1).

All the sheep, excluding the seeders, were challenged with 10 000 L_3 of *H. contortus* (UP strain) 6–7 months later on the days indicated in Table 1.

Additional vaccinations and treatment

A Dorper, Sheep 86 (Group 5), died on Day +66 with pneumonia. *Corynebacterium* abscesses were present, and there was also evidence of white muscle disease in the Dorpers. Both Dorpers and Merinos were vaccinated on Day +76 with *Corynebacterium ovis* and *Corynebacterium pyogenes* vaccines. Two days later (Day +78) all the Dorpers were injected with 0,5 mℓ of sodium selenite solution (= 0,5 mg selenium).

Deaths and slaughter

A list of the days on which sheep died or were slaughtered is given in Table 2.

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TABLE 1 Dorper field trial. Days on which infective larvae or anthelintics were dosed and sheep divided into groups at the University of Pretoria's experimental farm (UP)

Day	*Treatment*
−38	120 weaned Dorper lambs arrived from Olifantshoek at UP, were ear tagged and dosed with albendazole at 8 mg/kg
−31	120 Dorpers and 32 Merinos vaccinated with enterotoxaemia and bluetongue vaccines
−7	120 Dorpers dosed with albendazole at 8 mg/kg
−4	25 Dorpers arrived, ear tagged and dosed with albendazole at 8 mg/kg
0	22 September 1978. 71 Dorpers divided into 6 groups as follows: Group 1: 11 lambs controls Group 2: 12 lambs 40 000 infective larvae (L_3) of *T. axei* Group 3: 12 lambs 40 000 L_3 of *T. axei* and with closantel at 10 mg/kg *per os* Group 4: 12 lambs closantel at 10 mg/kg Group 5: 12 lambs 40 000 L_3 of *T. axei* Group 6: 12 lambs 40 000 L_3 of *T. axei* irradiated at 0,3 kGy
+21	Seeders 14 Dorpers 2 000 L_3 of *H. contortus* (UP strain)
+40	Groups 12 & 13: 21 Merinos fenbendazole at 20 mg/kg
+47	Groups 13 & 14: 22 Merinos 40 000 L_3 of *T. axei*
+59	Groups 7–11: 46 Dorpers albendazole at 8 mg/kg Group 4: 11 Dorpers 40 000 L_3 of *T. axei* Group 5: 11 Dorpers closentel at 10 mg/kg 58 Dorpers divided into 5 groups as follows: Group 7: 10 Dorpers controls Group 8: 12 Dorpers 40 000 L_3 of *T. axei*
+63	Group 9: 12 Dorpers 40 000 L_3 of *T. axei* and closantel at 10 mg/kg Group 10: 12 Dorpers closentel at 10 mg/kg Group 11: 12 Dorpers 40 000 L_3 of *T. axei* irradiated at 0,3 kGy
+76	All sheep vaccinated with *Corynebacterium ovis* and *Corynebacterium pyogenes* vaccine
+78	All Dorpers injected with 0,5 mℓ of sodium selenite solution = 0,5 mg selenium
+186	Groups 1–6: Dorpers 10 000 L_3 of *H. contortus* (UP strain)
+187	Groups 1–6: Dorpers 10 000 L_3 of *H. contortus* (UP strain)
+229	Groups 12–14: Merinos 10 000 L_3 of *H. contortus* (UP strain)
+230	Groups 12–14: Merinos 10 000 L_3 of *H. contortus* (UP strain)
+264	Groups 7–11: Dorpers 10 000 L_3 of *H. contortus* (UP strain)
+265	Groups 7–11: Dorpers 10 000 L_3 of *H. contortus* (UP strain)

TABLE 2 Dorper field trial. Days on which sheep died or were slaughtered

Day	Group	Number and breed
0		22 September 1978
+15	7	1 Dorper died
+25	8	1 Dorper died
+40	4	1 Dorper died
+51	2	1 Dorper died
+54	5	1 Dorper died
+58	3	1 Dorper died
+62	2	1 Dorper died
+66	5	1 Dorper died
+68	2	1 Dorper died
+78	2	1 Dorper died
+104	9 & 3	2 Dorpers died
+105	2	1 Dorper died
+126	8	1 Dorper died
+152	4	1 Dorper died
+159	8 & 9	2 Dorpers died
+169	5	1 Dorper died
+194	4 & 8	2 Dorpers died
+214	1–6	26 Dorpers slaughtered
+228	1–6	29 Dorpers slaughtered
+229	8	1 Dorper died
+230	8	1 Dorper died
+263	12–14	16 Merinos slaughtered
264	8	1 Dorper slaughtered *in extremis*
271	8	2 Dorpers died
277	12–14	16 Merinos slaughtered
298	7–11	24 Dorpers slaughtered
312	7–11	24 Dorpers slaughtered
		31 July 1979 experiment ended

Rain and temperature

The monthly rainfall, mean monthly maximum and mean monthly minimum temperatures at UP are recorded in Table 3.

Faecal worm egg counts

Seeders: Faeces were collected every 7 days from Day +47–Day +264 from 11 of the seeders.

TABLE 3 The total monthly rainfall, number of days on which rain fell and mean monthly maximum and minimum temperatures at the University of Pretoria

	Total rain-fall (mm)	No. of days rain fell	Mean maximum tempera-ture (°C)	Mean minimum tempera-ture (°C)
August 1978	6,7	3	23,1	8,7
September	30,4	3	23,8	10,6
October	34,8	5	24,3	12,8
November	39,1	9	26,5	14,5
December	52,4	8	27,9	15,2
January 1979	41,0	9	26,6	15,2
February	27,8	9	27,3	16,5
March	57,4	8	26,9	14,1
April	51,3	5	25,4	12,2
May	12,1	4	21,5	7,5
June	0	0	17,4	4,1
July	5,7	1	16,1	3,6

Group 1: Faeces were collected for worm egg counts at irregular intervals from 10 out of 11 Dorpers from Day +69–Day +223.

Group 7: In 5 of the Dorpers in this group faeces for worm egg counts were collected at irregular intervals from Day +159–Day +293.

Worm recovery at autopsy

Worm recovery techniques identical with those described earlier were used (Reinecke *et al.*, 1984b).

Analysis of results

The mean and range of weekly egg counts in seeders were converted to the square root of each egg count. The results are illustrated in Fig. 1. The worm burdens of the controls were compared with those of the other groups by the Mann- Whitney U test (Siegel, 1956).

RESULTS

Weather

Of the 358,7 mm rainfall recorded from August 1978 to the end of July 1979, only 261,1 mm fell from November to the end of May. The mean maximum temperatures ranged from 21,5–26 °C and the mean minimum temperature from 7,5–16,5 °C, both suitable for the survival of *H. contortus* on pastures (Table 3).

Faecal worm egg counts

Seeders: Egg counts rose to a peak at the end of November [Sheep 169 had 40 600 eggs per gram (epg)], necessitating the treatment of 5 seeders with counts of 23 000 epg or higher. Thereafter they fell to very low levels in autumn (Fig. 1).

Dorpers

Group 1: The highest egg count prior to challenge with *H. contortus* (on Day +186 and Day +187) in this group was 67 000 epg in Sheep 59.

Group 7: A count of 4 800 epg in Sheep 94 was the maximum recorded in this group prior to challenge with *H. contortus* (on Day +265).

Worms recovered at autopsy

Groups 1–6 (Table 4)

H. contortus: The Mann-Whitney U test showed that Group 2 (P = 0,003) and Group 4 (P = 0,049) had lower total worm burdens than the controls (Group 1). Sheep in Group 2 received 40 000 infective larvae of *T. axei* on Day 0 and Group 4 on Day + 59, respectively. In addition, closantel (10 mg/kg) was dosed to the sheep in Group 4 on Day 0.

T. axei: The maximum worm burden of 23 547 (Sheep 10 Group 2) in those that received normal larvae was considerably higher than the 2 937 worms recorded in Sheep 30 (Group 6) that received irradiated larvae.

Groups 7–11 (Table 5)

H. contortus: Total worm burdens in Groups 8–10 showed no significant difference when compared with those of Group 7, but Group 11, which was predosed with irradiated larvae of *T. axei* on Day +63, had significantly lower worm burdens of *H. contortus* ($P < 0,025$) than Group 7.

T. axei: The range in Group 11, predosed with irradiated infective larvae of this species on Day +63, was higher than that of the equivalent Group 6, predosed on Day 0 with irradiated infective larvae of *T. axei*.

Merinos

Groups 12–14 (Table 6)

There was no significant difference in the burdens of *H. contortus* of either Group 13 or Group 14 when compared with the burden of Group 12 (controls).

Dorpers that died

In Table 7 there are records of 22 Dorpers that died. In 11 of them the worms present were counted, and *T. axei* was predominant, as was to be expected, because most of them died early in the trial before the sheep were challenged with *H. contortus*. With the exception of 4 sheep (Sheep 14 & 74, Group 3; Sheep 75, Group 4;

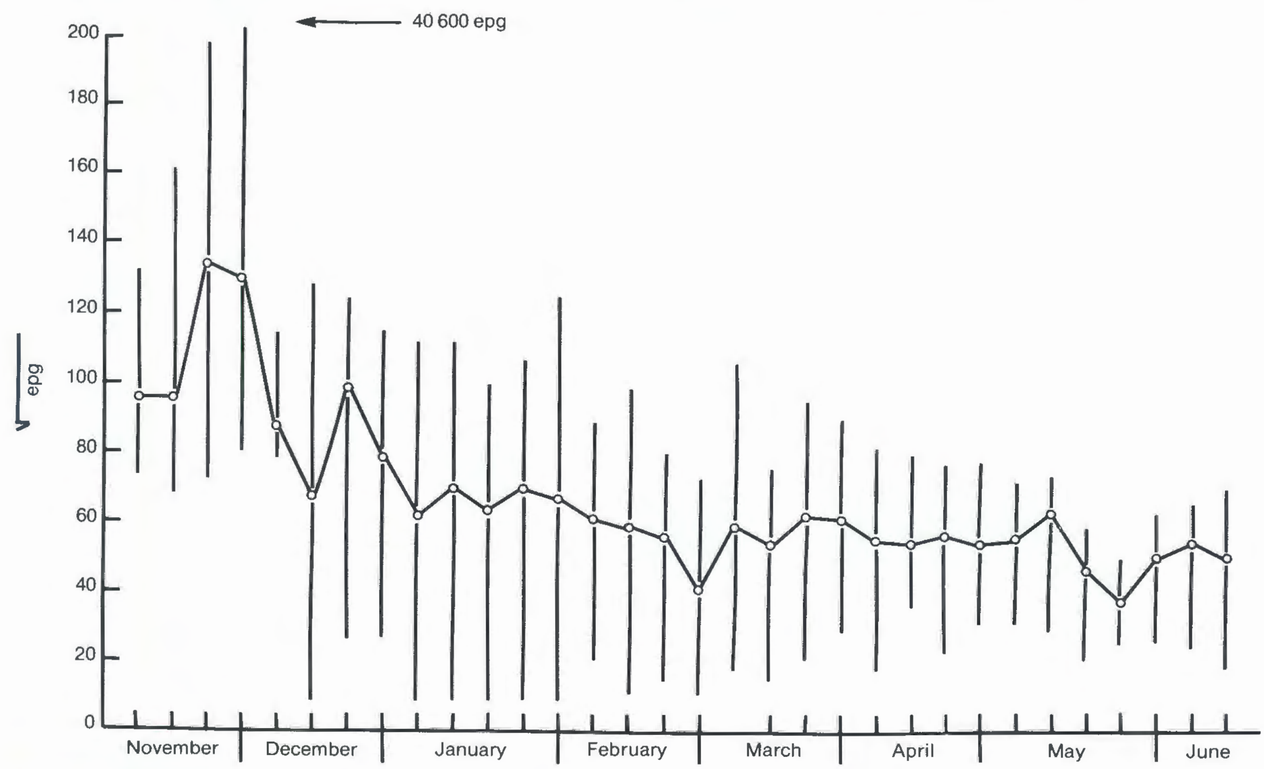

FIG. 1 Dorper seeders. Variations in the mean, upper limit and lower limit of the faecal worm egg counts converted to the square root of each count

Sheep 99, Group 8) the total numbers of *T. axei* recovered fell within the range of *T. axei* recovered in the respective groups (compare Table 7 with Table 4 and Table 5).

DISCUSSION

This is the final field trial at UP in which the prophylactic effect of *T. axei* against challenge with *H. contortus* in sheep on natural pasture is assessed. In 2 previous trials we protected Merinos efficiently in the first trial by dosing them early in November and following this up by a fairly strong challenge of *H. contortus* in the following summer (Reinecke *et al.*, 1984 a). In the second trial, however, predosing with *T. axei* was delayed either to 23 November or 7 December 1978 when the wettest January on record (486,9 mm) and heavy rains in February (131,9 mm) occurred. The faecal worm egg counts rose to peak egg counts from February to April, individual sheep showing counts ranging from 14 000–100 400 epg. The veld was heavily infested with *H. contortus* and a considerable number of sheep (41 out of 127) died or were killed *in extremis* (Reinecke *et al.*, 1984 b). Most of the sheep that died had been predosed with a bovine strain of *T. axei* only in December, and late dosing, combined with massive challenge, was the probable reason for the inability of these sheep to withstand challenge from haemonchosis. In other words, challenge followed too closely on predosing with *T. axei*.

In this present trial Dorpers rather than Merinos were used, but deaths occurred early in the experiment. Although Dorpers may be more sensitive than Merinos to the pathogenic effects of *T. axei*, most of the worm counts in the various groups fell within the range of those that survived. These early deaths may have been exacerbated by white muscle disease and *Corynebacterium* infection. These were controlled with injections of selenium and *C. ovis* and *C. pyogenes* vaccinations.

TABLE 4 Dorper field trial (Groups 1–6); worms recovered at necropsy. All sheep dosed with *H. contortus* on Day +16 and Day +170 and slaughtered either on Day +214 or Day +215

Group 1 Controls

Sheep No.	*H. contortus*				*T. axei*		
	L_4	5th	Adults	Total	5th	Adults	Total
1	501	20	131	652	300	163	463
2	93	2 240	2 707	5 040	740	896	1 636
3	64	420	7 747	8 231	360	241	601
4	472	200	6 036	6 708	1 126	209	1 335
5	461	40	1 686	2 187	—	303	303
58	105	232	471	808	100	131	231
59	184	20	823	1 027	—	244	244
60	261	40	740	1 041	—	338	338
61	112	225	5 403	5 740	20	534	554
62	83	1 673	8 423	10 179	269	987	1 256
161	894	420	6 769	8 083	—	761	761

Group 2 *T. axei* Day 0

Sheep No.	*H. contortus*				*T. axei*		
	L_4	5th	Adults	Total	5th	Adults	Total
7	261	—	20	281	800	8 057	8 857
10	1 378	—	20	1 398	1 780	23 547	25 327
63	1 769	23	171	1 963	273	5 903	6 176
65	361	40	240	641	420	13 872	14 292
66	2 279	—	101	2 380	820	10 753	11 573
160	647	—	100	747	180	6 149	6 329

P=0,003

Group 3 *T. axei* and closantel Day 0

Sheep No.	*H. contortus*				*T. axei*		
	L_4	5th	Adults	Total	5th	Adults	Total
11	667	60	2 371	3 098	540	9 341	9 881
12	563	—	842	1 405	100	6 267	6 367
13	1 091	60	1 560	2 711	240	10 281	10 521
15	426	1	1 171	1 598	60	10 043	10 103
69	247	—	1 047	1 294	—	638	638
70	99	242	8 612	8 953	7	3 088	3 095
72	96	168	5 450	5 714	1 708	8 551	10 259
73	1 074	—	338	1 412	154	6 957	7 111
159	264	180	6 206	6 650	349	9 901	10 250

Group 4 Closantel Day 0. *T. axei* Day +63

Sheep No.	*H. contortus*				*T. axei*		
	L_4	5th	Adults	Total	5th	Adults	Total
17	351	—	987	1 338	100	2 872	2 972
18	882	—	1	883	6 480	7 701	14 181
76	1 301	—	381	1 682	80	4 889	4 969
77	105	101	2 823	3 029	—	523	523
78	301	—	1 220	1 521	140	8 121	8 261
79	556	260	1 940	2 756	200	11 827	12 027
80	932	—	280	1 212	220	8 062	8 282

P=0,049

TABLE 4 (contd)

Group 5 *T. axei* Day 0. Closantel Day +63

Sheep No.	*H. contortus*				*T. axei*		
	L_4	5th	Adults	Total	5th	Adults	Total
21	314	21	1 524	1 859	140	7 709	7 849
22	353	60	2 481	2 894	280	8 367	8 647
23	91	140	3 802	4 033	139	9 559	9 698
24	867	60	2 087	3 014	200	7 609	7 809
25	422	40	4 400	4 862	8	14 249	14 257
81	972	60	2 903	3 935	260	8 031	8 291
82	721	40	2 411	3 172	140	10 701	10 841
83	170	21	5 245	5 436	80	6 933	7 013
84	1 601	—	983	2 584	80	6 389	6 469
85	468	40	841	1 349	221	8 456	8 677

Group 6 *T. axei* 0,3 kGy Day 0

Sheep No.	*H. contortus*				*T. axei*		
	L_4	5th	Adults	Total	5th	Adults	Total
26	67	140	3 201	3 408	—	1 041	1 041
27	368	441	5 244	6 053	—	675	675
28	71	340	7 003	7 414	—	927	927
29	41	80	16 165	16 286	1	923	924
30	153	60	4 123	4 336	40	2 897	2 937
31	61	20	6 104	6 185	2 082	217	2 299
87	101	65	4 103	4 269	—	977	977
88	59	102	1 449	1 610	13	1 108	1 121
89	45	40	8 381	8 466	—	1 065	1 065
90	1 477	460	8 185	10 122	—	1 697	1 697
91	20	540	8 211	8 771	—	2 242	2 242
156	442	80	5 680	6 202	—	917	917

TABLE 5 Dorper field trial (Groups 7–11); worms recovered at necropsy. All sheep dosed with *H. contortus* on Day +264 and Day +265 and slaughtered either on Day +298 or Day +312

Group 7 Controls

Sheep No.	*H. contortus*				*T. axei*		
	L_4	5th	Adults	Total	5th	Adults	Total
32	733	142	10 116	10 991	20	1 874	1 894
33	723	160	6 062	6 945	—	1 559	1 559
34	423	40	2 801	3 264	—	2 204	2 204
35	1 524	200	3 646	5 370	—	1 273	1 273
36	1 031	100	4 866	5 997	—	1 437	1 437
93	101	20	2 788	2 909	—	833	833
94	186	—	1 822	2 008	—	170	170
95	463	—	2 020	2 483	—	682	682
96	6 611	—	254	6 865	380	9 420	9 800
120	586	60	6 397	7 043	—	1 475	1 475

Group 8 *T. axei* Day +63

Sheep No.	*H. contortus*				*T. axei*		
	L_4	5th	Adults	Total	5th	Adults	Total
38	1 001	—	982	1 983	300	18 441	18 741
39	822	40	2 427	3 289	220	10 261	10 481
40	244	40	2 397	2 681	120	8 358	8 478
41	772	400	424	1 596	320	12 343	12 663
97	1 120	—	1 662	2 782	180	14 787	14 967
98	2 572	—	420	2 992	160	9 124	9 284
101	1 181	—	421	1 602	480	16 063	16 543
102	174	—	960	1 134	60	5 949	6 009

Group 9 *T. axei* and closantel Day +63

Sheep No.	*H. contortus*				*T. axei*		
	L_4	5th	Adults	Total	5th	Adults	Total
42	1 505	—	2 226	3 731	220	9 096	9 316
43	377	—	680	1 057	20	6 249	6 269
44	879	20	1 681	2 580	272	13 873	14 145*
45	1 071	—	1 283	2 354	340	14 786	15 126
103	1 045	40	1 580	2 665	280	11 568	11 848
104	1 540	140	1 632	3 312	140	8 953	9 093
105	1 277	60	3 776	5 113	940	12 270	13 210
107	1 048	—	—	1 048	—	9 870	9 870
106	1 050	340	1 453	2 843	120	18 192	18 312
108	1 244	80	420	1 744	80	8 221	8 301
153	1 628	—	80	1 708	1 220	9 563	10 783

* Including 12 L_3

TABLE 4 (contd)

Group 10 Closantel Day +63

Sheep No.	*H. contortus*				*T. axei*		
	L_4	5th	Adults	Total	5th	Adults	Total
47	1 727	20	2 823	4 570	60	4 438	4 498
48	652	—	960	1 612	620	7 608	8 228
49	2 549	60	2 580	5 189	480	7 723	8 203
50	351	20	2 429	2 800	40	2 027	2 067
51	309	21	2 603	2 933	—	2 741	2 741
52	460	160	3 189	3 809	140	5 216	5 356
109	117	140	2 201	2 458	—	1 193	1 193
110	434	40	2 026	2 500	80	3 060	3 140
111	529	100	2 242	2 871	40	2 608	2 648
112	901	240	1 525	2 666	160	4 612	4 772
113	658	140	4 230	5 028	—	2 213	2 213
152	2 581	—	1 994	4 575	20	1 972	1 992

Group 11 *T. axei* 0,3 kGy Day +63

Sheep No.	*H. contortus*				*T. axei*		
	L_4	5th	Adults	Total	5th	Adults	Total
53	1 826	—	420	2 246	140	7 102	7 242
54	1 101	20	400	1 521	40	4 423	4 463
55	1 473	—	583	2 056	140	2 962	3 102
56	2 117	60	2 383	4 560	20	7 170	7 190
57	2 051	—	640	2 691	—	1 439	1 439
114	1 573	100	1 455	3 128	240	8 950	9 190
115	692	—	170	862	420	8 850	9 270
116	491	—	341	832	80	4 767	4 847
117	80	100	2 733	2 913	80	8 861	8 941
118	16	—	671	687	340	9 167	9 507
119	6 350	—	376	6 726	—	8 490	8 490
151	395	—	60	455	140	21 402	21 542

$P<0{,}025$

TABLE 6 Merinos; worms recovered at necropsy. All sheep dosed with *H. contortus* on Day +229 and Day +230 and slaughtered on Day +263 or Day +277

Group 12 Controls fenbendazole Day +40

Sheep No.	*H. contortus*			*T. axei*		
	L_4	5th and adults	Total	L_3	5th and adults	Total
134	551	809	1 360	—	312	312
139	2 066	4 518	6 584	—	1 408	1 408
143	510	222	732	—	221	221
153	2 016	2 353	4 369	—	428	428
164	2 337	41	2 378	—	786	786
176	2 112	6 216	8 328	—	328	328
183	1 820	3 918	5 738	—	172	172
190	2 224	4 213	6 437	160	1 276	1 436
196	1 940	3 242	5 182	—	528	528
201	2 456	771	3 227	—	388	388

Group 13 Fenbendazole Day +40 *T. axei* Day +47

Sheep No.	*H. contortus*			*T. axei*		
	L_4	5th and adults	Total	L_3	5th and adults	Total
135	194	—	194	—	8 122	8 122
140	3 496	7 889	11 385	—	1 532	1 532
148	788	2 287	3 075	—	17 116	17 116
154	208	110	318	—	6 792	6 792
171	556	2 800	3 356	—	584	584
179	1 260	253	1 513	—	2 788	2 788
184	2 928	5 034	7 962	—	780	780
193	1 584	3 817	5 401	—	720	720
198	3 974	4 080	8 054	—	461	461
202	46	100	146	—	5 000	5 000
205	1 558	1 062	2 620	—	768	768

TABLE 6 (contd)

Group 14 *T. axei* Day +47

Sheep No.	*H. contortus*			*T. axei*		
	L_4	5th and adults	Total	L_4	5th and adults	Total
137	1 900	1 144	3 044	—	7 940	7 940
142	1 000	2 834	3 834	—	6 592	6 592
152	616	21	637	—	12 148	12 148
158	5 134	1 210	6 344	—	2 088	2 088
172	2 268	1 086	3 354	—	24 220	24 220
180	452	1 708	2 160	—	1 244	1 244
187	222	1	223	—	30 775	30 775
194	1 144	941	2 085	—	4 784	4 784
199	256	—	256	—	15 524	15 524
203	1 270	1 826	3 096	—	1 496	1 496
206	40	78	118	—	2 828	2 828

TABLE 7 Dorpers that died; worms recovered at necropsy

Sheep No.	*H. contortus*					*T. axei*		
	Date of death	L_4	5th	Adults	Total	5th	Adults	Total
Group 2 *T. axei* Day 0								
6	5 January	No necropsy						
8	12 December	—	—	—	—	260	7 062	7 322
9	12 November	No necropsy						
64	29 November	—	—	—	—	420	19 806	20 226
68	23 November	—	—	—	—	260	8 009	8 269
Group 3 *T. axei* and closantel Day 0								
14	14 January	228	—	20	248	860	22 015	22 875
71	24 April	460	160	80	700	—	2 440	2 440
74	19 November	—	—	—	—	740	16 458	17 198
Group 4 Closantel Day 0, *T. axei* Day +63								
16	—	No necropsy						
19	21 February	—	—	40	40	140	8 407	8 547
20	1 November	Pneumonia (no necropsy)						
75	4 April	—	—	—	—	20	15 092	15 112
158	—	—	—	500	500	—	6 180	6 180
Group 5 *T. axei* Day 0, closantel Day +63								
86	27 November	—	—	341	341	—	9 858	9 858
157	15 November	No necropsy						
Group 7 Controls								
92	—	No necropsy						
155	7 October	No necropsy						
Group 8 *T. axei* Day +63								
37	13 June	Broken leg (no necropsy)						
99	9 May	—	—	280	280	—	20 213	20 213
100	26 January	No necropsy						
154	17 October	No necropsy						
Group 9 *T. axei* and closantel Day + 63								
46	28 February	No necropsy						

In contrast to the flooding conditions in 1978 (Reinecke *et al.*, 1984 b), the summer of 1979 was very dry (only 242,0 mm of rain falling from December to May) and unsuitable for the pasture stages of *H. contortus*. This was confirmed in the first place by the fall in worm egg counts of the seeders from a peak in November, but after treatment of those sheep having 23 000 epg or more, the egg count fell steadily throughout the summer and autumn (Fig. 1). Moreover, the controls (Groups 1 & 7) acquired very light infestations, maximum egg counts ranging from 4 800–6 700 epg compared with 14 000–100 400 epg above, more than twice to 15 times higher than in comparable groups of Merinos in the previous summer (Reinecke *et al.*, 1984 b). Moreover, under the hot, dry conditions the grass did not grow normally and the paddock had very little grazing.

From March 1979 supplementary chaffed lucerne hay (about 300 kg per day) was placed in troughs and eaten overnight. It was apparent that these sheep would have to be challenged experimentally with the UP strain of *H. contortus*, so, on 2 successive days 6–7 months after initial dosage with *T. axei*, Groups 1–6 were challenged in March, Groups 7–11 in mid-June and Groups 12–14 (Merinos) early in May. Four–6 weeks later the respective groups were killed for worm counts. When compared with the controls, only Group 11, predosed with irradiated *T. axei* on Day +63, showed a significant reduction (P = 0,025) when compared with the controls Group 7. In the other groups, Group 2 (P = 0,003) and Group 4 (P = 0,049) showed only a significant reduction when compared with their controls Group 1. Possibly delaying the challenge with *H. contortus* for 6 months was too long to expect good results. Even the Merinos that had survived from the previous year showed no significant difference (Groups 13 & 14) when compared with the controls (Group 12).

It was apparent that the results of the present trial showed none of the real protection we had seen in the first field trial in Merinos (Reinecke *et al.*, 1984 a). In restrospect, the predosing was done at the right time, the challenge with *H. contortus* took place over months and there was excellent protection (Reinecke *et al.*, 1984 a). The following year massive challenge broke down the resistance and sheep started dying in autumn (Reinecke *et al.*, 1984 b). The present experiment was not a field trial. Challenge with infective larvae of *H. contortus* on natural grazing was very light and our experimental challenge with *H. contortus* 6–7 months after predosing with *T. axei*, with a few exceptions, developed normally, ending with similar worm burdens of *H. contortus* both in the predosed groups and the controls.

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