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PARASITES OF DOMESTIC AND WILD ANIMALS IN SOUTH AFRICA. VI. HELMINTHS IN CALVES ON IRRIGATED PASTURES ON THE TRANSVAAL HIGHVELD

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ABSTRACT

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Sets of tracer calves, which were exposed for 2 months on irrigated pasture and then slaughtered, provided evidence of the extent of seasonal helminth infestation.

Haemonchus spp. were the most abundant nematodes, the largest numbers of which were generally recovered from May–August. Marked inhibition of development in the 4th larval stage was noted from May–November.

Trichostrongylus spp. were recovered in modest numbers with the highest burdens generally present in May, June and October.

In the first year of the survey *Cooperia* spp. were recovered in small numbers, but in the second year burdens increased from February–June.

Résumé

PARASITES DES ANIMAUX DOMESTIQUES ET SAUVAGES EN AFRIQUE DU SUD. VI. HELMINTHES DES VEAUX SUR PÂTURAGES IRRIGUÉS DES HAUTS PLATEAUX DU TRANSVAAL

L'amplitude de l'infestation helminthique saisonnière a été documentée au moyen de groupes de veaux indicateurs, exposés pendant 2 mois sur pâturages irrigués et sacrifiés ensuite.

Les divers Haemonchus *ont été les nématodes les plus abondants: les récoltes ont généralement atteint leur plus grande abondance de mai à août. De mai à novembre on a observé une nette inhibition du développement au 4e stade larvaire.*

Les espèces de Trichostrongylus *ont été récoltées en quantités modestes, les charges maximales se présentant généralement en mai, juin et octobre.*

Pendant la première année de l'enquête Cooperia *spp. n'ont été cueillis qu'en petites quantités, mais pendant la seconde année les charges se sont accrues de février à juin.*

INTRODUCTION

The seasonal incidence of certain parasitic nematodes of cattle has been determined from slaughtered tracer calves exposed to infestation for short periods in the United Kingdom (Anderson, Armour, Jennings, Ritchie & Urquhart, 1965, 1969; Michel, Lancaster & Hong, 1970), in New Zealand (Brunsdon, 1972), and in Canada (Smith, 1974). A striking feature of these surveys is inhibited larval development during the 4th stage if infestation is acquired during autumn or winter. Only Brunsdon (1972), however, followed the incidence of infestation throughout the year in New Zealand by regularly slaughtering tracer calves. In the other 2 countries, probably because of the severe winters, calves were exposed only from spring or summer until autumn.

In South Africa, the seasonal incidence of nematode infestation in calves has been determined in 2 surveys based largely on differential faecal worm egg counts (Reinecke, 1960b; Hobbs, 1961). Both these surveys were conducted in summer rainfall regions, one in the north-western Cape Province and the other in the Natal coastal region. So far no surveys in cattle, based on actual worm counts at necropsy, have been published in this country.

This paper describes a survey in which tracer calves were slaughtered at fairly regular intervals after exposure to infestation on irrigated pastures at Hennops River (25° 50′S; 27° 58′E; Alt. ±1280 m) in the Transvaal. This survey was conducted concurrently with a similar survey in sheep (Horak & Louw, 1977) and the results are compared.

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MATERIALS AND METHODS

Pastures

The calves were grazed from spring until autumn on a newly-established Kikuyu grass (*Pennisetum clandestinum*) pasture approximately 0,4 ha in size and, during the winter, on an adjacent grass/clover pasture of approximately 0,6 ha.

Infestation and management

During January 1969 two 10-month-old Afrikaner oxen with worm egg counts of 300–500 eggs per gram of faeces from naturally acquired infestations of *Haemonchus placei, Trichostrongylus* spp., *Cooperia* spp., *Oesophagostomum radiatum* and *Trichuris* spp., were placed in a movable pen enclosing 0,05 ha of pasture.

Four days later two 5-month-old Friesland-type calves, raised under wormfree conditions, were added to the pen. One of these calves died, but the other was left with the Afrikaners for 3½ months to infest the pasture. The Afrikaners were then removed, but the surviving Friesland calf remained on the pasture for a further year.

Before the tracer calves were introduced, the pen with infested calves was moved every few days so that the entire Kikuyu pasture could become contaminated. Thereafter the pen was only moved when the enclosed vegetation had been depleted.

On 23 May 1969, the calves were removed from the Kikuyu pasture, and since it was badly frosted and had stopped growing, were placed on the adjacent grass/clover pasture, which had previously been grazed by sheep (Horak & Louw, 1977). The calves were reintroduced on to the Kijuyu pasture on 8 October 1969. The grass/clover pasture was grazed by the sheep during October 1969 and thereafter was cut for hay until April 1970, when sheep were grazed for a week; the calves were reintroduced on 11 May and remained there until the completion of the survey.

Owing to a shortage of grazing, the calves were fed lucerne hay in the pen from April–July 1969.

The pastures were irrigated by means of sprinklers, approximately 37,5 mm of water being supplied on each occasion, and fertilizer was applied when necessary. Rainfall and daily minimum and maximum atmospheric temperatures were recorded.

Tracer calves

After the seeders had been on the Kikuyu pasture for about a month, 2 wormfree Friesland-type calves, approximately 5 months old, were placed in the pen. This procedure was repeated at monthly intervals whenever possible until April 1970. The newly introduced calves were kept on the pasture for 2 months before slaughter, thus allowing an overlap of 1 month between successive pairs. On their removal from the pasture the calves were starved for 48 hours prior to slaughter.

Slaughter and counting techniques

The right lung and the abomasal-intestinal tract of each calf were processed for worm recovery in a modified Baermann apparatus in a waterbath maintained at 42° C. Scrapings, made separately from the mucosa of the abomasum, small intestine and large intestine, were subjected to pepsin/HCl digestion (Reinecke, 1967; Horak & Pienaar, 1972).

Worm burdens were calculated from total counts and from counts made on representative samples.

RESULTS

The worm burdens of the tracer calves are summarized in Table 1.

Haemonchus spp.: The adult worms were identified as *H. placei* but the immature worms could have been either this species or *Haemonchus contortus* of ovine origin. The calves slaughtered from July–October 1969 and during June 1970 had all grazed pasture previously grazed by sheep infested with *H. contortus* and could therefore have picked up this species. Peak 4th stage burdens, mainly early 4th stage larvae, of over 17 000 worms were recovered from both the calves slaughtered during July 1969 and from 1 calf during June 1970. Adult burdens of over 1 500 worms were recovered from some of the calves slaughtered during April 1969 and February and March 1970.

Ostertagia circumcincta: This nematode was acquired from the pasture previously grazed by sheep.

Trichostrongylus spp.: Both *Trichostrongylus axei* and *Trichostrongylus colubriformis* were recovered in small numbers, their combined burdens only exeeding 1 000 worms in 1 of each pair of calves slaughtered during May and October 1969 and June 1970.

Cooperia spp.: The level of infestation with *Cooperia pectinata* and *Cooperia punctata* was considerably higher during 1970 than during 1969. Peak burdens were recovered from the calves slaughtered during May and July 1969 and from March–June 1970. With the exception of the burdens of the calves slaughtered from October–December 1969, 4th stage larvae rarely accounted for more than ⅓ of the total worm burden.

TABLE 1 Total worm burdens of the tracer calves

Date slaughtered	No. of nematodes recovered at autopsy											
	Haemonchus spp.		*O. circumcincta*		*Trichostrongylus* spp.		*Cooperia* spp.		*N. spathiger*	*O. radiatum*		*Trichuris* spp.
	4th	Audult	4th	Adult	4th	Adult	4th	Adult	Total	4th	Adult	Total
1969												
13 Apr.	4 355	1 556	0	0	0	285	0	25	0	1	32	6
14 May	7 860	20	0	0	0	1 405	45	309	2	32	45	4
14 May	4 510	54	0	0	0	308	26	230	0	9	38	18
11 Jul	18 390	95	650	0	0	210	15	422	0	0	0	15
11 Jul	17 270	0	125	0	0	103	4	126	1	0	3	18
11 Aug	7 366	86	0	0	0	85	0	147	97	0	2	174
11 Aug	7 045	83	0	0	0	123	0	89	63	16	1	5
10 Sep	2 162	2	0	0	0	25	0	28	9	1	3	22
10 Sep	2 560	8	0	0	20	51	0	22	0	0	1	11
8 Oct	244	28	0	0	540	592	12	8	17	10	0	11
8 Oct	1 107	28	0	0	0	366	1	38	3	4	4	9
5 Nov	1 107	5	0	0	100	590	33	32	4	0	0	6
5 Nov	961	13	0	0	83	241	22	13	6	1	0	4
3 Dec	2 687	765	0	1	0	11	61	123	35	0	1	6
3 Dec	5 540	1 395	0	0	0	204	154	178	0	0	3	0
1970												
8 Jan	343	183	0	2	0	49	33	186	0	0	0	1
8 Jan	802	1 025	83	20	15	118	29	325	0	12	5	1
9 Feb	2 905	1 803	0	0	0	124	153	456	0	2	0	5
9 Feb	2 299	2 879	60	105	0	235	345	751	4	0	6	47
19 Mar	3 260	1 803	0	0	4	675	1 640	8 749	0	1	13	3
19 Mar	1 750	397	0	0	8	313	495	4 545	0	0	0	31
15 Apr	195	5	0	0	0	15	195	5 423	0	2	0	3
15 Apr	1 700	176	0	0	0	91	800	2 612	0	0	2	8
14 May	2 720	1 078	50	0	80	355	6 660	19 034	15	3	7	15
12 Jun	7 790	127	0	95	235	975	320	6 236	5	0	2	65
12 Jun	17 130	55	400	0	0	885	490	22 215	27	0	7	65

4th=Fourth stage larvae

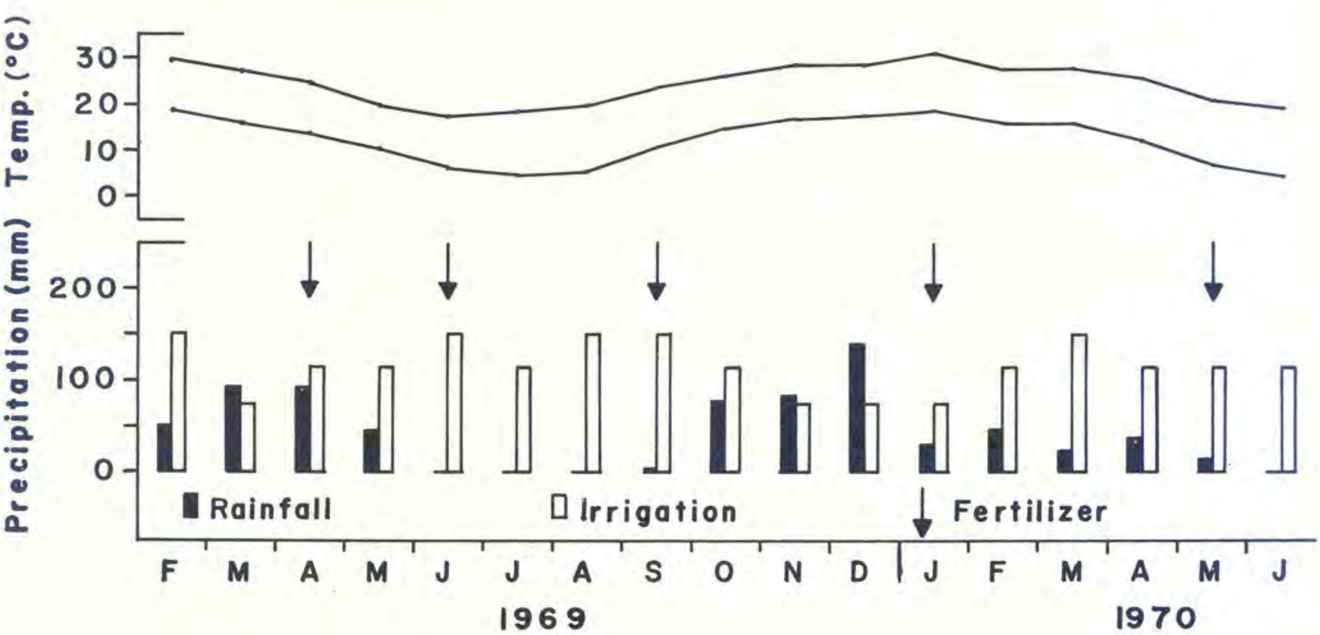

FIG. 1 Atmospheric temperature, rainfall, irrigation and fertilizer applications on the pastures

Nematodirus spathiger: This parasite was probably introduced on to the pastures by sheep and was erratically recovered in small numbers throughout the trial period.

Oesophagostomum radiatum: The first 3 calves slaughtered had burdens of over 30 worms, but subsequently burdens were low and 4 calves harboured no worms at all.

Trichuris spp.: Worm burdens of this genus were generally low, the highest individual burdens being recorded during August 1969 and June 1970.

Other helminths: Three calves harboured 28, 26 and 11 adult *Bunostomum phlebotomum* respectively and 3 other calves harboured 5, 2 and 4 *Moniezia* spp. scolices respectively.

The monthly rainfall, mean minimum and maximum atmospheric temperatures, irrigation and fertilizer applications on the pastures are graphically reproduced in Fig. 1.

Peak atmosheric temperatures were recorded from November 1969–January 1970 and the lowest during June–August 1969 and May and June 1970. The amount of water supplied to the pasture by irrigation never fell below a monthly total of 75 mm.

The mean monthly totals and percentages of *Haemonchus* spp. 4th stage larvae recovered from the tracer calves and of *H. contortus* recovered from tracer lambs grazing the pastures at Hennops River (Horak & Louw, 1977) are summarized in Table 2.

Peak total burdens were recorded in the calves slaughtered from May–August, while burdens of fewer than 2 000 worms were recovered from the calves slaughtered during January, October and November. More than 90% of the worms were in the 4th larval stage in the calves slaughtered from May–November.

Peak total burdens were recovered from the tracer lambs during April and May, while burdens of fewer than 1 000 worms were recorded during January and from June–December. From April–July more than 90% of the worms were 4th stage larvae.

TABLE 2 The mean monthly *Haemonchus* spp. burdens of tracer calves and lambs at Hennops River

Month slaughtered	Calves			Lambs		
	Total No. slaughtered	*Haemonchus* spp. recovered		Total No. slaughtered	*H. contortus* recovered	
		Mean total	% 4th stage		Mean total	% 4th stage
Jan.	2	1 177	48,7	9	696	43,8
Feb.	2	4 943	52,6	10	1 168	65,2
March	2	3 605	69,5	10	1 003	61,6
April	3	2 662	78,3	13	3 840	92,5
May	3	5 414	92,9	13	4 127	92,9
June	2	12 551	99,3	10	720	95,6
July	2	17 878	99,7	10	198	92,1
Aug.	2	7 290	98,8	8	238	82,6
Sept.	2	2 366	99,8	8	33	60,8
Oct.	2	704	96,0	10	32	75,2
Nov.	2	1 043	99,1	13	137	10,1
Dec.	2	5 194	79,2	13	462	36,6

Discussion

In the surveys conducted in sheep at Hennops River marked inhibited development of *Haemonchus contortus* during April–July was a striking feature (Horak & Louw, 1977). In this survey more than 90% of *Haemonchus* spp. failed to develop to maturity from May–November.

In the former surveys the tracer sheep were exposed to infestation for periods of only 33 days and it was felt that immunity induced by continuous exposure was unlikely to have caused any retardation of larval development. In this survey the tracer calves were allowed to graze for 2 months and the continuous ingestion of larvae may have stimulated an immune response, resulting in inhibited development, as noted by Roberts (1957) in calves infested artificially each day. From May–November inhibition was virtually complete, irrespective of whether the calves harboured burdens of 1 000 or 18 000 worms, whereas during December–April some worms developed to adulthood whether total burdens consisted of 500 or 6 900 worms. This largely discounts the possibility that immunity was the sole inhibiting factor, though it was probably partly responsible for the generally high degree of inhibition encountered in all calves throughout the survey.

It could be argued that the accumulation of 4th stage larvae in the calves slaughtered during July 1969 and June 1970 was due to the ingestion of *H. contortus* larvae on the pastures previously grazed by sheep and the failure of this parasite to develop to adulthood in calves. The calves slaughtered in May 1969, however, had grazed on the Kikuyu pastures contaminated only with *Haemonchus* spp. of bovine origin and these larvae also failed to develop into adults.

The calves were slaughtered 48 hours after their removal from the pasture, thus recently ingested 3rd stage larvae had time to develop to the 4th stage (Bremner, 1956). In this way the large burdens of immature worms could have been recently acquired. This, however, would not explain why the vast majority of larvae were still in the 4th stage after a 2-month grazing period.

Despite the above possibilities it is obvious that from May–November the development of *Haemonchus* spp. beyond the 4th larval stage was inhibited and that this nematode probably overwinters in the host animal in this state of hypobiosis.

This finding coincides with those arrived at for *Ostertagia ostertagi* by Anderson *et al.*, (1965, 1969) in Scotland and for *Cooperia oncophora* by Michel *et al.* (1970) in England and Smith (1974) in Canada. These helminths become inhibited in the host to survive severe winters whereas *H. placei,* a parasite of cattle in milder climates, uses the same method to survive comparatively mild winters.

The trigger mechanism for this inhibition could be environmental stimuli, such as chilling, acting on the infective larvae (Armour & Bruce, 1974). It has been suggested by Waller & Thomas (1975), however, that cold is not necessarily a stimulus for subsequent inhibition of development in *H. contortus* and that it may be due to adaptation of the parasite to the particular environment in which it finds itself.

The acquisition of *Haemonchus* spp. infestation from the pastures at Hennops River differed markedly between tracer calves and tracer lambs, particularly during the winter. The calves slaughtered during July and August harboured mean burdens of more than 7 000 worms whereas the lambs examined during the same months had mean burdens below 250 (Table 2). This variation in ability to survive on the pastures during winter indicates that the infestations acquired by the calves and lambs were either not of the same *Haemonchus* spp. or strain or that the cattle dung pat is a more effective reservoir of larvae during the winter than the faecal pellets of sheep.

The pattern of arrested larval development in the 2 host species also differed. In the calves more than 90% of the *Haemonchus* spp. burdens were in the 4th stage of larval development from May–November whereas this occurred in the lambs from April–July (Table 2). The generally higher proportion of larvae to adults in the calves is probably partly due to immunity as the calves grazed for 2 months compared with 33 days for the lambs.

These findings suggest that the generation interval of *Haemonchus* spp. in cattle at Hennops River is considerably longer than that of *H. contortus* in sheep. Marked inhibition of development was present for 7 months of the year in the former helminth compared with only 4 months in the latter. This observation appears to be anomalous because, judging by the large numbers of larvae acquired from the pastures during the winter, larvae of *Haemonchus* spp. of bovine origin can apparently survive on the pastures during these months better than those of ovine origin (Table 2). Yet this parasite undergoes a longer period of larval inhibition in calves in order to survive in the host rather than on the pastures.

The survival of the free-living stages of *Haemonchus* spp. during the winter is in agreement with the findings of Reinecke (1960b). He found that during winter in the north-western Cape Province, the larvae of *H. placei* could develop to the infective stage in the dung pat, albeit in reduced numbers, and that adequate moisture was essential for their survival. Irrigation of the pastures at Hennops River would have supplied the necessary moisture for wetting the crust of the dung pat, and thus have allowed the infective larvae to migrate on to the pastures (Roberts, O'Sullivan & Riek, 1952; Reinecke, 1960a).

The increased numbers of adult *H. placei* recovered from the calves slaughtered during December–April also agree with the findings of Reinecke (1960b). The increases he recorded in faecal worm egg counts due to *H. placei* from December onwards reached peaks in the autumn months. In Queensland, Australia, Roberts *et al.* (1952) recorded the highest egg counts for this nematode during the autumn and winter. The large larval burdens present in the calves slaughtered during autumn and winter confirm the observations, made also in Queensland by Durie (1962), who found that the larvae of *H. placei* were most abundant on a calf pasture during the late summer and winter.

Arrested development of *Cooperia* spp. was not evident in this survey. At Wallaceville in New Zealand, where the winters are colder than at Hennops River, Brunsdon (1972) recorded varying degrees of retardation in the 4th larval stage from April–September. In England and Canada, where the winters are still colder Michel *et al.* (1970) and Smith (1974) found that retardation of *C. oncophora* in the 4th larval stage was virtually complete in calves slaughtered during the late autumn. It would thus appear that the degree of larval inhibition and the time of its onset is dictated by the severity of the cold period during autumn and winter and consequently by its effect on the survival of the free-living stages.

The peak adult *Cooperia* spp. worm burdens recovered during the autumn and early winter coincide with the seasonal incidence of this parasite as described in the north-western Cape Province by Reinecke (1960b). In Queensland Durie (1962) estimated the daily ingestion of *Cooperia* spp. by calves to be greatest during June, July and December.

In the helminth surveys conducted in sheep at Hennops River (Horak & Louw, 1977), although *Oesophagostomum columbianum* was introduced on to the pastures by infested sheep during 1968, the infestation took a long time to become established; it was only during 1972 and 1973 that fairly large numbers of worms were recovered from the tracer lambs. Something similar seems to have befallen *O. radiatum* in the present survey: the first 3 calves slaughtered had fair burdens but thereafter infestation was erratic and burdens were small. It is, however, possible that the removal of the infested Afrikaner calves during May 1969 eliminated a major source of pasture contamination before the Friesland calf had become an active source of infestation.

The recovery from the tracer calves of immature and adult *O. circumcincta* and *N. spathiger*, which are regarded as parasites of sheep, indicates that they can survive in calves in the absence of their normal host.

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