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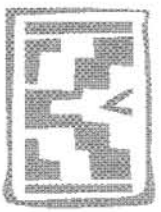

Parasites of domestic and wild animals in South Africa. XLII. Helminths of sheep on four farms in the Eastern Cape Province

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ABSTRACT

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At monthly intervals for periods ranging from 9 to 25 consecutive months between three and four Merino yearling-sheep and two Merino lambs on three farms in Eastern Cape Thornveld, and two Dorper yearling-sheep on a farm in Valley Bushveld were slaughtered and examined for helminths. The Merino sheep were infected with 15 nematode species, of which *Haemonchus contortus*, *Nematodirus spathiger* and *Trichostrongylus* spp. were the most numerous, and with four cestode species. The Dorper sheep were infected with 17 nematode species, of which *Trichostrongylus rugatus* and *N. spathiger* were the most numerous, and with two cestode species.

Haemonchus contortus was most numerous in older sheep during the summer months and exhibited no tendency to over-winter as arrested fourth stage larvae. The largest numbers of *N. spathiger* were present in sheep on the most coastally located of the farms during autumn and winter; on a farm further inland during spring; and on an inland farm in Valley Bushveld during spring and summer. As Merino lambs progressed from birth to 9 months of age a larger proportion of their dwindling burdens of *N. spathiger* was present as fourth stage larvae. Dorper sheep in Valley Bushveld harboured most *Teladorsagia circumcincta* in May and from October to January. *Trichostrongylus rugatus* was most numerous in Merino sheep on one of the Thornveld farms during September, whereas all *Trichostrongylus* spp., including *T. rugatus*, were most numerous in Dorper sheep on the Valley Bushveld farm during January.

Keywords: Cestodes, coastal Thornveld, Dorper sheep, Eastern Cape Province, Merino sheep, nematodes, seasonal occurrence, Valley Bushveld

INTRODUCTION

Several surveys of helminths parasitizing small domestic ruminants on farms in the Eastern Cape Province have been conducted. Rossiter (1964) has examined sheep on a coastal farm at Bathurst, and Barrow (1964) and Horak (1987) sheep on inland farms near Stutterheim, Fort Brown, Paterson and Sidbury, while Boomker, Horak & MacIvor (1989), Fivaz, Horak & Williams (1990), Horak, Knight & Williams (1991b) and Horak, MacIvor & Greeff (2001) have examined goats on inland farms.

The results of some of the surveys on nematodes of sheep and goats in the Eastern Cape Province were presented by Horak (1987) at a Workshop on Worm Resistance, but were not dealt with in any great detail on that occasion, while those of others were based on preliminary data as not all the sur-

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veys had been completed. Comprehensive results on the ticks collected from the sheep, and the helminths and ticks and other ectoparasites of the goats at the various localities mentioned at the Workshop, have subsequently been published (Boomker *et al.* 1989; Horak, Williams & Van Schalkwyk 1991a; Horak *et al.* 1991b; 2001). The present paper is aimed at rectifying this situation for the helminths of sheep.

MATERIALS AND METHODS

Survey farms and sheep

The localities of the farms and the survey design are summarized in Table 1. In addition to Merino sheep the farms "Reed Valley" and "Sidbury" each ran a herd of dairy cattle, while the farm "Grasmere" ran Merino sheep, a flock of Angora goats and a herd of beef cattle as well as several springbok, *Antidorcas marsupialis*. Mean maximum air temperatures on these farms range between approximately 20 °C in winter and 30 °C in summer and mean minima between 8 °C in winter and 18 °C in summer. Mean annual rainfall in this region is approximately 500 mm and is non-seasonal with most falling during spring and summer. At the time of the survey "Bucklands" accomodated approximately 300 Dorper sheep, 4 000 Angora goats and 185 cattle, plus numerous greater kudus, *Tragelaphus strepsiceros* and other antelopes. Average maximum monthly temperatures on this farm can vary from approximately 19 °C in mid-winter to 33 °C in mid-summer, and average monthly minima from approximately 5 °C in mid-winter to 20 °C in mid-summer. Long-term average annual rainfall is 484 mm and is non-seasonal with slightly more than 300 mm falling from October to March.

The sheep used as tracers on "Reed Valley" and on "Sidbury" were treated with an anthelmintic 1 month prior to slaughter and then put out to graze with sheep of their own age for that month, while the Dorper sheep on "Bucklands" received no anthelmintic treatment for at least 3 months prior to slaughter. The Merino lambs on "Grasmere" were not treated with an anthelmintic.

Necropsy procedure

After collection from the survey farms and transportation to Grahamstown the sheep were starved for 24 h before slaughter. At slaughter they were eviscerated and their digestive tracts opened. The contents of the abomasum and small intestine were washed over sieves with 38 µm apertures and the sieve contents retained. The caecal and colonic contents of the sheep were washed over sieves with 150 µm apertures. The trachea and bronchae of one lung were cut open and the tracheal and bronchial surfaces thoroughly washed over a sieve with 38 µm apertures. Mucosal scrapings of the abomasum, small intestine and large intestine were digested separately with pepsin and HCl and the digested material was washed over sieves with 38 µm apertures. Digestion of the mucosae of the small and large intestines was later stopped as the digested material yielded no worms.

Helminth identification and counts

Two representative samples of the contents of the various organs and of the digested material were examined under a stereoscopic microscope and nematodes were identified to genus level and counted under the microscope. Males were collected, cleared in warm lactophenol and specifically identified under a standard binocular microscope, while larvae were identified in water under this microscope. Those female worms that could not be identified beyond genus level were allocated to the various species within that genus in proportion to the number of males identified. After removing the representative samples the remainder of the gastro-intestinal ingesta was examined macroscopically for large nematodes. Cestodes were collected, identified and counted by macroscopically examining the small intestinal contents for complete worms and thereafter examining it microscopically for scolices and small cestodes.

The worms recovered each month from Merino sheep examined on "Reed Valley" and "Sidbury", and Dorper sheep examined on "Bucklands" have been separately pooled and expressed as monthly averages starting from March for each of the three farms, irrespective of the year in which the sheep were examined. The total nematode burdens of the lambs examined on "Grasmere" from 1 day of age until they were 9 months old have been presented graphically to illustrate the accumulation of infection.

RESULTS

The total numbers of worms recovered from the sheep on the four survey farms are summarized in Tables 2–5. Eleven nematode and three cestode species were recovered from sheep on "Reed Valley", where *Nematodirus spathiger* was the domi-

TABLE 1 Localities in the Eastern Cape Province at which helminth surveys were conducted on sheep

Farm	Co-ordinates	Veld type	Duration of survey	Sheep breed	No. examined monthly (total)	Age (months)	Anthelmintic treatment
"Reed Valley"	33°33' S, 26°02' E	Eastern	March 1983 to March 1984	Merino	4 (52)	10–14	1 month prior to
"Sidbury"	33°25' S, 26°11' E	Province	March 1986 to March 1988	Merino	3 (75)	10–14	slaughter
"Grasmere"	33°31' S, 25°53' E	Thornveld	May 1986 to February 1987	Merino	2 (22)	1 day to 9 months	None
"Bucklands"	33°06' S, 26°41' E	Valley Bushveld	February 1985 to January 1987	Dorper	2 (48)	8–12	None for 3 months prior to slaughter

TABLE 2 Helminths of 52 Merino sheep on the farm "Reed Valley" in Eastern Province Thornveld

Helminth species	No. of helminths recovered			Proportional density (%)	No. of animals infected
	4th stage larvae	Adults	Total		
Nematodes					
Cooperia spp.	644	32	676	0.87	3
Cooperia oncophora	–	25	25	0.03	1
Haemonchus contortus	4	5 003	5 007	6.46	24
Nematodirus spathiger	34 179	8 012	42 191	54.46	43
Oesophagostomum venulosum	0	30	30	0.04	4
Teladorsagia spp.	661	–	661	0.85	12
Teladorsagia circumcincta	–	2 051	2 051	2.65	25
Teladorsagia trifurcata	–	95	95	0.12	2
Trichostrongylus spp.	213	–	213	0.28	9
Trichostrongylus axei	–	8 568	8 568	11.06	17
Trichostrongylus falculatus	–	934	934	1.21	7
Trichostrongylus pietersei	–	668	668	0.86	5
Trichostrongylus rugatus	–	15 788	15 788	20.38	15
Trichuris sp.	57	503	560	0.72	37
Total	35 758	41 709	77 467		
Cestodes					
Avitellina sp. and/or *Thysanezia* sp.					30
Stilesia hepatica					8

TABLE 3 Helminths of 75 Merino sheep on the farm "Sidbury" in Eastern Province Thornveld

Helminth species	No. of helminths recovered			Proportional density (%)	No. of animals infected
	4th stage larvae	Adults	Total		
Nematodes					
Cooperia spp.	1 000	25	1 025	1.46	4
Cooperia oncophora	–	1 125	1 125	1.60	5
Cooperia punctata	–	100	100	0.14	4
Haemonchus contortus	8 729	38 336	47 065	67.03	68
Nematodirus helvetianus	0	475	475	0.68	1
Nematodirus spathiger	5 126	7 850	12 976	18.48	51
Ostertagia/Teladorsagia spp.	575	–	575	0.82	3
Ostertagia ostertagi	–	5	5	0.01	1
Teladorsagia circumcincta	–	376	376	0.54	5
Trichostrongylus spp.	6	–	6	0.01	5
Trichostrongylus axei	–	284	284	0.40	10
Trichostrongylus falculatus	–	25	25	0.04	1
Trichostrongylus pietersei	–	50	50	0.07	2
Trichostrongylus rugatus	–	5977	5 977	8.51	34
Trichuris sp.	–	154	154	0.22	26
Total	15 436	54 782	70 218		
Cestodes	Scolices		Total		
Avitellina sp.	10		10	14.3	6
Moniezia expansa	60		60	85.7	8

TABLE 4 Helminths of 48 Dorper sheep on the farm "Bucklands" in Valley Bushveld in the Eastern Cape Province

Helminth species	No. of helminths recovered			Proportional density (%)	No. of animals infected
	4th stage larvae	Adults	Total		
Nematodes					
Cooperia spp.	625	75	700	0.41	13
Cooperia curticei	–	100	100	0.06	5
Cooperia oncophora	–	300	300	0.18	3
Cooperia pectinata	–	1 775	1 775	1.05	7
Cooperia punctata	–	825	825	0.49	4
Haemonchus contortus	1	1 377	1 378	0.81	21
Nematodirus spathiger	10 950	16 950	27 900	16.49	42
Oesophagostomum venulosum	100	305	405	0.24	30
Ostertagia/Teladorsagia spp.	655	100	755	0.45	21
Ostertagia ostertagi	–	25	25	0.01	2
Teladorsagia circumcincta	–	8 022	8 022	4.74	44
Teladorsagia trifurcata	–	50	50	0.03	1
Skrjabinema sp.	–	4 525	4 525	2.67	18
Strongyloides papillosus	0	1 075	1 075	0.64	10
Trichostrongylus spp.	1 028	–	1 028	0.61	17
Trichostrongylus axei	–	7 078	7 078	4.18	45
Trichostrongylus falculatus	–	209	209	0.12	3
Trichostrongylus pietersei	–	3 075	3 075	1.82	25
Trichostrongylus rugatus	–	109 581	109 581	64.76	46
Trichuris sp.	77	326	403	0.24	32
Total	13 436	155 773	169 209		
Cestodes	Scolices		Total		
Avitellina sp.	2		2	10.5	2
Moniezia expansa	17		17	89.5	4

TABLE 5 Helminths of 22 Merino lambs on the farm "Grasmere" in Eastern Province Thornveld

Helminth species	No. of helminths recovered			Proportional density (%)	No. of animals infected
	4th stage larvae	Adults	Total		
Nematodes					
Haemonchus contortus	129	12 197	12 326	46.99	16
Nematodirus spathiger	1 376	2 700	4 076	15.54	15
Ostertagia/Teladorsagia spp.	1	–	1	0.004	1
Ostertagia ostertagi	–	226	226	0.86	2
Teladorsagia circumcincta	–	300	300	1.14	4
Paracooperia serrata	1	152	153	0.58	4
Trichostrongylus spp.	4	75	79	0.30	5
Trichostrongylus axei	–	552	552	2.10	9
Trichostrongylus falculatus	–	8 010	8 010	30.53	10
Trichostrongylus pietersei	–	350	350	1.33	4
Trichuris sp.	–	160	160	0.61	13
Total	1 511	24 722	26 233		
Cestodes	Scolices		Total		
Avitellina sp.	37		37	100.0	8

nant species. On "Sidbury" *Haemonchus contortus* and *N. spathiger* were the dominant members of the 12 species recovered. The Dorper sheep examined at "Bucklands" were infected with 17 nematode and two cestode species. The most numerous species were *Trichostrongylus rugatus* and *N. spathiger.* Nine nematode species and a single cestode were present in the Merino lambs on "Grasmere", and *H. contortus* and *Trichostongylus falculatus* were the dominant worms.

The proportional densities of the major nematode species in sheep on the four survey farms, as well as in adult Angora goats examined at the same time as the Dorper sheep on "Bucklands" (Horak *et al.* 1991b), have been summarized in Table 6. The larger burdens of most species in the Dorper yearling-sheep examined on "Bucklands" during the period October to January correspond closely to the higher burdens recorded during the period September or October to January in 4–6 year-old Angora goats examined on "Bucklands" at exactly the same time.

The seasonal patterns of abundance of the major species are graphically illustrated in Fig. 1–4. Peak numbers of *H. contortus* were acquired by sheep on "Sidbury" from November to April and very few from June to October. Peak numbers of *N. spathiger* were present in sheep on "Reed Valley" from May to July, on "Sidbury" during September and October, and in February, and on "Bucklands" from October to February. *Teladorsagia circumcincta* was most numerous on "Bucklands" during May and from October to January. On "Sidbury" *T. rugatus* was most numerous during September, while on

TABLE 6 The relative density (and total numbers of worms) of the major nematode infections of sheep and goats on four farms in the Eastern Cape Province

Nematode species	Proportional density of infection (%) (total no. of worms recovered)				
	"Reed Valley" (52 Merino sheep)	"Sidbury" (75 Merino sheep)	"Grasmere" (22 Merino lambs)	"Bucklands" (48 Dorper sheep)	"Bucklands" (48 Angora goats)
H. contortus	6.46 (5 007)	67.03 (47 065)	46.99 (12 326)	0.81 (1 378)	0.77 (1 277)
N. spathiger	54.46 (42 191)	18.48 (12 976)	15.44 (4 076)	16.49 (27 900)	3.54 (5 859)
Skrjabinema sp.	0	0	0	2.67 (4 525)	30.07 (49 825)
S. papillosus	0	0	0	0.64 (1 075)	6.37 (10 550)
T. circumcincta	2.65 (2 051)	0.54 (376)	1.14 (300)	4.74 (8 022)	9.82 (16 277)
T. axei	11.06 (8 568)	0.40 (284)	2.10 (552)	4.18 (7 078)	3.24 (5 370)
T. falculatus	1.21 (934)	0.04 (25)	30.53 (8 010)	0.12 (209)	0
T. rugatus	20.38 (15 788)	8.51 (5 977)	0	64.76 (109 581)	44.62 (73 944)

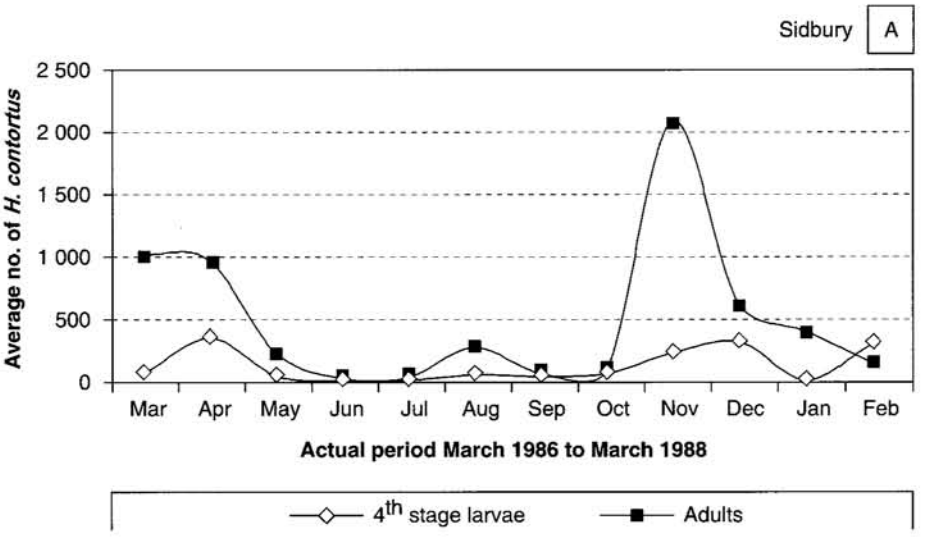

FIG. 1 The seasonal occurrence of *Haemonchus contortus* in Merino sheep on the Farm "Sidbury", Eastern Cape Province

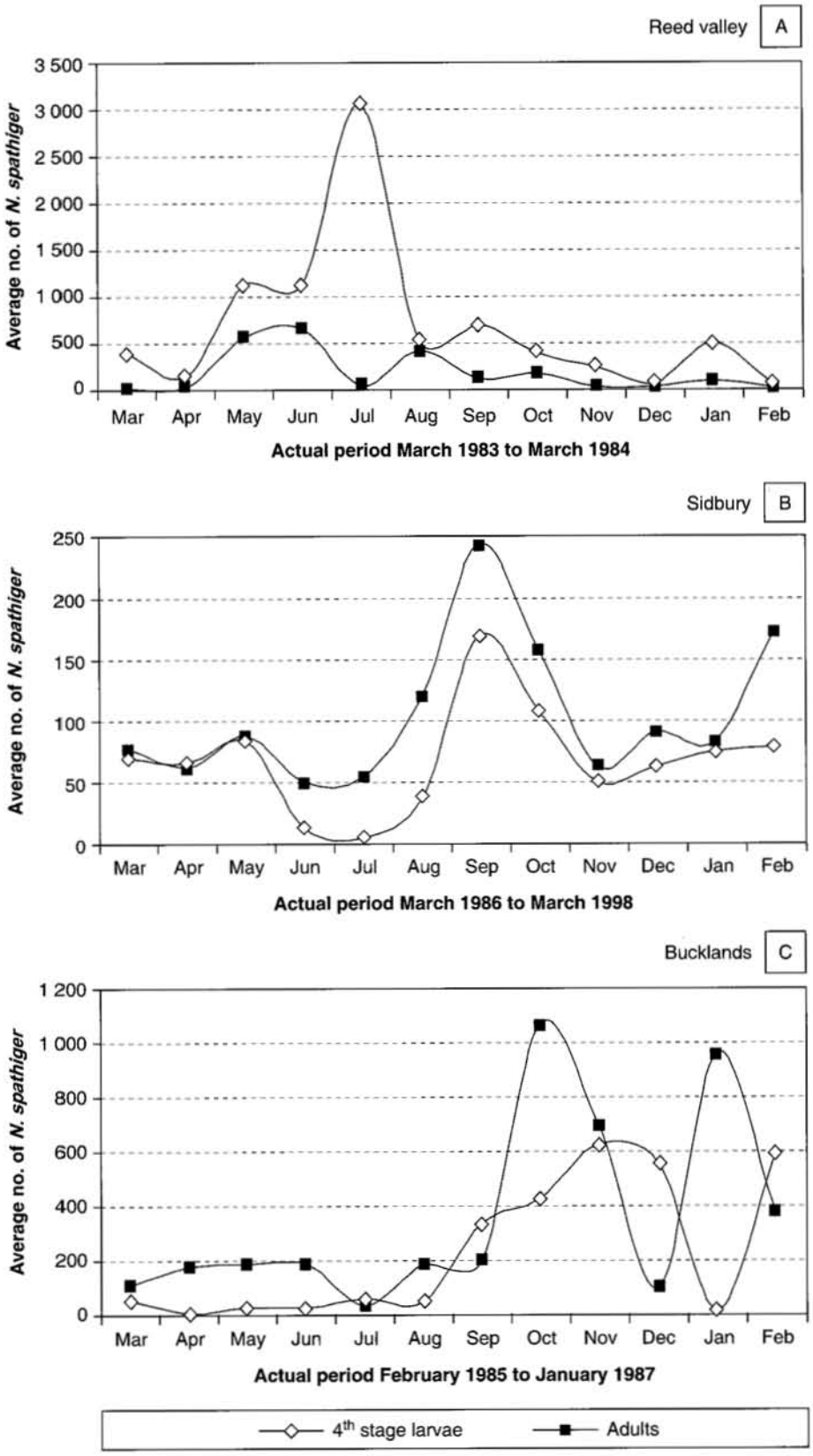

FIG. 2 The seasonal occurrence of *Nematodirus spathiger* in Merino sheep on the farms (A) "Reed Valley" and (B) "Sidbury" and (C) Dorper sheep on the farm "Bucklands", Eastern Cape Province

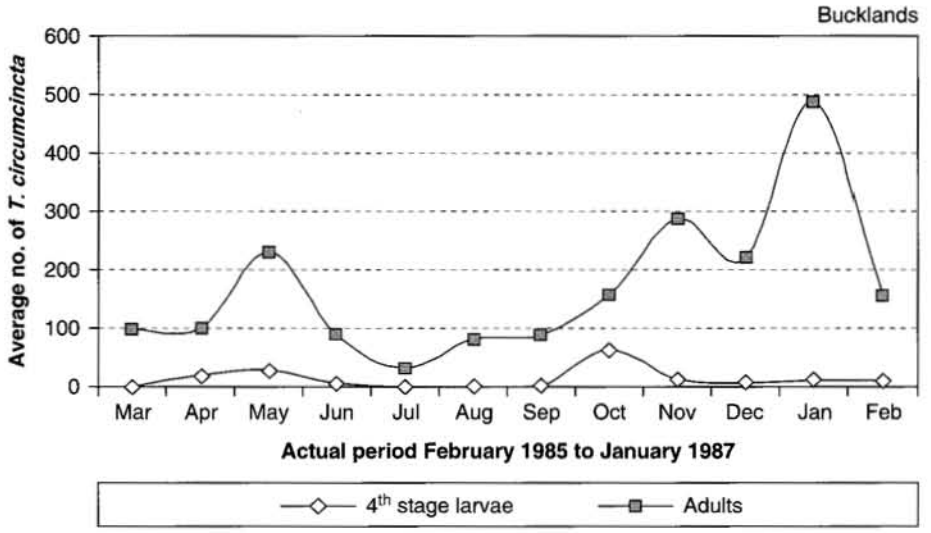

FIG. 3 The seasonal occurrence of *Teladorsagia circumcincta* in Dorper sheep on the farm "Bucklands", Eastern Cape Province

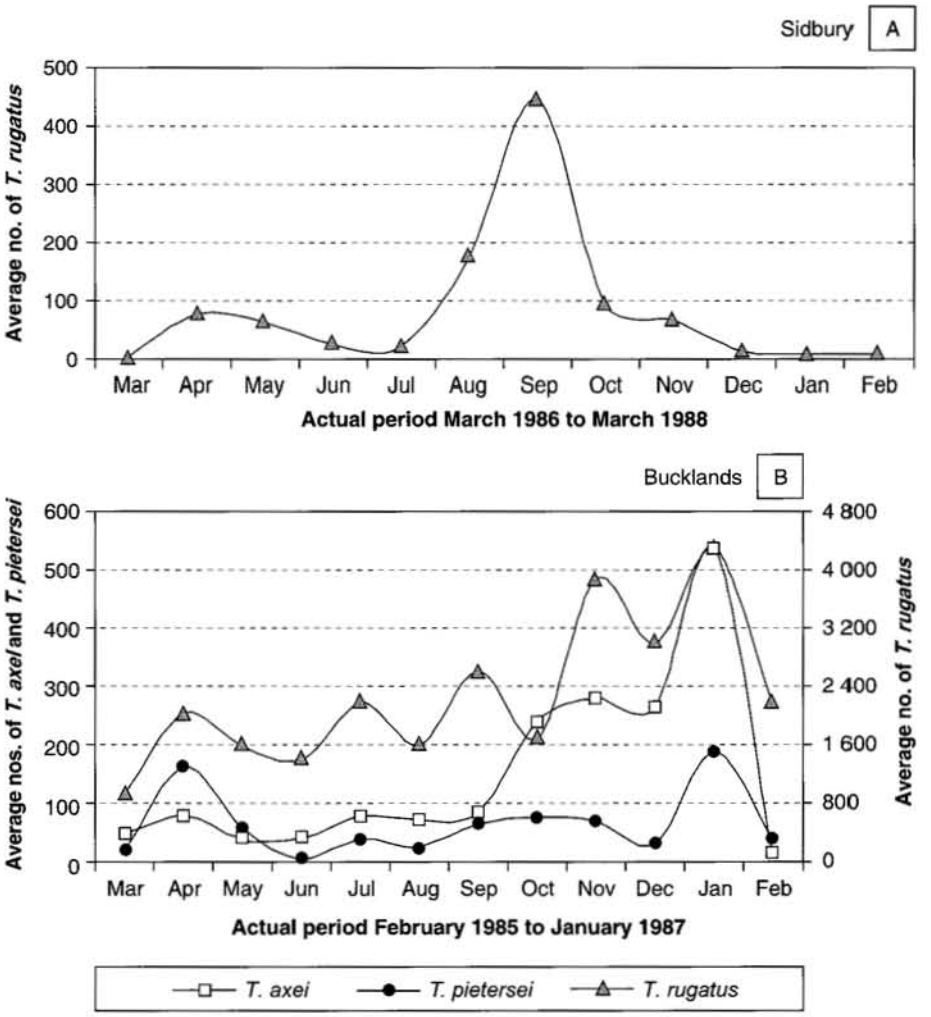

FIG. 4 The seasonal occurrence of (A) *Trichostrongylus rugatus* in Merino sheep on the farm "Sidbury", and (B) *Trichostrongylus* spp. in Dorper sheep on the farm "Bucklands", Eastern Cape Province

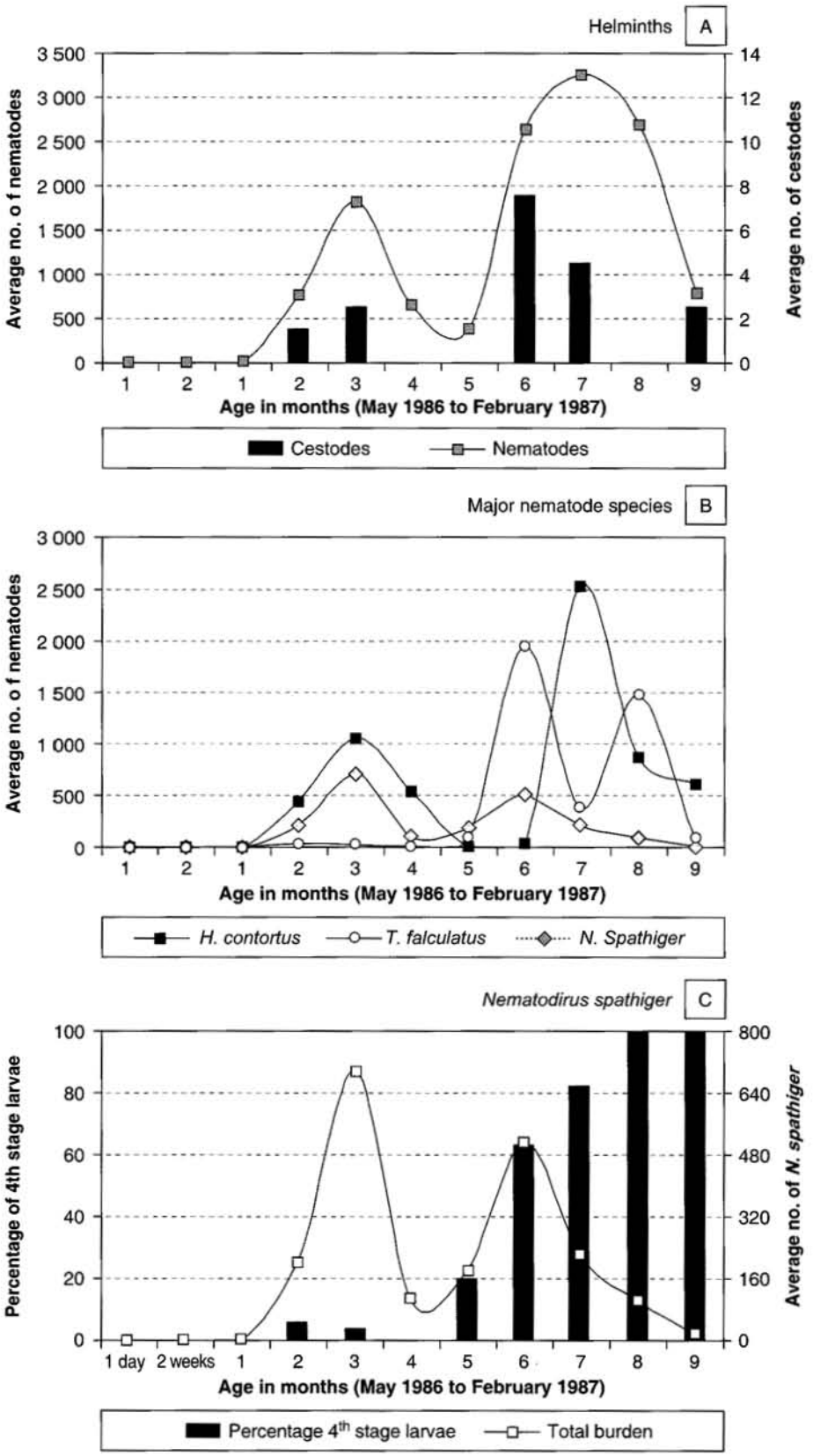

FIG. 5 The acquisition of helminth infection by Merino lambs from 1 day to 9 months of age on the farm "Grasmere", Eastern Cape Province, (A) total infection (B) major nematode species, and (C) *Nematodirus spathiger*

"Bucklands" infection with the major *Trichostrongylus* spp. was at its peak during January.

The cumulative acquisition of nematode infection by lambs on "Grasmere" as well as the change in the composition of their *N. spathiger* burdens are graphically illustrated in Fig. 5. The 1-day, 2-week and 1-month old lambs picked up no infection, but thereafter acquisition and loss of infection appeared to fluctuate irregularly between *H. contortus* and *T. falculatus*. Peak burdens of *N. spathiger* were present in the lambs at 3 months of age, but as they aged these burdens decreased and an increasing proportion of worms were in the fourth larval stage.

DISCUSSION

Although several worms of the same species were present in the sheep on the various farms, their relative densities differed considerably. This emphasizes the importance of determining the species composition of helminth infection on individual farms, either by slaughter or larval culture, before recommending anthelmintic intervention.

Cooperia spp.

Cooperia curticei has been recovered in substantial numbers from sheep grazing artificial pastures in the coastal region of the southern Western Cape Province (Muller 1968), but not from sheep in the southern regions of the Eastern Cape Province (Barrow 1964; Rossiter 1964). Its presence in a single Dorper sheep in Valley Bushveld, and in no other animals in the present surveys, indicates that this region possibly lies at the easterly limit of its distribution. *Cooperia oncophora* is a parasite of cattle and its recovery from sheep can be linked to the presence of cattle on the survey properties. The other *Cooperia* spp. recovered from the sheep were probably also of cattle origin.

The occurrence of *Paracooperia serrata* in four lambs on "Grasmere" is undoubtedly due to the presence of springbok, a preferred host of this nematode, on the farm (Horak, Meltzer & De Vos 1982; Boomker, Horak, Watermeyer & Booyse 2000).

Haemonchus contortus

Most infection with *H. contortus* on the farm "Sidbury", on which it was the dominant parasite, was acquired from November to April, with little available on the pastures from June to October. There was no evidence of arrest in the development of the fourth larval stage in the host during the cooler months, and the larger numbers of fourth stage larvae present during the summer are evidence of recent infection. The autumn-born lambs on "Grasmere" picked up their first substantial infections with *H. contortus* during August, at the age of 3 months, and then again in December.

The virtual absence of *H. contortus* in small stock in the Valley Bushveld (Boomker *et al.* 1989; Horak *et al.* 1991b), even on irrigated pastures in this region (Fivaz *et al.* 1990), reduces the necessity for specific anthelmintic treatment of this highly pathogenic species.

Nematodirus spathiger

This nematode is widespread in sheep and goats in the Eastern Cape Province and Karoo (Barrow 1964; Rossiter 1964; Viloen 1964; 1969; Boomker *et al.* 1989; Horak *et al.* 1991b; 2001). It is particularly a parasite of young animals, in which it rapidly develops to adulthood. As lambs grow older their worm burdens become progressively smaller (Reinecke 1989), while in older animals a large proportion of worms may not progress beyond the fourth larval stage of development (Viljoen 1969). The decrease in total numbers and increasing proportion of fourth stage larvae as the age of the autumn-born lambs on "Grasmere" increased, confirms this phenomenon.

The findings on "Bucklands" suggest that sheep either pick up more infective larvae than do goats or that 8–12 month-old Dorper sheep are better hosts for *N. spathiger* than adult goats (Horak *et al.* 1991b; Table 6). The recovery of *Nematodirus helvetianus* from a single sheep on the farm "Sidbury" is evidence of the presence of cattle, the preferred hosts of this nematode, on the farm.

Oesophagostomum venulosum

The distribution of *O. venulosum* is limited to the southern and south-western winter and non-seasonal rainfall regions of the Western and Eastern Cape Provinces (Muller 1968; Reinecke, Kirkpatrick, Swart, Kriel & Frank 1987; Reinecke & Louw 1989), extending rather tenuously into the Valley Bushveld of the latter province (Boomker *et al.* 1989; Horak *et al.* 1991b). Compared to *Oesophagostomum columbianum*, the other species that infects sheep, it is apparently never present in large numbers. Nor is it as pathogenic because infection does not lead to the characteristic caseous or calcified nodules associated with the latter worm

(Horak & Clark 1966), which is present in the more northern temperate as well as semi-arid summer rainfall regions of the country (Horak 1981).

Skrjabinema sp.

This nematode was not identified beyond generic level. It is typically a parasite of grazing antelopes and of goats, and it would appear more particularly of Angora goats (Boomker *et al.* 1989; Horak *et al.* 1991b; 2001). The approximately 4 000 Angora goats on "Bucklands", in which worms of the genus *Skrjabinema* were probably most numerous after *T. rugatus* (Horak *et al.* 1991b), were the likely source of infection for the Dorper sheep.

Strongyloides papillosus

"Bucklands" was the only farm on which sheep were infected with this nematode and it accounted for 0.64 % or 1 075 of the worms in their total worm burdens. Of 48 adult Angora goats examined on "Bucklands" at exactly the same times as the Dorper sheep, 77 % were infected with *S. papillosus*, and the proportional density of infection and total number of worms recovered were nearly exactly ten times those in the Dorper sheep (Table 6). Infection takes place via the milk of the dam (Moncol & Grice 1974), percutaneously, or by the ingestion of larvae, which then penetrate the buccal and oesophageal epithelium (Dunn 1978).

Teladorsagia circumcincta

With the possible exception of "Bucklands", where most sheep were infected with *T. circumcincta*, albeit with small numbers, this was a minor species in the sheep. The higher prevalence of *T. circumcincta* in the Dorper sheep and Angora goats on "Bucklands" than in animals on the other survey farms appears to be anomalous in that this nematode is usually associated with milder climates (Barrow 1964; Rossiter 1964), or with irrigated pastures in the Eastern Cape Province (Fivaz *et al.* 1990), whereas farms in inland Valley Bushveld regions are generally both warmer and drier than those lying closer to the coast. However, it is possible that the dense bush, particularly in some of the valleys on "Bucklands" afforded some protection for the eggs and larvae of this helminth. The summer peak in the seasonality of *T. circumcincta* on "Bucklands" agrees with observations made several years previously in sheep on a coastal farm near Bathurst, approximately 70 km south of "Bucklands" (Rossiter 1964).

All but one of the 48 adult Angora goats examined on "Bucklands" at the same time as the Dorper sheep were infected with *T. circumcincta*, and the relative density of infection and numbers of worms recovered from the goats were both slightly more than double those in the sheep (Table 6). The large number of goats on the farm probably served as a potential reservoir of infection for the sheep. The recovery of *Ostertagia ostertagi* from a small number of sheep on three of the four farms can be ascribed to accidental cross-infection from cattle.

Trichostongylus spp.

Trichostrongylus axei is an abomasal parasite of domestic livestock in South Africa (Horak 1981; Reinecke 1983). It is frequently encountered in sheep in the coastal and adjacent inland regions of the Western and Eastern Cape Provinces (Barrow 1964; Rossiter 1964; Muller 1968; Reinecke *et al.* 1987; Louw & Reinecke 1991). *Trichostrongylus falculatus* is a species that infects wild antelopes and sheep, particularly in the drier inland regions of the country (Viljoen 1964; 1969; Horak 1981; Horak *et al.* 1982). It has, however, been recovered in substantial numbers from sheep on artificial pastures in the southern Western Cape Province (Muller 1968). Its presence in the lambs on "Grasmere" in considerably greater numbers than in the sheep on any other farm is possibly a reflection of the presence of springbok on the farm. *Trichostrongylus pietersei* was originally described from sheep and Angora goats in the Karoo (Le Roux 1932), but its preferred habitat seems to be the southern regions of the Eastern and Western Cape Provinces (Rossiter 1964; Muller 1968), where it has also been recovered from grysbok, *Raphicerus melanotis* (Boomker *et al.* 1989).

Trichostongylus rugatus is a numerically dominant species encountered in sheep and goats in the south-eastern, southern and south-western Eastern and Western Cape Provinces, and in gemsbok, *Oryx gazella* in the West Coast National Park in the latter province. It seems to flourish both on natural grazing and on artificial pastures (Barrow 1964; Rossiter 1964; Reinecke *et al.* 1987; Boomker *et al.* 1989; 2000; Reinecke & Louw 1989; Fivaz *et al.* 1990; Horak *et al.* 1991b). It was the most numerous species of *Trichostrongylus* in sheep on three of the four farms in the present study, and its absence on "Grasmere" and virtual absence in sheep on artificial pastures near George in the southern Western Cape Province (Muller 1968), are thus difficult to explain.

Cestodes

Moniezia spp. are parasites particularly of young domestic and wild ruminants, whereas *Avitellina* spp. appear to infect older animals (Horak, De Vos & Brown 1983; Horak *et al.* 1991b; 2001). In the Westerrn Cape Province Reinecke *et al.* (1987) recovered *Moniezia expansa* from sheep on artificial pastures mainly during the summer, whereas *Avitellina* spp. appeared to be present during both summer and winter.

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