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PARASITES OF DOMESTIC AND WILD ANIMALS IN SOUTH AFRICA. X. HELMINTHS IN IMPALA*

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ABSTRACT

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Two to four impala in the Nylsvley Nature Reserve were culled each month from February 1975–February 1976.

Two trematode species, 1 cestode species and 13 species of nematodes were recovered from these antelope. Of these, *Fasciola gigantica*, *Gongylonema pulchrum*, *Haemonchus placei* and *Trichostrongylus falculatus* are new records for impala.

In general, *H. placei*, *Longistrongylus sabie* and *Impalaia tuberculata* exhibited a similar pattern of seasonal occurrence. Adult worms were present during November–February, while marked inhibition in the development of large numbers of 4th stage larvae occurred from April–September or October. *Cooperia hungi*, *Cooperioides hamiltoni* and *Cooperioides hepaticae* followed a similar pattern, but inhibition in the 4th larval stage was not as marked and lasted from June–September.

No seasonal pattern of prevalence could be determined for *Trichostrongylus* spp.

The worm burdens of young impala increased with the age of the animals and reached a peak when the impala were 1 year old.

Résumé

PARASITES DES ANIMAUX DOMESTIQUES ET SAUVAGES EN AFRIQUE DU SUD. X. HELMINTHES DE L'IMPALA

Deux à quatre impalas ont été éliminés mensuellement de la Réserve naturelle de Nylsvley, de février 1975 *à février* 1976.

On a retrouvé chez ces antilopes 2 *espèces de trématodes, une de cestode et* 13 *de nématodes. Dans cette faune*, Fasciola gigantica, Gongylonema pulchrum, Haemonchus placei *et* Trichostrongylus falculatus *n'avaient pas encore été observés chez l'impala.*

De façon générale, H. placei, Longistrongylus sabie *et* Impalaia tuberculata *ont manifesté le même cycle d'occurrence saisonnière. Il y avait des vers adultes de novembre à février, cependant que d'avril à septembre ou octobre on a constaté une inhibition marquée du développement abondant des larves du* 4*e stade.* Cooperia hungi, Cooperioides hamiltoni *et* Cooperioides hepaticae *suivaient un cycle analogue, mais l'inhibition au* 4*e stade larvaire était moins marquée et ne durait que de juin à septembre.*

On n'a pu dégager aucun schéma de prévalence saisonnière chez les diverses espèces de Trichostrongylus.

Chez les jeunes impalas, les charges helminthiques augmentaient avec l'âge de l'animal, atteignant un sommet avec l'impala d'un an.

INTRODUCTION

Impala, the most numerous of all antelope species in the Transvaal, are of considerable commercial value as they are utilized for hunting, cropping, commercial game farming and as an attraction in game reserves. Any factors, including helminths, which may affect their productivity must be considered as important.

The helminths of impala have been studied by numerous authors (Mönnig, 1923, 1933; Ortlepp 1938, 1964; Heinichen, 1973; Gibbons, 1973; Sachs, Gibbons & Lweno, 1973; Anderson, 1976), and Round (1968) has compiled a check-list of these helminths. However, no studies on the seasonal prevalence of helminths in impala have been published.

On many ranches impala graze the same pastures as cattle, and cross-infestation between impala and cattle is a potential problem.

The present paper describes a survey conducted in impala culled on a farm in the northern Transvaal over a period of 13 months, the results of which are discussed in the light of similar surveys undertaken in sheep (Horak, 1978a; Horak & Louw, 1977), cattle, (Horak & Louw, 1978) and blesbok (Horak, 1978b), in the Transvaal.

* This survey forms part of the South African Savanna Ecosystem Project.

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MATERIALS AND METHODS

Study area

The Nylsvley Nature Reserve (24°29′S; 28°42′E; Alt. ±1 100 m) is situated in the Naboomspruit District of the Transvaal, and the impala were all culled within a 750 ha area in this reserve. The vegetation in this area is dominated by the woody species *Burkea africana* and *Ochna pulchra* and the grass species *Eragrostis pallens*. This area is grazed annually from January–May by approximately 200–300 cattle.

Helminth collection

Two to four impala were shot monthly from February 1975–February 1976. The carcasses were transported to a central point where they were skinned and eviscerated and the ages of the antelope determined on dentition. The rumens were opened immediately and the contents and walls examined for paramphistomes. The livers, lungs and gastro-intestinal tracts were placed in plastic bags and transported to the laboratory for further processing.

At the laboratory faeces were collected from the recta for faecal worm egg counts and the oesophagi opened and examined for *Gongylonema* spp. The tracheae and bronchial trees were opened and the air passages thoroughly washed over sieves with 38 μm apertures. *Fasciola* spp. were collected from the major bile ducts of the liver and the liver itself was finely sliced and incubated for 3 h in a 0,9% NaCl solution

TABLE 1 The total worm burdens of impala culled in the Nylsvley Nature Reserve

No. and sex	Age (m = months)	Month culled	Number of helminths recovered																	
			Param-phisto-mum sp.	*H. placei*		*L. sabie*		*Trichostrongylus* spp.				*I. tuberculata*		*Cooperia* and *Cooperioides*				*O. columbianum*		Other helminths
								4th	*T. axei*	*T. col.*	*T. falc.*			4th	*C. hungi*	*C. hamiltoni*	*C. hepaticae*			
				4th	Adult	4th	Adult		Adult	Adult	Adult	4th	Adult		Adult	Adult	Adult	4th	Adult	
1 M.	3m.	Feb. 75.	0	6	40	0	0	10	0	50	0	20	249	60	256	30	0	0	0	
2 M.	15m.	Feb. 75.	0	102	250	5	225	0	0	1 415	112	1 327	4 649	281	1 403	795	0	0	12	
3 F.	Adult.	March.	91	448	187	442	220	40	0	435	267	3 362	3 859	2 640	1 122	2 611	0	0	23	
4 F.	Adult.	March.	68	185	15	471	15	5	16	0	0	2 426	0	7 333	490	60	2	0	0	
5 M.	Adult.	March.	60	96	65	30	155	6	0	901	0	2 241	1 752	241	1 009	800	33	0	12	4 *F. gigantica*, 1 *Trichuris* sp.
6 M.	5m.	April.	0	445	200	11	0	0	25	90	20	1 856	211	547	219	35	9	0	0	
7 M.	5m.	April.	0	282	0	109	5	30	16	191	80	2 129	562	358	212	80	33	0	0	
8 F.	Adult.	April.	0	826	50	198	10	5	0	553	163	6 107	124	1 874	496	624	1	23	2	2 *M. expansa*
9 M.	Adult.	April.	0	604	20	167	20	0	0	1 040	0	7 154	3 349	1 727	1 964	240	3	1	35	1 *G. pulchrum*
10 F.	6m.	May.	0	471	25	183	0	30	275	414	80	2 095	414	612	354	268	33	0	0	
11 F.	Adult.	May.	2	5 040	13	1 099	1	20	66	1 562	0	10 354	421	3 013	685	2 436	1	30	2	3 *M. expansa*
12 F.	7m.	June.	0	467	5	81	5	26	130	183	261	3 050	131	907	116	73	4	0	0	2 *M. expansa*
13 M.	Adult.	June.	54	1 493	60	307	120	200	293	1 670	241	4 696	60	1 790	140	181	2	0	9	
14 M.	Adult.	June.	22	1 175	40	551	170	80	161	1 723	260	12 800	3 874	4 888	586	972	34	0	6	
15 F.	20m.	July.	18	770	1	519	0	4	0	631	0	9 469	0	5 165	10	200	0	10	1	
16 F.	Adult.	July.	31	600	10	1 135	0	0	0	0	0	1 947	0	3 748	20	343	5	20	0	
17 F.	Adult.	July.	16	1 490	10	8 586	0	80	60	2 600	0	9 354	0	11 868	110	0	2	0	6	3 *G. pulchrum*, 1 *M. expansa*
18 M.	Adult.	July.	37	1 777	20	577	10	164	361	3 040	180	18 285	3 740	3 665	885	1 300	492	30	26	1 *M. expansa*
19 M.	Adult.	August.	0	645	0	683	0	1	518	1 020	0	16 780	40	6 285	0	715	37	40	19	
20 M.	Adult.	August.	17	833	0	393	1	40	0	1 265	10	13 360	535	2 805	2 981	720	92	0	8	
21 M.	10m.	Sept.	0	66	30	103	27	20	92	515	480	4 705	520	1 145	281	80	169	0	21	
22 M.	10m.	Sept.	0	553	100	53	26	0	130	220	260	3 610	365	795	120	0	320	0	4	1 *M. expansa*
23 M.	22m.	Sept.	6	1 588	40	3 396	11	20	150	8 058	0	7 040	0	18 285	180	780	61	0	5	
24 M.	23m.	October.	0	462	270	262	12	1	0	540	0	3 910	1 195	1 290	520	855	33	0	1	1 *M. expansa*
25 M.	23m.	October.	17	870	450	86	1	0	0	540	0	280	665	120	90	80	2	0	13	
26 M.	Adult.	October.	41	320	220	235	0	0	0	0	0	4 590	1 705	750	385	185	14	0	18	
27 M.	12m.	November.	0	50	61	95	247	0	70	874	154	1 330	9 022	604	1 652	1 596	97	0	51	2 *M. expansa*
28 M.	12m.	November.	0	110	80	8	540	0	30	581	400	180	3 984	301	1 063	784	78	0	24	
29 M.	12m.	November.	0	131	131	36	769	0	160	694	100	632	5 050	802	1 168	1 459	112	0	28	3 *M. expansa*
30 F.	Adult.	December.	11	27	0	320	419	20	0	3 692	110	6 152	8 146	1 322	1 559	4 560	3	20	71	
31 M.	Adult.	December.	11	20	70	24	94	0	0	0	0	7 243	20	4 902	531	30	0	0	0	
32 F.	1½m.	Jan. 76.	0	0	0	0	1	0	0	2	0	0	6	0	2	0	0	0	0	3 *Strongyloides* sp.
33 F.	1½m.	Jan. 76.	0	0	0	0	0	0	0	1	0	0	4	0	10	0	0	0	0	
34 M.	1½m.	Jan. 76.	0	5	9	0	3	0	0	12	13	0	46	0	29	1	0	0	0	5 *Strongyloides* sp.
35 M.	15m.	Feb.	285	0	20	30	390	0	10	0	0	1 290	260	640	120	420	112	1	3	
36 M.	15m.	Feb.	16	20	40	0	120	0	0	10	0	1 520	208	360	350	60	1	0	0	

T. col. = *T. colubriformis* *T. falc.* = *T. falculatus* M = Male F = Female
4th = Fourth stage larvae

in a waterbath maintained at 45 °C. The slices were thoroughly washed and the washings and saline in which the liver had been incubated were poured through sieves with 38 μm apertures.

All sieved material was preserved with 10% formaldehyde solution and stored for later examination.

Worm counts

Two aliquots, each representing either 1/10th, 1/20th or 1/40th of the gastro-intestinal ingesta were examined microscopically and the worms counted, while the balance of the contents of the small and large intestine was examined macroscopically for large helminths. The digests and lung and liver washings were examined microscopically *in toto*.

Helminth identification

The majority of adult worms recovered from the lungs, oesophagi, rumens, livers and ingesta of the gastro-intestinal tracts were identified specifically, while 50 immature worms in the abomasal samples and all the immature worms in one of the small intestinal samples and in both the large intestinal samples, when present, were identified generically.

General

Minimum and maximum atmospheric temperatures and rainfall were recorded in the study area.

RESULTS

The total helminth burdens of each of the impala are presented in Table 1.

The following trends were observed in the worm burdens of animals aged 12 months and more:

(a) Burdens of adult *Haemonchus placei* in excess of 100 worms were recovered from individual animals during February, March and November and from all animals in October 1975. Fourth stage larvae reached peak levels from April–October.

(b) *Longistrongylus sabie* adults reached peak levels in February, March, June, November and December, and 4th stage larvae from May–September.

(c) No clear pattern could be determined for the seasonal incidence of *Trichostrongylus* spp., but burdens below the mean were recovered during March, April and October 1975 and February 1976.

(d) More than 4 000 adult *Impalaia tuberculata* were recovered from animals culled during February, November and December 1975. Peak numbers of 4th stage larvae were recovered from April–September and in December.

(e) In general terms the adult burdens of *Cooperia hungi* and *Cooperioides hamiltoni*, following similar patterns, reached peaks from February–May and during August, November and December 1975. Adult *Cooperioides hepaticae* appeared to be more abundant from July–November. Peak numbers of 4th stage larvae of all 3 species were recovered from July–September, but since they could not be identified generically they are grouped as one.

(f) Fourth stage larvae of *Oesophagostomum columbianum* were recovered from animals slaughtered during April, May, July, August and November, while the largest numbers of adult worms were encountered during November and December.

One animal harboured 4 *Fasciola gigantica* and 1 *Trichuris* sp., 2 harboured *Gongylonema pulchrum*, 2 of the 3 six-week-old impala were infested with *Strongyloides* sp., and 9 animals were infested with *Moniezia expansa*.

Table 2 is a record of the mean monthly total burdens of the major genera and the percentage of these worms, excluding *Trichostrongylus* spp., in the 4th stage of larval development in the animals aged 12 months and more.

More than 90% of the worms were retarded in the 4th stage at different times: *H. placei* from April–September, *L. sabie* during April and May and from July–October, *I. tuberculata* during May and from July–September and *C. hungi*/*Cooperioides* spp. during September.

The animals 1–12 months of age are ranked according to age and their worm burdens summarized in Table 3.

TABLE 2 The mean monthly worm burdens of older impala culled in the Nylsvley Nature Reserve

Month	No. of impala examined	Mean numbers of worms recovered								
		H. placei		*L. sabie*		*Trichostrongylus* spp.	*I. tuberculata*		*Cooperia & Cooperioides*	
		Total	% 4th	Total	% 4th	Total	Total	% 4th	Total	% 4th
1975										
February	1	352	29,0	230	2,2	1 527	5 976	22,2	2 479	11,3
March	3	332	73,2	444	70,7	557	4 547	58,9	5 447	62,5
April	2	750	95,3	198	92,4	881	8 367	79,2	3 465	52,0
May	1	5 053	99,7	1 100	99,9	1 648	10 775	96,1	6 135	49,1
June	2	1 384	96,4	574	74,7	2 314	10 715	81,6	4 297	77,7
July	4	1 170	99,1	2 707	99,9	1 780	10 699	91,3	6 953	87,9
August	2	739	100,0	539	99,9	1 427	15 358	98,1	6 818	66,7
September	1	1 628	97,5	3 407	99,7	8 228	7 040	100,0	19 306	94,7
October	3	864	63,7	199	97,8	360	4 115	71,1	1 441	50,0
November	3	188	51,7	565	8,2	1 021	6 733	10,6	3 239	17,6
December	2	59	40,2	429	40,1	1 911	10 781	62,1	6 454	48,2
1976										
January	0	—	—	—	—	—	—	—	—	—
February	2	40	25,0	270	5,6	10	1 639	85,7	1 032	48,5

4th—4th stage larvae

TABLE 3 The worm burdens of impala up to 1 year of age culled in the Nylsvley Nature Reserve

No. and sex	Age in months	Month culled	Total numbers of helminths recovered												
			H. placei	*L. sabie*	4th stage *Trichostrongylus* spp.	**T. axei*	**T. colubriformis*	**T. falculatus*	*I. tuberculata*	4th stage *Cooperia* and *Cooperioides* spp.	**C. hungi*	**C. hamiltoni*	**C. hepaticae*	*O. columbianum*	Other helminths
32 F......	1½	Jan. 76........	0	1	0	0	2	0	6	0	2	0	0	0	3 *Strongyloides* sp.
33 F......	1½	Jan. 76........	0	0	0	0	1	0	4	0	10	0	0	0	0
34 M......	1½	Jan. 76........	14	3	0	0	12	13	46	0	29	1	0	0	5 *Strongyloides* sp.
1 M.......	3	Feb. 75........	46	0	10	0	50	0	269	60	256	30	0	0	0
6 M.......	5	Apr. 75........	645	11	0	25	90	20	2 067	547	219	35	9	0	0
7 M.......	5	Apr. 75........	282	114	30	16	191	80	2 691	358	212	80	33	0	0
10 F......	6	May 75........	496	183	30	275	414	80	2 509	612	354	268	33	0	0
12 F......	7	June 75........	472	86	26	130	183	261	3 181	907	116	73	4	0	2 *M. expansa*
21 M......	10	Sept. 75.......	96	130	20	92	515	480	5 225	1 145	281	80	169	21	0
22 M......	10	Sept. 75.......	653	79	0	130	220	260	3 975	795	120	0	320	4	1 *M. expansa*
27 M......	12	Nov. 75.......	111	342	0	70	874	154	10 352	604	1 652	1 596	97	51	2 *M. expansa*
28 M......	12	Nov. 75.......	190	548	0	30	581	400	4 164	301	1 063	784	78	24	0
29 M......	12	Nov. 75.......	262	805	0	160	694	100	5 682	802	1 168	1 459	112	28	3 *M. expansa*

* Adult worms only M—Male F—Female

TABLE 4 Mean monthly faecal worm egg counts, atmospheric temperature and rainfall

Month	Faecal worm egg count (e.p.g.)	Atmospheric temperature °C			Rainfall	
		Min.	Max.	Mean	mm	No. of days on which rain fell
1975						
Feb.	6 800	—	—	—	—	—
Mar.	2 567	—	—	—	—	—
Apr.	1 450	—	—	—	—	—
May	200	8,3	24,1	16,2	5,7	5
Jun.	700	5,1	20,6	12,9	10,6	3
Jul.	50	3,1	21,0	12,1	0,0	0
Aug.	300	7,0	23,7	15,4	4,5	1
Sep.	433	10,9	27,8	19,4	0,2	1
Oct.	433	13,4	28,9	21,2	22,3	5
Nov.	3,667	15,5	29,4	22,5	57,7	13
Dec.	2 300	16,0	27,6	21,8	203,4	18
1976						
Jan.	—	16,5	27,9	22,2	102,6	11
Feb.	100	16,3	27,8	22,1	149,7	10

No climatic data are available for February–April 1975
e.p.g.—Eggs per g of faeces

Only the youngest animals were infested with *Strongyloides* sp., and they also harboured small burdens of *H. placei. L. sabie, Trichostrongylus* spp., *I. tuberculata, C. hungi* and *C. hamiltoni*. As the animals became older they harboured greater burdens of all these helminths excluding *Strongyloides* sp.

The first *C. hepaticae* infestations were encountered in 5-month-old animals, *M. expansa* in an animal of 7 months, and *O. columbianum* in impala 10 months of age.

The mean monthly atmospheric temperatures, rainfall and faecal worm egg counts of all impala over 6 months of age are summarized in Table 4.

Egg counts were at a high level from February–April, but a subsequent decrease was followed by a marked rise in November and December.

Rainfall was virtually confined to the warmer months.

Discussion

This survey yielded 4 new parasite records for impala, namely, *F. gigantica, G. pulchrum, H. placei* and *T. falculatus*. These helminths and *M. expansa, T. axei, T. colubriformis, O. columbianum* and *Paramphistomum* sp., are usually encountered in sheep or cattle in South Africa. Of the other helminths recovered from the impala, *I. tuberculata* and *L. sabie* have been found in small numbers in cattle grazing in the same area as the buck at Nylsvley and these parasites have been transmitted artificially to sheep and cattle (Horak, unpublished data). From this it is obvious that a considerable overlapping of the helminthic fauna parasitic in sheep, cattle and impala occurs. This is not surprising considering the long history of close association between these hosts on farms in South Africa. The large number of helminth species recovered from the impala in the present survey, however, is in sharp contrast to the small number, 6 species in all, recovered from blesbok in a survey in the northern Transvaal (Horak, 1978b).

Marked seasonal inhibition in the development of a number of the nematode species parasitizing the impala in the present survey was evident during the cooler months. Baker & Anderson (1975) recorded this phenomenon in *Ostertagia* spp. infesting white-tailed deer in Ontario, Canada, and Horak (1978b) described it in *H. contortus* in blesbok in the Transvaal. It is thus probable that it occurs in many nematode species parasitizing wildlife.

The period of marked inhibition of development of *H. placei* in the 4th larval stage in the impala is more prolonged than that of *H. contortus* in sheep on dryland or irrigated pasture in the Transvaal (Horak, 1978a; Horak & Louw, 1977). Its duration is shorter however, than that of *Haemonchus* spp. in cattle on irrigated pasture (Horak & Louw, 1978). In blesbok, in the northern Transvaal, *H. contortus* also exhibited a tendency to inhibition in the 4th larval stage during July–September (Horak, 1978b).

Gibbons (1977) proposed that the genera *Bigalkenema* and *Kobusinema* be regarded as synonyms of the earlier genus *Longistrongylus* because of morphological similarities, and that the species of the 2 genera be transferred to *Longistrongylus*. *L. sabie* is used here therefore, instead of *Bigalkenema sabie*. Adult *L. sabie* are similar in morphology to *Ostertagia* spp. and the description by Douvres (1956) of the 4th stage larvae of *Ostertagia ostertagi* was used to identify 4th stage *L. sabie* larvae. Not only are these worms similar in appearance but their development in the abomasum is also similar, as will be discussed later.

A larger percentage of *L. sabie* were inhibited for a longer period than was the case with *Ostertagia* spp. in sheep on dryland or irrigated pasture (Horak, 1978a; Horak & Louw, 1977). In both these genera, however, there was a temporary break in inhibition in June when greater numbers developed to the adult stage.

Impalaia tuberculata also exhibited a high degree of larval inhibition during the cooler months. The infective larvae of *Impalaia nudicollis*, described by Mönnig in 1931, are characterized by a pigmented, cup-shaped anterior swelling of the oesophagus and a tail with 2 distinct points. The infective larvae of *I. tuberculata* appear identical with those of *I. nudicollis* and, because the tail also has 2 distinct tips in the 4th larval stage, these larvae could be differentiated from those of *Cooperia* spp. and *Cooperioides* spp.

Unfortunately the 4th stage larvae of *C. hungi* and the 2 *Cooperioides* spp. could not be differentiated but it would appear that inhibition, which was not as marked as in *I. tuberculata*, was present in these species from June–September. These findings differ from those for *Cooperia* spp. (*C. pectinata* and *C. punctata*) in cattle on irrigated pasture in which there was no inhibited development during the cooler months of the year (Horak & Louw, 1978). They are similar, however, to those observed in sheep on dryland pasture in which *Cooperia* spp. exhibited increasing degrees of inhibited development from February–May, after which infestation disappeared from the pasture (Horak, 1978a).

It must be remembered that in the present survey the impala had been continuously exposed to infestation, whereas in the sheep and cattle surveys referred to the animals were kept worm-free until exposure on the pastures and were only then exposed for a short period of time before slaughter. Immunity resulting from the continual challenge thus probably also played a role in inhibiting larval development in the impala. This probability is supported by the fact that in the majority of young impala, that is, animals that had been exposed to infestation for a comparatively short time, the worm burdens contained a greater proportion of adult worms than in adult animals culled at the same times. Nevertheless, the seasonal pattern of larval inhibition in these young animals was similar to that of the older antelope.

The seasonal inhibition of larval development inside the host ensures the survival of the parasite in a favourable environment, while conditions on the pasture are unsuitable for its continued existence (Muller, 1968; Southcott, Major & Barger, 1976). The trigger mechanism bringing about arrested larval development could be one of the environmental stimuli, such as chilling, acting on the infective larvae (Armour & Bruce,1974). It has been suggested by Waller & Thomas (1975) that in certain environments cold is not necessarily a stimulus for subsequent inhibition of development of *H. contortus*, but that instead it may be due to adaptation of the parasite to its particular environment.

The release of these larvae from their inhibited state and the resumption of their development to adulthood account for the rapid rise in egg counts during November and December. In the impala ewes it is possible that, as in the case of sheep, periparturient relaxation of resistance (Kelly, Gordon & Whitlock, 1976) and the effects of lactation on the immune response (Connan, 1976) would also release immunologically inhibited larvae and thus further enhance the rise in egg counts. Since this increase in pasture contamination coincides with the birth of the impala lamb crop, which takes place in November and December, young susceptible animals are exposed to infestation at an early age. Judging by the worm burdens and faecal egg counts of the three, 12-month-old impala culled during November (Table 4), lambs born in the previous year play a major role in contaminating the pasture for the succeeding lamb crop.

The resumed development of the arrested larvae of *L. sabie* in November and December is comparable with that of *O. ostertagi* in cattle in Scotland in which Type II ostertagiasis occurs in late winter or early spring following the resumed development of inhibited 4th stage larvae (Armour, 1974). The only macroscopic lesions caused by *L. sabie* were encountered in the impala culled during November and December (early summer). As many as 165 clearly circumscribed, raised nodules approximately 4 mm in diameter were present in the abomasa of these buck. The mucosal covering of the centre of some of these nodules had eroded and adult parasites extruded through these openings. Intact nodules when opened were found to contain adult parasites coiled in the mucosa. These nodules were seen at no other time of the year and, as relatively large numbers of arrested 4th stage larvae had been encountered in the abomasal digests in the preceding months, it seems logical to assume that they were due to the resumed development of these larvae in the abomasal mucosa. The normal, presumably rapid, development of larvae to adults which occurred in the months of February and March did not produce any macroscopically visible changes in the abomasal mucosa.

Although *Strongyloides* sp. larvae were recovered from the faecal cultures of a number of the impala, it was only in the $1\frac{1}{2}$-month-old impala that nematodes of this genus were recovered, and then only in very small numbers. The presence of this parasite in the very young buck suggests that the infestation may be milkborne as is the case with *Strongyloides papillosus* in sheep, cattle and goats (Lyons, Drudge & Tolliver, 1970; Moncol & Grice, 1974).

The majority of 4th stage larvae of *O. columbianum* were recovered from the antelope culled from April–August and the majority of older impala were infested with adult worms of this species from April–December, with peak burdens being recorded in November and December. This seasonal incidence closely corresponds to that of *O. columbianum* in sheep in South Africa as discussed by Reinecke (1964). No nodules, characteristic of *O. columbianum* infestation in sheep, were encountered in the small or large intestines of any of the antelope infested with this nematode, which suggests that the impala is possibly a better host than sheep for this parasite.

Moniezia expansa infestation was confined to those animals slaughtered from April–July and September–November. In sheep exposed to infestation for limited periods, major infestations were acquired from February–May and during November (Horak, 1978a; Horak & Louw, 1977).

The *Paramphistomum* sp. and *F. gigantica* infestations were most probably acquired from a large marshy area outside the study site, to which the impala had free access. *F. gigantica* has apparently not been found in wildlife in South Africa (Neitz, 1965), but it has been encountered in wildlife in other countries on the continent (Hammond, 1972).

In her study of the helminths of impala in the Umfolozi area of Zululand, Heinichen (1973) noted that a large proportion of the antelope was infested with the lungworm *Pneumostrongylus calcaratus*. Although the lungs of all the impala in the present survey were examined and processed for the recovery of lungworms, none were encountered.

A comparison of the worm burdens of the young impala culled at successive occasions until they reached 1 year of age made possible the determination of the seasonal availability of larvae on the pasture. The very young impala shot during January and February would not as yet have been making use of the vegetation as their major source of nutrition, but in spite of this it can be seen from their worm burdens that the larvae of *H. placei*, *L. sabie*, *Trichostrongylus* spp., *I. tuberculata*, *C. hungi* and *C. hamiltoni* were available during these months. This was confirmed by the worm burdens of the 5-month-old impala shot during April which had in the interim also acquired *C. hepaticae*.

No further infestation with any nematode species was acquired during May or June as the static worm burdens of the young impala examined during these months would indicate, but 2 *M. expansa* were recovered from the buck culled during June. In September, however, the presence of the larvae of *Trichostrongylus* spp., *I. tuberculata* and *C. hepaticae* on the pastures was evident in the increased worm burdens, and both antelope culled during this month harboured *O. columbianum* and 1 harboured a single *M. expansa*. In November, in addition to increased numbers of *Trichostrongylus* spp. and *I. tuberculata*, larvae of *L. sabie*, *C. hungi* and *C. hamiltoni* were present on the pastures.

These findings indicate that the colder months of May and June and quite probably July and August are unsuitable for larval survival or the development of eggs to the infective larval stage on the pastures at Nylsvley. The faecal worm egg counts of the impala were generally low during these months thus further reducing pasture contamination. These results confirm the inability of the free-living stages to survive on the pasture at this time and stress the necessity for most species to overwinter as arrested larvae in the host animal.

Judging by the condition of the carcasses of the culled impala and the presence of abdominal fat deposits, it did not appear as if the worm burdens they were harbouring affected them adversely. Similar burdens of adult worms in sheep would probably not cause more than a few kilogrammes loss in live mass (Horak, Honer & Schröder, 1976).

The control of helminth infestation in free-ranging impala could probably best be achieved by the administration of a non-toxic, soluble anthelmintic in an artificially created water supply, provided that other water sources are excluded. It is essential that the anthelmintic be non-toxic because of the varying amounts of water that may be consumed by the impala. An alternative method of treatment would be the provision of a medicated mineral lick containing sufficient anthelmintic to supply a full therapeutic dose in the amount of lick normally consumed in one day or over a period of several days. The best time for treatment would be in June or July as little infestation survives on the pastures during these months and the elimination of the parasitic burden would thus considerably reduce the chances of recontamination of the pastures.

The presence of *P. calcaratus* in the impala in Zululand (Heinichen, 1973) and its absence in this survey stress the necessity of treating all captured animals destined for translocation with a broad-spectrum anthelmintic. This precaution would reduce the chances of introducing potentially pathogenic helminth species into a locality in which they do not occur.

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