

## SEASONAL ABUNDANCE AND DISTRIBUTION OF *PARAFILARIA BOVICOLA* OVIPOSITIONAL BLOOD SPOTS ON CATTLE IN SOUTH AFRICA\*

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### ABSTRACT

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More than 23 000 cattle of both sexes and different ages were examined for blood spots caused by egg-laying females of *P. bovicola*. Although these studies extended over four years and involved 5 farms in different parts of the Transvaal Bushveld, the overall results were the same.

Ovipositional bleeding was strongly seasonal with blood spots first appearing in winter (June), reaching a peak in spring (September–November) and thereafter declining rapidly as summer progressed. In a single year at Zoutpan Research Station up to 92.1 % of the 1st year heifers had already bled by November and this proportion increased only slightly to 95.1 % by the end of the bleeding season (May). The number of blood spots per animal showed a similar seasonal abundance except for a second peak of abundance in June for 1st year heifers and oxen.

The prevalence of blood spots in cattle of different ages and sex varied markedly. At Mara Research Station half as many oxen bled in their 2nd year as in their 1st year, while at Zoutpan 19.2 % fewer heifers bled in their 2nd year than in their 1st. Bulls bled the most, then 1st year oxen, 1st and 2nd year heifers and 2nd year oxen, with breeding cows bleeding the least. A high female hormone level appears to be associated with the development of immunity.

The shortest period from birth to 1st blood spot (the apparent prepatent period) was 191 days, while 81.8 % of oxen bled for the 1st time within 279 days after birth. Blood spots were equally distributed on the left and right sides, with 92.1 % on the dorsolateral regions and 59.9 % on the shoulder and rib regions. The blood spot distribution more or less matched the carcass lesion distribution. This suggests that ovipositing females are largely responsible for carcass lesions in these areas.

### INTRODUCTION

When female *Parafilaria bovicola* wish to oviposit, they make a hole through the skin to the outside and lay their eggs in the blood which oozes from this lesion. These blood spots therefore indicate that an animal is infected and also pinpoint the exact location of the gravid female worm. A survey of blood spots can provide information on the prevalence of infection in a herd, the time of the year when vector flies are most likely to become infected, the prevalence of infection in cattle of both sexes and different ages, and the prevalence on farms in different parts of an enzootic area.

In those countries in which parafilaria is enzootic the presence of blood spots has been used in its clinical diagnosis (Nevill, 1975). Blood spots have also been used to evaluate the results of chemotherapy, especially in India (Gulati, 1934; Sahai, Singh & Srivastava, 1965); and at Onderstepoort by Viljoen (1976) and Viljoen & Boomker (1977). Viljoen (1976) also used the appearance of the 1st blood spots in calves to determine the approximate prepatent period of the worms.

The primary aim of the present survey of the abundance and distribution of blood spots on cattle in different parts of the Transvaal Bushveld was to correlate the presence of these egg-laden blood spots with the recoveries of 3rd stage larvae of *P. bovicola* from vector flies in these regions (Nevill, 1975; 1980), and so determine the main transmission period(s).

The prevalence of infection in cattle is directly related to the number of infective blood spots on which vector flies can feed. This prevalence may be influenced by the age or sex of the animal so, where possible, this aspect was investigated. The number of blood spots on infected cattle which could affect the amount of infective material available to flies, and the distribution of these blood spots on the different parts of the body which may be connected with the method and site of worm transmission were also recorded.

In limited experimental infections of cattle, the prepatent period was shown to be 242 days (Nevill, 1979). Since the prepatent period constitutes a major portion of the developmental cycle of *P. bovicola*, more information on this period could help to explain the results obtained on *P. bovicola* transmission. The period from birth to 1st ovipositional blood spot was therefore determined for 353 'Zoutpan' cattle, on the assumption that many calves were infected soon after birth.

Initially cattle were examined on all the farms where flies were collected (Nevill, 1975; 1980), but only 4 of these farms were chosen for regular examination every 2 months over a period of 1-2 years, and 1 for weekly to fortnightly examination for 4 years.

### MATERIALS AND METHODS

#### *Cattle examined for blood spots*

The farms 'Doornpan', 'Leamington' and 'Mooiplaats' were visited every 2 months for a full year (September 1973–September 1974); 'Mara' every 2 months for 2 years (October 1973–October 1975) and 'Zoutpan' weekly to fortnightly for nearly 4 years (July 1973–May 1977). The geographic co-ordinates of these 5 farms are given in Nevill (1975; 1980). On the 1st 3 farms an attempt was made at each visit to examine between 100 and 500 cattle in their 1st or 2nd seasons of exhibiting blood spots due to *P. bovicola* infection. It was not always possible to examine the same cattle each time, because animals were sometimes sold or moved, so any available cattle were inspected.

At Mara Research Station all cattle were numbered and often kept in herds of the same age and sex. A series of comparable observations could therefore be made on heifers and oxen in their 1st and 2nd years of showing blood spots; on breeding cows in the Afrikaner, Bonsmara, Hereford and Simmentaler herds; on the herd of bulls; and on the small dairy herd of Jersey cows and heifers.

Zoutpan Research Station was conveniently situated and more frequent examinations could be made. Here, too, all cattle (crossbred Afrikaner and Simmentaler) were numbered and kept in separate homogeneous herds.

\* Part of a D.Sc. thesis submitted to the University of Pretoria, October 1980



Heifers were examined fortnightly from the age of 6 months until approximately 25 months old, when they were transferred to the breeding herd. No oxen born during 1972 were kept on the farm; those born in 1973 and 1974 were retained and examined weekly for blood spots during the 1st 4 or 5 months of their 1st season of bleeding until they were used in chemotherapy trials (Viljoen, 1976; Viljoen & Boomker, 1977). The 1975 group of oxen, however, was examined fortnightly throughout their entire 1st season of exhibiting *P. bovicola* blood spots. A 'bleeding season' was taken to extend from June to the following May.

#### Method of examination for blood spots

Cattle were usually examined in a crush and the presence of blood spots, both fresh and dry, was noted for each side separately. The body surface was divided into separate regions (Fig. 1) so that the precise distribution of the blood spots could also be recorded. If there was doubt about the cause of the spot, a sample of blood was taken from it and examined for *P. bovicola* eggs as described by Nevill (1979). In some breeds, such as Herefords, Simmentaler and their crosses, which have long hair, especially in winter and spring, the blood spots had to be located by lightly running the hand over the body surface.

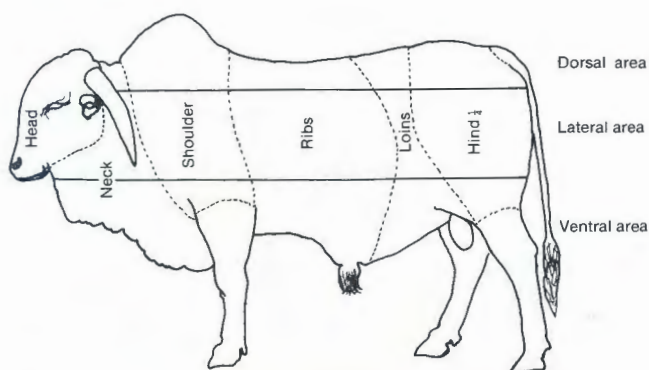


FIG. 1 Diagram of a bull indicating body regions used in the study of the distribution of *Parafilaria bovicola* ovi-positional blood spots

Where no crush was available, or where there was a danger of injuring small calves, the blood spots were located by walking around the animals or watching as they moved individually through a gateway. Some spots, (especially in long-haired animals) may have been overlooked when these methods were used.

## RESULTS

#### The prevalence of cattle with blood spots on 5 bushveld farms

Table 1 summarizes the prevalence of cattle with blood spots among the 16 757 cattle examined during the period September 1973–October 1975.

During the spring and summer of 1973/74, cattle with blood spots were common on all 5 farms. They were most abundant in November on 'Doornpan', 'Leamington' and 'Mooiplaats'; in October at 'Mara'; and in September at 'Zoutpan'. Except on 'Doornpan', which had a prevalence in January of 26,2%, the prevalence of cattle with blood spots on all the farms visited dropped to below 12% during January. At 'Mara' and 'Zoutpan' the number of cattle with blood spots began to increase from July during both 1974 and 1975, and the records for these 2 farms during these 2 years generally confirmed those of 1973.

#### The seasonal incidence of heifers and oxen with blood spots at 'Zoutpan'

The mean monthly percentage of cattle with blood spots at 'Zoutpan' is shown in Fig. 2 for—

- (i) heifers born in 1972, 1973 and 1974 and examined regularly throughout their 1st and part of their 2nd season of bleeding (June–May);
- (ii) heifers born in 1975 and examined regularly throughout their 1st bleeding season only, and
- (iii) oxen born in 1973, 1974 and 1975 and examined either for a part of or for the full 1st year of bleeding.

TABLE 1 The prevalence of cattle with *Parafilaria bovicola* ovi-positional blood spots on 5 Bushveld farms, September 1973–October 1975

Month	'Doornpan'		'Leamington'		'Mara'		'Mooiplaats'		'Zoutpan'	
	No. of cattle examined	% cattle positive	No. of cattle examined	% cattle positive	No. of cattle examined	% cattle positive	No. of cattle examined	% cattle positive	No. of 1st year heifers examined	% heifers positive
Sept. 1973	276	17,4	85	20,0			130	15,4	80	51,3
Oct.					458	22,4			78	32,1
Nov.	314	33,8	93	59,1			179	16,8	77	27,6
Dec.					375	19,3			77	29,9
Jan. 1974	248	26,2	85	11,8			241	6,6	77	10,4
Feb.					761	7,8			78	9,0
Mar.	468	3,8	171	3,5					78	6,4
Apr.					634	3,9		3,5	78	7,7
May	380	1,8	245	1,6					78	12,8
June					721	1,8		4,0	82	7,3
July	301	10,0	148	5,4					164	19,5
Aug.					1 105	3,7			246	37,0
Sept.							399	8,8	164	47,6
Oct.					1 022	20,7			154	44,8
Dec.					974	11,2			154	31,2
Feb. 1975					757	11,2			164	18,3
Apr.					652	2,5			81	3,7
June					701	1,9			156	1,9
Aug.					982	8,0			156	29,5
Oct.					1 005	23,5			154	38,3
Totals	1 987		827		10 147		1 420		2 376	

During the 1st season of bleeding the initial blood spots were noticed in May and June in approximately 8-month-old heifers and oxen. The incidence of spots increased rapidly thereafter and the greatest number of bleeding heifers was recorded in August or September and oxen in October. The highest mean monthly percentage for 4 groups of heifers born in successive years (and during their 1st season of bleeding) was 49,2 in September (Fig. 2).

The prevalence of cattle with blood spots decreased gradually until December (heifers 31,0%; oxen 20,0%), then dropped rapidly until March (heifers 6,3%; oxen

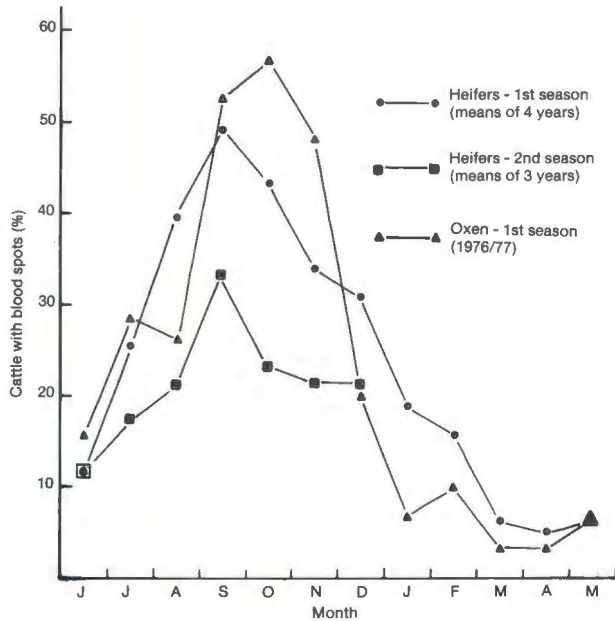


FIG. 2. The mean monthly percentage of cattle with *Parafilaria bovicola* blood spots at 'Zoutpan', 1973-1977

3,3%), after which it stabilized until May, when the next season of ovipositional bleeding began. In the 2nd year of bleeding in heifers, all peaks occurred in September (Fig. 2).

In the groups of heifers and oxen born in 1975 most heifers bled in September (61,6%), while most oxen bled in October (56,7%). The cumulative percentage of heifers and oxen which bled during at least 1 visit is summarized on a monthly basis for the 1st and 2nd seasons during which these cattle showed blood spots (Fig. 3).

The percentage of heifers clinically proven to be infected increased rapidly each year until November, when a mean of 85,7 (81,4-92,1) of heifers in their 1st bleeding season was infected. The subsequent increase was gradual until the maximum infection was reached in January-March (Fig. 3).

The maximum percentage of 1st year heifers which had shown blood spots by the end of the bleeding season ranged from 87,5%-95,1%.

#### *The effect of age on the percentage of heifers with blood spots at 'Zoutpan'*

A comparison of the mean monthly percentage of heifers with blood spots in their 1st and 2nd bleeding seasons (Fig. 2) shows a sharp decline in the 2nd season, when the maximum had dropped from 49,2 to 33,5.

Since most of the heifers have bled by November, and because records are available for this month for heifers in both their 1st and 2nd bleeding seasons, it is convenient to compare the cumulative prevalence of infected heifers in each group during this month (Fig. 3).

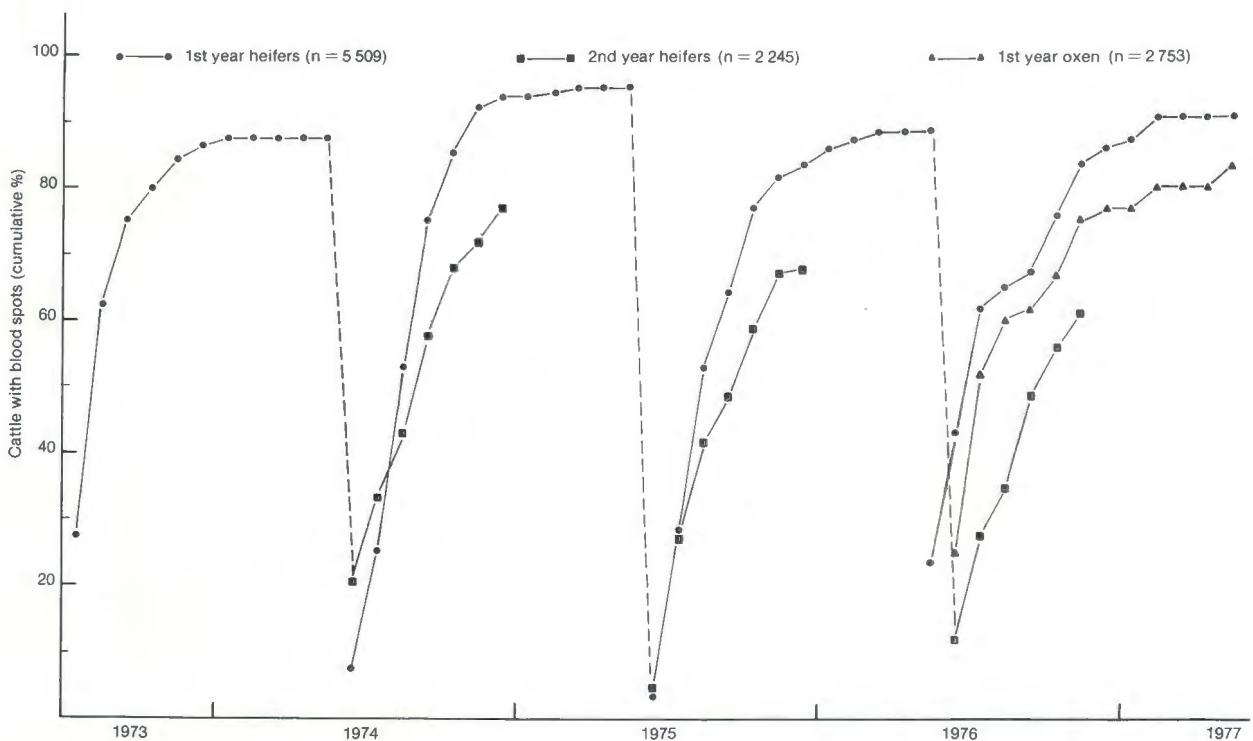


FIG. 3 The cumulative monthly percentage of cattle with *Parafilaria bovicola* blood spots at 'Zoutpan', 1973-1977



TABLE 2 The percentage of cattle at 'Mara' positive for *Parafilaria bovicola* blood spots, October 1973–October 1975

Date	Cattle group and percentage cattle positive for blood spots**						
	1st year oxen	1st year heifers	2nd year oxen	2nd year heifers	Breeding cows	Bulls	2-monthly means
Oct. 1973	34,8	16,2	23,6	15,0			22,4
Dec.	30,1	20,0	21,1	6,0			19,3
Feb. 1974	10,4	10,8	5,7	0	0,7	18,9	7,8
Apr.	4,8	4,1	***	***	1,1	5,5	3,9
June	Weaners*	Weaners*	1,2	3,4	0,7	1,7	1,8
Aug.	6,4	1,4	3,3	4,1	1,4	5,5	3,7
Oct.	32,7	10,7	34,0	13,8	3,1	29,8	20,7
Dec.	12,6	6,5	12,0	7,7	2,2	25,9	11,2
Feb. 1975	3,0	5,6	4,0	***	4,2	39,3	11,2
Apr.	1,9	0	***		1,1	7,1	2,5
June	Weaners*	Weaners*	0	0	0,6	6,8	1,9
Aug.	11,9	6,5	2,6	2,9	0,5	23,5	8,0
Oct.	34,2	15,3	8,3	11,4	1,3	70,4	23,5
Group means	17,2	8,3	8,1	6,4	1,5	21,1	

\* Weaners—too young for blood spots

\*\* None of the 188 Jersey cows and heifers examined on 8 visits showed blood spots

\*\*\* During the 2nd half of summer 2nd year oxen were sold or slaughtered and 2nd year heifers culled or transferred to the breeding herd

During November 1974, 1975 and 1976, heifers in their 2nd bleeding season regularly showed a much lower infection level than heifers in their 1st bleeding season (71,8 % versus 92,1 %; 66,9 % versus 81,4 %; and 61,0 % versus 83,7 % respectively), despite the fact that both groups examined in each of these years had an equal opportunity of becoming infected. The mean difference between 1st and 2nd year bleeders over the 3 year period was 19,2 % (Fig. 3).

In a comparison of the November infection level for 2 consecutive years for each of the heifer groups born in 1972, 1973 and 1974 a mean of 19,3 % fewer heifers was found to bleed in their 2nd year than in their 1st (71,8 % versus 84,2 %; 66,9 % versus 92,1 %; and 61,0 % versus 81,4 %) (Fig. 3).

#### *The effect of age on the percentage of cattle with blood spots at 'Mara'*

The percentage of cattle of both sexes and different ages that were positive for *P. bovicola* blood spots at 'Mara' during 13 visits at 2-month intervals is summarized in Table 2.

The study showed only a small, irregular difference in the percentage of 1st and 2nd year heifers with blood spots. This did not support the results of the more thorough and extensive study made at 'Zoutpan'.

There was, however, a considerable difference in the percentage of oxen with blood spots in their 1st and 2nd years of bleeding. In general twice as many oxen bled during their 1st year as did oxen during their 2nd year of bleeding (17,2 % versus 8,1 %), although in October 1974 a slightly greater percentage of older oxen was infected when compared with their younger counterparts (Table 2).

#### *The effect of sex on the percentage of cattle with blood spots*

At 'Mara' bulls constituted the most heavily infected group of cattle examined, with up to 70,4 % showing blood spots on a single visit and an overall mean of 21,1 % after 11 examinations during both winter and summer.

First year oxen formed the next most heavily infected group (max. 34,8 %, mean 17,2 %), followed by 1st year heifers (max. 20,0 %, mean 8,3 %), 2nd year oxen (max. 34,0 %, mean 8,1 %) 2nd year heifers (max. 15,0 %, mean 6,4 %), breeding cows (max. 4,2 %, mean 1,5 %) and the dairy's Jersey cows and heifers (0 %) (Table 2).

The differences between infection rates in 1st year heifers, 2nd year heifers, and 2nd year oxen were not clear-cut, but the percentage 1st year oxen with blood spots was more than double the percentage for each of these 3 groups.

Comparisons at 'Zoutpan' between groups of 1st year oxen and heifers born in 1975 showed, however, that only 83,3 % of the oxen had bled by May compared with 90,7 % of the heifers (Fig. 3).

#### *The number of blood spots per animal on 5 bushveld farms*

The distribution and number of *P. bovicola* ovipositional blood spots on cattle on the 5 Bushveld farms visited between July 1973 and May 1977 are summarized in Table 3.

The mean number of blood spots per animal in the various herds on these farms ranged from 2,2–3,7. Bulls at 'Mara' had noticeably more blood spots (3,3) than the next highest group at 'Mara', namely, 1st year oxen, which had a mean of 2,5 spots per animal, and these in turn had more spots than 1st and 2nd year heifers (Table 3).

The mean number of blood spots per 1st year heifer at 'Zoutpan' was 2,3 compared with 2,5 for 2nd year heifers. There was thus a slight increase in the number of blood spots per animal in the heifers' 2nd year of bleeding, although 19,2 % fewer 2nd year heifers bled (Fig. 2 & 3). As at 'Mara', 1st year oxen at 'Zoutpan' had noticeably more blood spots than 1st and 2nd year heifers (Table 3).

The mean number of blood spots recorded monthly for heifers in their 1st and 2nd years of bleeding over a period of 1–4 years at 'Zoutpan' is given in Fig. 4.

TABLE 3 The distribution and number of *Parafilaria bovicola* ovipositional blood spots on cattle on 5 Bushveld farms, July 1973–May 1977

Farm	No. of visits	Sex and age	No. of cattle examined	No. of cattle with blood spots	Total No. of blood spots	Mean No. of spots per animal	The percentage of blood spots at various sites on cattle (see Fig. 1)													
							Left side	Right side	Dorsal	Lateral	Ventral	Head	Neck	Shoulders	Ribs	Loins	Hind-quarters	Front legs	Hind legs	Tail
Doompan*	6	Mixed	1 987	274	868	3.2	45.0	55.0	39.0	51.5	9.5	0.7	15.9	33.6	30.2	11.4	6.1	1.3	0.7	0.1
Leamington*	6	Mixed	827	100	366	3.7	42.9	57.1	46.7	49.2	4.1	0.3	13.4	32.8	29.2	14.5	9.3	0.3	0.3	0
Mooiplaats*	6	Mixed	1 420	119	281	2.4	46.4	53.6	38.0	55.4	6.5	0.7	31.0	33.5	21.4	5.0	6.8	1.1	0.7	0
Mara**	11	1st year oxen	1 760	302	750	2.5	49.5	50.5	46.4	47.8	5.8	0.4	12.5	24.3	35.9	15.9	10.0	0.7	0.4	0
Mara**	11	2nd year oxen	790	64	151	2.4	46.7	53.3	35.6	52.7	11.6	0.7	17.9	22.5	34.4	8.6	13.9	0.7	1.3	0
Mara**	11	1st year heifers	1 630	136	292	2.2	55.7	44.3	44.4	49.3	6.3	0.7	16.8	24.3	33.6	13.4	9.6	1.0	0.7	0
Mara**	10	2nd year heifers	1 290	83	189	2.3	47.6	52.4	46.3	46.8	6.9	0	17.5	30.7	36.0	7.4	7.9	0.5	0	0
Mara**	11	Breeding cows	4 070	63	150	2.4	54.7	45.3	29.7	50.7	19.6	0.7	22.0	34.7	25.3	4.7	10.7	0.7	0.7	0.7
Mara**	11	Mixed bulls	607	128	416	3.3	52.3	47.7	43.3	47.0	9.7	0.2	7.7	27.4	41.8	10.6	10.8	1.0	0.5	0
Zoutpan***	30	1st year oxen	1 412	416	1 158	2.8	54.2	45.8	33.1	59.0	7.9	0.1	15.3	31.3	27.5	13.2	12.0	0.5	0.1	0
Zoutpan***	92	1st year heifers	5 586	1 384	3 124	2.3	52.7	47.3	38.6	55.0	6.4	0.7	14.4	30.6	30.1	11.5	12.1	0.3	0.4	0
Zoutpan***	37	2nd year heifers	2 245	485	1 215	2.5	49.0	51.0	33.8	55.2	11.0	0.2	25.8	30.5	22.5	8.1	11.3	1.0	0.6	0.1
Totals and means (as %)	242		23 624	3 554	8 960	2.5	50.7	49.3	38.6	53.5	7.8	0.5	16.5	30.2	29.7	11.3	10.7	0.6	0.4	0.1

\* Cattle examined during period September 1973–September 1974

\*\* Cattle examined during period October 1973–October 1975

\*\*\* Cattle examined during period July 1973–May 1977



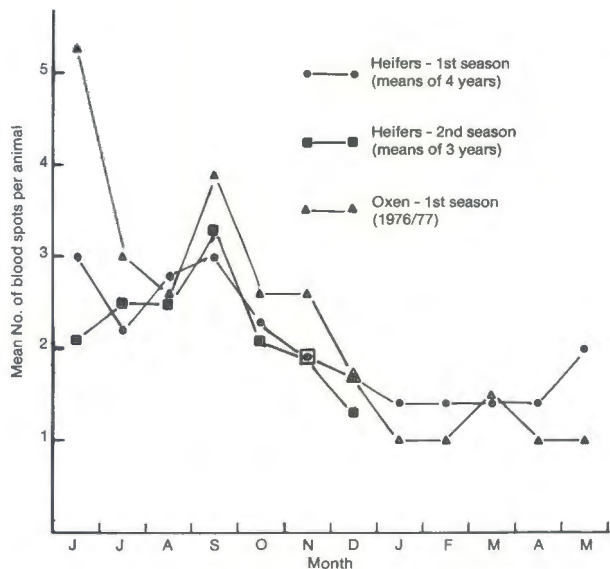


FIG. 4 The mean number of *Parafilaria bovicola* blood spots recorded monthly on cattle at 'Zoutpan', 1973-1977

These data show that most blood spots are present during winter and through to early summer (June-November). Heifers and oxen in their 1st year of bleeding had 2 peaks of blood spots, the 1st in June (3.0 and 5.3 respectively) and the 2nd in September (3.0 and 3.0 respectively), while heifers in their 2nd bleeding season showed only the September peak (3.3). This September peak corresponded to the peak incidence of heifers bleeding within these herds (Fig. 2).

In December, blood spots per 1st year heifer or ox dropped to 1.7, and from January-April or May to 1.4 and lower.

The number of blood spots per individual on the 5 study farms varied greatly, but was usually within the range of 1-14 at any 1 examination. Occasionally, however, and usually on the same animal, up to 27 spots were recorded on a single beast.

#### The prepatent period of *P. bovicola* in cattle at 'Zoutpan'

The period from birth to 1st ovipositional blood spot was calculated for each of 221 heifers born over 4 consecutive years (1972-1975) and for 132 oxen born from 1973-1975. The shortest period from birth to 1st blood spot was 191 days, and in 66 of the 353 cattle examined this period was less than 240 days. Nearly all oxen (81.8%) and many heifers (47.1%) bled for the 1st time within 279 days after birth.

The mean apparent prepatent periods for heifers born in consecutive years were as follows: 1972-299.3 days; 1973-288.6 days; 1974-309.7 days, and 1975-289.6 days. This gave an overall mean for the 4 years of 297.0 days. The same periods for oxen were: 1973-251.0 days; 1974-252.4 days, and 1975-297.8 days; overall mean for the 3 years 260.0 days.

#### Distribution of blood spots

**Bilateral distribution.** Blood spots were almost equally distributed on the left and right sides of the 3 554 cattle found to be infected (50.7% left; 49.3% right). The mean minimum recorded per side in a group was 42.9% on the left side and the maximum 57.1% on the right side (Table 3).

**Dorso-ventral distribution.** The mean percentage of blood spots on the 'dorsal area' of all cattle examined was 38.6%. Most blood spots were seen laterally, the overall mean being 53.5%. Only 7.8% of the spots were found ventrally (Fig. 1; Table 3).

The distribution of blood spots in various groups of cattle on different farms was generally similar, except that breeding cows at 'Mara' had only 29.7% of blood spots dorsally but as many as 19.6% ventrally (Table 3).

**Cranio-caudal distribution.** The data in Table 3 indicate that very few blood spots were recorded from the head, legs and tail. In 9 of the 12 groups examined, less than 20% of blood spots were recorded from the neck, bulls having the lowest prevalence (7.7%).

Most spots were on the shoulders (30.2%) and ribs (29.7%). The number of spots diminished posteriorly, the loins having a mean of 11.3% and the hindquarters 10.7%.

Bulls at 'Mara' had the lowest prevalence of neck spots and the highest of rib spots recorded, while 'Mara' breeding cows had the lowest prevalence of loin spots and the highest of shoulder spots.

## DISCUSSION

### Seasonal prevalence and periodicity of *P. bovicola* ovipositional activity

Worms (1972) reviewed seasonal rhythms in blood parasites and presented evidence of seasonal periodicity in microfilaraemia caused by *Dirofilaria immitis* and *Dirofilaria repens*. The mechanism governing this periodicity was not known, although work in Japan by Kata-mine, Aoki & Iwamoto (1970) on *D. immitis* suggested that seasonal periodicity is related to the increase in temperature during summer.

Anderson (1956) found the prepatent period of *Ornithofilaria fallisensis* in experimentally infected ducks to be 30-36 days but said that . . . 'Generally speaking, the microfilaraemias of these ducks reached their peaks during the late winter or early spring of the year following exposure.'

The present study, in which 23 624 cattle were examined on 5 farms in different parts of the Transvaal Bushveld, provides overwhelming evidence that egg-laying in *P. bovicola* is strongly seasonal mainly from winter to early summer. This supports the observations by numerous workers on *P. bovicola* (De Jesus, 1934; Faure, 1935; Metianu, 1949; Niilo, 1968 and *Parafilaria multipapillosa* (Railliet & Moussu, 1892; Baumann, 1946; Gibson, Pepin & Pinsent, 1964; Andersson, Jalkanen & Nurmio, 1976), all of whom claimed that most blood spots were seen in spring and summer.

At 'Zoutpan' the peak month of bleeding (September) was the same for heifers in either their 1st or 2nd year; the timing of bleeding was not dictated by their date of birth.

Further evidence of seasonal periodicity is provided by the fact that the highest numbers of blood spots per infected animal were also recorded during spring—in other words cattle bleed most when most cattle bleed!

The study indicated that bulls and calves bled most. In their 2nd year, however, 19% fewer heifers bled; breeding cows hardly bled at all, and no Jersey cattle bled. An explanation for the apparent lower infection rate in older heifers and cows could be that the development of immunity is influenced by the balance of the sex hormones,



and that the more female hormones there are present the greater is the immunity. This could explain the complete absence of bleeding in the Jersey cows and heifers at 'Mara', since animals belonging to this breed become sexually mature when 5–8 months old (Osterhoff, Couvaras, Genis & Van Niekerk, 1977). This statement is supported to some extent by the results of studies on filariasis in humans which showed that fewer young women and older men were infected than young men and older women, a phenomenon which Nelson (1966) believed to be hormone-linked.

A practical implication of the high infection rate in bulls is that new foci of infection may be established when these animals are sold to farmers in uninfected areas.

#### *The prepatent period of P. bovicola in cattle at 'Zoutpan'*

Although cattle may become infected at any time after birth, the period from birth to the 1st blood spot does give some indication of the prepatent period in each animal. Judging from the present study, the prepatent period of 242 days given by Nevill (1979) can be shortened to a minimum of 191 days. The latter figure agrees closely with the 195-day period found in *in vivo* studies for *P. bovicola* females to become sexually mature and for embryonated eggs to appear in their uteri (Viljoen, 1982).

Many cattle at 'Zoutpan' bled for the 1st time within 279 days after birth. This could be due to 1 or more of the following factors:

- (i) a variable prepatent period similar to that seen in experimentally infected cattle;
- (ii) infection of calves at various times from birth onwards;
- (iii) a combination of (i) and (ii).

In the 'Zoutpan' studies the overall mean apparent prepatent period in oxen appears to be shorter than in heifers. This, however, is not always so, since the mean apparent prepatent period in oxen born in 1975 was found to be 297,8 days, which agrees closely with the 289,6 days mean in heifers born in the same year. This figure for oxen born in 1975 is, however, considerably higher than the means of 251,0 and 252,4 days in oxen born in 1973 and 1974.

These ostensible differences in mean apparent prepatent periods may be related to the fact that the oxen which had the shortest mean apparent prepatent periods were examined weekly, while all other groups were examined fortnightly. It is fair to assume that the 1st blood spots would be more likely to be detected in cattle examined at the shorter intervals.

This shows that the blood spot records are only a means of measuring and comparing infections; that actual blood spot counts may easily be altered by time, weather, method of examination, etc.; and that absolute comparisons of infections can possibly only be achieved by necropsy and worm recovery techniques such as those used by Viljoen (1982), in which worms were recovered after migrating out of superficial tissue layers and pieces of skin placed in saline baths for 4 h at approximately 40 °C.

#### *Distribution of P. bovicola blood spots*

With few exceptions the dorso-ventral distribution of blood spots on the 3 554 infected cattle examined in different parts of the Transvaal Bushveld followed a fixed pattern, with 92,1 % of the blood spots occurring dorso-laterally. These results support those of the experimental transmission attempts reported by Nevill (1979) in which, after subcutaneous infection in the neck area, carcass lesions, worms and blood spots were often recorded in the dorsolateral areas of the trunk. Within the preferred areas of the body the worms are, however, randomly distributed, since almost equal numbers of blood spots were recorded from the left and right sides of the body.

A fixed pattern was also followed in the cranio-caudal distribution with 71,2 % of the blood spots occurring on the shoulders, ribs and loins.

These blood spot sites agree closely with the sites of lesions recorded on 35 carcasses by Viljoen (1976). For example, he recorded 71,3 % of carcass lesions from the region comprising the withers, shoulders, upper fore-legs, rib cage, flanks, back and loins. In the present study 71,2 % of the blood spots were recorded from the same region. However, in a survey of lesions on 150 carcasses at Pretoria abattoir, Van den Heever, Nevill & Horton (1973) found 58,2 % occurred in this area, while Carmichael (personal communication, 1979), in a survey of 300 affected carcasses at Lobatsi abattoir, found less than 38 % of carcass lesions in the above-mentioned region, but 62 % on the neck area. The generally good correlation between the prevalence of blood spots and carcass lesions in certain body areas suggests that the ovipositing females are largely responsible for the carcass lesions in these areas.

The carcass lesions on the neck may be caused by 3rd and 4th stage larvae migrating posteriorly after entering the host via the eyes, a proven possible port of entry (Nevill, 1979; Bech-Nielsen, 1982). This is supported by *in vivo* life cycle studies on *P. bovicola* conducted by Viljoen & Coetzer (1982), in which they demonstrated carcass lesions during the period of the life cycle when these immature stages were still actively migrating.

The fixed pattern of worm distribution as revealed by blood spots suggests that this worm has distinct predilection sites. However, very little is known about the factors governing the choice of these sites. It is interesting to speculate on the reason for the blood spot distribution found in this study. Since the distribution is similar in cattle of all ages and sizes, the sites of the blood spots are not determined by the distance a worm can migrate from the point of infection. It would rather seem that other factors, either external or internal, may influence the worms' destination.

Solar radiation appears to be a likely factor, since most spots are on the upper half of the body. However, in artificial infection experiments Ox No. 367 spent the entire period between subcutaneous infection in the neck area and necropsy 270 days later in a shaded stable and still showed well-developed carcass lesions in the dorso-lateral area from the shoulder to the hindquarters (Nevill, 1979).

Viljoen (1982) and Viljoen & Coetzer (1982) in their work concluded that because most carcass lesions were found in the forequarters, particularly the scapular region, that this area could be a predilection site for natural infestations by intermediate fly hosts. The writer, however, cannot accept this conclusion as the main predilection sites for the vector face flies are around the eyes and



muzzle. Viljoen (1982) himself showed that various stages of *P. bovicola* are capable of considerable migration from the site of infection. The mobility of this worm, in fact, favours the theory of predilection sites for the worm itself.

It is perhaps more rewarding to speculate on the transmission value of the presence of most infective blood spots dorso-laterally on the shoulders, ribs and loins. The 3 *Musca* vectors are often seen around the muzzle, eyes and wounds in full sun, so they readily feed on blood spots on the upper half of the body. The significance of this observation may be better appreciated by reference to the transmission of *Stephanofilaria stilesi* by the horn fly *Haematobia irritans* in North America. Here infective lesions are situated in the skin along the mid-ventral line of the body. Daily temperatures above 26,7 °C force horn flies to move to the shaded areas of the host, usually the belly. Since they prefer to feed on lesions, their infection is assured (Hibler, 1966).

Another more relevant example of the differing predilection sites found within the genus *Parafilaria* is that of *Parafilaria bassoni*. Although it is not yet known whether its adults occur in the sub-cutis of the trunk, as do the 4 remaining species of this genus, adult worms have been repeatedly collected from the connective tissue in the orbit of the springbok, *Antidorcas marsupialis* (Ortlepp, 1962). This *Parafilaria* species appears to find it essential to reach the eye for oviposition. The eggs are possibly released into the lachrymal secretions, and ingested and transmitted by the same flies (*Musca* spp. of the subgenus *Eumusca*) that transmit eyeworms (*Thelazia* spp.) in cattle. In the present study 3 species of these flies were found to be infected with the 3rd stage larvae both of *Thelazia* spp. and *P. bovicola*.

In 1957 Anderson discussed the evolution of the Filarioidea and Spiruroidea from a common ancestor which inhabited the gut. Hawking & Worms (1961) reviewed this work and suggested that the 3rd rung in the developmental ladder was filled by a hypothetical form, whose adults established themselves in subcutaneous tissue and returned to the orbit to deposit their larvae. *Parafilaria bassoni* appears to fill this gap!

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