

Parasites of domestic and wild animals in South Africa. XXXIX. Helminth and arthropod parasites of Angora goats in the southern Karoo

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ABSTRACT

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Parasites were collected from 160 Angora goats and kids on the Jansenville Experimental Farm, Eastern Cape Province. Six nematodes were identified to species level and three to generic level. *Nematodirus spathiger* was the most numerous of the economically important nematodes recovered. It was always present, and fourth stage larvae were collected from untreated goats from August to March, while animals used as tracers also picked up most infection from August to March. Kids born on the farm during October acquired their first nematode infections between 2 and 3 months of age and the intensity of infection increased erratically thereafter to reach a plateau once the kids were 14 months of age. Eight of the nine kids between 3 and 5 months of age and examined between January and March were infected with *Moniezia expansa*.

Five ixodid tick species were collected from the goats of which *Rhipicephalus glabroscutatum* was the most numerous and prevalent. Its immature stages were present mainly from March to September and adults from July to January. The goats also harboured the biting louse *Damalinia limbata* and the sucking louse *Linognathus africanus*. The greatest intensity of infestation with *L. africanus* occurred on the kids during the first few months of their lives. The larvae of the nasal bot fly, *Oestrus ovis* were present in kids at 1 month of age, and infestation took place mainly from spring to late summer.

Keywords: Angora goats, biting and sucking lice, cestodes, ixodid ticks, Karoo, nasal bot fly larvae, nematodes

INTRODUCTION

A number of surveys on the seasonal intensity of parasitic infections of goats have been conducted in South Africa. These involved goats (breed not stated)

farmed at four altitudes in KwaZulu-Natal (Baker & Ducasse 1968); Angora and Boer goats in the Eastern Cape Province (Rechav 1982; MacIvor & Horak 1984; Horak 1987; Boomker, Horak & MacIvor 1989; Horak, Knight & Williams 1991b); Angora goats on irrigated grass pasture in the Eastern Cape Province (Fivaz, Horak & Williams 1990); Angora goats in False Upper Karoo vegetation in the south-western Free State (Fourie & Horak 1991); and indigenous goats in Sour Bushveld or in Mixed Bushveld in the Northern Province (Rechav & De Jager 1991; Boomker, Horak & Ramsay 1994).

A survey on the prevalence of *Oestrus ovis* infestation in goats slaughtered at the Johannesburg Municipal abattoir has also been conducted (Horak & Butt 1977).

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These surveys demonstrated that goats browsing natural scrub vegetation had lighter nematode burdens than those grazing irrigated kikuyu grass (*Penisetum clandestinum*) pasture (Boomker *et al.* 1989; Fivaz *et al.* 1990; Horak *et al.* 1991b). They also confirmed the link between the seasonal intensity of infestation with adult *Amblyomma hebraeum* and adult *Rhipicephalus glabroscutatum* and the prevalence of foot abscess in goats (MacIvor & Horak 1987). In addition, the seasonal intensity of infestation with adult *Ixodes rubicundus* and adult *Rhipicephalus warburtoni* (then referred to as a tick of the *Rhipicephalus pravus* group) determined in these surveys, corresponded to the occurrence of paralysis caused by these ticks (Fourie, Horak & Marais 1988; Fourie & Horak 1991; Fourie, Horak & Van Zyl 1992). The surveys also indicated that goats are particularly prone to infestation with the biting louse *Damalinea limbata* (MacIvor & Horak 1984; Horak *et al.* 1991b). It was apparent from the abattoir survey on goats and one conducted on sheep that these animals are probably equally susceptible to infestation with the larvae of the nasal bot fly *O. ovis*, but that goats harbour fewer larvae than sheep (Horak 1977; Horak & Butt 1977).

Although goats are farmed extensively in the Karoo, no surveys on the parasites of these animals in this region have been published. The object of the present survey was an attempt to rectify this shortcoming to some extent by determining not only the species composition of the parasitic macro-fauna of Angora goats in the Noorsveld vegetation region of the south-eastern Great Karoo, but also the acquisition of infection by kids from 1 week of age until the age of 23 months, as well as the seasonal acquisition and intensity of infection in older goats.

MATERIALS AND METHODS

The Jansenville Experimental Farm (32°55'S, 24°41'E) is 2 128 ha in extent and is situated 2 km north-east of Jansenville in the Eastern Cape Province. The vegetation in this region is classified as Noorsveld and is dominated by *Euphorbia coerulescens* colloquially known as noors (Acocks 1988). At the time of the survey there were 916 Angora goats on the farm.

Sets of three untreated Angora goat wethers born during October 1984 were slaughtered at monthly intervals from the age of 10 months until they reached 24 months of age. Sets of three similarly aged wethers (hereafter referred to as tracers) were treated in consecutive months with the anthelmintic Ivomec (Ivermectin: Merial) approximately 1 month prior to slaughter and were slaughtered at the same time as the untreated wethers. Both sets of goats ran with a flock of goats of the same age, and were not treated with pesticides for the control of ticks and lice.

In addition, sets of three untreated kids of mixed sex born during October 1985 were slaughtered at monthly intervals from 1 week of age until they were 23 months old. These kids ran with their dams in the ewe flock until weaning and thereafter with a flock of goats of their own age.

The right lung, liver, abomasum, small intestine and large intestine of each goat were processed for helminth recovery as described by Boomker *et al.* (1989). This included digesting the mucosa of the abomasum and the small and large intestines. Two aliquots, each representing 1/50th of the volume of the ingesta of the latter three organs separately, were made. These aliquots, and the material resulting from the digests and from the processed lung and liver, were examined under a stereoscopic microscope and the female worms identified to generic level and counted. All immature worms were identified and counted under a standard light microscope, while the males were first cleared in lactophenol and then identified and counted under the same microscope. The remainders of the abomasal and small and large intestinal ingesta were decanted into a large, flat-bottomed plastic tray and examined macroscopically for adult nematodes belonging to the larger species, and for cestode scolices and strobila.

The skins of the goats were processed for the recovery of ticks and lice as described by Horak, Boomker, Spickett & De Vos (1992). The processed material was examined under a stereoscopic microscope and the ticks and lice present were collected, identified and counted. Oestrid fly larvae were collected from the nasal passages and sinuses as described by Malan, Reinecke & Scialdo (1981). Unfortunately, the data on the numbers of individual goats infested with the larvae of *O. ovis* and detailing the stages of development of the larvae were mislaid, but that on the total numbers of larvae recovered from each set of three goats were not.

RESULTS AND DISCUSSION

Helminths

The species and genera of helminths recovered from the three groups of goats are summarized in Table 1.

Six nematodes were identified to species level and three to generic level. A single cestode species was also recovered. The intensity of infection with *Nematodirus spathiger* followed by those of *Trichostrongylus rugatus* and *Trichostrongylus pieterse* were the highest for the economically important nematodes recovered, but the total numbers of the former worms were nevertheless always low. Angora goats spend more time browsing than grazing (Aucamp 1979) and hence are less likely to acquire third stage infective

TABLE 1 Helminths collected from three groups of Angora goats in the southern Karoo, Eastern Cape Province

Helminth species	Total numbers of helminths recovered and goats infected					
	Tracers (n = 43)	No. infected	Untreated goats (n = 45)	No. infected	Kids (n = 72)	No. infected
Nematodes						
<i>Haemonchus contortus</i> (MM)	0	0	2	2	0	0
<i>Nematodirus spathiger</i> (4 th)	1 425	14	2 860	23	1 200	17
<i>Nematodirus spathiger</i> (Ad)	1 411	20	15 290	44	8 131	49
<i>Skrjabinema</i> sp. (4 th , Ad)	73 540	43	81 850	44	5 500	25
<i>Teladorsagia</i> sp. (4 th)	0	0	1	1	0	0
<i>Teladorsagia</i> sp. (F)	0	0	0	0	1	1
<i>Trichostrongylus axei</i> (MM)	0	0	25	1	9	3
<i>Trichostrongylus falculatus</i> (MM)	0	0	175	6	0	0
<i>Trichostrongylus pietersei</i> (MM)	0	0	741	15	25	1
<i>Trichostrongylus rugatus</i> (MM)	75	2	926	12	175	5
<i>Trichostrongylus</i> spp. (FF)	125	5	1 468	23	504	22
<i>Trichuris</i> sp. (Ad)	46	18	111	33	131	31
Cestodes						
<i>Moniezia expansa</i> (Scolices)	1	1	1	1	61	9

N = Number of animals examined

4th = Fourth stage larvae

Ad = Adults

MM = Males

FF = Females

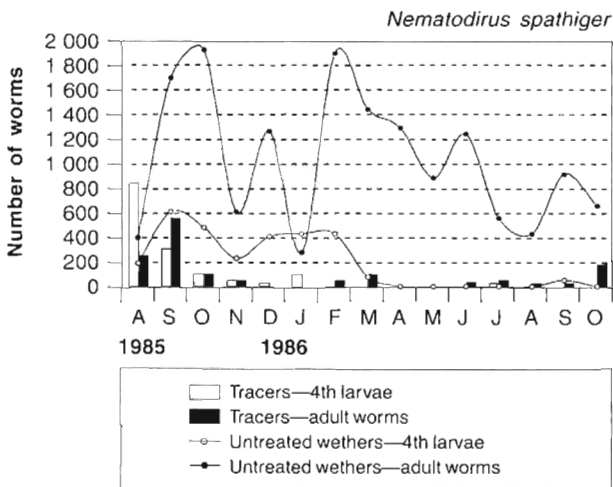


FIG. 1 The seasonal intensity of infection with *Nematodirus spathiger* in Angora goats in the southern Karoo, Eastern Cape Province

larvae from the grass in their diet than are animals that graze. This is particularly so in the Noorsveld region around Jansenville where noors, shrubs and small trees dominate (Acocks 1988).

Only two *Haemonchus contortus* and two worms belonging to a *Teladorsagia* sp. were recovered. Both these nematodes are important parasites of goats. The first has been recovered in substantial numbers

from indigenous goats in Mixed Bushveld in the Northern Province, South Africa and in Maputo and Gaza Provinces, southern Mozambique (Boomker *et al.* 1994; Atanásio 2000). The second, with *Trichostrongylus rugatus*, was responsible for several mortalities in Angora goat kids on irrigated kikuyu grass pastures near Grahamstown, Eastern Cape Province (Fivaz *et al.* 1990). The near absence of these nematodes at Jansenville can be ascribed to the arid climate, with an average annual rainfall of 250 mm, poor ground cover and very high summer temperatures.

Nematodirus spathiger

The seasonal intensity of infection with *N. spathiger* in the wethers and its monthly acquisition by the tracer goats are graphically illustrated in Fig. 1.

Nematodirus spathiger was always present with total burdens for the sets of three untreated wethers fluctuating between 425 and 2 375 worms. Fourth stage larvae were recovered from these wethers from August 1985 to March 1986 and again from two goats in September 1986. The tracer goats picked up infection from the pastures from August 1985 to March 1986, matching the months in which fourth stage larvae were present in the untreated wethers. The tracers acquired no infection during April and May 1986, but then picked up small numbers of worms from June till October 1986.

Nematodirus spathiger is widespread in South Africa, but is particularly prevalent in the south and south-western regions of the country, in the adjacent inland regions and in the Karoo (Viljoen 1964; 1969; Muller 1968; Horak 1981; Boomker & Horak 1992; Boomker, Horak, Watermeyer & Booyse 2000). The eggs and third stage larvae, which develop inside the eggs, are resistant to heat and to desiccation (Viljoen 1969). In the Karoo these eggs accumulate wherever there are faecal concentrations and the larvae hatch whenever rain falls. This results in large numbers of infective larvae within a small area in which there may also be a flush of green vegetation, hence resulting in infection (Reinecke 1983). Judging by the presence of fourth stage larvae in the tracers and the untreated wethers, infection is available on the pastures at the time kids are born and during their first few months of life. However, the very young kids only became lightly infected, acquiring their major infection with this nematode once they were approximately a year old.

Skrjabinema sp.

Large numbers have been recovered from goats and from grysbok (*Raphicerus melanotis*) in Valley Bushveld and considerably fewer from goats in Mixed Bushveld (Boomker *et al.* 1989; 1994; Horak *et al.* 1991b). Little is known about these reputedly non-pathogenic worms (Reinecke 1983). No explanation can be given as to why the intensity and prevalence of infection in the kids born at Jansenville in 1985 were significantly lower than those in the tracers and untreated wethers born in 1984 (Table 1).

Trichostrongylus spp.

Trichostrongylus falculatus is a parasite of wild ruminants in South Africa (Horak 1981; Horak, Meltzer & De Vos 1982; Boomker *et al.* 2000), but is frequently encountered in domestic small stock (Viljoen 1964; Muller 1968; Boomker *et al.* 1989; 1994). *Trichostrongylus pietersei* was originally described from Angora goats and sheep in the Karoo (Le Roux 1932), but appears to be more common in the southern coastal regions of the country (Rossiter 1964; Muller 1968). *Trichostrongylus rugatus* is the dominant *Trichostrongylus* species in goats in the Valley Bushveld (Boomker *et al.* 1989; Horak *et al.* 1991b), including those grazing irrigated kikuyu grass pastures within this region (Fivaz *et al.* 1990). In addition, it is an important parasite of sheep in the coastal and inland areas of the Eastern Cape Province (Barrow 1964; Rossiter 1964).

The few *Trichostrongylus* spp. worms recovered in the present survey are probably a reflection of the prevailing arid climate in the Jansenville region. The combined totals of all the *Trichostrongylus* spp. in the untreated wethers and those acquired monthly by the

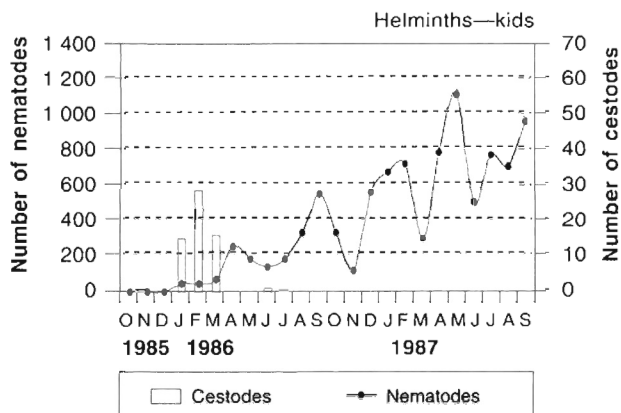


FIG. 2 The acquisition of helminth infection by Angora goat kids from 1 week to 23 months of age in the southern Karoo, Eastern Cape Province

tracer goats were too small to determine meaningful patterns of seasonal intensity of infection.

The acquisition of helminth infection and increase in burdens (excluding *Skrjabinema* sp.) in the kids from 1 week to 23 months of age are graphically illustrated in Fig. 2.

The kids acquired their first nematode infections between 2 and 3 months of age (December 1985 to January 1986) and the intensity of infection increased erratically as the kids grew older, reaching a plateau generally varying between 600 and 1 200 worms once the kids had reached 14 months of age in December 1986.

Moniezia expansa

Eight of the nine kids examined between the ages of 3 and 5 months (January to March 1986) were infected with *M. expansa* (Fig. 2). Only one other kid was infected with this cestode. The virtual absence of cestodes in kids older than 6 months indicates an age resistance to infection in Angora goats. A similar observation has been made in Angora goat kids in Valley Bushveld and in indigenous goat kids in Mixed Bushveld in the Northern Province (Horak *et al.* 1991b; Boomker *et al.* 1994). The presence of *M. expansa* in kids practically only from January to March implies that its life cycle in Angora goats at Jansenville takes a year to complete, with infection surviving during the intervening months in oribatid mite intermediate hosts. The pattern of infection in the goats differs from that recorded in young tracer sheep on irrigated pastures on the Gauteng Province highveld where infection was acquired throughout the year with peaks during the early and the late summer months (Horak & Louw 1977).

Arthropods

The total numbers of arthropods collected from all 160 goats examined are summarized in Table 2.

TABLE 2 Arthropod parasites collected from 160 Angora goats and kids in the southern Karoo, Eastern Cape Province

Arthropod species	Total numbers of arthropods collected					Number of goats and kids infested
	Larvae	Nymphs	Males	Females	Total	
<i>Amblyomma marmoreum</i>	66	0	0	0	66	5
<i>Hyalomma truncatum</i>	0	0	12	9	21	5
<i>Rhipicephalus evertsi evertsi</i>	297	310	8	13	628	33
<i>Rhipicephalus exophthalmos</i>	0	0	111	86	197	36
<i>Rhipicephalus glabroscutatum</i>	1 780	492	412	168	2 852	94
Lice	Nymphs		Adults			
<i>Damalinea limbata</i>	712 865		436 387		1 149 252	159
<i>Linognathus africanus</i>	60 892		60 787		121 679	81
Oestrid fly larvae	Larvae					
<i>Oestrus ovis</i>	1 190				1 190	Unknown

Five ixodid tick species were collected from the goats of which *Rhipicephalus glabroscutatum* was the most abundant and prevalent. These ticks are all adapted to hot, arid environments (Theiler 1950; Howell, Walker & Nevill 1978; MacIvor 1985; Walker & Olwage 1987; Walker, Keirans & Horak 2000). The goats were also infested with the biting louse *Damalinea limbata* and the sucking louse *Linognathus africanus* as well as the larvae of the nasal bot fly *Oestrus ovis*.

Amblyomma marmoreum

The adults of this tick prefer tortoises as hosts, and while the immature stages can also be found on these animals, the larvae particularly parasitize various mammals and birds (Theiler 1962; Norval 1975; Horak, MacIvor, Petney & De Vos 1987; Dower, Petney & Horak 1988). The collection of larvae in the present survey during March, May and August falls within the period February to August or September recorded on goats in Valley Bushveld approximately 200 km to the east of the survey locality (Horak *et al.* 1991b), and observed on leopard tortoises (*Geochelone pardalis*) in the Eastern Cape Province by Norval (1975).

Hyalomma truncatum

Only 21 adult ticks were collected and these were present during November 1985 and October and November 1986. The adults of this tick prefer large ruminants or equids as hosts, but will attach to smaller animals (Norval 1982; Walker 1991). The early summer intensity of infestation noted at Jansenville has also been recorded on Cape mountain zebras (*Equus zebra zebra*) and eland (*Taurotragus oryx*) near Cradock, approximately 130 km to the

north-east of the survey farm (Horak, Fourie, Novellie & Williams 1991a).

Rhipicephalus evertsi evertsi

The preferred hosts of all stages of development of this two-host tick are domestic and wild equids and ruminants, on which the adults attach under the tail and the immature stages in the ear canals (Walker *et al.* 2000). With the exception of Cape mountain zebras, Burchell's zebras (*Equus burchelli*) and eland (Horak *et al.* 1991a), adults are seldom collected in large numbers.

Rhipicephalus exophthalmos

This tick is present in the drier southern and western regions of South Africa and also in Namibia (Keirans, Walker, Horak & Heyne 1993; Walker *et al.* 2000). It has been collected from Angora goats in Valley Bushveld [as *Rhipicephalus* sp. (near *R. oculatus*)], approximately 200 km to the south-east of the study site, but only three of 98 animals examined there were infested (Horak *et al.* 1991b). Its hosts are domestic and wild ruminants and scrub hares (Keirans *et al.* 1993; Walker *et al.* 2000). Ticks were present on cattle in the Valley Bushveld site chiefly from spring to late summer (Horak 1999) compared to a peak in the intensity of infestation during spring on the goats in the present survey.

Rhipicephalus glabroscutatum

The seasonal intensity of infestation with *R. glabroscutatum* derived from the tick burdens of all the goats examined between August 1985 and October 1986 is graphically illustrated in Fig. 3.

The immature stages of this two-host tick were present mainly from March to September and the adults from July to January.

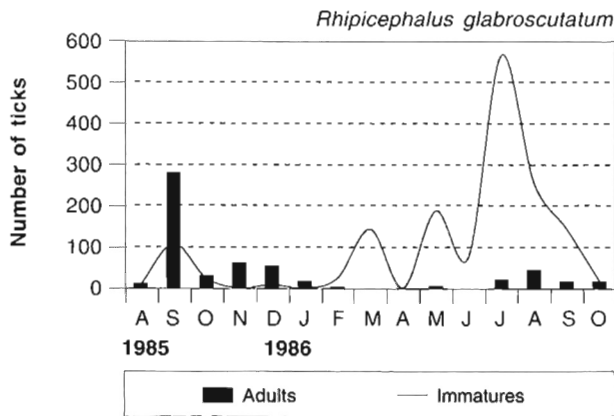


FIG. 3 The seasonal intensity of infestation with *Rhipicephalus glabroscutatum* on Angora goats in the southern Karoo, Eastern Cape Province

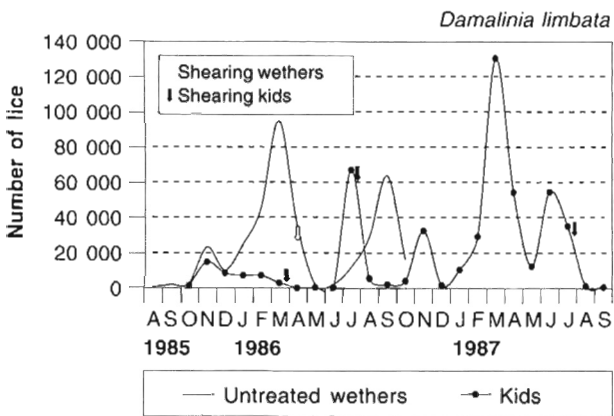


FIG. 4 The intensity of infestation with the biting louse *Damalinia limbata* on Angora goats in the southern Karoo, Eastern Cape Province

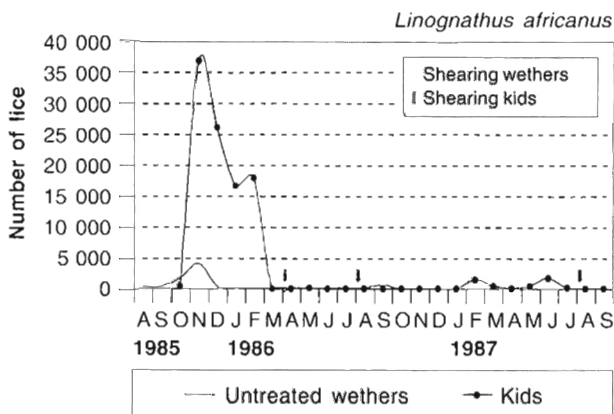


FIG. 5 The intensity of infestation with the sucking louse *Linognathus africanus* on Angora goats in the southern Karoo, Eastern Cape Province

Rhipicephalus glabroscutatum is found only in South Africa, where it occurs in the more arid south-eastern summer rainfall regions and in the southern and south-western winter rainfall regions (MacIvor 1985; Walker *et al.* 2000). The preferred hosts of all stages of development are domestic and wild ruminants to which the vast majority of ticks attach around the feet and the lower legs (Walker *et al.* 2000). The seasonal intensity of infestation recorded in the present study is similar to that on Angora goats, cattle and greater kudus in Valley Bushveld (Horak *et al.* 1991b, 1992; Horak 1999), and confirms the single annual life cycle of the tick. The presence of adult ticks is significantly associated with the occurrence of foot abscess in goats (MacIvor & Horak 1987).

Damalinia limbata

The intensity of infestation of this louse on the untreated wethers and on the kids is graphically illustrated in Fig. 4.

This is the most prevalent biting louse of Angora goats in the Eastern Cape Province and very large burdens can be present. Kids were already infested with *D. limbata* at 1 week of age. In previous surveys kids were also infested within a few days of birth and burdens increased rapidly thereafter (Fivaz *et al.* 1990; Horak *et al.* 1991b). In the present survey, the intensity of infestation was adversely affected by shearing and remained low for 1–3 months thereafter and then rapidly increased in all groups of goats signifying a short life cycle and prolific reproduction. Murray (1968) noted that at shearing lice are removed with the shorn fleece of sheep, and that on newly-shorn animals the biting louse *Damalinia ovis* and its eggs can be killed by a rise in skin temperature caused by solar radiation, thus accounting for a further reduction in louse burdens.

Linognathus africanus

The intensity of infestation with this louse on the untreated wethers and on the kids is graphically illustrated in Fig. 5.

Linognathus africanus was present on the kids during the first few months of their lives and again just before they became 1 and 2 years old, respectively.

This louse was not collected in any of the previous surveys conducted on Angora goats in the Eastern Cape Province. It is, however, considered by goat farmers to be a pathogenic infestation of both heavily pregnant ewes as well as their new-born kids. If the time of its occurrence on the untreated wethers in the present survey can be equated to that on the dams of the kids in the survey it is apparent that older goats harbour infestation at precisely the time that the kids are born. The new-born kids then serve as an ideal vehicle to harbour and propagate infestation.

The kids were already infested with small numbers of *L. africanus* at 1 week of age, and these increased dramatically in the following 3 weeks to reach a mean intensity of infestation exceeding 12 000 lice by the time they were 1 month old. This increase probably originated from two sources, firstly further transfer of infestation from the ewes and secondly rapid multiplication on the highly susceptible kids. The virtual disappearance of the louse once the goats had reached 5 months of age is related to shearing, seasonality and probably resistance to infestation as the goats grew older. Its reappearance on the wethers in late winter and spring would correspond to increases on goat ewes during the periparturient period. This increase is possibly related to the stress suffered by most animals, and particularly heavily pregnant ewes, after winter.

Oestrus ovis

The seasonal intensity of infestation with the larvae of *O. ovis* in the three groups of goats is graphically illustrated in Fig. 6.

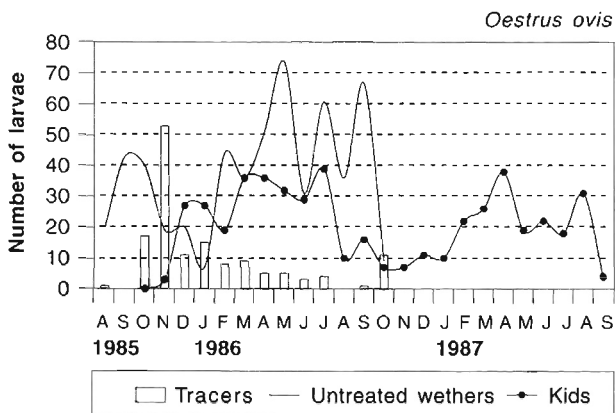


FIG. 6 The seasonal intensity of infestation with the larvae of *Oestrus ovis* in the nasal passages of Angora goats in the southern Karoo, Eastern Cape Province

Larvae were always present in the untreated goats. No larvae were recovered from the tracer goats in September 1985 and August 1986, while the largest numbers were collected from October 1985 to January 1986 and again in October 1986. Infestation was already present in the kids at 1 month of age in November 1985.

Kids born during September in Valley Bushveld were first infested with the larvae of *O. ovis* during December (Horak *et al.* 1991b), whereas kids born during October in Valley Bushveld, but maintained on irrigated kikuyu grass pastures, were infested for the first time during February (Fivaz *et al.* 1990). The seasonal pattern in the intensity of infestation in the

kids, untreated wethers and the tracer goats in the present study indicates that new infestation generally took place during spring, from September onwards, probably as a result of the synchronous hatching of flies from pupae accumulated during the late winter months (Horak 1977). The intensity of infestation then peaked from late summer to late winter because of the successive generations of flies that developed. These flies were probably only present until late summer. As a result very few larvae were deposited in the nostrils of the tracer goats during the autumn and winter months and larvae over-wintered in the nasal passages of untreated goats. A similar pattern of infestation has been recorded in sheep in Gauteng Province, South Africa (Horak 1977).

Control

Contrary to the general practice of treating Angora goat kids within the survey region with anthelmintics five or six times before they reach 6 months of age, a single treatment against cestodes during late January or in February and against nematodes when the kids reach a year of age in October would seem to be adequate for the control of helminths. The control of lameness in goats caused by the adults of *R. glabroscutatum* attaching to the feet between the claws, and of foot abscess, the prevalence of which has been statistically correlated with the presence of this tick (MacIvor & Horak 1987), can be accomplished by applying acaricide in a foot dip from August to October. If at all practicable, biting and sucking lice can be controlled by treating ewes shortly before parturition. A second treatment 2 weeks later should kill lice that had hatched from eggs unaffected by the first treatment and should also delay the build up of infestation. If this is not feasible because of the possibility of abortion when handling heavily pregnant animals, the kids should be treated during their first month of life followed by a second treatment 2 weeks later. The ewes can then be treated at the same time as the kids. Thereafter, two treatments 2 weeks apart after each shearing should assist in keeping infestation in control. Treatment administered during October or November for the control of *O. ovis* larvae will interrupt the life cycle of this fly before it becomes well established during summer.

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REFERENCES

- ACOCKS, J.P.H. 1988. *Veld types of South Africa* (Memoirs of the Botanical Survey of South Africa, no. 57).
- ATANÁSIO, ALSÁCIA 2000. Helminths, protozoa, heartwater, and the effect of gastro-intestinal nematodes on the productivity of goats of the family sector in Mozambique. Ph.D. thesis, Medical University of Southern Africa.
- AUCAMP, A.J. 1979. Die produksie -potensiaal van die Valleibosveld as weiding vir Boer- en Angorabokke. D.Sc. thesis, University of Pretoria.
- BAKER, MAUREEN K. & DUCASSE, F.B.W. 1968. Tick infestation of livestock in Natal. The role played by goats as reservoirs of the economically important cattle ticks. *Journal of the South African Veterinary Medical Association*, 39:55–59.
- BARROW, D.B. 1964. The epizootiology of nematode parasites of sheep in the Border area. *Onderstepoort Journal of Veterinary Research*, 31:151–162.
- BOOMKER, J., HORAK, I.G. & MACIVOR, K.M. DE F. 1989. Helminth parasites of grysbok, common duikers and Angora and Boer goats in the Valley Bushveld in the Eastern Cape Province. *Onderstepoort Journal of Veterinary Research*, 56:165–172.
- BOOMKER, J. & HORAK, I.G. 1992. Parasites of South African wildlife. XIII. Helminths of grey rhebuck, *Pelea capreolus*, and of bontebok, *Damaliscus dorcas dorcas*, in the Bontebok National Park. *Onderstepoort Journal of Veterinary Research*, 59:175–182.
- BOOMKER, J., HORAK, I.G. & RAMSAY, K.A. 1994. Helminth and arthropod parasites of indigenous goats in the northern Transvaal. *Onderstepoort Journal of Veterinary Research*, 61:13–20.
- BOOMKER, J., HORAK, I.G., WATERMEYER, R. & BOOYSE, D.G. 2000. Parasites of South African wildlife. XVI. Helminths of some antelope species from the Eastern and Western Cape Provinces. *Onderstepoort Journal of Veterinary Research*, 67:31–41.
- DOWER, KATHY M., PETNEY, T.N. & HORAK, I.G. 1988. The developmental success of *Amblyomma hebraeum* and *Amblyomma marmoreum* on the leopard tortoise, *Geochelone pardalis*. *Onderstepoort Journal of Veterinary Research*, 55:11–13.
- FIVAZ, B.H., HORAK, I.G. & WILLIAMS, E.J. 1990. Helminth and arthropod parasites of Angora goats on irrigated Kikuyu grass pastures in the eastern Cape Province. *Journal of the South African Veterinary Association*, 61:112–116.
- FOURIE, L.J. & HORAK, I.G. 1991. The seasonal activity of adult ixodid ticks on Angora goats in the south-western Orange Free State. *Journal of the South African Veterinary Association*, 62:104–106.
- FOURIE, L.J., HORAK, I.G. & MARAIS, L. 1988. An undescribed *Rhipicephalus* species associated with field paralysis of Angora goats. *Journal of the South African Veterinary Association*, 59:47–49.
- FOURIE, L.J., HORAK, I.G. & VAN ZYL, J.M. 1992. Seasonal occurrence of Karoo paralysis in Angora goats in relation to the infestation density of female *Ixodes rubicundus*. *Veterinary Parasitology*, 41:249–254.
- HORAK, I.G. 1977. Parasites of domestic and wild animals in South Africa. I. *Oestrus ovis* in sheep. *Onderstepoort Journal of Veterinary Research*, 44:55–63.
- HORAK, I.G. & BUTT, M.J. 1977. Parasites of domestic and wild animals in South Africa. II. *Oestrus ovis* in goats. *Onderstepoort Journal of Veterinary Research*, 44:65–68.
- HORAK, I.G. & LOUW, J.P. 1977. Parasites of domestic and wild animals in South Africa. IV. Helminths in sheep on irrigated pasture on the Transvaal Highveld. *Onderstepoort Journal of Veterinary Research*, 44:261–270.
- HORAK, I.G. 1981. Host specificity and the distribution of the helminths of sheep, cattle, impala and blesbok according to climate. *Journal of the South African Veterinary Association*, 52:201–206.
- HORAK, I.G., MELTZER, D.G.A. & DE VOS, V. 1982. Helminth and arthropod parasites of springbok, *Antidorcas marsupialis*, in the Transvaal and western Cape Province. *Onderstepoort Journal of Veterinary Research*, 49:7–10.
- HORAK, I.G. 1987. Parasites of very young goats from birth to one year of age. *Angora Goat and Mohair Journal*, 29:13–15.
- HORAK, I.G., MACIVOR, K.M., PETNEY, T.N. & DE VOS, V. 1987. Some avian and mammalian hosts of *Amblyomma hebraeum* and *Amblyomma marmoreum* (Acari: Ixodidae). *Onderstepoort Journal of Veterinary Research*, 54:397–403.
- HORAK, I.G., FOURIE, L.J., NOVELLIE, P.A. & WILLIAMS, E.J. 1991a. Parasites of domestic and wild animals in South Africa. XXVI. The mosaic of ixodid tick infestations on birds and mammals in the Mountain Zebra National Park. *Onderstepoort Journal of Veterinary Research*, 58:125–136.
- HORAK, I.G., KNIGHT, M.M. & WILLIAMS, E.J. 1991b. Parasites of domestic and wild animals in South Africa. XXVIII. Helminth and arthropod parasites of Angora goats and kids in Valley Bushveld. *Onderstepoort Journal of Veterinary Research*, 58:253–260.
- HORAK, I.G., BOOMKER, J., SPICKETT, A.M. & DE VOS, V. 1992. Parasites of domestic and wild animals in South Africa. XXX. Ectoparasites of kudu in the eastern Transvaal Lowveld and the eastern Cape Province. *Onderstepoort Journal of Veterinary Research*, 59:259–273.
- HORAK, I.G. 1999. Parasites of domestic and wild animals in South Africa. XXXVII. Ixodid ticks on cattle on Kikuyu grass pastures and in Valley Bushveld in the Eastern Cape Province. *Onderstepoort Journal of Veterinary Research*, 66:175–184.
- HOWELL, C.J., WALKER, JANE B. & NEVILL, E.M. 1978. *Ticks, mites and insects infesting domestic animals in South Africa. Part 1. Descriptions and biology*. Department of Agricultural Technical Services, Republic of South Africa (Science Bulletin, no. 393).
- KEIRANS, J.E., WALKER, JANE B., HORAK, I.G. & HEYNE, HELOISE 1993. *Rhipicephalus exophthalmos* sp.nov., a new tick species from southern Africa, and redescription of *Rhipicephalus oculatus* Neumann, 1901, with which it has hitherto been confused (Acari: Ixodida: Ixodidae). *Onderstepoort Journal of Veterinary Research*, 60:229–246.
- LE ROUX, P.L. 1932. On *Trichostrongylus pieterse*, sp. n., a parasite of sheep and goats. *Annals and Magazine of Natural History*, Series 10, 10:502–504.
- MACIVOR, K.M. DE F. & HORAK, I.G. 1984. The internal and external parasites of Angora and Boer goats in Valley Bushveld. *Angora Goat and Mohair Journal*, 26:7–14.
- MACIVOR, K.M. 1985. The distribution and hosts of *Rhipicephalus glabroscutatum*. *Onderstepoort Journal of Veterinary Research*, 52:43–46.
- MACIVOR, K.M. DE F. & HORAK, I.G. 1987. Foot abscess in goats in relation to the seasonal abundance of adult *Amblyomma hebraeum* and adult *Rhipicephalus glabroscutatum* (Acari: Ixodidae). *Journal of the South African Veterinary Association*, 58:113–118.
- MALAN, F.S., REINECKE, R.K. & SCIALDO, R.C. 1981. The recovery of helminths post mortem from equines. II. Helminths and larvae of *Gasterophilus* in the gastro-intestinal tract and oestrids from the sinuses. *Onderstepoort Journal of Veterinary Research*, 48:145–147.

- MULLER, G.L. 1968. The epizootiology of helminth infestation of sheep in the south-western Cape. *Onderstepoort Journal of Veterinary Research*, 35:159–194.
- MURRAY, M.D. 1968. Ecology of lice on sheep. VI. The influence of shearing and solar radiation on populations and transmission of *Damalinea ovis*. *Australian Journal of Zoology*, 16:725–738.
- NORVAL, R.A.I. 1975. Studies on the ecology of *Amblyomma marmoreum* Koch 1844 (Acarina: Ixodidae). *Journal of Parasitology*, 61:737–742.
- NORVAL, R.A.I. 1982. The ticks of Zimbabwe. IV. The genus *Hyalomma*. *Zimbabwe Veterinary Journal*, 13:2–10.
- RECHAV, Y. 1982. Dynamics of tick populations (Acari: Ixodidae) in the eastern Cape Province of South Africa. *Journal of Medical Entomology*, 19:679–700.
- RECHAV, Y. & DE JAGER, C. 1991. Seasonal abundance of ticks associated with indigenous goats on a northern Transvaal farm. *Journal of the South African Veterinary Association*, 62: 10–11.
- REINECKE, R.K. 1983. *Veterinary Helminthology*. Durban & Pretoria: Butterworths Publishers (Pty) Ltd.
- ROSSITER, L.W. 1964. The epizootiology of nematode parasites of sheep in the coastal area of the Eastern Province. *Onderstepoort Journal of Veterinary Research*, 31:143–150.
- THEILER, GERTRUD. 1950. Zoological Survey of the Union of South Africa. Tick Survey—Part V. Distribution of *Rhipicephalus evertsi*, the red tick. *Onderstepoort Journal of Veterinary Science and Animal Industry*, 24:33–36.
- THEILER, GERTRUD. 1962. *The Ixodoidea parasites of vertebrates in Africa south of the Sahara (Ethiopian region)*. Project S 9958. Report to the Director of Veterinary Services, Onderstepoort. Mimeographed.
- VILJOEN, J.H. 1964. The epizootiology of nematode parasites of sheep in the Karoo. *Onderstepoort Journal of Veterinary Research*, 31:133–142.
- VILJOEN, J.H. 1969. Further studies on the epizootiology of nematode parasites of sheep in the Karoo. *Onderstepoort Journal of Veterinary Research*, 36:233–263.
- WALKER, JANE B. & OLWAGE, A. 1987. The tick vectors of *Cowdria ruminantium* (Ixodoidea, ixodidae, genus *Amblyomma*) and their distribution. *Onderstepoort Journal of Veterinary Research*, 54:353–379.
- WALKER, JANE B. 1991. A review of the ixodid ticks (Acari, Ixodidae) occurring in southern Africa. *Onderstepoort Journal of Veterinary Research*, 58:81–105.
- WALKER, JANE B., KEIRANS, J.E. & HORAK, I.G. 2000. *The genus Rhipicephalus (Acari, Ixodidae): a guide to the brown ticks of the world*. Cambridge: Cambridge University Press.