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Contents ● Inhoud

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THE PHARMACOKINETICS OF PHENOBARBITONE IN FASTING AND NON-FASTING DOGS

G D THURMAN*, M L McFADYEN** and R MILLER**

ABSTRACT

The pharmacokinetics of oral phenobarbitone was studied in 10 clinically healthy adult dogs. The drug was given once daily in tablet form, at a dose of 5 mg kg^{-1} of body mass. Serial venous blood samples (n=9) were collected from each dog on Day 1 (the first day of drug dosing), on Day 22, and on Day 24 after continuous dosing. Trough serum concentrations were determined on Day 7, Day 14 and Day 21. The drug was administered to the dogs on an empty stomach, except on Day 24, when it was given with food, in order to assess the influence of food on its absorption. Drug serum concentrations were described by a one-compartmental open model with first order absorption and elimination. An average steady-state trough serum level of phenobarbitone of 52,96 ± 8,40 mmol ℓ^{-1} was achieved after 3 weeks of daily dosing. The mean elimination half-lives for Day 1 and Day 22 were 46,3 ± 11,3 h and 29,3 ± 4,6 h respectively. The area under the curve for Day 22 was 1 656,17 ± 186,45 μmol h^{-1} ℓ^{-1} and for Day 24 was 1 493,06 ± 205,4 μmol h^{-1} ℓ^{-1}. The mean clearance value for Day 22 was 0,0133 ± 0,0016 ℓ h^{-1} kg^{-1}. Side effects of polyphagia, polydipsia, sedation and ataxia were commonly observed in the first 2-9 d, but disappeared thereafter.

It was concluded that a dose of 5 mg kg^{-1} would achieve an average serum concentration of 64,59 μmol ℓ^{-1} in adult dogs. Once daily dosing should be adequate, since relatively small peak-through fluctuations were observed (27,6 μmol ℓ^{-1}). The dose may be given with food for convenience, even though the extent of absorption is approximately 10% less than when given on an empty stomach. If the 10% difference is considered clinically significant, the dose can be adjusted accordingly. Dosing should continue unchanged for at least 3 weeks to allow enzyme induction to settle and to achieve steady-state before adjusting doses based on serum concentrations.

Key words: Canine, epilepsy, pharmacokinetics, phenobarbitone.

Thurman G.D.; McFadyen M.L.; Miller R. **The pharmacokinetics of phenobarbitone in fasting and non-fasting dogs.** *Journal of the South African Veterinary Association* (1990) 61 No. 3, 86-89 (En.) Biomedical Resource Centre, University of Durban-Westville, Private Bag X54001, 4000 Durban, Republic of South Africa.

INTRODUCTION

Seizure disorders are amongst the most frequently seen neurological problems in small animal practice. Seizures often present a diagnostic dilemma because they are episodic, frequently not observed by the veterinarian and often present with no other clinical abnormality. Seizures, epilepsy, fits or convulsions have been described as collective terms used to describe a disorder of brain function characterised by paroxysmal, stereotyped alterations in behaviour[3]. The term epilepsy indicates that the seizures are recurring, but does not imply the cause of the seizures. The most common form of epilepsy in the dog presents as a tonic-clonic seizure, with petit-mal and Jacksonian forms of seizures being rarely diagnosed[3].

Epileptic seizures in dogs may be controlled by a variety of drugs, the most common of which is phenobarbitone alone or in combination with other anticonvulsant drugs which is administered orally[7].

Barbiturates were the first class of drugs to be used for treatment of epilepsy. Phenobarbitone was first introduced as an effective anticonvulsant in 1912, providing therapeutic control against most varieties of seizures except absence (petit-mal) seizures[6].

In order to achieve a reasonable therapeutic effect without marked adverse effects in man, phenobarbitone plasma concentrations of 40 to 110 μmol ℓ^{-1} are considered necessary[7]. In order to achieve a therapeutic plasma level, the recommended oral maintenance dose of phenobarbitone in adults and adolescents is from 1.5 to 2 mg kg^{-1} per day[1]. Infants and children require approximately twice the adult dosage, or 3 to 4.5 mg kg^{-1} per day, because they clear the drug faster than adults[1]. Because of its long half-life in man, dosing once daily at bedtime is adequate in most patients. It requires 2-3 weeks (5 half-lives) for phenobarbitone to reach steady-state therapeutic levels in man.

The control of epileptic seizures in dogs is, however, not as well-described as is the case in man. The literature offers dosage ranges for dogs of 2 to 20 mg kg^{-1} phenobarbitone per day which may be divided into twice daily or even 3 times daily dosing, or given "to effect"[3,7]. As phenobarbitone requires only once daily administration in man because of its long half-life (50-120 hours), it would therefore appear that, in dogs, the clearance of phenobarbitone is more rapid than in humans.

The purpose of this study was to monitor and evaluate plasma serum phenobarbitone concentrations over a period of 3 weeks on daily dosing. The effect of food on the absorption of the drug was also investigated.

MATERIALS AND METHODS

Ten adult dogs of mixed breeds and sex were selected for the purpose of the drug trial (Table 1). All were short-haired and without excess body fat. Two weeks prior to commencement of the trial, the dogs

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Table 1: **Breed, sex, age, body mass and condition of experimental dogs**

No.	Breed	Sex	Age (yrs)	Mass (kg)	Condition
1	Lab. X G.S.D.	M	4	24	lean
2	Mixed	M	9	17	lean
3	Mixed	M	1	15	lean
4	Fox Terrier X	M	2	24	lean
5	Bull Terrier	M	2	23	well-muscled
6	Mastiff X	M	7	23	lean
7	Bull Mastiff X	M	8	28	lean
8	Lab. X Bull Terrier	F	1	19	well-muscled
9	G.S.D.	F	2	22	lean
10	Doberman	M	8	27	lean

M = Male; F = Female; X = Mixed breed.

were examined and evaluated for tractability and clinical soundness. This involved recording the body mass of each animal, a thorough physical examination, and the collection of venous blood for haematological and biochemical screening (full blood count, plasma (P)-glucose, serum (S)-urea, serum (S)-creatinine, alanine transaminase (ALT), serum (S)-bilirubin, serum alkaline phosphatase (ALP), total serum proteins (S-TSP), serum (S)-albumin and serum (S)-globulins). Animals showing any deviation from the accepted norm, were excluded from the test group. The selected animals were inoculated and dewormed in accordance with standard veterinary preventive medicine and quarantined individually in kennels for a period of 2 weeks prior to the study. For the duration of the drug trial, the animals were provided with water ad lib. and were fed dry commercial, pelleted dog food daily at 15:00. Following the quarantine period, the dogs were again clinically examined for soundness and their mass was recorded.

Sodium phenobarbitone (PHB) (Lethyl, Lennon Laboratories, 30 mg per tablet) was administered orally in tablet form at a dosage rate of 5 mg kg^{-1} of body mass per day. It was administered with 20 ml tap water to all the dogs on an empty stomach at 08:00 each day, until the last day of the trial. On Day 24, food was given directly after dosing, in order to evaluate the effects of food on drug absorption, as this would probably simulate the clinical situation.

On Day 1 (the first day of drug dosing), Day 22 (empty stomach) and Day 24 (with food), serial venous blood samples (n=9) were withdrawn from the jugular vein, over a 24 h period following drug administration (i.e. at 0,5; 1; 2; 4; 8; 12; and 24 h after dosing). On Day 7, 14, and 21, one blood sample was withdrawn from the cephalic vein just prior to dosing (i.e. trough-level). All blood samples were withdrawn into sterile, dry 3 ml syringes and placed into capped test tubes without anti-coagulant (Venoject-plain). The serum was separated by centrifugation at 1 500 rpm for 5 min at 20°C and then stored at -20°C until assayed for PHB concentration.

The animals were monitored daily for signs of poor health or side-effects, in particular for polyphagia, polydipsia, polyuria, sedation, ataxia, and hyperkinesis which have been reported in the literature[3 7].

The concentration of phenobarbitone in the serum samples was determined, using the TDx System which uses the fluorescence polarisation immunoassay (FPIA) technology (Abbot Laboratories Diagnostic Division, Irving Texas, United States of America).

The serum concentration time pairs for each dog were fitted for single dose, steady state without food, and steady state with food using nonlinear least squares regression (STATIS (Version 2.1) 1987 Aydesoft statistical and scientific software, Larkhall). A one- and a two-compartment open model were compared for effectiveness of fit by the residual sum of squares and Akaike's Information Criterion (AIC)[9]. Estimations of the absorption rate constant (K_A) and the elimination rate constant (K_E) were obtained.

The first-order elimination constant (K_E) was used to calculate the biological half-life using the following equation:

$$t^1/_2 = 0.693/K_E \quad (1)$$

The area under the curve (AUC) was calculated by the linear trapezoidal rule. The total body clearance at steady state can be calculated in a model-independent fashion by using the following equation:

$$Cl = F \times dose/AUC \ (\ell\ hr^{-1}\ kg^{-1}) \quad (2)$$

Analysis of variance was used on the half-life and AUC values in order to test variation between subjects and also between treatments ($P<0,05$ taken to be significant).

RESULTS

A one-compartment open model was adequate to describe the data. Calculated pharmacokinetic values indicating the absorption, accumulation and excretion of PHB from Days 1, 22 and 24 are presented in Table 1 and Fig. 1. On Day 1 there was a fairly rapid absorption of PHB with average peak serum concentrations of 28.03 ± 2.84 $\mu mol\ \ell^{-1}$ occurring 2 h after dosing. Absorption rate constants (Table 2) showed a large variation.

Serum levels measured on Day 22, showed a trough concentration of 52.96 ± 8.40 $\mu mol\ \ell^{-1}$. Following drug administration, there was again a fairly rapid absorption with an average peak concentration of 80.52 ± 6.63 $\mu mol\ \ell^{-1}$ attained within 2 to 4 h of dosing.

Following Day 1, there was a slow accumulation in the PHB plasma concentration followed by a decline to a stable trough level of 52.96 ± 8.18 $\mu mol\ \ell^{-1}$ which occurred 22 d from commencement of initial dosing (Fig. 2).

The mean elimination half-life ($t^1/_2$) for Day 1 was 46.3 ± 11.3 h and for Day 22 it was 29.3 ± 4.6 h. The results are given in Table 2. Dog 5, a bull terrier, could not be used in this comparison as there was doubt as to the dose it had received on Day 1. The results obtained were compared by two-way analysis of variance, which showed that there was no significant difference between subjects ($P<0.5$), but there was a significant difference between Day 1 and Day 22 ($P<0.0066$).

The area under the curve (AUC) is a measure of extent of drug absorption if clearance is constant. A difference of approximately 10% in the AUC was found when Day 22 and Day 24 were compared ($P = 0.0496$), suggesting that a lesser amount of the drug had been absorbed when given with the food (Table 2).

The mean clearance value for the sample group on Day 22, was 0.0133 ± 0.0016 $\ell\ h^{-1}\ kg^{-1}$.

The majority of dogs showed mild to moderate side-effects to the drug. The side-effects of polyphagia, polydipsia and sedation were initially observed from Day 2 in all test animals. In addition, 3 dogs showed hindquarter ataxia. All these side-effects, however, were of short duration and were no longer evident by Day 10. All haematological and biochemical parameters measured remained within normal physiological limits and no significant changes were recorded.

DISCUSSION

Phenobarbitone distributes into most body tissues fairly rapidly, permitting the

Table 2: **Phenobarbitone pharmacokinetics in dogs given phenobarbitone once daily per os**

	$t^1/_2$ h		K_A h^{-1}		K_E h^{-1}		AUC μmol h ℓ^{-1}		Cl/F $\ell\ h^{-1}\ kg^{-1}$	ΔC_p μmol ℓ^{-1}
	Day 1	Day 22	Day 1	Day 22	Day 1	Day 22	Day 22	Day 24	Day 22	Day 22
MEAN	46.3	29.3	3.0085	0.9068	0.0156	0.0242	1656.17	1493.06	0.0133	27.60
SD	11.31	4.6	2.7085	0.7287	0.0032	0.0036	186.45	205.4	0.0016	7.49
CV%	24.4	15.7	90.02	80.35	20.5	14.9	11.3	13.8	12.0	27.18

ΔC_p = average peak - trough serum concentrations

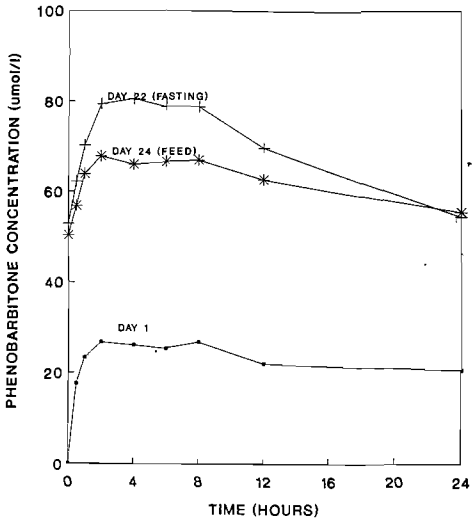

Fig. 1: **Average serum phenobarbitone concentrations in dogs for the initial day of dosing (Day 1), 22 days after dosing (Day 22) and after the intake of food on Day 24**

plasma pharmacokinetics to be described adequately by a one-compartment open model. Absorption rate constants showed a 80-90% variation, but were within the ranges found in other studies[4,5]. The time required to reach peak levels after oral PHB, was between 2 to 4 h on Day 1, Day 22, and Day 24. It would therefore appear that the administration of food, together with the tablets, has little effect on rate of absorption. However, if one compares the extent of absorption using the AUC values, there is a statistically significant difference between administration with and without food. The lower AUC on Day 24 is unlikely to be the result of further enzyme induction and increased clearance, as trough levels on Days 21, 22 and 24 are similar. Thus, it would appear that the feeding of food together with the tablets, reduces the extent of PHB absorption by approximately 10%. Continuous dosing with food therefore, would be expected to produce serum level profiles, on average 10% lower, than if dosing were given on an empty stomach. In general, a difference of less than 20% is considered to be bio-equivalent[8]. Therefore it is unlikely that feeding and simultaneously dosing the animals, will have a clinically significant effect on the control of epilepsy in the dog.

In this particular study, the mean elimination half-life of phenobarbitone sodium declined from 46.3 ± 11.6 h calculated for Day 1, to 29.3 ± 4.6 h after 3 weeks of daily oral dosing. It is assumed that this decline is due to microsomal enzyme induction[5,7]. The initial rise in trough levels from Days 1 to 7 and the decline and stabilisation by 3 weeks, supports this assumption. Both the initial and final half-lives in this study were considerably shorter than those reported in a single dose study by Pedersoli et al.[4], where the $t^1/_2$ for oral dosing was 72.3 ± 15.5 h. The half-life of 53.0 ± 15 h reported in another study[5] after 5 d of oral dosing, is comparable to the initial half-life reported in this study. Five d is probably not long enough for enzyme induction to reach a maximum. Another possible reason for the relatively short half-lives found in the present study could be the relatively short sampling interval of only 24 h after dosing, whereby distribution may still be operative. The other studies sampled over 288 and 131 h respectively[4,5]. Considerable intersubject variation in the half-life has also been reported[4,5] which was not as apparent in this study (coefficient of variation for Day 22 = 15.7%) possibly because of our larger numbers.

Steady-state is assumed to be close to 5 times the elimination $t^1/_2$. Using this to estimate the time necessary to reach steady-state in this study would have given a period of 6 or 9 d, utilising our calculated $t^1/_2$ for Day 1 and Day 22 respectively. Ravis et al[5]. in their study, assumed steady-state would be reached at approximately 11 d. However, in this study where dosing was continued over a longer period of time, trough levels only stabilised between 14 to 21 d, as indicated in Fig. 2.

It therefore is apparent that 3 weeks of daily dosing is required before enzyme induction is complete (14 d at least) and steady state at a constant clearance can be achieved.

Since phenobarbitone was not administered intravenously, it was not possible to estimate the relative bioavailability (F) of oral phenobarbitone. Clearance in this situation is therefore more correctly termed oral clearance, since it includes the oral bioavailability factor (Cl/F). In humans and dogs, bioavailability has been shown to be essentially complete (88-100%)[2,4]. Oral clearance (Cl/F) will therefore closely approximate total body clearance (Cl).

Clearance of phenobarbitone in dogs was calculated as 0.0133 ± 0.0016 $\ell\ h^{-1}\ kg^{-1}$ which is more than 4 times that for humans (0.0032 $\ell\ h^{-1}\ kg^{-1}$)[1]. Using oral clearance, the following equation can be used to calculate a dose for a desired concentration (C_p). [Note 0.232 is the conversion factor from mmol to mg]

$$\text{Dose} = \frac{\text{Cl/F} \times C_p \times \text{Dosing Interval}}{0.232} \times \quad (3)$$

Using the above equation, therefore, indicates that a dose of 5 mg kg^{-1} 24 h^{-1} should maintain an average serum concentration in the region of 65 μmol ℓ^{-1} which is within the therapeutic range determined in man (40-110 μmol ℓ^{-1})[1,6,8]. Further studies are being undertaken to determine the therapeutic range in epileptic dogs.

The small fluctuation in the serum concentration (ΔC_p) as shown in Table 2, combined with the relatively long $t^1/_2$ (29,3 ± 4.6 h) would support that once daily dosing is probably adequate to maintain reasonable therapeutic effects. This would then enhance owner compliance, thus hopefully achieving better epileptic control.

In conclusion, our recommendations subject to determination of the therapeutic range in dogs, are as follows:

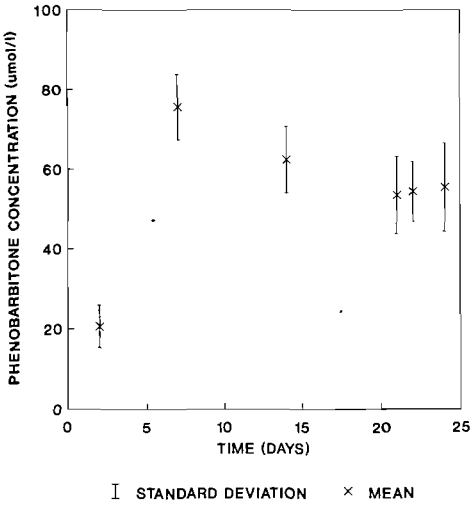

Fig. 2: **Average trough serum phenobarbitone concentrations in dogs (n = 10) over 24 days**

1) An oral dose of 5 mg kg^{-1} should give average serum PHB concentrations of 65 μmol ℓ^{-1} in adult dogs. Once daily dosing may be adequate since relatively small peak-trough fluctuations were observed.
2) The dose may be given with food, although the extent of absorption is approximately 10% less than when given on an empty stomach. This is probably of little clinical significance, especially if serum levels are monitored.
3) Side-effects of polyphagia, polydipsia, sedation and ataxia are commonly observed in the first 2-9 d but disappear thereafter. This is probably due to tolerance to the effects.
4) After initiation of therapy, dosing should continue unchanged for 3 weeks (steady-state) before measuring serum concentrations and adjusting the dose accordingly.

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BOLO DISEASE: A SPECIFIC, LOCALISED SKIN DISEASE OF WOOLLED SHEEP

PHILIPPA A COLLY[1], LUCIA A LANGE[2], ADRIANA DE RUITER[3], E M VAN TONDER[4], S O VERMEULEN[6], G E KELLERMAN[5] and C J WHITEHEAD[7]

ABSTRACT

Bolo disease is limited to Merino and Döhne merino sheep in the Stutterheim and Cathcart districts of the eastern Cape Province. It occurs under natural grazing conditions regardless of the season of the year and the condition of the natural grazing. Ewes and wethers are most frequently affected. Skin lesions are well-defined, and the corresponding fleece has dark-grey to almost black spots, patches or bands varying in number, size and distribution between individual sheep. The wool in the affected areas is visibly shorter, less dense and tender, and the tips of the staples are spiky. In freshly-shorn sheep, the affected areas appear chalky white. Chronic and superimposed acute lesions are present in the same specimen histologically. Skin lesions include superficial and follicular hyperkeratosis, acanthosis, and sebaceous gland hyperplasia and hypertrophy. These changes are accompanied by dilatation of some of the follicles in the midshaft area, and collapse of the subepidermal tissue with only a few remaining collagen fibres separating the follicles and the sebaceous glands from the thickened epidermis.

Corynebacterium spp. is the most consistent bacterium isolated from the lesions. Lesions produced by suspensions of this organism simulated both clinical signs and histopathological findings of the natural condition.

Key words: Bolo disease, *Corynebacterium* spp., skin disease, woolled sheep.

Colly P.A.; Lange L.A.; De Ruiter A; Van Tonder E.M.; Vermeulen S.O.; Kellerman G.E.; Whitehead C.J. **Bolo disease: A specific, localised skin disease of woolled sheep.** *Journal of the South African Veterinary Association* (1990) 61 No. 3, 90-95 (En.) State Veterinarian, Directorate of Animal Health, Private Bag X 1098, 1120 Lydenburg, Transvaal, Republic of South Africa.

INTRODUCTION

A wide variety of hereditary, nutritional, chemical, ectoparasitic, mycotic and bacterial conditions affecting the wool and often also the skin of sheep, have been categorised by Henderson[8]. Lumpy wool caused by *Dermatophilus congolensis* first described in South Africa[1], and later in Australia[3 17] and in Great Britain[10 12], and fleece-rot with or without accompanying bacterial discolouration[18 19], appear to be the more common and economically-important conditions affecting the skin of woolled sheep in these countries. Despite the similar climatic conditions under which these 2 diseases occur, they can be readily distinguished[2 4 7 8 16 17 21]. Under South African conditions, both these problems intermittently assume serious proportions[1 11 17 21].

More recently, a condition characterised by the appearance of localised areas of retarded wool growth in the fleece of rams fed highly nutritious diets, was reported[9]. Its occurrence was associated with a high yolk content of the wool and the presence of enteric bacteria (*Enterobacter aerogenes, Enterobacter agglomerans*, and *Hafnia alvei*) in the affected areas of wool.

The purpose of this paper is to record preliminary observations on a specific skin condition of woolled sheep, locally known as Bolo disease, which differ from the above conditions. At present, the disease is mainly confined to certain districts of the eastern Cape Province of the Republic of South Africa[5 22].

Bolo disease was first reported a few years ago from the Bolo area of the Stutterheim district in the eastern Cape Province. It has since been observed on some 40 farms in the same, and the adjoining Cathcart district, while a few suspected cases were also reported from elsewhere in the Cape Province[5 22] and from Natal (G F Bath 1986 Allerton Regional Veterinary Laboratory, Pietermaritzburg, personal communication).

Thus far, the disease has only been found in Merinos and Döhne Merinos, and their crosses. All sex groups are affected, but on account of their overwhelming numbers, ewes and wethers are most frequently involved. Older sheep and those in poorer condition are mostly affected. The condition also seems to favour those animals carrying medium to medium-strong wool of the more dense type and with a high yolk content[5 22].

No specific climatic or nutritional factors appear to affect the occurrence of Bolo disease. It is encountered almost exclusively in sheep under natural grazing conditions and its occurrence has remained unaffected by the extreme fluctuations in the climate experienced over the past decade. The problem is encountered with equal frequency throughout the year. The restricted occurrence of the disease to the areas indicated, remains unexplained.

In order of preference, typical lesions are found in the skin on the sides of the neck, the shoulders and then the rest of the body. Occasionally and in more severly affected cases, they are also seen on the back. In unshorn sheep, lesions are more clearly visible on those carrying shorter wool (2-5 months growth). The lesions appear on the fleece as well-defined, dark-grey to almost black spots, patches or bands, varying in number, size and distri-

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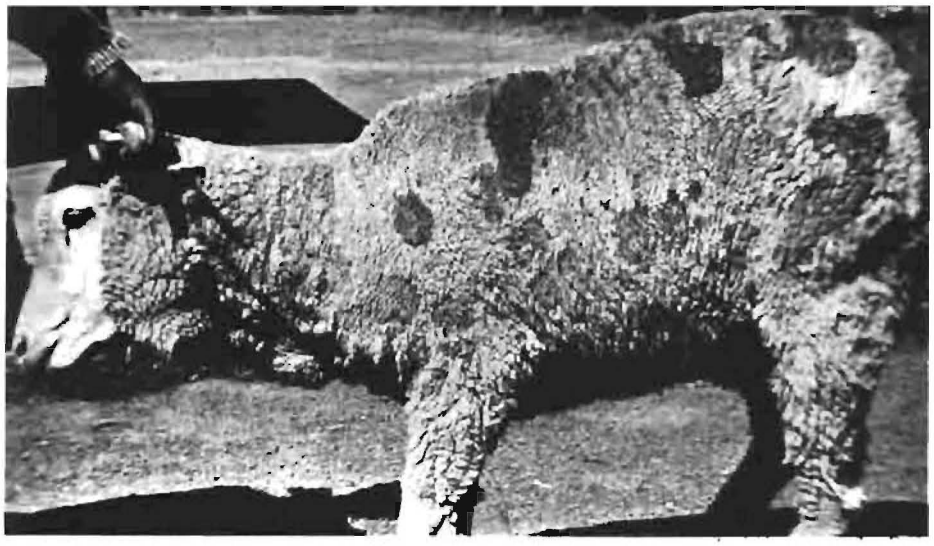

Fig. 1: **Typical dark-grey to almost black lesions of Bolo disease. Note the depressed surface of the fleece in these areas**

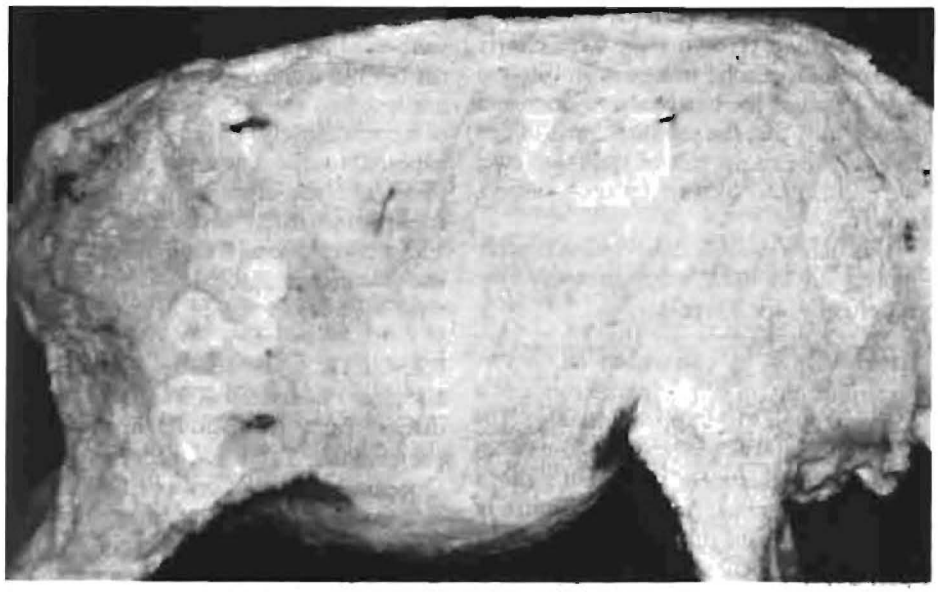

Fig. 2: **The chalky-white lesions of Bolo disease in a freshly shorn sheep**

bution (Fig. 1). In freshly-shorn sheep the affected areas are chalky-white[5 22] (Fig. 2). The wool in the affected areas is visibly shorter than elsewhere on the body, less dense and tender. When the wool is parted, yellowish to greyish-white, sticky, scaly deposits are found adjacent to the skin and in between the wool fibres causing the wool to stick together, resulting in a spiky staple.

The appearance of the affected skin depends on the nature and duration of the lesions. In the more acute form, the lesions are well-circumscribed, and reddish-purple in colour. The affected skin is tender and sensitive to the touch, and cracks easily when handled[5 22].

None of the cases examined, showed any visible or microscopic evidence of arthropod, insect, helminth or fungal involvement. Histopathological lesions in the affected skin vary considerably and correspond with the degree of severity. Consistent microscopical features include varying degrees of acanthosis, superficial and follicular hyperkeratosis, and hyperpigmentation. In some instances, the follicular sebaceous glands are focally prominent and hyperplastic. In the more acute lesions, the subepidermal connective tissue is oedematous and shows mild haemorrhage, associated with focal accumulations of lymphocytes and a few neutrophils. In longer-standing cases, there is collapse of the subepidermal connective tissue and the hair follicles and sebaceous glands are consequently very close to the thickened epidermis.

On account of the physical changes, affected wool is of inferior quality and of low economic value. It has to be carefully sorted and classed with the inferior lines of the clip, which in itself is a time-consuming procedure. Often the entire fleece has to be degraded. If considered that up to 90% of the members of any particular flock can be affected to a varying degree, the economic impact is staggering[5 22].

Investigations were undertaken to establish the aetiology of Bolo disease and to determine whether the condition could be reproduced experimentally.

MATERIALS AND METHODS

Animals in the Middelburg and Queenstown areas of the Cape Province involved in these investigations, were either presented by the owners, or selected during farm visits on a random basis: Both recently-developed and long-standing cases, representative of the typical disease, were used, irrespective of the age and sex of the sheep or the severity and distribution of lesions. Specimens from the Middelburg area were collected at a time when the fleeces of the animals were thoroughly wet, due to continuous rain.

Wool specimens

Wool specimens (n = 36) were obtained by clipping a staple of the affected wool as close to the skin as possible. The clipped end was then introduced into a sterile, wide-mouth McCartney bottle and severed approximately 2 cm from the base, whereafter the container was closed.

Specimens from the skin surface

Two methods were used to obtain specimens of the affected skin surface. Firstly, the wool over the appropriate area was clipped as close to the skin as possible. The skin surface was then scraped with a sterile scalpel blade and the debris collected in a sterile container. Secondly, disposable, sterile throat swabs (Anchor Rand, P O Box 83006, South Hills, 2136) were used for the collection of skin surface deposits. The cotton tip of the swab was thoroughly rubbed onto the bared, affected surface and the swab then replaced into its sterile container.

Biopsy specimens

Specimens from affected areas of the skin were excised without local anaesthesia and preserved in 10% buffered formalin. These were routinely processed in paraffin wax, sectioned and stained with haematoxylin and eosin for histological examination.

Culture media and identification

Columbia agar (Merck SA (Pty) Ltd, P O Box 3067, Port Elizabeth, 6000) enriched with 5% of either horse or sheep blood, was used as the basic culture medium. The processing of specimens, and the isolation and identification of bacterial cultures, were done according to routine laboratory methods.

Biological testing of cultures

Specific bacterial isolates were selected on the basis of their known association with lesions of Bolo disease and the relative frequency with which they were recovered from the specimens examined (Table 1). The following fluids and/or isolates were tested on animals as indicated:

Experiment 1. From each of 3 different properties, samples of affected wool from different sheep on the same farm, were pooled. Between 5 and 10 g of each of the poolled samples, were suspended in 50 ml physiological saline and thoroughly stirred. These were then incubated for 2 h at 37°C during which time they were well-stirred every half-hour. Each suspension was then filtered through several layers of sterile cheese-cloth and the filtrate used as inoculum.

Two areas, one on the shoulder and one on the rump, were clearly demarcated on the fleece of each of 4 adult Merino ewes carrying 5 months of wool-growth. Each sheep was infiltrated on the marked areas with 20 ml of the suspension prepared from material from a particular farm, while the fourth sheep acted as a control, its fleece being infiltrated with physiological saline.

From the day following treatment, and once each day for 5 consecutive days thereafter, all the experimental sheep were sprayed with ordinary tap water until thoroughly wet.

Experiment 2: Pure cultures of bacteria isolated from natural cases of Bolo disease were used as inocula. These included *P. aeruginosa, S. epidermidis, M. luteus, E. aerogenes* and a B-haemolytic *Bacillus* sp. (See Table 1).

In each case, bacterial growth harvested from 24 h surface cultures, was suspended in physiological saline to obtain a density equal to Brown's opacity tube no. 3.

Of a group of Merinos consisting of 2 to 4 tooth old ewes and wethers carrying 4-5 months of wool growth, 2 sheep were used for each treatment. On either side of each animal, two 10 cm square areas, one opposite the shoulder and one at the level of the rump, were distinctly marked. Within each treatment group, all the marked areas were infiltrated with 10 ml of the suspension of the specific bacterial growth.

From the first day following treatment, the left side of the fleece of all experimental animals was thoroughly wetted with ordinary tap water, once daily for 8 d.

Experiment 3. Suspensions in physiological saline of 48 h cultures of *Corynebacterium* spp. (Queenstown isolate) and *P. aeruginosa,* to a density equalling the opacity of Brown's tube no. 3, were prepared and administered to 2 adult Merino ewes carrying approximately 5 months of wool-growth. Two areas on each side, one opposite the shoulder and the other opposite the rump of each ewe, were clearly demarcated. Each area was infiltrated with 10 ml of the bacterial suspension in such a way, that the shoulder areas of one ewe and the rump area of the other ewe, were infiltrated in turn by each suspension.

The left sides of these animals were thoroughly wetted with ordinary tap water daily, for 3 weeks.

Experiment 4. A suspension of *Corynebacterium* spp. in physiological saline at a concentration of approximately 10^9 organisms/ml was used as inoculum to administer the treatment to 2 freshly-shorn adult Merino rams. Areas, approximately 15 cm square, on the flank and thigh of one side of each animal, were clipped short and clearly demarcated.

An amount of 100 ml of the inoculum was infiltrated in each area, which was then massaged with sterile gloved hands, so as to effect thorough wetting and exposure of the skin.

Experiment 5. A suspension of *Corynebacterium* spp. in nutrient broth was used as inoculum to administer to the same 2 rams used in the previous experiment, after they had been rested for approximately 6 weeks. Two areas on either side of the shoulders of both rams were clearly demarcated and the wool clipped short. The skin in these areas was lightly curetted and thoroughly wetted with 100 ml of bacterial suspension. This treatment was repeated again on Days 3, 11-15, 18 and 29 after the first treatment, and each time after swabs for bacteriological examination were first taken. Swabs for bacteriological examination were also taken on Days 59, 80, 147 and 169, while on Day 59, biopsy specimens for histopathological examination were also collected in 10% buffered formalin.

Table 1: **Bacteria isolated at the Middelburg Regional Laboratory, from affected wool and skin deposit of sheep suffering from Bolo disease. Prior to collection of specimens, the fleeces were soaked due to continuous rains**

BACTERIAL ISOLATE	Wool samples	Skin scrapings
No of specimens examined	**9**	**1**
Bacillus spp	2	-
Enterobacter aerogenes	3	-
Micrococcus luteus	5	-
Pseudomonas aeruginosa	*2*	*1*
Staphylococcus epidermidis	4	-

Experiment 6: Suspensions of *Corynebacterium* spp., both in physiological saline and in nutrient broth, were used in quantities of 100 ml. The same 2 animals from the previous experiments (4 & 5) were used in this experiment. An area on the left hip region of each ram was clearly marked, and the wool clipped to a length of approximately 1,5 cm. One ram was exposed to the bacterial suspension in saline and the other ram to that in nutrient broth. After exposure, the 2 rams became wet due to a sudden spell of rain and were then stabled, whereafter they were kept dry.

RESULTS

Bacteria isolated from sheep with Bolo disease from the Middelburg area are presented in Table 1. In sheep from the Queenstown area, *Corynebacterium* spp., was the most prominent isolate obtained from swabs of the affected skin of sheep with Bolo disease. In the wool samples *Bacillus* spp. and yeasts *(Rhodotorula* spp.) were the more consistent isolates. (Table 2).

Results of transmissions experiments:

Experiment 1: Application of filtrates of wool from the lesions failed to cause Bolo disease. In 3 sheep, the filtrates only caused the development (from the 7th day onwards) of horizontal, light-brown bands immediately above the skin in the treated areas. On Day 10, 2 of the treated sheep developed a mild dermatitis which disappeared on Day 15 leaving greyish-white scales in the wool adjacent to the skin surface, which by then appeared normal. One treated sheep and the control remained negative throughout.

Experiment 2: Four bacteria *P. aeruginosa, S. epidermididis; M. luteus* and a B-haemolytic *Bacillus* sp. were consistently isolated from specimens taken from exposed sheep. These bacteria, however, also failed to cause Bolo disease and, with the exception of *E. aurogenes,* only in-

Table 2: **Bacteria isolated from sheep with Bolo disease from the Queenswood area**

BACTERIAL ISOLATE	NATURE AND NUMBER OF POSITIVE SPECIMENS		
	Wool samples	**Skin scrapings**	**Skin swabs**
No of specimens examined	**36**	**9**	**129**
Bacillus spp	35	2	40
Corynebacterium xerosis	-	-	3
Corynebacterium spp	10	1	56
Enterobacter spp	-	-	11
Escherichia coli	-	-	2
Gram-negative bacilli	-	-	3
Gram-negative cocco-bacilli	-	-	5
Gram-positive cocci	-	-	4
Gram-negative cocci	-	-	3
Micrococcus roseus	-	-	2
Pseudomonas spp	-	-	1
Staphylococcus aureus	-	-	1
Staphylococcus epidermidis	4	-	27
Streptococcus spp	4	-	1
Fungi - untyped	1	-	-
Yeasts - (*Rhodotorula* spp)	27	3	26

duced a mild dermatitits in the exposed areas on the wetted sides of all sheep. On the sides which were not wetted, slight signs of skin irritation in the infected areas were only noticed in the 2 sheep exposed to *S. epidermidis* and one sheep exposed to the *Bacillus* spp. The dermatitis became noticeable from Day 9-13 after exposure and disappeared 7-11 d later leaving a fine, scabby layer which gradually grew out with the wool.

Experiment 3: Cultures of *P. aeruginosa* caused lesions characteristic of fleece-rot. The reactions abated from approximately Day 6 after wetting treatment was stopped, while the scale deposits and brown, discoloured band grew out with the wool towards the end of the experimental period. On the wetted sides, *Corynebacterium* spp. suspensions caused lesions indistinguishable from fleece-rot. The lesions on the 'dry' sides resembled Bolo disease both macroscopically and histopathologically. These lesions remained unchanged until the end of the observation period of 3 months. From skin swabs taken from the lesions of experimental Bolo disease on the 'dry' sides, both *Corynebacterium* spp. and *P. aeruginosa* were isolated on Day 7 and again on Day 13 after exposure, whereafter *Corynebacterium spp.*, but not *P. aeruginosa*, could regularly be isolated from skin swabs taken at 14 d intervals until the end of experimental period. From the skin swabs taken from the infected areas on the wetted sides, *P. aeruginosa* could be regularly isolated throughout the experimental period. *Corynebacterium* spp. on the other hand, was not isolated on any single occasion, as the primary cultures were invariably contaminated.

Experiment 4: No visible affection of the skin could be produced. Skin swabs taken on 3 occasions, with weekly intervals, proved negative for *Corynebacterium* spp. on bacteriological culture.

Experiment 5 and 6: *Corynebacterium* spp. did not invariably cause Bolo disease after experimental application. However, after reapplication of suspensions in both saline and nutrient broth to the same animals, lesions characteristic of Bolo disease developed. During the development of the lesions in both rams, cultures were negative on Days 1 and 3 but were generally positive for *Corynebacterium* spp. from Day 11 onwards and consistently so from Day 18 until Day 169 when the experiment was terminated. An almost pure and abundant growth of *Corynebacterium* spp. was obtained from Day 29 onwards.

In the lesions of Bolo disease that developed during this period, scabs were clearly visible from Day 18 after infection. From Day 147 onwards and particularly on Day 169, the ram with stronger wool appeared to be more severely affected. its skin had a more intense purple colour with profuse scab-formation, while the wool closer to the skin had lost its crimp. Histological examination of sections of the affected skin of both rams taken on Day 21 and 59, respectively, revealed lesions consistent with those found in natural cases of Bolo disease, namely, mild follicular acanthosis and hyperkeratosis, hyperplasia and hypertrophy of sebaceous glands, mild subepidermal oedema and perifollicular lymphocyte infiltration.

Wetting and curetting of the skin prior to application, as well as application of the bacterial suspensions to clipped wool, appear to enhance the development of the experimental lesions of Bolo disease. The lesions were also more severe in the animals exposed to suspension in physiological saline, rather than to suspensions in nutrient broth.

DISCUSSION

In the various trials aimed at the induction of Bolo disease, lesions resembling the natural disease both clinically and histopathologically, could only be produced when suspensions of *Corynebacterium* spp. were used without post-infective wetting of fleeces.

The other experiments, where suspensions of affected wool or other bacterial isolates were used, were either unsuccessful or produced lesions comparable to fleece-rot, particularly where the fleece was wetted after exposure to the infective material.

A wide variety of saprophytic bacteria are consistently found on the normal skin and in the fleece of sheep. Some of them may, under certain circumstances, exert harmful effects, such as in the case of fleece-rot. On the other hand, known pathogenic bacteria may also be found to be present on the skin and to invade the

skin from time to time.

From clinical, epidemiological and histopathological observations[5 22], it seems clear that Bolo disease presents a disease entity quite distinct from lumpy wool[10 12 13 18], and fleece-rot with or without accompanying discolouration of the wool[7 19 20]. The hot, humid conditions required for the occurrence of both lumpy wool[6 8 10 12 13 18 21] and fleece-rot[2 4 7 8 17 19 21], are not essential for the occurrence of Bolo disease[5 22]. From an epidemiological point of view, Bolo disease also differs markedly from the condition of retardation of wool-growth in Merino rams on highly nutritious diets described by Jansen & Hayes[9].

The lesions of lumpy wool can readily be distinguished from those found in Bolo disease by the appearance of erythema, slight swelling and tenderness of the skin, papule formation, exudation, the formation of thin dome-shaped scabs which grow in depth by continuous exudation underneath. As the exudate is carried away from the skin, it becomes more sticky and dry with the result that wool fibres stick together to form hard, dome-shaped lumps or spikes, particularly over the back and rump, while underneath these lumps the skin has a raw and often bleeding surface[3 18 10 12 6 8 2 21].

The histopathological features of lumpy wool are fairly typical with the filaments of *D. congolensis* penetrating the epidermal layers down to the basement membrane causing cornification of the epidermal cells as soon as they are damaged with a consequent thickening of the corneal layer of the epidermis. At the same time a dense mass of granulocytes accumulate beneath the epidermis, which becomes separated from its dermal matrix. This is followed by the formation of new hyperplastic epidermal tissue underneath the accumulation of granulocytes. These new layers of epidermal cells may again be penetrated by filaments from the sheaths of adjacent infected wool follicles, with consequent cornification and a repetition of the whole process. Filaments also penetrate the follicular sheath tissues, causing intense proliferation. Filaments of *D. congolensis* are readily found in the cornified tissues of the epidermis as well as in the sheaths of infected wool follicles.

From a diagnostic point of view, lumpy wool can be easily be distinguished by its epidemiological, clinical and histological features. Gram-stained smears prepared from debris of the affected skin surface, normally reveal the presence of typical, segmented filaments containing parallel rows of cocci[13 15] on microscopic examination, while the motile zoospores can also be demonstrated in wet preparations from the skin surface or prepared from broth cultures, by phase-contrast microscopy. Final identification of *D. congolensis* can be done by bacterial isolation[13 15].

The lesions of fleece-rot are more difficult to distinguish from those of Bolo disease, but can be differentiated by the fact that only in 2% of cases are they found in regions other than the withers and back. The wool in the affected areas is also always saturated with moisture and is characteristically leached and dingy, while individual locks become hard and stringy and the tips over the affected areas tend to be more open. Exudation normally continues for a few days after wet weather ceases, after which the serous exudate dries to form the characteristic, matted band across the staple[2 7 8 17]. In the active stage of the non-specific bacterial fleece-rot, the transverse band is usually dirty grey[2 7 17], while subsequently it changes to a dirty greyish-yellow colour[2 8]. Often when specific bacteria are involved, colours such as green, brown, or shades of orange, pink or blue are also seen[2 4 7 8 17 19 21]. These colours are not always in association with the matted band[7].

Although the lesions of fleece-rot[4 7], wool retardation[9] and bolo disease have some histopathological features in common, there are, however, distinct differences A L Lange 1984, 1986. Unpublished data). The common changes which, however, appear to be more severe in Bolo disease, include hyperaemia, mild sub-epidermal oedema, acanthosis, hyperkeratosis and desquamation, cellular infiltration in the dermis and perifollicar areas[7 4 9]. (A L Lange 1984, 1986. Unpublished data). Whereas the infiltrated cells in fleece-rot[7 4] and retarded wool-growth[9] mainly consist of neutrophilis, lymphocytes are the predominant cell-type in Bolo disease, and are accompanied by relatively few neutrophils, eosinophils and plasma cells. Distinghuishing features of fleece-rot include focal spongiosis of the stratum germinativum and micro-abscessation in the stratum corneum[4].

The clinical diagnostic features of fleece-rot would include the characteristically wet and dingy appearance of the affected wool, the distribution of lesions mainly over the back and withers and the typically dirty grey to greyish-yellow transverse band across the affected wool staples as well as the distinguishing epidemiological features such as prevailing hot, humid conditions.

The gross lesions in the retardation of wool-growth in Merino rams described by Jansen & Hayes[9], seem to be indistinguishable from those of Bolo disease, except that the appearance of the depressed areas in unshorn rams are described as rough and dirty, while in Bolo disease, the typical lesions are well-defined and almost black (Fig. 1). Whereas no mention is made of the appearance of lesions in shorn animals showing retarded wool-growth, the chalky-white lesions in shorn Bolo disease sheep are very typical (Fig. 2).

Whereas the active lesions in both lumpy wool and fleece-rot are of temporary nature and only last for a few days to a few weeks after the wet weather ceases, after which the affected wool grows out with the fleece[2 7 8], the lesions in Bolo disease remain active for a prolonged period (E M van Tonder, P A Colly 1985 Unpublished data).

Epidemiologically, Bolo disease occurs under natural grazing conditions throughout the year, irrespective of prevailing climatic conditions[5 22].

Further diagnostic evidence in the case of fleece-rot, wool retardation and Bolo disease can be obtained by bacteriological examination of specimens taken from the affected skin. Whereas *P. aeruginosa* and other chromogenic bacteria can usually be isolated from the skin lesions of fleece-rot[4 7 8 17 20 21], and the enteric organisms (*E. aerogenes, E. agglomerans* and *H. alvei)* from the lesions of retarded wool-growth[9], *Corynebacterium* spp. is the most consistent bacterium of pathogenic importance, that can be isolated from the affected skin of sheep suffering from Bolo disease.

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To the editor/Aan die redaksie

HEPATOZOON AND *EHRLICHIA* IN THE SAME CANINE NEUTROPHIL

The kennel tick *Rhipicephalus sanguineus* is the common vector of the rickettsial organism *Ehrlichia canis* and the protozoa *Hepatozoon canis* and *Babesia canis* in dogs[4]. Concurrent infections of these organisms are frequently encountered in dogs[2,7]. In a canine peripheral blood smear of unknown origin in the teaching collection of the Department of Parasitology, we found a neutrophil harbouring both an *Ehrlichia* morula and a *Hepatozoon* gametocyte (Fig. 1). The large gametocytes of *Hepatozoon canis* occur in the cytoplasm of neutrophils or monocytes[1]. Morulae of *Ehrlichia canis* typically occur in agrunulocytes such as monocytes and lymphocytes, and rarely in neutrophils[3,4,6,8]. *Ehrlichia*-like organisms in granulocytes are usually assigned to the genus *Cytoecetes*[8]. It has been suggested that *Ehrlichia* organisms in canine neutrophils may actually be *Ehrlichia equi*[6], which has not been reported from South Africa. This organism, closely related to *Ehrlichia canis* but serologically distinct, causes severe clinical signs in horses but mild or subclinical infections in other animals, including dogs, sheep, goats, cats and non-human primates[5].

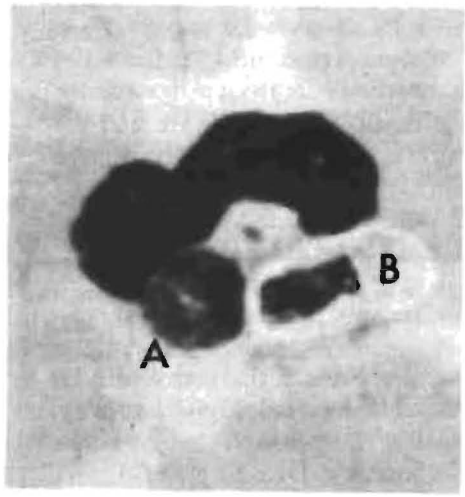

Fig. 1: **A canine neutrophil (outline indistinct) harbouring both an *Ehrlichia* morula (A) and a *Hepatozoon* gametocyte (B)**

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BOLO DISEASE : A BACTERIOLOGICAL SURVEY

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ABSTRACT

A total of 718 sheep, 381 severely and 190 mildly affected with Bolo disease as well as 147 visibly unaffected animals emanating from 15 farms in the Stutterheim and Cathcart districts in the eastern Cape were subjected to bacteriological examination of skin surfaces and wool specimens. Altogether, 1 168 specimens were examined. These included skin swabs, skin scrapings and wool samples. *Corynebacterium* spp represented 94,4% of the primary isolates in cultures prepared from all specimens and 97,2% in those derived from skin swabs only, while a variety of other bacteria collectively constituted the remainder of primary isolates. In all, *Corynebacterium* spp was isolated from specimens of 94,2% of sheep severely affected with Bolo disease and from 83,7% of those mildly affected, whereas it could only be isolated from 1,36% clinically unaffected sheep.

In a comparative study, swabs taken directly from the skin surface, proved to be the method of choice for the collection of specimens for bacteriological examination of Bolo disease. Using this method, *Corynebacterium* spp. was isolated from 98,7% of severely, and 85,3% of mildly affected sheep as well as 4% of sheep apparently unaffected by Bolo disease. The isolation of *Corynebacterium* spp. from skin scrapings collected from the 3 categories of affection (73,3%, 57,3% and 4% respectively) and from wool samples (52%, 41,3% and 1,3% respectively) proved these 2 methods of sampling to be less reliable.

A close association has been established between the incidence of *Corynebacterium* spp. and the occurrence of clinical Bolo disease.

Key words: Bolo disease, *Corynebacterium* spp., bacteriological survey.

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INTRODUCTION

Bolo disease is a specific skin disease of sheep which was first noticed to occur in the Bolo area of the Stutterheim district and was first reported on by Vermeulen[10,11] and Colly[4].

In initial investigations to elucidate the possible cause of this condition, 5 different bacterial organisms, *Micrococcus luteus, Staphylococcus epidermidis, Bacillus* spp., *Pseudomonas aeruginosa* and *Enterobacter aerogenes* were isolated from wool specimens taken at a time when continuous rain occurred[5]. In a subsequent investigation, 15 different types of bacterial organisms and a specific yeast, *Rhodotorula rubra,* were isolated[5].

Typical clinical and histopathological changes could only be caused by exposure of the skin to suspensions of *Corynebacterium* spp. without subsequent wetting of the fleece[5]. Various other bacterial organisms also caused some form of irritation of the skin and superficial dermatitis, but only when the fleece was wetted regularly after exposure.

On investigating retardation of wool-growth in Merino rams on highly nutritious diets from outside the known Bolo disease area, Jansen & Hayes[8] isolated 3 different types of organisms viz *E. aerogenes, Enterobacter agglomerans* and *Hafnia alvei* from specimens of the affected wool. By using cellular extracts or live bacterial suspensions of these organisms, they succeeded in causing hyperaemia and a superficial dermatitis in experimental sheep.

In a subsequent study, Jansen & Hayes[9] isolated 10 different bacterial species from specimens of the affected wool of 5 Merino ewes suffering from Bolo disease from the Stutterheim district. By exposing clipped areas of the skin of experimental sheep 3 times daily for 14 d to live suspensions of the organisms isolated, after the sites had been wetted with 0,15 N NaCl and horse-meat extract broth, irritation of the skin and round cell infiltration into the dermis were caused with suspensions of all 10 species of bacteria isolated.

In order to attempt to clarify the confusing situation, and since farmers were experiencing the problem throughout the year irrespective of prevailing climatic conditions, it was decided to conduct a specific bacteriological survey on selected farms in the known Bolo disease area at a time when conditions would be most unfavourable for the occurrence of other skin conditions such as fleece-rot and general bacterial and mycotic dermatitis.

MATERIALS AND METHODS

Time of the survey

The survey was carried out during July 1985. Total rainfall, mean monthly humidity as well as mean minimum and maximum temperatures were recorded during July 1985 and the preceding 3 months. Data were obtained from 3 weather recording stations within the Bolo disease area, namely Dohne, Underchurch and Bolo (SA Weather Bureau: Department of Transport Services, Pretoria, 1985).

Selection of farms

Fifteen farms with a known history of a high incidence of Bolo disease in the Bolo, Henderson, Toise and Dohne areas of the Stutterheim and Cathcart districts were selected.

Selection of animals and clinical evaluation

The sheep on each farm were visually inspected for clinical signs of Bolo disease and then closely inspected for skin lesions by repeatedly parting the fleece on either

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side of the body, starting in the neck region and working caudally. Sheep were classified as severely affected, mildly affected or not affected.

Apart from the presence of viscid, waxy scales on the surface of the skin, cases were classified as severe on account of the presence of well circumscribed, raised, reddish-purple lesions of the skin, which were tender, tore easily and were sensitive to the touch.

Mildly affected cases were those where the skin lesions were not as pronounced and with a lesser degree of hyperaemia. A variable amount of yellowish to greyish-white, sticky, waxy scales were present on the skin and between the wool fibres causing them to stick together to a lesser or greater extent.

Animals were judged to be unaffected when no lesions could be found in a least 25 inspection areas on either side of the sheep.

The inspections of each particular flock continued until at least 10 animals in each category were identified, if available, for the collection of specimens. Following this, examinations were continued until, if available, another 20 severely or mildly affected animals were identified for the collection of specimens. Ultimately, specimens were obtained from 718 sheep, comprising 381 severely affected, 190 mildly affected and 147 sheep not affected by Bolo disease.

Collection of specimens

In order to evaluate the efficiency of wool specimens, skin scrapings and skin swabs for bacteriological examination of skin and fleece abnormalities, parallel specimens, as close to one another as possible were collected from the first 5 sheep in each category. Seventy-five sheep in each category of affliction were examined in this way and in addition skin swabs were collected from a further 306 severely affected, 115 mildly affected and 72 visibly unaffected sheep.

Specimens from infected sheep were collected from the centre of well-defined lesions and from non-infected sheep from any suitable site behind the shoulders.

Wool specimens: After parting the fleece at the appropriate site, a staple of wool was held at the tip and clipped as close to the skin as possible using a pair of sterile, curved scissors. The distal end of the staple was introduced into a sterile, wide-mouthed McCartney bottle for approximately 1 cm and severed, after which the container was immediately closed.

Skin scrapings: By using a pair of sterile curved scissors, the wool at the appropriate site was cut as close to the skin as possible.

A sterile scalpel blade was then used to scrape the surface of the skin thoroughly, after which, the collected material was transferred to a sterile skin swab (anchor Rand, Box 83006, South Hills) which had been moistened with sterile physiological saline solution. The swab was immediately replaced in its original container.

Skin swabs: Skin swab specimens were collected from the surface of the skin, after the wool at the selected site had been parted. Disposable sterile throat swabs (Anchor Rand, South Hills) were thoroughly rubbed onto the skin surface and immediately replaced in their original containers. All specimens were transported in suitable, insulated containers to the temporary laboratory at the Dohne Research Station, where they were processed and primary cultures prepared at the end of each day. Cultures of the previous day or days were examined at the same time and, where required, the necessary subcultures prepared. At the end of the week, all cultures were sealed and transported in dust-free containers to the laboratories at Queenstown and Middelburg, Cape, where they were subjected to further bacteriological examinations.

Wool specimens were removed from their containers by means of sterile forceps and their distal ends streaked across the surface of the primary culture media, consisting of Columbia agar (Merck S A (Pty)Ltd, P.O. Box 3067, Port Elizabeth), enriched with 5% of either horse or sheep blood.

Similarly the skin swabs, taken directly or containing transferred material from the skin scrapings, were streaked across the surface of the Columbia agar plates.

Bacteriological examinations

Primary and sub-cultures were incubated in an aerobic atmosphere at 37°C. All bacteriological examinations and tests were conducted following standard bacteriological techniques, while identification of the organisms was done according to Bishop et al.[2] and Buchanan & Gibbons[3].

Cultures were examined after 48 h incubation and primary cultures were classified as negative when no bacterial growth was evident or when single colonies of obvious contaminants were present; positive when possibly significant growth either in pure or predominant form occured; non-specific when single or a limited number of similar colonies of a wide variety of bacterial types appeared on the same plate or overgrown where cultures were overgrown by motile organisms or by fungi.

All primary cultures that showed no growth or were overgrown by contaminants or showed obviously insignificant or non-specific bacterial growth only, were discarded.

Pure cultures were subjected to immediate further bacteriological testing, while in the case of mixed cultures, subcultures were made from the predominant bacterial growth as well as from second and where necessary, also third forms of bacterial growth, in order of abundance of their bacterial colonies. Once obtained in pure form, each of these isolates was subjected to further standard bacteriological examinations in order to establish their identity.

RESULTS

Meteriological data

Apart from a total precipitation of 0,2 mm recorded at Dohne, no rain occurred in the area during July while total monthly rainfalls varying from 8,3 to 8,8 mm for June, 10,8 to 11,2 mm for May and 13,5 to 22,9 mm for April were registered at the 3 stations. The mean monthly relative humidity prevailing in the area during July, varied from 45,1 to 57% while in the preceding 3 months it fluctuated between 44,5 and 59,9% except for a mean recording of 63,3% in Bolo during April. Mean monthly figures of recorded daily temperatures showed that an average minimum temperature varying between 1,5° to 7,2°C, and maximum temperatures of 18,9° and 20,9°C were experienced in July with a similar range of temperature variations in June. The figures for April were somewhat higher, however, the highest mean minimum temperature of 12,9°C was recorded at Dohne and the highest mean maximum temperature was 26,1°C recorded at Underchurch for the month of April.

Clinical findings

The nature and distribution of lesions in the animals from the 15 properties examined during the bacteriological survey, are shown in Table 1. Whereas the incidence of severe lesions was only slightly higher in ewes than in rams and wethers, it was noted that these lesions tended to be more diffusely spread in the ewes. In the great majority of ewes and wethers with mild afflictions, the lesions were of a localised nature, while no conclusion could be drawn about the rams as too few were examined.

Bacteriological culture

Results of the primary bacterial cultures are given in Table 2. In Table 3, bacteria other than *Corynebacterium* spp which occurred in pure or predominant growth in primary cultures of specimens from affected and unaffected sheep, are listed and their incidence is expressed as a percentage of primary cultures. Table 4 in-

Table 1: **Nature and distribution of lesions in sheep with Bolo disease examined during a bacteriological survey**

Animals examined :		Nature and distribution of lesions			
		Severe		Mild	
Type	Number	Diffuse	Focal	Diffuse	Focal
Ewes	405	126 (31,1%)	147 (36,3%)	40 (9,9%)	92 (22,7%)
Wethers	158	41 (25,9%)	62 (39,2%)	9 (5,7%)	46 (29,1%)
Rams	8	2 (25,0%)	3 (37,5%)	1 (12,5%)	2 (25,0%)

Table 2: **The relative incidence of *Corynebacterium* spp and other bacteria in primary cultures of specimens collected during a bacteriological survey from sheep affected by and unaffected by Bolo disease**

Specimens and degree of affliction		NS		*Corynebacterium* spp. ***			Other bacteria ***		
Degree of affliction	Number	Negative	NS* or overgrown	Positive ** growth	Pure growth	Predominant growth	Mixed growth	Pure growth	Predominant growth	Mixed growth
Total specimens	1168									
Severe	531 (45,5%)	11 (2,1%)	63 11,9%	457 (86,1%)	241 (52,7%)	139 (30,4%)	72 (15,8%)	5 (1,1%)	0 (0,0%)	0 (0,0%)
Mild	340 (29,1%)	20 (5,9%)	64 (18,8%)	256 (75,3%)	123 (48,0%)	63 (24,6%)	45 (17,6%)	23 (9,0%)	2 (0,8%)	0 (0,0%)
Unaffected	297 (25,4%)	84 (28,3%)	193 (65,0%)	20 (6,7%)	7 (35,0%)	0 (0,0%)	2 (10,0%)	9 (45,0%)	2 (10,0%)	0 (0,0%)
% of all specimens	1168	115 ((9,8%)	320 (27,4%)	733 (62,8%)	371 (31,7%)	202 (17,3%)	119 (10,2%)	37 (3,2%)	4 (0,3%)	0 (0,0%)
% of positive growth only					371 (50,6%)	202 (27,6%)	119 (16,2%)	37 (5,0%)	4 (0,5%)	0 (0,0%)
Skin swabs only:	718									
Severe	318 (53,1%)	7 (1,8%)	13 (3,4%)	361 (94,8%)	210 (58,2%)	111 (30,7%)	37 (10,2%)	3 (0,8%)	0 (0,0%)	0 (0,0%)
Mild	190 (26,5%)	14 (7,4%)	11 (5,8%)	165 (86,8%)	92 (55,8%)	45 (27,3%)	20 (12,1%)	7 (4,2%)	1 (0,6%)	0 (0,0%)
Unaffected	147 (20,5%)	57 (38,8%)	81 (55,1%)	9 (6,1%)	4 (44,4%)	0 (0,0%)	1 (11,1%)	4 (44,4%)	0 (0,0%)	0 (0,0%)
% of all skin swabs	718	78 (10,9%)	105 (14,6%)	535 (74,5%)	306 (42,6%)	156 (21,7%)	58 (8,1%)	14 (1,9%)	1 (0,1%)	0 (0,0%)
% of positive growth only					306 (57,2%)	156 (29,2%)	58 (10,8%)	14 (2,6%)	1 (0,2%)	0 (0,0%)

*Obviously non-significant bacterial growth
**Appreciable number of morphologically similar colonies indicating possible significance
***Expressed as a % of positive cultures only

dicates secondary and tertiary isolates from specimens of affected sheep, and their incidence is expressed as a percentage of primary cultures.

Table 5 compares the total number of *Corynebacterium* spp isolates to other bacteria recovered from primary cultures from all affected as well as unaffected sheep. Bacteriological examination of skin swabs yielded more positive cultures in comparison to examination of skin scrapings and wool speciments (Table 6).

DISCUSSION

In their report, Jansen & Hayes[9] explain Bolo disease as it occurs in the Stutterheim district, to be due to the presence of sufficient moisture to cause bacteria present on the skin to multiply and to initiate the lesions found on affected sheep; the moisture is however insufficient to cause typical fleece-rot.

Table 3: **Bacteria other than *Corynebacterium* spp which occurred in pure or predominant growth in primary cultures of specimens from affected and unaffected sheep obtained during the bacteriological survey**

ORGANISMS ISOLATED	NUMBER OF BACTERIAL ISOLATES			
	Affected sheep		Unaffected sheep	
				*
Staphylococcus epidermidis	14	1,9	4	0,55
Staphylococcus aureus	3	0,4	0	0
Staphylococcus saprophyticus	5	0,7	0	0
Micrococcus roseus	0	0	1	0,14
Streptococcus spp	0	0	2	0,27
Gram-positive coccus	1	0,14	0	0
Alcaligenes faecalis	1	0,14	0	0
Proteus spp	2	0,27	4	0,55
TOTAL	26	3,55%	11	1,5%

*Expressed as a percentage of primary cultures

Table 4: **Secondary and tertiary bacterial isolates from primary cultures of skin and wool specimens of affected sheep, collected during the bacteriological survey**

BACTERIA ISOLATED	NUMBER OF BACTERIAL ISOLATES			
	Secondary growth		Tertiary growth	
Staphylococcus epidermidis	22	3,0*	4	0,55*
Staphylococcus saprophyticus	7	0,95	0	0
Staphylococcus aureus	5	0,7	0	0
Micrococcus luteus	1	0,14	1	0,14
Micrococcus roseus	1	0,14	0	0
Micrococcus spp	2	0,27	0	0
Gram-negative coccus	5	0,7	1	0,14
Pseudomonas spp	5	0,7	1	0,14
Beta-haemolytic *Bacillus* spp	7	0,95	1	0,14
Arthrobacter freundii	2	0,27	2	0,27
Alcaligenes faecalis	2	0,27	0	0
Yeasts	2	0,27	0	0
Sub-cultures died	2	0,27	0	0
TOTAL	: 63	8,63%	: 10	1,33%

*Expressed as a percentage of primary cultures

Their assumption seems to be based on the annual incidence of an average of 111 rainy days, recorded in this district from 1939 to 1975, which would amount to an average wet to dry day ratio of 1:3,3. In the literature, continuous thorough wetness of fleece and skin of sheep in excess of 4 days[7], for 4 to 6 weeks[1] or 1 week or longer[6], is stated as being a basic prerequisite for the multiplication of bacteria present on the skin of sheep and for the development of fleece-rot. Furthermore, Hayman[6] clearly showed that the ratio of wet to dry days and total precipitation, were critical climatic factors; that rainfall per wet day in itself was not critical, since fleece-rot was not observed after heavy downpours of rain of relatively short duration. In his studies Hayman[6] found that ratios of wet to dry days were never more than 1:1,1 during periods of fleece-rot development and never less than 1:3,1 during periods when it did not occur, while total precipitation for the corresponding periods varied from 96,5 to 413,75 mm and 73,25 to 138 mm respectively. During these studies, conducted over 5 years, periods of continuous wet weather, preceding the occurrence of fleece-rot, persisted for 12 to 54 d. Compared to these rainfall figures recorded over such limited periods, it seems unlikely that the average figures of 736,7 mm of rainfall and 111 wet days over a period of 12 months as presented by Jansen & Hayes[8] could be conducive to the multiplication of bacteria on the skin of sheep and the persistent occurrence of a condition such as Bolo disease.

During the year of this bacteriological survey (1985), total rainfall figures of 753,3 mm at Underchurch, 1 022 mm at

Table 5: **Comparison of the total number of *Corynebacterium* spp. isolates to other bacteria recovered from primary cultures of specimens from all affected as well as unaffected sheep, collected during a bacteriological survey of Bolo disease**

SPECIMENS		TYPE OF SHEEP	NUMBER OF ISOLATES			
Type	**Number**	**Type**	**Number of specimens**	***Corynebacterium* spp.**	**Other bacteria**	**Negative N/S* overgrown**
All Specimens	1 168	Affected	871 (74,6%)	683 (78,4%)	30 (3,4%)	158 (18,1%)
		Unaffected	297 (25,4%)	9 (3,0%)	11 (3,7%)	277 (93,3%)
Skin swabs only	718	Affected	571 (79,5%)	515 (90,2%)	11 (1,9%)	45 (7,9%)
		Unaffected	147 (20,5%)	5 (3,4%)	4 (2,7%)	138 (93,9%)

*Non-significant bacterial growth

Table 6: **An evaluation of 3 different methods for the collection of specimens for bacteriological examination of skin conditions in woolled sheep, with specific reference to Bolo disease**

		Skin swabs			**Skin scrapings**			**Wool**		
Type of affliction	**Number of sheep**	**Negative N/S * overgrown**	**Positive *Corynebacterium* spp.**	**Positive other bacteria**	**Negative N/S * overgrown**	**Positive *Corynebacterium spp***	**Positive other bacteria**	**Negative N/S * overgrown**	**Positive *Corynebacterium* spp**	**Positive other bacteria**
Severe	75	1 (1,3%)	74 (98,7%)	0 (0,0%)	19 (25,3%)	55 (73,3%)	1 (1,3%)	35 (46,7%)	39 (52,0%)	1 (1,3%)
Mild	75	7 (9,3%)	64 (85,3%)	4 (5,3%)	18 (24,0%)	43 (57,3%)	14 (18,7%)	41 (54,7%)	31 (41,3%)	3 (4,0%)
Unaffected	75	68 (90,7%)	3 (4,0%)	4 (5,3%)	70 (93,3%)	3 (4,0%)	2 (2,7%)	69 (92,0%)	1 (1,3%)	5 (6,7%)

*Non-significant bacterial growth

Bolo and 1 167,1 mm at Dohne were recorded. However, from the total rainfall figures for each of the preceding 3 months as well as the month during which the survey was conducted, it can be seen that it was a relatively dry period with the highest recording of 22,9 mm at Dohne during April and only 0,2 mm at this station during July. Despite these unfavourable rainfall conditions, particularly during the 3 weeks preceding the survey, severe affliction (acute lesions) was found in 66,7% of the affected animals examined (Table 1). It seems highly unlikely that wetness of the skin and fleece played any part in the development of the acute lesions of Bolo disease encountered during this survey. Henderson[7] states that production of exudate stops spontaneously when the skin is dried, while Hayman[6], found this period to be 2 to 3 d.

According to Hayman[6], the range of mean daytime relative humidity (69 to 93%) when fleece-rot occurred, was distinctly higher than the range (58 to 76%) when lesions did not occur. Although not strictly comparable, the range of mean monthly daytime relative humidity values in this study is of a distinctly lower order when compared to the range of mean daytime values recorded by Hayman[6] at times when lesions of fleece-rot did not occur. Apart from reflecting the dry climatic conditions which prevailed during the period, and also during the bacteriological survey, the relative humidity values seem to emphasise the unlikeliness of wetness playing any role in the occurrence of Bolo disease.

Should wetness have played a role, this situation, together with the low temperatures and relative humidity that prevailed, would have caused the skin lesions to abate[6 7] and consequently no lesions would have been encountered; except maybe for horizontal bands of scaly deposits and/or discolouration in fleeces, some distance away from the skin. Colly[5] successfully transmitted Bolo disease by a single application of a suspension of *Corynebacterium* spp. in physiological saline.

Possible explanations for the tendency towards a higher incidence of diffusely spread severe lesions in ewes could be their greater proportional representation and better opportunities for exposure, but more important, their poorer nutritional status, as was evidenced in a substantial percentage of these ewes which were weaned of their lambs shortly before the investigation.

On the first inspection after incubation for 48 h, primary cultures were classified into 3 categories according to the nature

and extent of bacterial growth displayed, as was previously explained namely positive, negative and non-significant or overgrown. The number of cultures in each category obtained from specimens of severely and mildly affected, as well as of unaffected animals (Table 2), is of significance. Of all the specimens examined, 86,1% collected from severely affected, and 75,3% from mildly affected animals, showed significant bacterial growth on the primary cultures, as compared to only 6,7% in the unaffected animals, which consequently had a substantial percentage (93,3%) of negative and non-significant or overgrown primary cultures. When skin swabs only were compared, the figures were even more dramatic, namely, 94,8% and 86,8% of possibly significant bacterial growth on primary cultures of severely affected and mildly affected sheep respectively, as compared to 6,1% in the unaffected animals. These results tend to show that at least some forms of bacterial growth predominated the sites of affliction.

From this bacteriological investigation, it soon became evident that *Corynebacterium* spp was the predominant type of growth. In Table 2 the incidence of *Corynebacterium* spp and other bacteria (grouped together) and the extent of growth on primary cultures prepared from specimens collected from severely and mildly affected sheep, as well as from unaffected sheep, are given. From this information it can clearly be seen that *Corynebacterium* spp was the most important isolate present.

Other bacteria were only obtained as primary isolates in a small percentage of cases. Their better representation in primary cultures of specimens from mildly affected sheep, seems to suggest their take-over of a primary infection as secondary invaders only.

The incidence of *Corynebacterium* spp in the form of pure or predominant growth on the primary cultures prepared from skin swabs of only affected sheep, was distinctly higher (87% of positive cases) and its presence in mixed cultures distinctly lower (10,8% of positive cases) than was the case in cultures prepared from all the specimens collected (65% + 13,4% of positive cases respectively). This seems to confirm the belief that other types of bacteria, incidentally present in specimens collected by skin scraping or in wool samples, were eliminated by this method of specimen collection, thus making it possible for a primary inhabitant such as *Corynebacterium* spp to be represented as a predominant or even pure growth on primary cultures in the majority of cases.

These results seem to prove beyond doubt, the aetiological significance of *Corynebacterium* spp in the occurrence of lesions of Bolo disease. Its isolation from a small percentage of unaffected cases can only be explained to the effect that the organism had already been present on the skin of these sheep, but that clinical lesions had not yet developed at the time that these animals were examined. These sheep can therefore be regarded as prospective cases of Bolo disease, as they were in the incubation stage of the disease at the time of bacteriological investigation.

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A CLINICAL STUDY OF AURICULOTHERAPY IN CANINE THORACOLUMBAR DISC DISEASE

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ABSTRACT

Auriculotherapy (ear-point acupuncture) was used in dogs (n = 30) suffering from thoracolumbar disc disease, Types I-IV, with a duration of 1 to(47 $\bar{x}$ = 8) d. During auriculotherapy treatment, no analgaesics or anti-inflammatory medications were used. Pressure-sensitive and electrically detectable points on the concave aspect of the external auricle were stimulated by insertion of stainless steel acupuncture needles for 20 min. One to 6 needles were used on each occasion in a maximum of 3 treatments. Fifty per cent of dogs recovered completely and 23% improved. Dogs with backpain only (Type I) and dogs with paresis (Type II) responded best with mean recovery times of 1,7 and 3,2 d respectively. The analgaesic effects were especially impressive. Auriculotherapy failed in 3 (50%) paralysed dogs (Types III and IV) in which post-mortem examinations confirmed focal myelitis and myelomalacia. Four of 12 dogs (33%) recorded relapsed in 1,4 to 26 weeks after successful treatment.

Key words: Dog, acupuncture, thoracolumbar disc disease.

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INTRODUCTION

In human acupuncture, only one small part of the body (for instance the nose, face, hand, foot and ear) is often used as the site for treating various diseases. The ear zone or auriculotherapy (ear-point acupuncture) is often used[4]. Auricular acupuncture points are pressure-sensitive and show decreased electrical skin resistance in comparison to the surrounding skin areas. Trials in humans[4] and animals[11 13 14] suggest that certain points reflect pathological processes situated in certain specific somatic regions and are thus diagnostically significant. The points are claimed to positively affect the corresponding pathological process when stimulated physically (for instance by a steel acupuncture needle)[8 17]. A large number of these points have been described in humans[5 6].

Clinical human studies[10 16] claim a high success rate with the use of auricular acupuncture (82-91%) in selected conditions. Musculo-skeletal pain is the main indication for auriculotherapy[5 6 10 17]. A recent study by Melzack & Katz[7], however, reported a powerful placebo effect of electrical stimulation of the auricular points in 36 patients suffering from chronic pain. Electrical stimulation of selected auricular and periauricular points induced analgaesia allowing a complete flank laparotomy in 46% of experimental dogs[12].

The purpose of this study was to evaluate auriculotherapy in dogs suffering from thoracolumbar disc disease.

MATERIALS AND METHODS

Dogs (n = 30) presented for treatment to the First Internal Clinic, University of Veterinary Science, Brno, Czechoslovakia, from May 1983 to May 1985 and classified according to the type of thoracolumbar disc disease[3] (Table 1 and 2), were treated by auriculotherapy. No dogs were excluded from the study.

A detailed neurological examination according to Hoerlein[2] and Janssens[3] was performed on each dog before the beginning of auriculotherapy and before each of the consecutive treatments. All dogs were subjected to radiological examination and the results were correlated with clinical findings to confirm the diagnosis[2] Most of the dogs (93%) were presented for auriculotherapy in the acute stage of thoracolumbar disc disease and most (70%) showed signs of backpain. Motor and sensory deficits (Types II—IV) behind the spinal lesion was diagnosed in 63% of dogs (Table 2).

All medical treatments prior to auriculotherapy were recorded. Only 2 dogs (7%) received anti-inflammatory doses of short-acting corticosteroids (prednisolone, Prednisolon - Galenika), before the beginning of auriculotherapy, one of which was suffering from Type I thoracolumbar disc disease and had received 2 doses of corticosteroids prior to acupuncture. Another dog which was suffering from Type IV thoracolumbar disc disease, received 4 doses of corticosteroids. Two days elapsed between the last corticosteroid treatment and auriculotherapy in both dogs. Non-steroidal analgaesics (aspirin, Acylpyrin-Spofa or ibuprofen, Bruffen - Galenika) were administered to 6 (20%) dogs, 2-4 d before the beginning of auriculotherapy. All drug medication was excluded during the course of auriculotherapy, with the exception of 2 acute patients with hind limb paralysis (Type III and IV) which received antibiotics (penicillin and streptomycin, Penstrepten - Biotika).

Acupuncture needles of 0.2mm gauge and 5-15 mm stainless steel were inserted into the pressure-sensitive and electrically active points on the concave aspect of the external auricle. The points were detected by an atraumatic spring-mounted search electrode probe of 1 mm² diameter at a detection pressure of 80-120 g/mm² (784-1 177 kPa). The electrode was connected to an Akudiast I apparatus (produced by Metra Blansko, Czechoslovakia) which registered changes of electrical skin resistance (impedance) in the points. A positive finding of the active point was characterised by a sudden jerk of the body and marked decrease of the electrical skin resistance under the value of 70 KΩ. The

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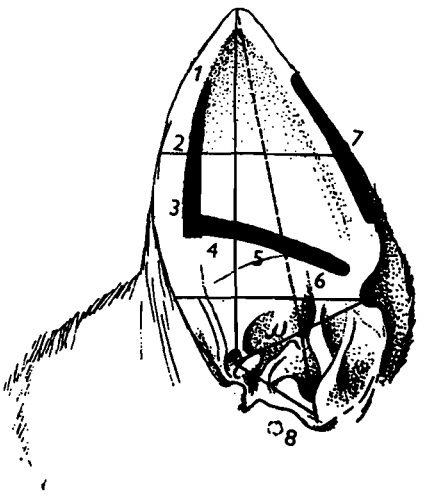

Fig. 1: **Auricular pressure- and electro-sensitive zones used for treatment of canine thoracolumbar disc disease. The somatotopic representation of the spinal and hind limb nervous areas are shown[13 14]**

1: "Hind paw" area; 2: "Knee" areas; 3: "Hip" area; 4: "Sacral and lumbar" area of the vertebral column, 5: "Thoracic" area of the vertebral column; 6: "Cervical" area of the vertebral column; 7: "Spinal cord" area; 8: "Hypothalamus" area

points occurred within the somatotopic zones (Fig. 1). One to 6 needles were used. The needles were placed into the zones occurring on one or both external auricles to investigate whether unilateral or bilateral needling is clinically more effective. The needles were left in situ for 20 min without any additional manipulation and then removed. Clinical progress was recorded daily.

The patients were considered to be experiencing relief of pain when muscular relaxation of the back and abdomen and tranquilisation of the previously anxious subjects were observed. Improved motility, allowing running or climbing of a staircase was considered to be an additional criterion of the relief of pain in dogs which were previously reluctant to perform these activities due to pain in the back. Relief of pain and improvement of the voluntary motility were used as criteria for clinical success of auriculotherapy in dogs of Types II—IV (Table 3).

One to 3 treatments were used in each dog. Auriculotherapy was terminated if no essential clinical improvement occurred after 3 sessions or if the dog's condition deteriorated.

Post-treatment clinical progress was followed up in the dogs by requesting owners to return a detailed questionnaire concerning the dogs' progress. A few dogs were also clinically re-evaluated.

No control experiments on dogs affected by thoracolumbar disc disease and non-treated or treated by drugs, were performed. A comparable study of treatment of the condition using body-point acupuncture was performed in the clinic[15 16].

Post-mortem examinations were performed on most of the dogs that died.

The Chi-square test was used to analyse results of the treatments statistically.

RESULTS

Results of auriculotherapy are summarised in Tables 3 and 4. Overall, 73% of dogs recovered or improved. Only 2 dogs of Type I remained unimproved. One progressively deteriorated to Type IV and died within a week, in spite of corticosteroid therapy; another showed a significant improvement only 1-2 d post-treatment, but long-term alleviation of pain was only obtained following corticosteroid therapy.

In the Type II group, 3 dogs did not improve during treatment. Two of them improved following acupuncture of points other than auricular points; one dog progressively deteriorated and died due to aggravation of associated chronic renal disease within a week.

Three of 6 (50%) dogs suffering from hind limb paralysis (Types III and IV), improved substantially during the few days of treatment. One dog, with backpain and urinary retention (Type IV) recovered completely after 2 treatments over 2 days; one dog of Type III, was able to walk after the first treatment, but mild residual ataxia was present; the third dog responded similarly after 3 sessions in 2 weeks. Another 3 dogs treated 1-3 times over a period of 2 to 6 d, did not improve and were euthanased. Post mortem examinations confirmed local myelitis or myelomalacia resulting from thoracolumbar disc protrusion in all of them.

Analgaesic effects were prominent, especially in Type I, in which 6 of 7 dogs (86%) were completely free of pain after one treatment. Four of 7 dogs (57%) (Type II) completely recovered from ataxia and backpain after one treatment. The difference in success rate between Types I and II was not significant ($p > 0,05$). Those with motor problems (hind limb paresis to paralysis) generally did not recover as well as those which only suffered pain. This was apparent in Type II, but especially in Types III and IV.

No statistically significant difference ($p > 0,05$) between the success rates of auriculotherapy in the dogs with previous short-term analgaesic drug treatment (88%), and non pre-treated dogs (57%) was confirmed. Bilateral auricular needling (75% of cases) was not significantly ($p > 0,05$) more effective in the treatment of thoracolumbar disc disease than unilateral needling (50%).

Post-treatment relapses to thoracolumbar disc disease, occurred in 4(31%) of the recorded dogs (Table 5). Backpain reappeared in 2 dogs classified pre-treatment as Type I, 3 weeks after temination of auriculotherapy, as well as in a Type II dog after 10 d. A dog classified as Type III, pre-treatment, relapsed to the same type 2 months after treatment.

DISCUSSION

Some recommended diagnostic methods of canine thoracolumbar disease[2 3 18] were not used in this study. These methods improve diagnostic reliability of the currently used clinical neurological examination and spinal radiography[1 3 18]. Spinal myelography can be potentially harmful to conservatively treated dogs[2 3 18] and other recommended diagnostic methods such as lumbosacral venography, discography and computer tomography[17] were not available. The diagnosis of canine thoracolumbar disc disease was therefore not beyond doubt in this or other studies[1 3 15 16].

The results indicate that auriculotherapy in dogs was effective in acute thoracolumbar disc disease and can be classified as a conservative treatment. Corticosteroid therapy is commonly employed in practice[1 2] and body-point acupuncture (needling points on the back and hind limbs) was also found to be highly effective in canine thoracolumbar disc disease, Types I and II[3 15 16]. However, only one sufficiently detailed comparable study of conservative treatment of Type I and II canine thoracolumbar disc disease (using body-point acupuncture) has been recorded[15 16]. Comparable and clinically acceptable[1] success rates were obtained in those studies. The mean recovery time was, however, shorter in the case of auriculotherapy (1,7 d for Type I and 3,2 d for Type II) than in the case of body-point acupuncture (3,4 and 9,2 d respectively). The reliability of analgaesic effects, the short duration of treatment and an acceptably high success rate, suggest auriculotherapy as an interesting therapeutic alternative to other therapies of thoracolumbar disc disease in dogs affected by less severe spinal injury, classified clinically as Type I and II. Other comparable studies using conventional physical and drug treatments[2], would be highly desirable to evaluate objectively the clinical contribution of acupuncture in the treatment of canine thoracolumbar disc disease.

As only 20% of the dogs in this study were suffering from Types III and IV

Table 1: **Thoracolumbar disc disease classification (adapted according to Janssens[3]) at initial examination**

Type I	- backpain, no neurological deficit
Type II	- hind limb paresis/ataxia, recurrent backpain
Type III	- paraplegia with intact pain sensitivity of the hind limbs, back pain may be present
Type IV	- paraplegia with absence of pain sensitivity in the hind limbs, back pain may be present

Table 2: **Sex, age and breed distribution of dogs and duration of pre-treatment disease**

Dogs	Type of thoracolumbar disc disease				
	I	II	III	IV	all cases
n	11	13	4	2	30
Males/females	6/5	4/9	3/1	1/1	14/16
Mean age	7,0	6,1	7,8	5,0	6,6
Range (years)	3,5-11	2,5-11	6-11	3-7	2,5-11
Chondrodystrophic breeds (%)	82	85	100	50	84
Mean duration (d) of clinical signs pre-treatment	9	4	17	3	8
Range	2-30	1-9	2-47	1-5	1-47

Table 3: **Clinical therapeutic success of auriculotherapy**

Therapeutic success	Type of thoracolumbar disc disease				
	I	II	III	IV	all cases
Number treated	11	13	4	2	30
Number and %( ) recovered*	7(64)	7(54)	0(0)	1(50)	15(50)
Number and %( ) improved**	2(18)	3(23)	2(50)	0(0)	7(23)
Number and %( ) unimproved***	2(18)	3(23)	2(50)	1(50)	8(27)

* Types I to IV: no pain observed, motility as before the onset of the disease

** Type I: clinically free of pain, but occasionally a mild discomfort associated with the backpain observed by the owner
Type II: clinically free of pain, occasional gait instability of the hind limb
Type III and IV: clinically free of pain, voluntary motility of the hind limb, but ataxia persists

*** Types I to IV: no clinical improvement or deterioration

thoracolumbar disc disease, firm conclusions cannot be drawn as regards the therapeutic effectiveness of auriculotherapy in these cases. The method apparently failed in dogs with acute myelitis. Auriculotherapy also did not prevent further progressive deterioration in 2 dogs with Type I and II thoracolumbar disc disease, in which severe spinal injury could be suspected. The prognosis, using other conservative therapeutic methods, is generally poor in such cases[2]. The results of this study indicate that surprisingly good response to auriculotherapy can be obtained occasionally in paralytic dogs (Types III and IV), but cases presented within 48 h after the onset of clinical signs, should probably preferably be treated surgically[1 2 11].

Auricular pressure-sensitive and electrically active points on the canine external auricle can reflect some pathological processes in the body with surprisingly high reliability[9]. Previously we confirmed in 154 dogs with various neurological and musculoskeletal diseases (including the thoracolumbar disc disease syndrome), that the diagnostic correlation between the pathologically injured part of the body and the related auricular point, was highest in acute inflammatory (88%) and painful processes (91%)[14]. Most of the dogs treated by auriculotherapy in the present study, corresponded with these conditions and the auricular points were found in all of them within the projection areas (Fig. 1). Stimulation of the points by needling, induced clinically significant analgesia, which was not apparently associated with differences in nervous excitability (temperament) between the dogs. In contrast to this, significantly better surgical analgesia ($p < 0,05$) was obtained in nervous than in placid dogs[12]. No clinical pain or neurological disturbances were present in those dogs. Comparison of the previous study[12] with the present results (experimental pain compared with clinical pain), suggests that adequate stimulation of corresponding auricular points can activate partially different pain-killing mechanisms in the dog, depending on the characteristics of the injury. Both unilateral and bilateral auricular stimulation provoked good analgesia. This finding may be important for practical application of the method.

The physiological effects of auriculotherapy are mediated via the nervous system[4 5]. However, mechanisms of action of classical acupuncture and ear-acupuncture on the pathological process (reversible spinal lesion in thoracolumbar disc disease), may differ between both variants of acupuncture, although both approaches can offer comparable results. Classical acupuncture, employing traditional Chinese points[6 15] affect the local

Table 4: **Duration and course of auriculotherapy**

	Type of thoracolumbar disc disease				
	I	**II**	**III**	**IV**	**all cases**
Number treated	11	13	4	2	30
Mean duration of treatment (d)	1,7	3,2	6,0	2,0	3,0
Range	1-7	1-7	1-14	2	1-14
Number of sessions					
Average	1.3	1,7	1,2	2,0	1,5
Range	1-2	1-3	1-3	2	1-3
Number and %( ) improved after the first session	10(91)	7(54)	1(25)	1(50)	19(63)

Table 5: **Post-treatment evaluation of dogs treated by auriculotherapy**

	Type of thoracolumbar disc disease				
	I	**II**	**III**	**IV**	**all cases**
Number recorded post-treatment (% of total*)	4(50)	8(100)	1(50)	-	13(72)
Follow-up period (m)					
Average	3,9	6,1	2	-	5,1
Range	1,75-5	2-14	2	-	1,75-14
Number relapsed (% of recorded)	2(50)	1(12)	1(100)		4(31)

* recovered and improved cases in which no anti-inflammatory and/or analgaesic drugs were used during the follow-up period

anatomical structures around and behind the spinal lesion by segmental and supra-segmental mechanisms, but no apparent segmental connection exists between the lesion and related auricular points. The auricular method will involve the stimulation of supra-spinal mechanisms.

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OVERBERG RESEARCH PROJECTS. V. ANTHELMINTIC SALES IN THE BREDASDORP AREA OF THE SOUTHERN CAPE

J P Louw*

ABSTRACT

In the Bredasdorp anthelmintic market segment with its 327 764 sheep and goats and 19 818 cattle, 1 323 770 therapeutic doses of anthelmintic for sheep and goats and 6 622 therapeutic doses for cattle, worth R456 800,46 and R22 548,31, respectively, were sold during 1988. Fewer than 4 market segment therapeutic doses of nematocide, with an annual total average cost of R1,40 per animal, were sold for sheep and goats, while only an estimated 33⅓% of the cattle received an anthelmintic, at an annual average cost of R3,41 per animal. Anthelmintic prices fluctuated by -12 to +42% in 16 months. Benzimidazoles were responsible for 38,5%, ivermectins for 22,1% and combination products for 19,4% of sales. The injectable formulation of ivermectin was responsible for 38,5% of ivermectin sales and probably used primarily in the control of sheep scab.

Key words: Anthelmintic market, market share, market segment therapeutic dose, price, price escalation.

Louw J.P. **Overberg Research Projects. V. Anthelmintic sales in the Bredasdorp district of the southern Cape.** *Journal of the South African Veterinary Association* (1990) 61 No. 3, 106-109 (En.) Department of Parasitology, Faculty of Veterinary Science, University of Pretoria, Private Bag X04, 0110 Onderstepoort, Republic of South Africa.

INTRODUCTION

Determining the pattern and rate of anthelmintic usage is a difficult task. Stockpiling and transit time through the distribution network, render manufacturer sales figures unsuitable indicators of the volume and timing of anthelmintic consumption. Retail sales to the farmer, as the penultimate step in the distribution process, although still not perfect, are more reliable indicators of actual anthelmintic usage.

Anthelmintic sales surveys are not only useful sources of market intelligence, but will provide the scientist with valuable information regarding the chemotherapeutic helminth control practices in use, and their relevance to the known epizootiology of parasites of the region. The frequency with which the different generic classes of anthelmintics are used, is an important factor in the development of parasite resistance to these anthelmintics[1 4 6]. Reinecke[5] alleged that farmers treat their stock too frequently.

The purpose of the present study was to determine the number of therapeutic doses of all anthelmintics sold in a specific segment of the market, to relate the number of doses to the number of target animals and to determine the retail price, dosage cost and price adjustments which occurred in the anthelmintic market during 1988.

MATERIALS AND METHODS

The segment of the anthelmintic market included in the present study, comprised the whole of the area affiliated with the Bredasdorp/Napier Agriculture Co-operative. This institution has 4 outlets and sells to stock farmers owning 326 074 sheep, 1 690 goats and 19 818 cattle. As a result of extensive incentive schemes such as credit sales, deferred payment and discounts offered by the Co-operative to its members, all anthelmintic sales, even those made by representatives of the manufacturers, are channeled through the insitution. For this reason anthelmintic sales by the Co-operative were regarded as the total of all anthelmintic sales in this area. All stock figures used, were the official stock census figures for 1987/88, obtained from the Department of Agricultural Economics and Marketing.

Sales figures were processed by a central data processing unit and the trade names of all anthelmintics, the pack volumes and their prices as well as the quantities of each sold, recorded monthly. The crude sales figures were arranged by trade names and grouped generically by active ingredient, ivermectins (Ivm), benzimidazoles (Bnz), levamisoles (Lvz), morantel (Mrl) salicylanilides (Sa), combinations of Bnz and Sa (Cmb) and the cestocides. Sales volumes were expressed in 50 kg doses sold monthly to the sheep/goat and cattle market, respectively. Local prices for anthelmintics were recorded in August 1987 and again in December 1988 and the cost of individual doses, as well as the price fluctuation during the 16 month period, calculated.

Monthly sales of sheep/goat and cattle nematocides were accumulated in multiples of 327 764 doses of 50 kg and 19 818 doses of 450 kg, respectively. These were the number of doses required for a single treatment of all stock in this segment of the market (the market segment therapeutic dose). This analysis of the market provided a useful indication of the number of market segment therapeutic doses purchased, as well as the timing of anthelmintic treatments.

Mean monthly temperature and total monthly rainfall recorded in the vicinity of Bredasdorp, were incorporated in the study.

RESULTS

The percentage division of the sheep and goat nematocide market by generic group of products, is illustrated in Fig. 1, while the monthly sales of the 3 leading generic groups of anthelmintics are presented in Fig. 2. The benzimidazoles were the market leaders with a 38,5% share in the sheep and goat market, followed by the

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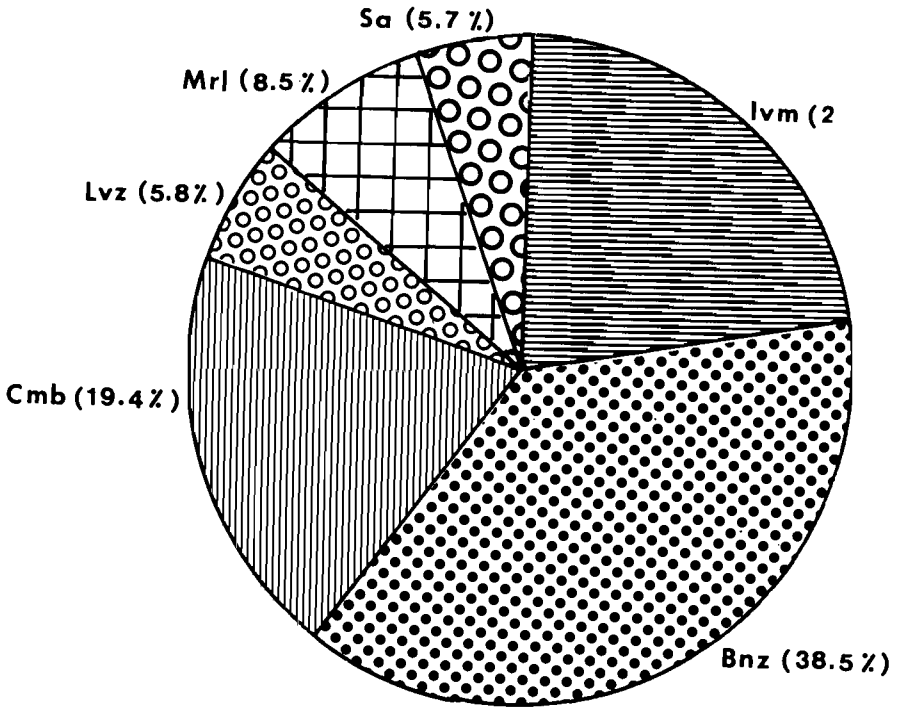

Fig. 1: **Percentage division of the nematocide market for sheep and goats in the Bredasdorp area in 1988. Ivm = ivermectins; Bnz = benzimidazoles; Cmb = combination of Bnz and Sa; Sa = salicylanilides; Lvz = levamisoles; Mrl = morantel**

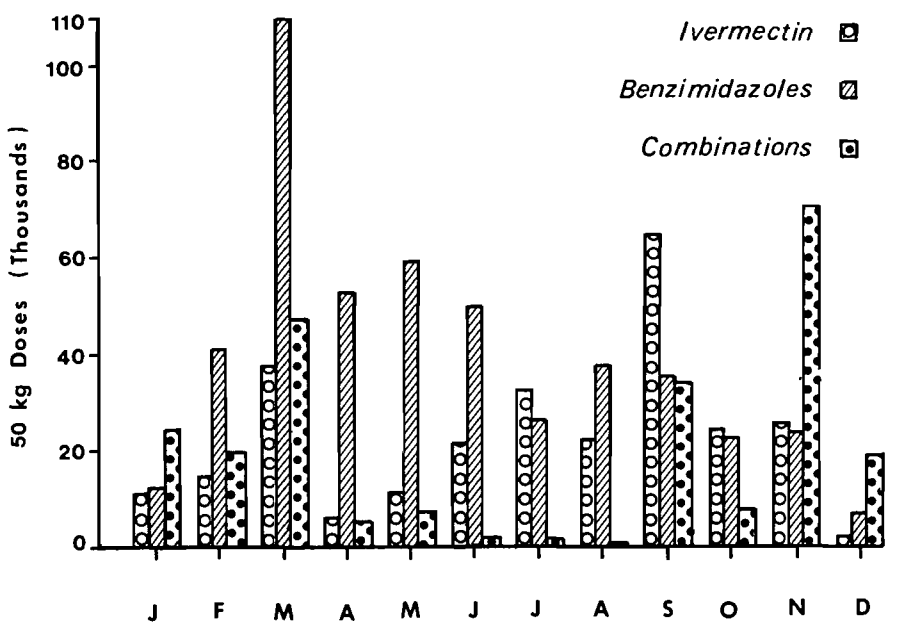

Fig. 2: **Monthly sales of the 3 leading generic groups of anthelmintics for sheep and goats in the Bredasdorp area during 1988**
Bredasdorp area during 1988

ivermectins (22,1%) and the combination products (19,4%). Products containing a benzimidazole accounted for 57,9% of all sheep and goat anthelmintic sales.

The number of 50 kg doses of anthelmintics sold during 1988, totalled 1 383 370 of which 1 323 770 doses were sheep and goat and 59 600 doses cattle anthelmintics. Converted to 450 kg doses, the estimated livemass of adult cattle, only 6622 doses were sold for cattle. Only 72 960 doses of the sheep and goat anthelmintics were pure cestocides, while 1 250 810 doses were nematocides. A number of benzimidazoles have claims of efficacy against nematodes as well as cestodes, but, because the purpose for which these benzimidazoles were purchased could not be determined, they were classified as nematocides. The actual compounded cost of all packs of each brand of anthelmintic sold, as well as the average cost of each therapeutic dose, were calculated and amounted to R479 348,77 if based on prices which prevailed in December 1988, or R430 152,66 if based on prices which prevailed in August 1987. The value of the sheep and goat anthelmintic market segment would be R456 800,46 or R410 647,83, respectively. Price fluctuations during the 16 months the survey lasted, ranged from -12 to +42%.

The total monthly sheep and goat nematocide and cestocide sales, together with mean monthly temperature and total monthly rainfall are presented in Fig. 3.

A cumulative monthly sales flow diagram (Fig. 4) illustrates the timing and pattern which characterised the purchasing of nematocides for sheep and goats in market segment therapeutic doses.

DISCUSSION

Market share

The sales success of the pure benzimidazole products may be attributed to their attractive prices and the efficacy of some against cestodes of lambs. The high incidence of nematode resistance to this group of products is to be expected, when taking into consideration how intensively they are used. The rate at which parasites develop resistance to an anthelmintic, is directly related to the intensity of exposure to that compound[1].

Although the sales of combination products were surpassed by ivermectin sales, the former were probably the anthelmintics of choice for the simultaneous control of nematodes and nasal bots. Nearly 40% of the doses of ivermectin sold were in injectable form, and were probably used primarily for the control of sheep scab and not applied as a deworming agent per se.

Sales volume analyses by individual compound, revealed that anthelmintics

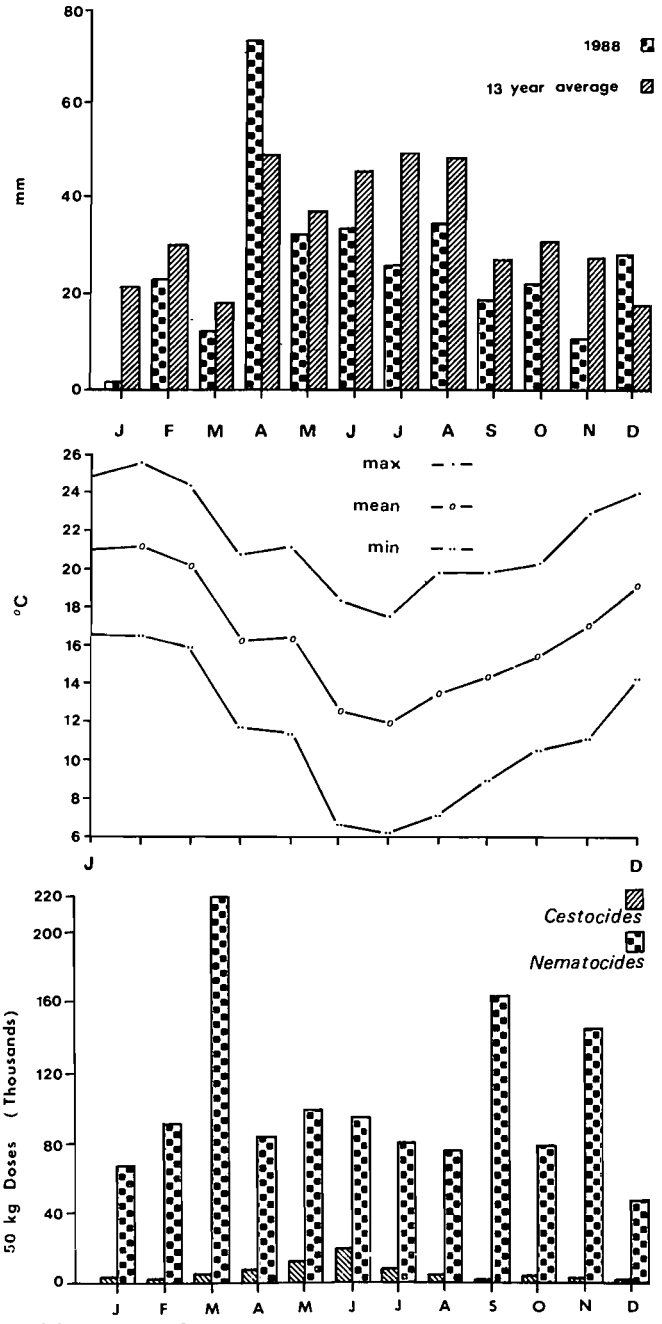

Fig. 3: **Monthly sales of nematocides and cestocides for sheep and goats, together with temperature and rainfall recorded in the Bredasdorp area during 1988**

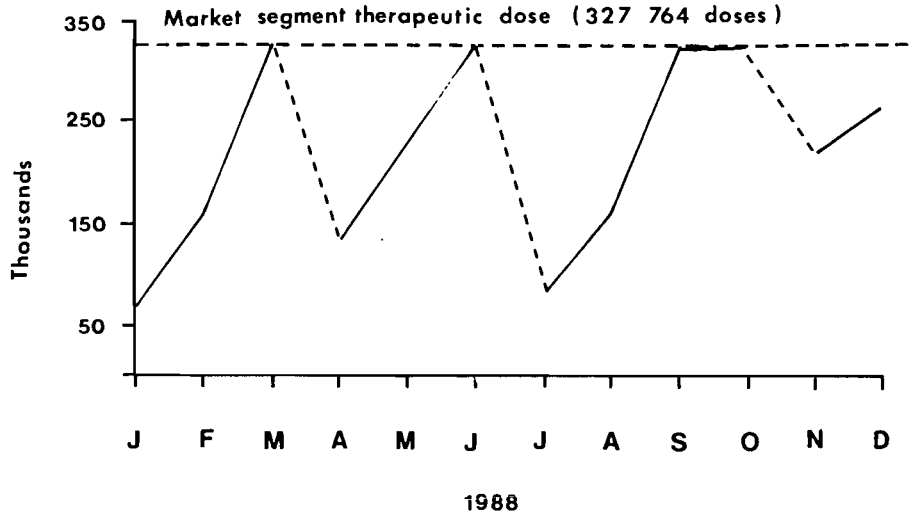

Fig. 4: **Market segment therapeutic doses of sheep and goat nematocides purchased in the Bredasdorp area during 1988**

containing albendazole were in greatest demand for sheep and goats, followed by ivermectin and the anthelmintics containing mebendazole.

Sheep nematocide sales peaked in March, September and November (Fig. 3), coinciding with the time of year when sheep are moved to winter pastures, lambs are weaned and sheep are moved to summer pastures. This purchasing pattern, if an indication of the helminth control programme which was being followed, indicated that the suggested strategic control programme based on the epizootiology of sheep helminths in the Rûens region of this area[3], was being followed to a certain extent. Cestocide sales coincided with the lambing season, reaching a peak in June when lambs were approximately 2 months of age, and in need of treatment (Fig. 3).

The cumulative monthly sales flow diagram (Fig. 4) starting in January, indicates that almost 4 market segment therapeutic doses of nematocides for sheep and goats were sold during 1988. These doses were sold by March, June, October and, with only 60 246 doses short, by December. Only 6 622 (450 kg) doses, 13 196 short of a market segment therapeutic dose for the cattle, were sold during 1988.

The injectable formulation of ivermectin for sheep, indicated primarily for the control of sheep scab, was purchased mainly during late winter and spring when conventional control by means of dipping, was probably too risky as a result of the bad weather conditions which prevail during this time of the year.

In December 1988 the average price of a dose of sheep and goat anthelmintic used in this segment of the market, was 35 cents. Niclosamide, ivermectin and the combination products sold for more than the average price, and cost 80, 52 and 39 cents, respectively. The cost of treating a 50 kg sheep or goat 4 times per year, as indicated in Fig. 4, could be as high as R2,08 if ivermectin was used or as low as R0,76 if morantel was used, but the average cost was R1,40. Cattle with a live mass of 450 kg would cost R3,42 to treat.

The mean price increase of all sheep and goat anthelmintics was only 11%, but the price of the ivermectins and the salicylanilides increased by 21% and 12%, respectively. During 1986 the average cost of all anthelmitnics used in the country, was 16 cents[2]. The difference of 19 cents (119%) between the 1986 national average cost of a therapeutic dose of sheep and goat anthelmintic and the 1988 average for the market segment under discussion, was therefore not due only to price increases, but also to more expensive classes of anthelmintics probably being used in this segment of the market.

The recorded average dosing frequency

pared to frequencies generally regarded as conducive to the development of anthelmintic tolerance in nematodes[6]. The extensive use made of the benzimidazoles as anthelmintics is more likely to precipitate such tolerance.

The average amount of R1,40 spent on sheep and goat anthelmintics is a negligible production cost factor and amounted to less than 1% of the gross current income of R159,18 quoted by the Directorate of Agriculture Economics for sheep in this region.

The timing and pattern of anthelmintic purchases corresponded to a large degree with the timing of treatment suggested in the strategic control programme based on the epizootiology of the parasites of sheep in the Rûens[3], an area constituting a large discussion.

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A SEROLOGICAL SURVEY FOR BRUCELLOSIS IN BUFFALO (*SYNCERUS CAFFER*) IN THE KRUGER NATIONAL PARK

F CHAPARRO*, J V LAWRENCE*, R BENGIS**, and J G MYBURGH*

ABSTRACT

A serological investigation was undertaken to determine the prevalence of brucellosis titres in buffalo in the Kruger National park. A total of 406 samples were collected over a period of one year. The rose bengal and the complement fixation tests were used in the investigation as these tests are routinely used for cattle sera and have proved to be reliable. In the females, 12,6% adult, 10,7% sub-adult and 3% juvenile animals reacted positively to the tests. In the males, 15,1% adults, 10,6% sub-adults and 5,3% juveniles were recorded as positive.

Key words: Buffalo, brucellosis, serology, prevalence

Chaparro F.; Lawrence J.V.; Bengis R.; Myburgh J.G. **A serological survey for brucellosis in buffalo *(Syncerus caffer)* in the Kruger National Park.** *Journal of the South African Veterinary Association* (1990) 61 No. 3, 110-111 (En.) Veterinary Research Institute, 0110 Onderstepoort, Republic of South Africa.

INTRODUCTION

Brucellosis is a contagious disease caused by bacteria of the genus *Brucella;* it can affect most domestic animals, causing abortion in pregnant females and orchitis and infection of the accessory sex glands in males. It occurs in most parts of the world. Man can also be affected[12].

The role of the disease in wildlife has not yet been adequately determined. On the African continent, isolations of *Brucella abortus* have been made from waterbuck[1], eland[2], and buffalo[7], which confirms that this bacterium can infect non-domestic animals. Several serological investigations have shown positive reactors in non-domesticated species in Africa, these include buffalo *(Syncerus caffer)*[2 3 5 9 15 16 20], Burchell's zebra *(Equus burchelli)*[2], eland *(Taurotragus oryx)*[2 10 14 15], impala *(Aepyceros melampus)*[2 5 17 18], tsessebe *(Damaliscus lunatus)*[4], bushbuck *(Tragelaphus scriptus)*[4], waterbuck *(Kobus ellipsiprymnus)*[5], hippopotamus *(Hippopotamus amphibius)*[5 15], nyala *(Tragelaphus angasi)*[10], beisa oryx *(Oryx beisa)*[14], blue wildebeest *(Connochaetes taurinus)*[17 18 20], black-backed jackal *(Canis mesomelas)*[18], and spotted hyaena *(Crocuta crocuta)*[18].

On other continents, seropositive reactions have been found among other animals, including foxes *(Vulpes vulpes)*[11 19], coyotes *(Canis latrans)*[6], opossum *(Didelphis marsupialis)*, racoon *(Procyon lotor)*[19], bison *(Bison bison)*, elk *(Cervus canadiensis)*, and moose *(Alces alces)*[13]. Isolations have also been made from coyotes[6], bison, elk, moose, white-tailed deer *(Odocoileus virginianus)*[13], grey foxes *(Dusicyon gymnocercus antiquus)*[19], and a large variety of rodents and hares[11 19].

The purpose of this study was to determine the prevalence of serological titres to brucellosis among buffalo in the Kruger National Park, and compare these results with those of other researchers.

MATERIALS AND METHODS

Blood was collected from Buffalo during routine culling in the park. It was left at room temperature until a clot had formed and the sera were collected in small plastic tubes and frozen. A total number of 406 samples were collected over a year, from different areas in the park. Before being sent to the serology laboratory at the Veterinary Research Institute, Onderstepoort, the samples were inactivated at 58°C for 30 min to prevent the possibility of transporting live foot-and-mouth disease virus.

Animals were classified according to age as adults (>3 years old), sub-adults (1-3 years old) and juveniles (<1 year old) and according to sex. Of the 216 females, 127 were adults, 56 sub-adults and 33 juveniles; of the 190 males, 86 were adults, 66 sub-adults and 38 juveniles.

All samples were subjected to the complement fixation test (CFT) used for routine brucellosis testing in cattle[8]. Titres are reported in International Units ml^{-1} (IU ml^{-1}); titres equal to or above 30 IU ml^{-1} were considered as positive.

All sera were also subjected to a rose bengal test[8] (RBT) done in WHO haem-agglutination plates, and any reaction from a small rimming to the complete clumping of the reagents in the well was regarded as positive.

RESULTS

The serological results are presented in Table 1. In the CFT, 45/406 samples (11,1%) showed a reaction equal to or above 30 IU ml^{-1}. Of these, 23 (5,7%) were from female animals and 22 (5,4%) from male animals. In adult females, 16/127 (12,6%) reacted positively, in sub-adults 6/56 (10,7%), and in juveniles 1/33 (3%). In males, 13/86 (15,1%) adults, 7/66 (10,6%) sub-adults and 2/38 (5,3%) juveniles showed positive titres.

All CFT-positive samples were also RBT positive, whilst not all RBT positives showed a CFT titre.

DISCUSSION

Compared with the results obtained by Herr & Marshall[9], who recorded a prevalence of 37,8% positive CFT serological reactions in adult female cows, we found only 12,6% to be positive; in adult males, the prevalences were 28,5% and 15,1% respectively. In the other age groups there was a difference in the age classification of the animals, but it can be stated that in general, the prevalence was lower as well.

De Vos & Van Niekerk[5] found a prevalence of 11,06% in 253 animals culled in the park between May and August 1964, which is similar to the prevalence found in this study; Condy & Vickers[3] described a prevalence of 22,6% in Wankie National Park after a study done on

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Table 1: **Number of buffalo reacting to the rose bengal test (RBT) and complement fixation test (CFT)**

Age and sex *	No. of samples	RBT positive(%)	CFT IU ml^{-1}		
			18-24	30-49	≥ 60
Adult F	127	28 (22)	9	5	11
Sub-adult F	56	8 (14,3)	0	1	5
Juvenile F	33	4 (12,1)	2	1	0
Adult M	86	24 (27,9)	4	5	8
Sub-adult M	66	9 (13,6)	2	3	4
Juvenile M	38	5 (13,2)	3	2	0
Totals	406	78	20	17	28

*F = Females M = Males

319 culled buffalo. Other reports[16 20] described the presence of serological positive titres for brucellosis in buffalo, but a reliable comparison could not be made from the number of animals tested.

The RBT is an exceedingly sensitive screening test and in comparison with results obtained with the CFT at the 30 IU ml^{-1} level, there were understandably a number of false positives in the RBT. This is commonly found in normal routine diagnostics on cattle sera as well.

The importance of brucellosis in buffalo populations is not well known. De Vos and Van Niekerk[5] stated that the disease has little effects on the buffalo population, nevertheless *Brucella abortus* biotype I has been isolated from foetal membranes of a buffalo foetus which apparently died before the cow was culled[7]. In other species such as the american bison, abortions and retained placentas have been observed, and isolations from bulls with orchitis have been made[13].

It is important, not only in the case of brucellosis, but with other controlled diseases as well, to consider that buffalo and wild antelope can become infected from domestic cattle and vice versa, and that this may have an impact on the control and eradiction of these diseases, since it is becoming more popular to have combined game and domestic stockfarming. The exact importance of brucellosis in buffalo populations should therefore be investigated.

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HELMINTH AND ARTHROPOD PARASITES OF ANGORA GOATS ON IRRIGATED KIKUYU GRASS PASTURES IN THE EASTERN CAPE PROVINCE

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ABSTRACT

Angora goat kids and yearlings grazing irrigated Kikuyu (*Pennisetum clandestinum)* grass pastures in the eastern Cape Province, became heavily infected with *Teladorsagia circumcincta* and *Trichostrongylus rugatus,* leading to high mortality in both age groups. Peak burdens of the former were recorded during March and May, and of the latter during May and June. Larger numbers of the cestode *Moniezia expanza,* occurred in the kids than in the yearlings. Despite the stress of high helminth burdens, no clinical cases of coccidiosis were seen.

Both groups of goats were infested with small numbers of immature stages of the tortoise tick, *Amblyomma marmoreum,* and the yellow dog tick, *Haemaphysalis leachi.* Infestation with the biting louse, *Damalinia limbata,* occurred within 2 d of birth, but never reached very large numbers. Larvae of the nasal botfly, *Oestrus ovis,* were present only from January to July.

Key words: Angora goats, irrigated artificial pastures, *Teladorsagia circumcincta, Trichostrongylus rugatus, Moniezia exapansa, Damalinia limbata, Oestrus ovis*

Fivaz B.H.; Horak I.G.; Williams E.J. **Helminth and arthropod parasites of Angora goats on irrigated Kikuyu grass pastures in the eastern Cape Province.** *Journal of the South African Veterinary Association* (1990) 61 No. 3, 112-116 (En.) Tick Research Unit, Department of Zoology and Entomology, Rhodes University, 6140 Grahamstown, Republic of South Africa.

INTRODUCTION

Angora goats are farmed extensively in the drier regions of the Cape Province of South Africa. Stock losses caused by severe winters, tick-borne disease and predation by caracal *(Felis caracal)* may be high under extensive conditions and therefore there has been a shift towards the intensification of Angora goat farming on artificial pastures. While there is some information on the occurrence of internal and external parasites of Angora goats grazing various natural veld types[2 7 8 12], little is known of the prevalence of these parasites in or on goats on artificial pastures.

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This paper records the results of a survey of the parasites of Angora goats on irrigated Kikuyu grass *(Pennisetum clandestinum)* pastures on a property north of Grahamstown in the Great Fish River Valley, eastern Cape Province.

MATERIALS AND METHODS

Study site

The farm "Kranzdrift" (33°08'S; 26°31E; Alt 340 m) with a mean annual rainfall of 375 mm, is 5 000 ha in extent and situated 19 km north of Grahamstown in a vegetation zone classified as Valley Bushveld[1]. Fifteen ha is planted with Kikuyu grass and this is regularly irrigated by means of a centre-pivot sprinkler system.

Pastures

The pastures on which the survey animals grazed, consisted of 4x2 ha paddocks, planted with Kikuyu grass. These paddocks had been grazed intermittently throughout the year for a number of years by 20 to 30 stud goats, but remained ungrazed on occasions for periods of 1 to 2 months. The paddocks were irrigated at 1 to 2 weekly intervals throughout the year, depending on rainfall and usage. All the goats in the survey were run together and grazed rotationally in each camp for periods of 1 to 2 weeks.

Goats

Twenty-five Angora goat ewes, with new-born kids at foot and 48 yearling goats that had previously grazed Valley Bushveld camps, were transferred to the Kikuyu grass pastures during October 1987. All stock, except the new-born kids, were dipped in a pyrethroid-containing dip (Sumifleece, Shell Chemicals), and drenched with morantel citrate (Banminth, Pfizer Laboratories) at 12,5 mg kg^{-1} just prior to transfer.

In order to serve as tracers of infestation on the pastures, 4 yearling goats (tracers) were drenched with ivermectin (Ivomec liquid, Logos Agvet) at 0,2 mg kg^{-1} and niclosamide (Lintex L, Bayer SA) at 50 mg kg^{-1}. No post-drenching faecal examinations were conducted to determine the efficacy of the drugs. These goats grazed the pastures for 30 d prior to slaughter. Commencing from October and December 1987 respectively, 2 of the untreated young kids and the 4 tracer yearlings were slaughtered at monthly intervals. With the exception of the consecutive groups of 4 tracer animals, it was inteded that the survey goats remain untreated. However, a considerable increase in internal parasite burdens necessitated the treatment of all the remaining yearlings on 4 separate occasions (approximately 2 months apart) during the trial period. These animals were treated with ivermectin and morantel citrate alternately at dosages of 0,2 and 12,5 mg kg^{-1} respectively. The young kids were not treated at all.

As all the yearlings had died from severe helminth infection by May 1988, they were replaced by 20 others, which had in turn all died by September 1988. Goats which died, were excluded from

Table 1: **Mean faecal nematode egg and coccidial oocyst counts, and numbers of helminths recovered from suckling Angora goat kids on irrigated Kikuyu grass pastures**

Month	No of goats	Age at slaughter	Mean numbers of helminths recovered: *Haemonchus contortus* Adult	*Nematodirus spathiger* 4L	*Nematodirus spathiger* Adult	*Teladorsagia circumcincta* 4L	*Teladorsagia circumcincta* Adult	*Trichostrongylus rugatus* 4L	*Trichostrongylus rugatus* Adult	*Moniezia expansa* scoleces	Mean nematode egg count	Mean faecal oocyst count
Oct 1987	2	0	0	0	0	0	0	0	0	0	0	0
Nov	2	1	0	0	0	0	0	0	0	0	0	50
Dec	2	2	0	12	50	463	813	338	300	1	0	25 425
Jan 1988	2	3	1	150	188	475	2163	25	4925	5	1400	32 200
Feb	2	4	1	100	12	825	3600	100	3838	4	3500	25 850
Mar	3	5	1	401	141	2036	5146	773	21 678	7	4800	8750

4L = 4th Stage larvae

Table 2: **Mean faecal nematode egg and coccidial oocyst counts, and numbers of helminths recovered from yearling Angora goat tracers on irrigated Kikuyu grass pastures**

Month	No. of goats	Mean numbers of helminths recovered: *Haemonchus contortus* Ad	*Nematodirus spathiger* 4L	*Nematodirus spathiger* Ad	*Teladorsagia circumcincta* 4L	*Teladorsagia circumcincta* Ad	*Trichostrongylus rugatus* 4L	*Trichostrongylus rugatus* Ad	*Trichuris sp.* Ad	*Moniezia expansa* scoleces	Mean nematode egg count	Mean faecal oocyst count
Dec 1987	4	0	144	50	525	1019	100	550	2	0	125	953
Jan 1988	4	0	506	556	513	3144	156	9813	0	0	1225	2475
February	4	0	31	75	44	1281	19	670	0	0	433	2150
March	4	4	37	0	2644	7825	644	31 650	0	0	2850	2516
April	4	10	431	331	238	4094	1094	16 704	0	1	1762	2050
May	3	6	0	0	1362	7875	1475	48 237	2	0	2300	2400
June	4	7	231	6	1631	3126	7256	42 050	1	2	3920	4308
July	3	0	163	163	175	494	1844	19 325	1	2	1416	1283
August	4	0	400	175	481	1881	813	2019	8	0	187	6157
September	3	0	8	0	167	550	42	83	0	0	83	6666

4L = 4th Stage larvae

the survey and were not processed for parasite recovery.

Necropsy

At slaughter the carcasses were skinned, decapitated and eviscerated and the skins, heads, lungs and gastro-intestinal tracts placed in separate plastic bags and transported to the laboratory for examination.

Faecal worm egg- and oocyst counts: Approximately 10 faecal pellets were collected from the rectum of each slaughtered goat and pooled in a composite sample. The pooled faecal pellets were thoroughly crushed and mixed in a mortar and pestle after which 4 g were weighed out and added to 46 ml of a 40% sucrose solution. This was followed by a further mix in a mortar and pestle, after which the contents were placed in a bottle and repeatedly inverted. Egg counts were carried out in the conventional manner, using a McMaster slide.

Helminth recovery and counting

Two 1/50 representative samples of the contents of both the abomasum and small intestine were sieved on a sieve with 38 μm apertures and 2, 1/50 representative samples of the contents of the large intestine were sieved on a sieve with 150 μm apertures. The mucosae of the abomasum, small intestine and large intestine were scraped separately and the scrapings were digested with pepsin/HCl prior to sieving on a sieve with 38 μm apertures. The contents of the sieves were collected, preserved with formalin and stored. Total worm burdens were calculated from the worms counted in the various representative samples and in the digested material.

Ectoparasite recovery and counting

The skins were processed for the recovery of arthropod parasites and the latter were counted and identified as previously described[5,6]. Nasal botfly larvae were recovered from the nasal passages and paranasal sinuses, identified to stage of development and counted[10].

RESULTS

The survey was intended to run for 1 year in both groups of goats. Hówever, all the kids had died after 5 months and all the yearlings, including the 20 that had been added to their number, after 11 months on the pastures.

Helminths and coccidia

Suckling kids

The worm burdens and faecal oocyst counts of the kids are summarised in Table 1. None of the kids slaughtered at a few days or at 1 month of age was infected. Thereafter nematode burdens, consisting mainly of *T. circumcincta* and *T. rugatus* increased steadily to reach approximately 30 000 worms in the last suckling kids slaughtered.

When kids from the survey group started dying at 3 months of age, during January 1988, the total burdens of the slaughtered kids, comprised approximately 8 000 worms.

Although the faecal oocyst counts reached fairly high levels, no cases of clinical coccidiosis occurred.

Tracer yearling goats

The worm burdens and faecal oocyst counts of the tracer yearling goasts are summarised in Table 2. The total worm burdens increased erratically from December 1987 (when the first tracers were slaughtered), to May and June 1988. The decreased thereafter to reach the lowest

levels in the last goats slaughtered during September 1988. As in the case of the suckling kids, *T. circumcincta* and *T. rugatus* were the dominant parasites, with the former reaching peak levels during March and May, and the latter during May and June 1988. There were several mortalities amongst the yearling goats once the total burdens in those yearlings that served as tracers had reached approximately 40 000 worms during March 1988.

The faecal worm egg counts (excluding *Nematodirus spathigher)* of the slaughtered yearling tracer goats, corresponded fairly closely with their total adult worm burdens (Fig. 1). The faecal oocyst counts of the tracers never reached very high levels (Table 2).

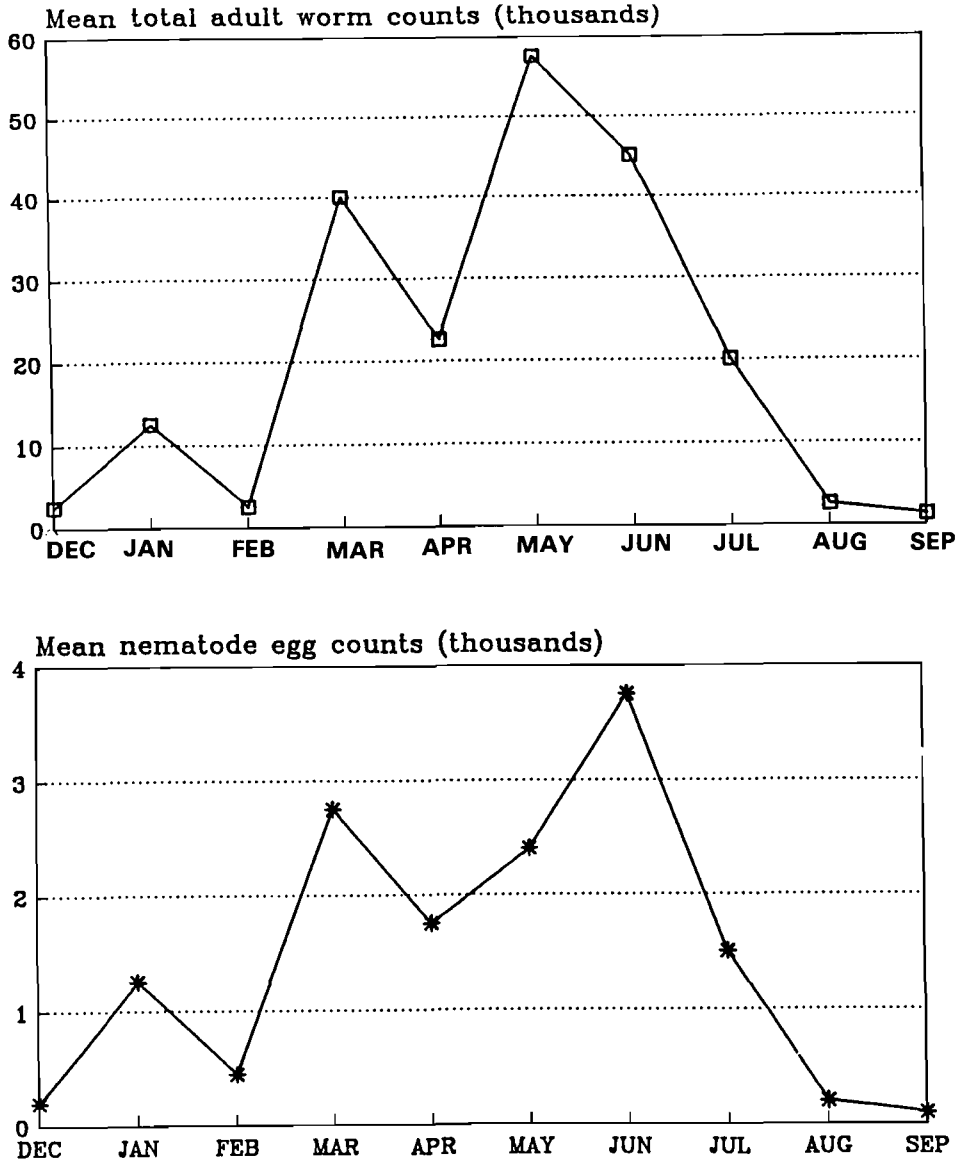

Fig. 1: **A comparison of the mean total adult worm burdens and mean faecal nematode egg counts of yearling Angora goat tracers grazing irrigated Kikuyu grass pastures**

Arthropods

Suckling kids

The numbers of ixodid ticks, lice and larvae of the nasal botfly, *Oestrus ovis,* recovered from the suckling kids are summarised in Table 3.

A single larva of the tortoise tick, *Amblyomma marmoreum,* and 7 larvae and a single nymbph of the yellow dog tick, *Haemaphysalis leachi,* were recovered. The lice burdens rose steadily to reach the highest level in the last group of goats slaughtered during March 1988. Larvae of *O. ovis* were first recovered during February 1988 when the kids were 4 months old.

Tracer yearling goats

The ectoparasite burdens of the tracers are summarised in Table 4. Larvae of *A. marmoreum* reached peak numbers from April to June 1988 and a single nymph was collected during December 1987. Three larvae only of *H. leachi* were recovered. Peak burdens of lice were present during May and August 1988, and the larvae of *O. ovis* from January to July 1988.

DISCUSSION

Helminths

Nematodes

Low worm burdens have previously been recorded in Angora goat kids and adults reliant on natural browse for their nutritional requirements[2 7 8]. Horak[7 8] has recorded total worm burdens below 500 and 300 per head, respectively, in untreated Angora kids from birth to either 7 or 18 months running on 2 farms, one close to "Kranzdrift" in the Valley Bushveld, and the other in Noorsveld, in the Karoo. The dominant parasites in these kids were *T. rugatus* and *Strongyloides papillosus* in the Valley Bushveld and *N. spathiger* in the Karoo[7 8].

In the case of adult Angora goats, 2 surveys were conducted in Valley Bushveld, with *N. spathiger, T. circumcincta* and *Trichostrongylus pietersei* dominant in one[2], and *T. circumcincta* and *T. rugatus* in the other[7], which, incidentally had been conducted on a farm close to "Kranzdrift". Individual total burdens in these animals exceeded 5 000 worms in only 5 of the 72 goats examined.

The high total burdens encountered in the present surveys are undoubtedly closely related to absence of browse, the high stocking density, lush vegetation and regular irrigation. Despite these factors favourable for the survival and increase of nematode populations, only 3 species, namely *N. spathiger, T. circumcincta* and *T. rugatus* occurred in substantial numbers. It seems strange that *Haemonchus contortus,* which normally favours these conditions, never reached very large numbers, an observation also applying to Angora goats and sheep running in Valley Bushveld on a nearby farm[7]. One is left to speculate whether the macro-climate for this region, which seems inimical to the establishment of *H. contortus,* overrides the advantages of the micro-climate created by regular irrigation of artificially established pastures. Suppression of *H. contortus* by the large *T. circumcincta* infection, is a further possibility[15].

As could be expected, there appeared to be a direct relationship between the size or age of the goats and the size of the worm burdens which caused mortality[3]. The kids died when their total worm burdens exceeded approximately 8 000, the yearlings when these numbers exceeded 40 000 worms, and none of the adult ewes running with the kids died. Despite the death of all the experimental goats before the survey had run for one year, it was

Table 3: **Total numbers of ectoparasites recovered from suckling Angora goat kids on irrigated Kikuyu grass pasture**

Month	No. of goats	Age at slaughter (months)	Total numbers of ectoparasites recovered: Ixodid ticks *Amblyomma marmoreum* L	*Amblyomma marmoreum* N	*Haemaphysalis leachi* L	*Haemaphysalis leachi* N	Lice *Damalinia limbata* N	*Damalinia limbata* Ad	Oestrid larvae *Oestrus ovis* L 1, 2, 3
Oct 1987	2	0	1	0	1	0	4	22	0
Nov	2	1	0	0	4	1	202	70	0
Dec	2	2	0	0	0	0	366	138	0
Jan 1988	2	3	0	0	2	0	904	380	0
Feb	2	4	0	0	0	0	2236	1344	3
Mar	3	5	0	0	0	0	6588	5394	14

L=Larvae; N=Nymphs; Ad=Adults; L1, 2, 3=Larval stages

Table 4: **Total numbers of ectoparasites recovered from yearling Angora goat tracers on irrigated Kikuyu grass pastures**

Month	No. of goats	Total numbers of ectoparasites recovered: Ixodid ticks *Amblyomma marmoreum* L	*Amblyomma marmoreum* N	*Haemaphysalis leachi* L	*Haemaphysalis leachi* N	Lice *Damalinia limbata* N	*Damalinia limbata* Ad	Oestrid larvae *Oestrus ovis* L 1, 2, 3
Dec 1987	4	1	1	2	0	1 816	3192	0
Jan 1988	4	0	0	0	0	2 576	2176	11
Feb	4	0	0	0	0	10 652	5380	2
Mar*	4	2	0	0	0	4 168	5580	18
April	4	80	0	0	0	4 188	4352	12
May**	3	35	0	1	0	11 103	10551	12
June	4	17	0	0	0	3716	3124	12
July	3	3	0	0	0	2 397	2736	6
Aug	4	1	0	0	0	15 280	18036	0
Sept	3	2	0	0	0	6 486	4434	0

**Hyalomma* sp. 1 female
***Rhipicephalus simus* 1 L
L = Larvae; N = Nymphs; Ad = Adult; L1, 2, 3 = Larval stages

possible to ascertain seasonal abundance in the yearling goats during the 10 months of the survey. As both *T. circumcincta* and *T. rugatus* (the major parasites) exhibited similar trends in their seasonal abundance, they will be discussed together.

Worm burdens of the tracer yearling goats, rose erratically but steadily to reach a peak in May and June 1988. Thereafter they declined to reach the lowest levels during September 1988, when the investigation was terminated (Fig 1). The most favourable time for the acquisition of infection appeared to be from late summer (March) to early winter (June). This corresponds to the concept that these worm genera, generally prefer cooler conditions[13]. It contrasts, however, with the findings of 2 other surveys conducted on Angora goats running in Valley Bushveld. In these surveys, total worm burdens were generally higher from August or September to January then were those from February to July[2 7]. It would thus appear as if the micro-climatic conditions pertaining on the irrigated pastures, overrode those of the macro-climate for the region, resulting in an altered pattern of seasonal abundance for *T. circumcincta* and *T. rugatus* in contrast to *H. contortus*, for which the converse seemed to be true.

The mean total faecal worm egg counts (excluding *N. spathiger)* closely corresponded to the mean total adult worm burdens of the tracer yearling goats. In this instance, faecal worm egg counts could therefore be used as an indicator of total adult worm burdens and also of pasture contamination. If, however, large numbers of worms are arrested in their development in the host animal because of previous climatic stimuli, or where older hosts are used and a degree of immunity is present, worm egg counts do not accurately reflect the total worm burdens.

Cestodes

During surveys conducted on Angora goat kids in Valley Bushveld on a farm near "Kranzdrift" and on another in the Karoo, the kids became infected with *Moniezia expansa* during January when they were 3 or 4 months old[7 8]. The kids in Valley Bushveld were accidentally

treated with a cestocide during February, while those in the Karoo, spontaneously lost their infection by April. In the present survey, the kids were first infected in December 1987 at the age of 2 months and infection was still present during March 1988 when the survey ended. Several of the tracer yearling goats were also infected (Table 2), whereas in the Karoo only 1 of 90 yearling goats harboured a single *M. expansa*[7]. Immunity to cestodes in the former yearling goats, may have been affected by the stress induced by the large nematode burdens.

Arthropods

Ixodid ticks

Adult *A. marmoreum* prefer tortoises as hosts, while the immature stages can be found on reptiles, birds and mammals[9 14]. There are large numbers of tortoises in the Valley Bushveld region in which the survey was conducted and most mammal species in this area are infested with the immature stages of *A. marmoreum*[9]. It is quite probable that tortoises also feed on the irrigated pastures at "Kranzdrift" and that the tick larvae on the goats, originate from adult ticks that have detached from the tortoises. The seasonal pattern of larval abundance on the yearling goats, corresponds to that observed by Norval[11] for *A. marmoreum* in the eastern Cape Province.

The immature *H. leachi* on the goats, probably originate from adult ticks on the sheep-dogs used to herd the stock.

Lice

With the possible exceptions of May and August 1988 (Table 4), the burdens of *D. limbata* were never very large on any of the goats and no clear pattern of seasonal abundance could be discerned. The kids were already infested at 2 d of age.

Oestrid fly larvae

The kids became infested with the larvae of *O. ovis* for the first time at 4 months of age, during February 1988. Infestation was, however, already present during January, as evidenced in the yearling goats. The seasonal pattern of infestation in the latter goats from January to July, differs from that observed in sheep slaughtered at the Pretoria Municipal Abattoir, where infestation mainly occurred from October to May or June[4].

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BLOOD CONSTITUENT RESPONSES OF ANIMALS CULLED WITH SUCCINYLDICHOLINE AND HEXAMETHONIUM

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ABSTRACT

Blood constituent responses of elephants and buffaloes culled in the Kruger National Park, using a mixture of succinyldicholine and hexamethonium, were compared to those of animals culled with succinyldicholine only. The results show a decreased physiological response in the animals culled with the mixture, characterised by lower total catecholamine, cortisol and glucose concentrations. Neither a delay of up to 30 min in obtaining blood samples from culled animals, nor a delay of up to 30 min in processing samples obtained immediately after cessation of respiration, gave any significant difference in the blood constituents which were measured.

Key words: culling, scoline, stress.

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INTRODUCTION

The results of a pilot experiment in which buffaloes were culled in the Kruger National Park (KNP) using a mixture of scoline (succinyldicholine) and hexamethonium, were reported recently[4]. The animals collapsed between 31 s and 1 min 35 s after darting (mean 57 s) and showed significantly higher haematocrit values, but significantly lower plasma cortisol, catecholamine and glucose levels compared to those of a control group of animals culled with scoline only. It was however not possible to investigate the control and experimental animals under the same culling conditions, because the carcasses from the hexamethonium group first had to be analysed for residues. On the basis of the results obtained in the pilot study, permission was granted by the Department of Agricultural Economics and Marketing to use such carcasses for human consumption. The results of the blood composition from elephants and buffaloes culled in the same operation with either scoline or a mixture of scoline and hexamethonium, are now reported here.

During elephant culling operations in the KNP, it is customary to chemically immobilise young ones for translocation purposes. They are darted towards the end of the procedure and ground teams cannot move in until the last animal collapses. This prolongs the time before conscious, but paralysed culled animals can be shot rhough the brain. In order to avoid this additional suffering, paralysed elephants are now shot from the helicopter. The delay between the time the animals collapse and the time of blood sampling, may influence the results. To ascertain whether this delay has any effect on the blood constituents measured, samples were taken up to 30 min after death from animals killed with scoline, as well as analysing heparinised blood samples not centrifuged for up to 30 min after being taken.

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MATERIALS AND METHODS

Culled animals:

Buffaloes and elephants were culled in the KNP as described previously[2,4]. Three groups were investigated: animals culled with scoline, animals culled with a mixture of scoline and hexamethonium and animals culled by being shot through the brain after herding. Heparinised blood samples were taken as soon as possible from the ears or jugular veins and the relevant times are shown in Table 1.

Blood sampling after death and in vitro time effects:

Six elephants and buffaloes were anaesthetised in the veld as described previously[3]. Control blood samples were taken after 20 to 30 min and the animals then received a culling dose of either scoline or scoline/hexamethonium. After cessation of respiration, a time zero (To) blood sample was taken and this was repeated at 10, 20 and 30 min (T_{10}, T_{20} and T_{30}). In addition, heparinised blood samples were drawn from 6 immobilised elephants at a To. An aliquot of this was immediately centrifuged and the remainder left to stand for up to 30 min in the shade (environmental temperature between 25° and 30°C). Further aliquots were centtrifuged at T_{10}, T_{20} and T_{30}.

Analytical techniques:

Blood samples were analysed immediately for haematocrit and centrifuged to obtain plasma, which was stored at -20°C for up to 7d. Plasma glucose, total lipids, cortisol and total catecholamine concentrations were determined as described previously[1]. Plasma lactate (enzymatic UV, Clinical Sciences), total protein (Biuret method) and osmolality (freezing point depression, Precision Instruments) were also determined.

Results were compared statistically using a Student's T test or non-parametric statistics, where appropriate. $P<0.05$ or less was considered significant. Results are reported as means ± S.D.

RESULTS

Effect of time on the composition of in vitro blood samples:

When heparinised blood samples were left to stand for up to 30 min in the shade, no significant change in concentration of any of the variables investigated occurred.

Table 1: **Time intervals for culled and captured animals (E = elephant and B = buffalo)**

Procedure	N	Time(min)from start of herding to dart/shot	dart/shot to sample taken	dart to collapse
Brain shot	E 4	22.7 ± 7.0	20.6 ± 1.3	-
	B 11	23.4 ± 3.0	8.9 ± 5.4	-
Scoline	E 16	23.2 ± 8.3	21.0 ± 6.6	-
	B 17	16.6 ± 2.9	14.3 ± 3.3	1.2 ± 0.4
Scoline/ hexamethonium	E 11	19.5 ± 5.9	26.7 ± 4.7	2.6 ± 0.6
	B 19	7.7 ± 3.1	24.4 ± 5.9	1.4 ± 0.5

Table 2: **Blood composition of elephants (E) and buffaloes (B) culled in different ways (*indicates significantly different to the Scoline results)**

Variable		Procedure		
		Shot	Scoline	Scoline/ hexamethonium
Cortisol (n mol ℓ^{-1})	E	*243 ± 111	348 ± 65	*246 ± 115
	B	*75 ± 26	100 ± 25	* 42 ± 22
Total catecholamine (ng ml^{-1})	E	150.7 ± 86	112.7 ± 61.2	*85.2 ± 45.8
	B	34.9 ± 15.1	48.2 ± 31.2	49.7 ± 31.2
Glucose (m mol ℓ^{-1})	E	*3.9 ± 0.5	5.1 ± 1.3	*4.7 ± 1.0
	B	8.2 ± 3.3	9.1 ± 2.5	*7.5 ± 2.4

Effect of time after cessation of respiration on the composition blood samples:

Time zero blood samples were obtained from anaesthetised elephants and buffaloes after cessation of breathing due to an overdose of scoline or scoline/hexamethonium. Further samples were obtained at T_{10}, T_{20} and T_{30}. No differences in pattern were observed between the results of the 2 procedures in any species or within a species, nor was a significant change observed for total protein and lipid concentrations and osmolality. For the other variables investigated, no consistent pattern of change was observed.

Blood composition of culled animals:

The results from animals culled in different ways are shown in Table 2. Compared to the scoline results, no differences were evident for either buffaloes or elephants culled, using the mixture, or by brain-shots for haematocrit, total protein, total lipid, osmolality and lactate. Glucose and cortisol values were significantly lower in both elephants and buffaloes culled with scoline/hexamethonium compared to scoline only, but total catecholamines were significantly lower only in the elephants.

DISCUSSION

The results reported here, indicate that no change in concentration of any of the variables investigated occurred in vitro blood samples left standing for up to 30 min after sampling. However, changes in composition did occur for some variables in samples obtained after cessation of breathing in both elephants and buffaloes, but no consistent trends were evident either within or between the species. The latter observation is in accordance with the results of Wesson et al[6] and is also supported by our own observations on impala (unpublished data). It is suggested here that cardiac activity is an important determinant as to whether changes in blood composition will occur or not. In the case of haematocrit, for example, absence of cardiac activity could result in an altered value, depending where the blood is sampled from. For other variables, eg. cortisol concentrations, the presence of cardiac activity may lead to a decrease in value because of continued clearance of the hormone by the liver and kidneys, whereas the absence of cardiac activity would not allow this to occur. In studies on the blood composition of culled animals, the above is an important, uncontrolled variable as is evident from the data in Table 1 where the different times to blood sampling amongst the different groups of animals are reported.

Hexamethonium as a possible adjunct to scoline during culling was introduced in an attempt, not only to block neuromuscular transmission, but transmission at autonomic ganglia as well. Results from the pilot study have shown significant differences between the haematocrit, cortisol, total catecholamine and glucose levels in animals culled with the mixture, compared to those culled with scoline only (see above)[4]. The present results, obtained under actual culling conditions, support the previous observations. It is suggested that, in the case of buffaloes, no difference in total catecholamine concentration was seen, because of the delay in time to sampling in the scoline/hexamethonium group (Table 1) compared to the scoline group. In the presence of cardiac activity, after collapse, hypoxia is a powerful stimulant for catecholamine release[5]. The results indicate a decreased physiological response to the stressors involved in the culling operation when the mixture is used, compared to when scoline only is utilised.

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THE BENT-LEG SYNDROME IN SHEEP. I. THE EFFECT OF PREGNANCY AND AGE OF THE EWE ON CONCENTRATIONS OF PLASMA MINERALS

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ABSTRACT

The effect of age of the ewe and pregnancy on concentrations of plasma calcium, phosphorus and magnesium and its relationship to the bent-leg syndrome in lambs, were investigated. This study included Merino ewes (n=74), Dohne Merino ewes (n=127), S A Mutton Merino ewes (n=123) and S A Mutton Merino lambs (n=145). Over a period of 8 years, 52 S A Mutton Merino ram lambs out of a total of 602 ram lambs weaned (8,6%), developed the bent-leg syndrome compared to the 2 ewe lambs out of 591 ewe lambs (0,3%) weaned. It was found that both the age of the ewe and pregnancy had no contributing effect in the development of this syndrome. The ewes of which the offspring developed the bent-leg syndrome, had an inverse plasma Ca:P ratio. Approximately 15% of the S A Mutton Merino ewes which gave birth to offspring which developed the bent-leg syndrome, had more than one lamb which developed this condition over the past 8 years. It is suggested that these ewes are carriers of certain genetic factors which can cause excessive phosphorus absorption. No differences in the concentration of plasma calcium, phosphorus and magnesium were found between ewe and ram lambs.

Key words: Age of ewe, pregnancy, plasma calcium, plasma phosphorus, bent-leg syndrome.

Van Niekerk F.E.; Van Niekerk C.H.; Coetzee J.; Heine E.W.P. **The bent-leg syndrome in sheep. I. The effect of pregnancy and age of the ewe on concentrations of plasma minerals.** *Journal of the South African Veterinary Association* (1990) 61 No. 3, 119-123 (En.) Elsenburg Agricultural Centre, Private Bag, 7606 Elsenburg, Republic of South Africa.

INTRODUCTION

The importance of plasma calcium (Ca) and phosphorus (P) concentrations for proper bone mineralisation were discussed by Van Niekerk et al[10].

High dietary P intake and the variation in P absorption between individual sheep can alter the concentration of P in plasma to such an extent that it could affect bone mineralisation. Concentrations of plasma Ca are normally regulated within narrow limits[6].

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The aim of this investigation was to confirm the hypothesis[10] that a high concentration of plasma P, is a possible contributing factor in the development of the bent-leg syndrome. The influence of age and pregnancy on concentrations of Ca, P and magnesium (Mg) in the plasma of ewes and the contributing effect thereof on the development of the bent-leg syndrome in their lambs, was investigated.

MATERIALS AND METHODS

Pregnant Merino (n=74), Dohne Merino (n=127) and S A Mutton Merino (n=123) ewes, kept as a single flock on the same pastures, were used in this investigation. The incidence of the bent-leg syndrome in the progeny of the 3 breeds had been recorded over the past 8 years. For the purpose of this study, the ewes of which the progeny never developed this syndrome, are referred to as "normal" animals. Ewes of which the progeny developed the bent-leg syndrome, are referred to as "carrier" animals.

Blood samples taken from the jugular vein, (10 ml), were collected from all the ewes of the 3 breeds at mid-pregnancy (January, 1988) in heparinised vacuum tubes (Vac-u-Test, Radem Laboratories). Blood was centrifuged within a period of 1 h after collection and the plasma removed and stored at -20°C for the determination of Ca, P and Mg.

Blood samples (10 ml) were collected from all the S A Mutton Merino lambs as well as from their dams after the lambs had been weaned, at the age of ± 100 d (June, 1988). Plasma was removed, as described for the determination of Ca, P and Mg. The concentrations of Ca, P and Mg were determined spectrophotometrically as previously described[10]. The mass of the lambs of both sexes recorded at 100 d were also available from the records kept over the previous 8 years.

Results were analysed according to standard one-way analysis of variance procedures, using the P7D program of the BMDP statistical packet[5]. Differences between treatment means were compared by the Bonferroni method[9]. The standard deviation of mean concentrations is indicated.

RESULTS

The incidence of the bent-leg syndrome in the S A Mutton Merino lambs as well as the mean masses of the lambs, are presented in Table 1. A mean of 8,6% of the S A Mutton Merino ram lambs developed the bent-leg syndrome over the previous 8 years. None of the lambs of the other 2 breeds developed the syndrome during this period. It also became evident that 15% of the ewes which were considered to be "carriers" of the "bent-leg gene", produced more than one lamb which developed this syndrome during this period (Table 2). The incidence of the development of the bent-leg syndrome in the progeny of the different rams used in this flock over the 8 years-period in question are compared in Table 3.

At mid-pregnancy mean concentrations

Table 1: **The occurrence of the bent-leg syndrome in the progeny of the S A Mutton Merino flock as well as the mean mass (kg ± sd) of the lambs**

Year	Number of ewes lambed	Number of lambs				Mean mass of lambs		
		Normal legs		Bent-legs				
		Rams	Ewes	Rams (%)	Ewes (%)	Rams	Bent-leg rams	Ewes
1982	88	69	45	4 (5,5)	-	32,86 ± 5,00	31,59 ± 2,39	27,93 ± 5,03
1983	90	60	73	3 (4,8)	-	27,77 ± 6,81	31,82 ± 5,55	25,48 ± 5,37
1984	87	61	84	11 (15,2)	-	33,97 ± 4,67	33,20 ± 3,67	30,86 ± 4,66
1985	95	78	62	6 (7,1)	-	37,32 ± 6,19	40,95 ± 4,45	34,43 ± 4,89
1986	95	65	84	10 (13,3)	1	37,96 ± 4,80	39,06 ± 3,48	32,82 ± 4,67
1987	105	60	79	12 (16,6)	-	32,16 ± 5,47	34,92 ± 4,32	28,85 ± 5,16
1988	104	81	79	1 (1,2)	-	32,49 ± 4,81	37,63	29,15 ± 4,00
1989	97	76	83	5 (6,2)	1	32,76 ± 4,87	31,47 ± 3,49	28,66 ± 3,60
TOTAL		550	589	52 (8,6)	2 (0,3)			

of plasma Ca, P and Mg (Table 4) revealed substantial differences between the 3 breeds. Merino ewes had higher ($P \leq 0,01$) concentrations of plasma Ca, compared to those of the other 2 breeds. Plasma P concentrations were higher ($P \leq 0,01$) in S A Mutton Merinos than in the other 2 breeds, while Merino ewes had higher ($P \leq 0,001$) concentrations of plasma Mg. No consistently significant differences in the concentrations of these minerals between ewes of different age groups (Table 5) were found for any of the 3 breeds.

Comparing concentrations of plasma Ca, P and Mg of "normal" (n=79) and "carrier" (n=12) S A Mutton Merino ewes at mid-pregnancy with those of non-pregnant ewes (Table 6), it became evident that reproductive status had no significant effect on the concentrations of plasma Ca. Nevertheless, carrier ewes had lower ($P \leq 0,05$) concentrations of plasma Ca than normal ewes. Concentrations of plasma P were affected by reproductive status, as pregnant S A Mutton Merino ewes had lower ($P \leq 0,05$) plasma P concentrations than did non-pregnant ewes (Table 6). Concentration of plasma Mg was not affected (Table 6).

After their lambs had been weaned, the plasma Ca, P and Mg concentrations did not differ between normal and carrier ewes (Table 7). No differences were found when concentrations of plasma Ca, P and Mg of ram and ewe lambs of normal and carrier ewes were compared after they had been weaned (Table 8).

DISCUSSION

The frequent occurrence of the bent-leg syndrome in the male offspring of the same S A Mutton Merino ewes, supports the theory of Van Niekerk et al[10] that the cause of this syndrome may be of genetic origin. Present results indicate that the number of lambs affected by this syndrome vary considerably from year to year (Table 1). The mass of the lambs (Table 1) is not considered to be a contributing factor in the development of this syndrome. This condition mainly affects ram lambs and only 2 ewe lambs out of a total of 591 (0,3%) ewe lambs weaned,

Table 2: **The occurrence of the bent-leg syndrome in the progeny of the carrier ewes over a period of 8 years**

Number of seasons in which ewe lambed	Number of seasons in which bent-leg lambs were produced	Number of ewes	Number of lambs				% with Bent-legs	
			Normal legs		Bent-legs			
			Ewe	Ram	Ewe	Ram	Ewe	Ram
1	1	8	7	1	-	9	-	90
2	1	3	2	4	-	3	-	43
	2	1	1	1	-	2	-	66
3	1	11	19	26	-	11	-	30
	2	1	3	-	-	2	-	100
4	1	8	25	24	-	8	-	25
	2	1	5	2	-	2	-	50
5	1	6	29	16	-	6	-	27
	3	1	5	-	1	3	16	100
6	2	1	9	4	-	2	-	33

Table 3: **A comparison of the incidence of the bent-leg syndrome in the male progeny of the rams used in this flock over a period of 8 years**

Ram Nr	Number of seasons used for breeding	Male progeny		% of male progeny with bent-legs
		Normal legs	Bent-legs	
0,28	1	25	-	-
5130	1	32	-	-
1160	1	20	-	-
5421	1	25	1	3,8
8128	1	24	2	7,6
0.60	1	10	1	9,1
7301	1	7	1	12,5
4219	1	7	3	30,0
7107	1	14	7	33,3
3242	2	38	1	2,5
0.67	2	39	2	4,8
2310	2	49	3	5,8
3126	2	29	2	6,4
0042	2	39	6	13,3
1101	2	36	8	18,2
3433	2	32	9	21,9
0037	3	59	3	4,8
2009	3	62	6	8,8

Table 4: **A comparison of the mean concentrations (m mol ℓ^{-1}) of plasma Ca, P and Mg of S A Mutton Merino, Dohne Merino en Merino ewes at mid-pregnancy**

MINERAL	BREED			Level of Significance
	S A MUTTON MERINO n = 123	DOHNE MERINO n = 127	MERINO n = 74	
Ca	$2,09^{a} \pm 0,26$ (1,49-2,69)	$1,87^{b} \pm 0,24$ (1,22-2,46)	$2,23^{c} \pm 0,35$ (1,42-3,33)	**
P	$1,80^{a} \pm 0,30$ (1,15-2,98)	$1,61^{b} \pm 0,28$ (1,08-2,64)	$1,65^{b} \pm 0,49$ (0,57-3,01)	**
Mg	$0,76^{a} \pm 0,05$ (0,61-0,97)	$0,78^{a} \pm 0,05$ (0,48-0,90)	$1,30^{b} \pm 0,30$ (0,87-2,41)	***
Ca:P ratio	1,16:1	1,16:1	1,35:1	

[a,b,c.]Values with different superscripts differ significantly ***($p \leq 0,001$); **($p \leq 0,01$)

developed this syndrome, compared with the 52 ram lambs out of 602 ram lambs weaned (8,6%), over the period of 8 years. The dam of the one ewe lamb, weaned 3 ram lambs which all developed the bent-leg syndrome. It became evident that the progeny of certain rams were more susceptable to the development of the bent-leg syndrome. Of the 18 rams used in this stud, 5 had a reasonably high percentage of bent-leg offspring ranging from 13,3% up to 33,3% (Table 3). The considerable variation in the occurrence of the bent-leg syndrome between different years, can partly be explained by the contributing effect of these specific rams which further emphasises the possibility of a genetic background.

Although S A Mutton Merino ewes had higher plasma P concentrations at mid-pregnancy (Table 4) than those of the other 2 breeds, these concentrations were still within normal ranges (1,29-1,94 mmol ℓ^{-1}) for adult sheep[10]. Differences in P metabolism between individual sheep, were descibed by Scott & McLean[8]. Sheep fed an excess P, excreted this excess mineral in the faeces, although in a small number of the sheep, the main route of excretion was via the urine[8]. The excretion of P in urine[8] only increased after plasma P concentrations exceeded 2,0 mmol ℓ^{-1}. Mean concentrations of plasma Ca differed ($P \leq 0,01$) between the 3 breeds with the Dohne Merino having the lowest and the Merino the highest concentrations (Table 4). Although there was no difference between the Ca:P ratios of the first 2 breeds, both the ratio as well as the concentrations of Ca and P in the plasma should be considered important.

No consistent significant effect of age on plasma Ca, P and Mg of ewes at mid-pregnancy could be found (Table 5) within these 3 breeds. Consequently it may be accepted that age of the ewe has no effect on the concentrations of these minerals and therefore it seems to be an unimportant factor in the development of this syndrome.

Non-pregnant carrier ewes had a mean Ca:P ratio of 0,93:1 compared to the 1,14:1 of the normal, non-pregnant ewes. The mean plasma Ca:P ratio of the pregnant carrier ewes, was 1,09:1 compared with the 1,19:1 of the normal, pregnant ewes. Consequently, the ewes which are considered to be carriers of the 'bent-leg genes', have a lowered plasma Ca:P ratio which is caused by a lower plasma Ca and a higher plasma P concentration compared to that of normal animals. This condition can possibly lead to improper mineralisation of the foetal skeleton.

Although the bent-leg syndrome develops under a wide variety of feeding conditions, it most frequently occurs on farms where ram lambs are raised partly or totally on concentrated diets (F van Niekerk, unpublished results). Many of these diets were found to have a P content in excess of 0,30% (F van Niekerk, unpublished results). Recommendations of the NRC[7], stipulate that the P content of the diet should be approximately 0,2% for growing ram lambs with a mass of 40 to 60 kg. In such cases, the existence of hyperphosphatemia cannot be excluded, although not confirmed, due to excessive P intake.

Normal plasma Ca concentrations, as well as normal Ca:P ratios, are controlled by the P concentration in the plasma, but also by the Ca homeostatic agents such as Vig. D, parathyroid hormone and calcitonin[4]. Besides individual differences in the absorption of P, ewes are also unable to absorb enough dietary Ca du-

Table 5: **A comparison of the mean concentrations (m mol ℓ^{-1}) of plasma Ca, P and Mg of the ewes in different age groups**

Age in years	Ca			P			Mg		
	Mer	DM	SAMM	Mer	DM	SAMM	Mer	DM	SAMM
3	$2,29^{ab} \pm 0,27(16)$	$1,96^{a} \pm 0,24(29)$	$2,19^{a} \pm 0,26(31)$	$1,89^{a} \pm 0,38$	$1,64^{ab} \pm 0,26$	$1,92^{a} \pm 0,32$	$1,17 \pm 0,17$	$0,78 \pm 0,04$	$0,75 \pm 0,06$
4	$2,34^{a} \pm 0,41(19)$	$1,86^{ab} \pm 0,20(27)$	$2,18^{a} \pm 0,26(25)$	$1,58^{ab} \pm 0,41$	$1,70^{a} \pm 0,32$	$1,73^{b} \pm 0,32$	$1,34 \pm 0,20$	$0,79 \pm 0,04$	$0,75 \pm 0,05$
5	$2,22^{ab} \pm 0,28(17)$	$1,88^{ab} \pm 0,21(19)$	$2,04^{b} \pm 0,19(30)$	$1,58^{ab} \pm 0,54$	$1,59^{ab} \pm 0,33$	$1,78^{b} \pm 0,29$	$1,25 \pm 0,26$	$0,79 \pm 0,05$	$0,76 \pm 0,07$
6	$2,14^{ab} \pm 0,36(10)$	$1,89^{ab} \pm 0,27(26)$	$1,95^{b} \pm 0,25(27)$	$1,49^{b} \pm 0,64$	$1,50^{b} \pm 0,20$	$1,76^{b} \pm 0,27$	$1,39 \pm 0,43$	$0,77 \pm 0,08$	$0,77 \pm 0,04$
7	$2,03^{b} \pm 0,41(8)$	$1,75^{b} \pm 0,29(19)$	$1,93^{b} \pm 0,26(5)$	$1,66^{ab} \pm 0,54$	$1,60^{ab} \pm 0,26$	$1,92^{a} \pm 0,33$	$1,36 \pm 0,46$	$0,77 \pm 0,06$	$0,73 \pm 0,03$
8	$2,15^{abb} \pm 0,39(4)$	$1,80^{ab} \pm 0,24(7)$	$2,11^{a} \pm 0,28(5)$	$1,68^{ab} \pm 0,29$	$1,58^{ab} \pm 0,36$	$1,82^{a} \pm 0,33$	$1,45 \pm 0,45$	$0,78 \pm 0,05$	$0,74 \pm 0,04$

*Mer - Merino; DM - Dohne Merino; SAMM - S A Mutton Merino
*Figures in parenthesis indicate the number of ewes in each age group of each breed
[a,b] Values in the same column with different headings differ significantly ($P \leq 0,05$)

Table 6: **A comparison of mean concentrations (mmol ℓ^{-1}) of plasma Ca, P and Mg between normal and carrier pregnant and non-pregnant S A Mutton Merino ewes at mid-pregnancy**

MINERAL	CARRIER (n = 18)		NORMAL (n = 106)		EFFECT DUE TO	
	Preg. (n = 12)	Non-Preg. (n = 6)	Preg. (n = 79)	Non-Preg. (n = 27)	Genetic status	Reprod. status
Ca	$1,99 \pm 0,25$	$1,88 \pm 0,19$	$2,09 \pm 0,26$	$2,17 \pm 0,25$	*	n.s.
P	$1,83 \pm 0,28$	$2,02 \pm 0,23$	$1,75 \pm 0,31$	$1,91 \pm 0,28$	n.s.	*
Mg	$0,74 \pm 0,04$	$0,74 \pm 0,04$	$0,76 \pm 0,05$	$0,74 \pm 0,06$	n.s.	n.s.
Ca:P	1,09 : 1	0,93 : 1	1,19 : 1	1,14 : 1	*	n.s.

Level of significance * ($P \leq 0,05$)

Table 7: **A comparison of the mean concentrations* (mmol ℓ^{-1}) of plasma Ca, P and Mg of normal and carrier S A Mutton Merino ewes after weaning**

Mineral	Carrier n = 12	Normal n = 84
Ca	$2,45 \pm 0,24$	$2,35 \pm 0,25$
P	$2,21 \pm 0,50$	$2,33 \pm 0,44$
Mg	$0,57 \pm 0,10$	$0,60 \pm 0,09$
Ca:P ratio	1,11:1	1,01:1

*None of the values differed significantly

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Table 8: **A comparison of the mean concentrations* (mmol ℓ^{-1}) of Ca, P, Mg and Ca:P ratio between normal and carrier S A Mutton Merino ram and ewe lambs at weaning**

Mineral	CARRIER		NORMAL	
	Rams (n = 11)	Ewes (n = 8)	Rams (n = 62)	Ewes (n = 64)
Ca	2,38 ± 0,18	2,27 ± 0,15	2,29 ± 0,12	2,35 ± 0,19
P	2,64 ± 0,29	2,51 ± 0,34	2,54 ± 0,32	2,76 ± 0,43
Mg	0,74 ± 0,07	0,74 ± 0,08	0,71 ± 0,07	0,75 ± 0,06
Ca:P	0,92:1	0,92:1	0,92:1	0,87:1

*None of the values differed significantly

ring late pregnancy and early lactation to meet the increasingly high demands of the foetus and suckling lamb[1]. Under these circumstances, Ca is mobilised from the maternal skeleton to keep the plasma Ca concentration constant. Ewes can lose up to 20% of their total skeletal Ca during pregnancy and early lactation, and it is largely replaced one month after the end of lactation[2].

Accumulation of Ca in the foetus increases rapidly from 90 d of gestation, and reaches a maximum at 143 d[3]. Foetal Ca homeostasis is largely independent of the ewe, and the former plays the major role in the control of Ca transport from mother to foetus, which is believed to be an active process[3].

When the concentrations of plasma Ca, P and Mg of the normal and carrier ewes were compared at the end of lactation, no differences were found in the concentrations of these minerals between these 2 goups. This is the period when replacement of the maternal skeletal mineral reserves are taking place at a high rate[1]. The higher plasma Ca concentrations of the carrier ewes at this stage, and the lower P concentrations than that of the normal ewes, resulting in a more favourable Ca:P ratio (1,16:1 carrier and 1,05:1 normal) for the carrier ewes, is just the opposite of those concentrations and ratios obtained during mid-pregnancy (Table 6). However, this could be a possible indication that the Ca metabolism of the carrier ewes is affected, especially during pregnancy.

Neither the sex of the lambs nor the genetic status of the mother had any effect on the concentrations of Ca, P and Mg or the plasma Ca:P ratio of the lambs. However, it is unknown if the lambs born from the carrier ewes in this experiment in fact inherited the bent-leg genes. During the present study (1988 lambing season), only one ram lamb developed the bent-leg syndrome, which is an exceptionally low figure for this flock, compared with that of the previous 6 years. Similarly, no differences in the concentractions of plasma Ca, P and Mg were found between ram lambs with normal, and ram lambs with bent-legs at the age of 6 months[10].

Consequently, the variation in the concentrations of plasma Ca and P, and especially the Ca:P ratio in certain sheep, can be considered to be a precipitating factor in the development of the bent-leg syndrome. The age of the ewes has no effect on Ca, P and Mg concentrations in the plasma of the ewes or of their lambs. The higher P concentration in the plasma of the carrier ewes compared to the normal ewes, can be due to genetic differences in their P metabolism. The possibility of genetic causes, is supported by the fact that certain ewes repeatedly produced offspring with bent-legs. Furthermore, it was evident that the male progeny of certain rams, were more susceptible to the development of this syndrome.

ACKNOWLEDGEMENT

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UNILATERALE LENTEKTOMIE IN 'N BLOUVALKIE

W.H. VAN NIEKERK* en S.W. PETRICK**

ABSTRACT

An extracapsular lentectomy was performed on an adult black-shouldered kite *(Elanus caeruleus)* presented with a history of head trauma resulting in a unilateral cataract and ventro-medial synechia of the right eye. One week post-operatively, the eye contents were clear and the iris appeared normal. The bird was released into a flight cage 3,5 weeks post-operatively. Two weeks later it was presented with a ruptured right cornea as a result of trauma and enucleation was recommended.

Key words: Black-shouldered kite *(Elanus caeruleus)*, cataract, synechia, lentectomy.

Van Niekerk W.H.; Petrick S.W. **Unilateral lentectomy in a black-shouldered kite.** *Journal of the South African Veterinary Association* (1990) 61 No. 3, 124-125 (Afr) P.O. Box 168, 1170 Machadodorp, Republic of South Africa.

In 'n retrospektiewe studie[6] van 931 vrylewende roofvoëls wat aangebied is vir veeartsenykundige behandeling, is gevind dat 135 (14,5%) van hulle oogletsels gehad het. Sowat 90% hiervan was as gevolg van fisiese beserings. Botsings met voertuie het 33% van die oogletsels veroorsaak. Unilaterale letsels het meer algemeen as bilaterale letsels voorgekom en die anterior segment van die oog was meer dikwels betrokke[2, 6]. Volgens Keymer[4] kom katarakke in vrylewende voëls baie selde voor. Murphy et al[6] het berig dat slegs 9% van vrylewende roofvoëls met oogletsels aan katarakke ly en slegs 1,5% aan posterior sinegie.

'n Volwasse blouvalkie *(Elanus caeruleus)* is gevind met 'n besering aan die regterkant van die kop; die weefsel om die regteroog was erg geswel en hifeem was teenwoordig. Na enkele weke was dit duidelik dat daar geen sig in die regteroog was nie en is die valkie vir ondersoek aangebied.

Die valkie (massa ca 200g), het sy kop voortdurend effens na die regterkant gekantel, maar was in 'n goeie algemene toestand. Die regteroog is ondersoek met behulp van 'n penlig en oftalmoskoop. 'n Duidelike posterior sinegie was ventromediaal teenwoordig, asook 'n vlieserige katarak met stukkies verskrompelde materiaal van die geskeurde lens daarin (Fig. 1). 'n Effense unilaterale miose kon aan die sinegie toegeskryf word (Fig. 2). Weens die katarak, kon geen ander struktuure in die posterior segment van die oog behoorlik ondersoek word nie.

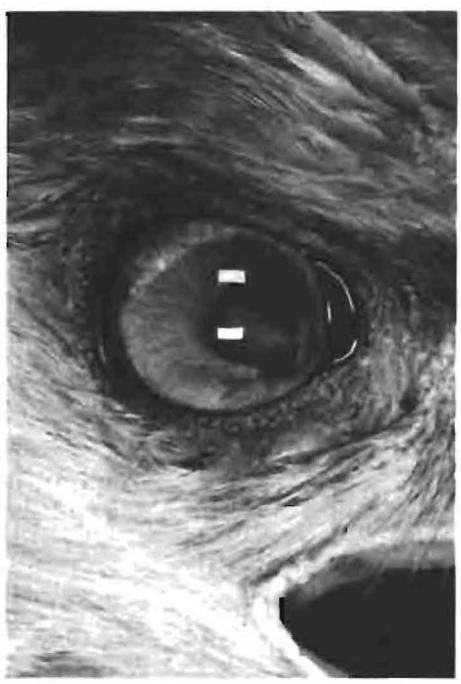

Fig. 1: **Die beseerde regteroog van 'n blouvalkie met 'n katarak en ventro-mediale posterior sinegie**

Vir kalmering van die valkie is 4mg ketamienhidrochloried (Ketalar, Parke - Davis) in die pektorale spier toegedien. Ongeveer 5 min daarna is begin om 2% halotaan (Fluothane, ICI) deur middel van 'n masker toe te dien. Intubasie is gedoen met 'n 2mm pediatriese endotracheale buis, wat met nie-rekbare kleefband aan die snawel vasgeplak is. Die buis is aan 'n Mapleson E-tipe T-buis asemhalingsbaan gekoppel en narkose is met 0,5 tot 0,75% halotaan gehandhaaf. 'n Warmwatersak (40°C) is onder die valkie geplaas.

Die area om die regteroog is chirurgies voorberei. 'n Laterale kantotomiesnit van ongeveer 6mm is gemaak om die palpebrale opening te vergroot. Lokale hemostase is bewerkstellig. Drie housteke van 2/0 Nylon is geplaas om die 3 ooglede oop te spalk. Die oogbal is gefikseer deur dit met 'n pinset aan die dorsale kant van die limbus vas te hou. Die oog is deeglik met normale soutoplossing afgespoel.

'n Steekwond is met 'n horingvliesmes op die twaalfuurposisie, net langs die limbus, deur die horingvlies gemaak. Watervog het ontsnap. Die pupil was steeds groot genoeg oop om deur te werk sodat 'n midriatikum onnodig was. Die steekwond is met 'n horingvliesskêr verleng tot by die nege-uurposisie en die drie-uurposisie. Die horingvliesflap is met behulp van 'n 7/0 Vicryl housteek weggetrek. 'n Irishaak is gebruik om die posterior sinegie los te wikkel sonder enige bloeding. Die voorste lenskapsel is met 'n sistotoom in 'n vertikale snit deurgesny. 'n Arruga-lenskapseltang is gebruik om die voorste lenskapsel en die stukkies harde, verskrompelde lensmateriaal en los kapselvesels te verwyder terwyl die oog van tyd tot tyd met normale soutoplossing uitgespoel is. Die proses van uithaal en uitspoel is herhaal totdat die meeste los materiaal verwyder is. 'n Paar kapselvesels het agter teen die iris gaan lê en kon nie met die kapseltang verwyder word nie.

Die horingvlies is met 7/0 Vicryl in 'n aaneenlopende wyse geheg. Voordat die laaste steek styfgetrek is, is die punt van 'n stomp spuitnaald deur die horingvlieswond gedruk en die oogbal opgevul met

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Fig. 2: **Die kop van die blouvalkie om die miose van die regteroog te toon**

Fig. 3: **Post-operatiewe edeem en dofheid van die horingvlies van 'n blouvalkie**

normale soutoplossing. Die kantotomiesnit is met 2 enkel onderbroke Vicrylsteke geheg.

Post-operatief was die horingvlies dof weens edeem (Fig. 2). Salivasie as neweeffek van die ketamien het ook voorgekom. Die valkie kon ongeveer een uur na die operasie sonder ondersteuning regop sit en is ontslaan met prednisiloonasetaatoogdruppels (Pred-Mild, Allergan) waarvan een druppel 2 keer per dag vir 7 dae toegedien moes word.

'n Week na die operasie was die horingvlies en ooginhoud helder en deursigtig. Die iris het normaal voorgekom en 'n pupillêre refleks was teenwoordig. Die valkie self was in 'n baie goeie toestand en het goed geëet wanneer dit met stukkies vleis per hand gevoer is. Die valkie is na 3,5 weke in 'n vlieghok losgelaat.

Na 5 weke is die valkie, met erge trauma van die kop en skouer aangebied, nadat hy in voorwerpe en in die draad van die vlieghok vasgevlieg het. Ten spyte hiervan, kon die valkie wel veilig op 'n tak land. Die beserings was slegs aan die regterkant, wat moontlik daarop dui dat sig met die regteroog onvoldoende was. Ruptuur van die horingvlies met inhoudsverlies het voorgekom en enukleasie is aanbeveel.

Katarakte in voëls word hoofsaaklik deur seniliteit of fokale trauma veroorsaak of mag geneties van oorsprong wees. Ander potensiële oorsake is post-inflammatoriese veranderinge in die lens, voeding of metaboliese siekte, chemiesgeïnduseerde veranderinge, bestraling, elektriese skok en liggeïnduseerde veranderinge[5]. Volgens Keymer[4] is seniliteit die grootste oorsaak van katarakte in voëls in aanhouding. Murphy et al[6] het egter getoon dat trauma die grootste oorsaak van katarakte in vrylewende roofvoëls is. Wanneer 'n roofvoël teen hoë spoed op sy prooi afduik, word sy oë aan gevaar blootgestel; 90% van alle ooglетsels in vrylewende roofvoëls vind plaas as gevolg van fisiese besering[6]. Voëls in aanhouding leef langer en kan deegliker bestudeer word. Dit kan dus verwag word dat die verspreiding van waargeneemde gesondheidsprobleme van dié van vrylewende voëls sal verskil. Die groot verskille in habitat, vreetgewoontes en gedrag van verskillende spesies kan ook, soos deur Keymer[4] aangetoon, tot 'n groot variasie in die voorkoms van katarakte in verskillende spesies lei.

voëlspesies in aanhouding beskryf. Lentektomie is bevredigend op 'n Andiese Katarakverwydering is reeds in verskeie kondor[6], 'n gebande uil[1] en 'n kanarie uitgevoer, terwyl fako-emulsifikasie op 'n uil en 'n valk toegepas is[3].

Aangesien 'n ruptuur van die lens by die blouvalkie die oorsaak van harde, verskrompelde lensmateriaal was, is daar op 'n ekstrakapsulêre lentektomie besluit. Fako-emulsifikasie is egter aangewese wanneer 'n sagte vorm van katarak verwyder moet word[3]. Na bilaterale verwydering van katarakte deur fako-emulsifikasie, was die sig van 'n uil van so 'n aard dat hy sonder probleme kon vlieg en self sy prooi kon vang en doodmaak[3].

Die oorsaak van die katarak, ander oogprobleme en die fisiese toestand van die voël, is belangrike faktore wat in ag geneem moet word wanneer op katarakchirurgie besluit word.

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CLINICAL, PATHOLOGICAL AND HISTOPATHOLOGICAL FINDINGS IN LAMBS IMPLANTED WITH A GROWTH PROMOTING PRODUCT CONTAINING PROGESTERONE AND OESTRADIOL

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ABSTRACT:

Six live wether lambs and the urogenital tracts of 4 others from 4 separate farms were presented for examination. In each case the wethers had been implanted several weeks previously with a growth promoting product containing progesterone and oestradiol. The affected wethers presented with dorsal retroflexion of a markedly distended bladder which caused persistent straining, bulging of the perineal muscles and rectal prolapse. Enlargement of the bulbo-urethral glands and seminal vesicles, with an increase in the volume and viscosity of the secretion of the bulbourethral glands was evident on gross examination. Histopathological examination of the prostate and bulbourethral glands revealed cystic dilation of the glands and hyperplasia and squamous metaplasia of the glandular epithelium. Desquamated cells and eesinophilic-staining material were present in many of the dilated lumens. In the seminal vesicles, interstitial fibrosis had resulted in the obliteration of large areas of glandular tissue.

The enlargement of the prostate and bulbo-urethral glands, and particularly the increased viscosity of the gland secretions, probably hindered urination, resulting in only partial evacuation of the bladder. Attempts to urinate by active contraction of the abdominal muscles may have accounted for the dorsal retroflexion of the distended bladder. The oestrogenic influence of the growth implants is thought to be responsible for these changes.

Key words: Hormonal implants, lambs, cystic dilation, bulbo-urethral glands.

Randles J.L. **Clinical pathological and histopathological findings in lambs implanted with a growth promoting product containing progesterone and oestradiol.** *Journal of the South African Veterinary Association* (1990) 61 No. 3, 126-127 (En.) Allerton Regional Veterinary Laboratory, P/Bag X9005, 3200 Pietermaritzburg, Republic of South Africa.

During 1987 and 1988, hormonal growth implants containing 100 mg progesterone and 10 mg oestradiol (Synogain C-L, Coopers Animal Health) were frequently used on farms in natal and elsewhere in the country to promote growth in slaughter lambs. Four instances where undesirable side effects occurred in 2 to 5% of implanted wethers were brought to the attention of Allerton Regional Veterinary Laboratory, Pietermaritzburg.

Clinical signs were noticed 2-5 months after implantation in pastured animals (3 instances), but within 2 weeks of implantation in feedlot animals (1 instance). A total of 6 live wethers were submitted for examination and presented with bulging of the perineal muscles and rectal prolapse of varying severity. In 4 cases, the distended bladder lying in the pelvic canal, could be felt on digital palpation per rectum and caused the lamb to strain almost continuously.

The bladder of one animal was drained under epidural anaesthesia by means of a needle inserted per rectum. Once the bladder was sufficiently reduced in volume, digital pressure was used to return it to its normal position. The wether was then seen to be able to urinate unaided, albeit slowly.

The remaining 3 wethers were euthenased by means of barbiturate overdose. Post mortem examination revealed that dorsal retroflexion of the markedly distended bladder had resulted in obstruction of urine flow from the bladder. In 2 instances, rupture of the bladder or one of the ureters had resulted in uroperitoneum. Dilation of the ureters and hydronephrosis was observed in 4 instances. Once the intact bladders of wethers were returned to their normal position, it was possible to slowly express urine from the bladder. The seminal vesicles and bulbo-urethral glands were noticeably enlarged. The secretion of the enlarged bulbo-urethral glands was copious and viscious, and oozed from the glands as they were dissected away from the penis. No evidence of urolithiasis was found. Four urogenital tracts from other wethers were also submitted for examination. Findings in these were similar to those described above.

Histopathological examination of the enlarged bulbo-urethral glands, revealed varying degrees of cystic dilation and hyperplasia and squamous metaplasia of the glandular epithelium. Cellular debris and eosinophilic-staining material were visible in many of the dilated lumens (Fig. 1 & 2). Similar changes were also evident in the prostate glands (Fig. 3). Examination of the enlarged seminal vesicles revealed extensive proliferation of fibrous connective tissue in the interlobular and intralobular septae, resulting in occlusion and obliteration of much of the glandular tissue (Fig. 4).

It seems likely that the increased viscosity and volume of the bulbourethral gland secretion passing into the pelvic urethra, together with cellular debris, hindered urination sufficiently to result in damming up of urine in the bladder. Enlargement of the prostate gland surrounding the pelvic urethra and the bulbo-urethral glands situated on either side of the penis at the ischial arch, might have exacerbated the problem.

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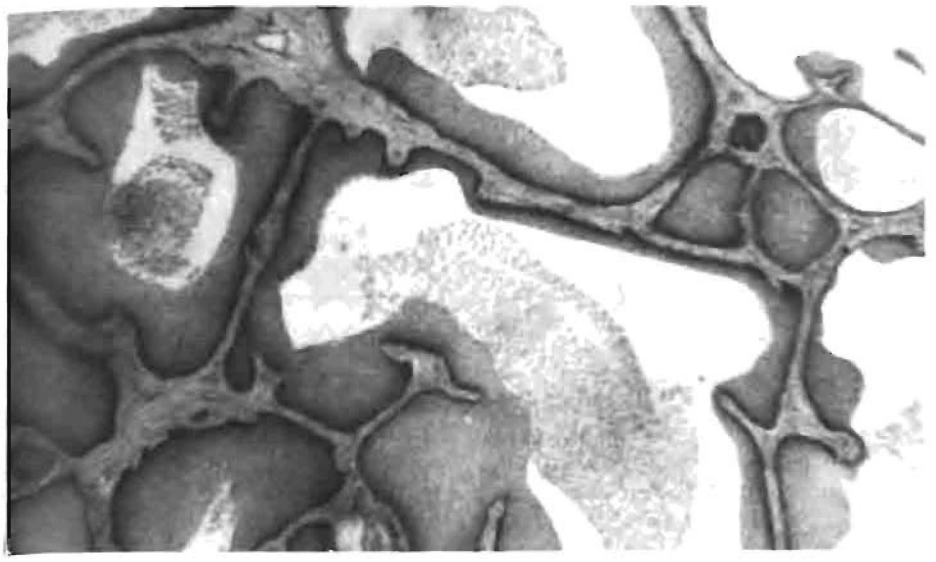

Fig. 1: **Squamous metaplasia of the glandular epithelium in a bulbo-urethral gland, with cellular debris in the gland lumens. HE X 3.2**

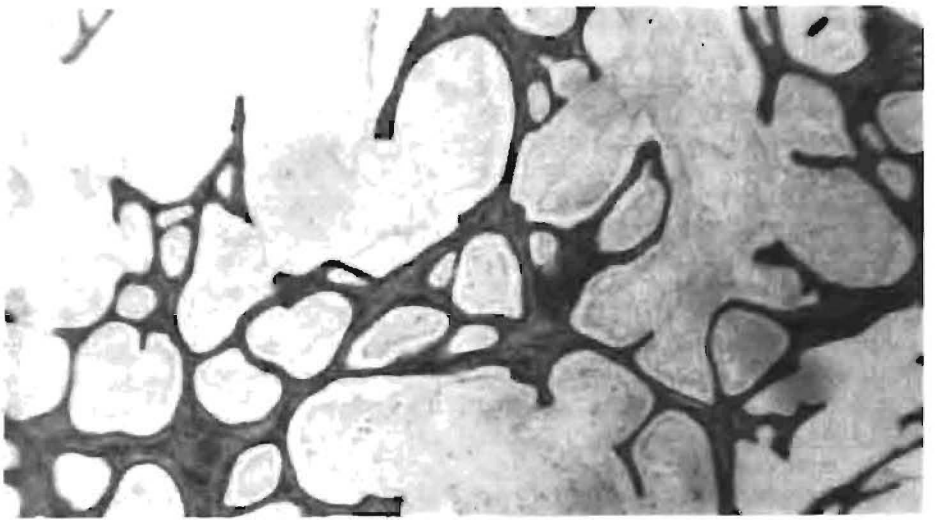

Fig. 2: **Dilation of the gland lumens in a bulbo-urethral gland, with proteinaceous material and cellular debris in the gland lumens. HE X 3.2**

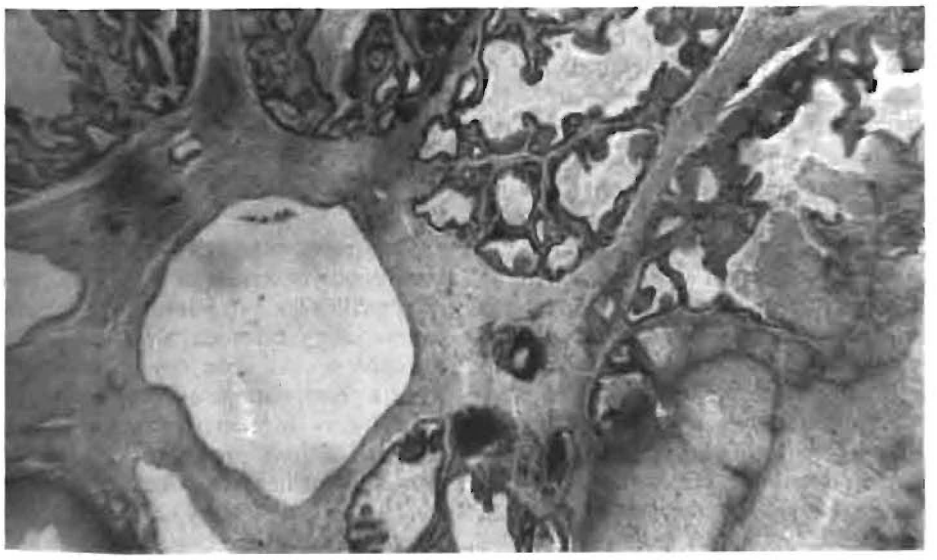

Fig. 3: **Squamous metaplasia of the glandular epithelium and ilation of gland lumens in a prostate gland, with accumulation of cellular debris in many gland lumens. HE X 3.2**

Attempts by affected wethers to urinate, by active contraction of their abdominal muscles, may have resulted in dorsal retroflexion of the distended bladder. Once in the pelvic canal, the pressure of the distended bladder would have resulted in further straining, causing bulging of the perineal muscles and rectal prolapse, as noted on clinical examination. Slackening of the pelvic ligaments under the influence of the oestradiol, might also have contributed to the pathogenesis.

Oestrogenic substances in clover and other pastures are of relative importance in Australia and New Zealand, but their importance in South Africa is uncertain[1 2 3]. On 2 of the farms investigated, the lambs were grazing a mixed clover pasture, so the influence of other oestrogenic substances cannot be ruled out entirely.

Although phyto-oestrogens present in certain clovers and lucerne are reported to cause similar changes in the bulbo-urethral glands of wethers[1 2 3], the fact that only lambs which had received these implants were affected in these cases supports the hypothesis that these implants were responsible for the histopathological changes observed in the accessory sex glands of these wethers and hence the clinical signs observed.

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A PUTATIVE OUTBREAK OF EQUINE LYME BORRELIOSIS IN NATAL

B H FIVAZ*, P BOTHA** and L M CAIRNS***

Lyme disease is caused by *Borrelia burgdorferi* which infects a wide range of mammals and birds and is transmitted by a variety of Ixodid tick species[1]. The disease in humans has been extensively reported in recent years and is characterised by the appearance of an enlarging annular erythematous rash at the site of the tick bite, termed erythema chronicum migrans (E C M). The skin lesion is followed by further clinical manifestations including pyrexia, fatigue, arthralgia and arthritis and a variety of neurological and cardiac symptoms[5 7]. Similar symptoms have been described in domestic animals, although they may subsequently remain symptomless carriers[2 3].

The incidence of Lyme disease in South Africa is unknown, as laboratory methods to identify the disease here have only been established relatively recently. This report describes an outbreak of arthritis which occurred in horses on a property in Natal during 1982/3. Recently acquired clinical and serological data provides speculative evidence that this disease outbreak may have been Lyme disease.

In 1982 the authors (BHF and LMC) were presented with 2 geldings which appeared stiff during walking and trotting. Palpation of the joints revealed nothing of significance, although flexion of both hind limbs elicited a distinct crepitus in the knee joints. Joint fluid aspirates were red-tinged and microscopic examination revealed a preponderance of lymphocytes and a few macrophages. Clinically the horses were normal and had no history of illness, apart from a transient febrile reaction 1-2 months before. A tentative diagnosis of arthritis was made and preliminary treatment comprised a daily oral administration of pheynylbutazone ("Equipalazone", Centaur) for 10 d.

Approximately one month later, the first horse was found cast in the stable and was unable to stand. The horse was euthanased and a full post mortem examination was performed. The second horse was euthanased a few weeks later, after similarly becoming recumbent in the stable. A post mortem examination was also conducted on this animal. Altogether 7/115 horses on the property were euthanased under similar circumstances over a 9-month period. It is noteworthy that all the horses had experienced a febrile reaction 1-6 months prior to the development of joint stiffness and recumbency. The febrile reaction had lasted for 2-3 d and occurred mainly during the preceding summer in January and February. The cause of the pyrexia was attributed to a suspected arbovirus, as a hitherto unidentified flavivirus had been isolated from a febrile horse some years previously by the Veterinary Research Institute, Onderstepoort. Treatment of the febrile cases varied with the consulting veterinarian concerned and included the use of long-acting penicillin ("Compropen", Glaxo), tetracycline ("Engemycin", Coopers) or antipyretics ("Dexatomanol", Byk Gulden). No further clinical cases of this nature occurred at the riding school after May 1983.

The most consistent finding in the 4 horses necropsied, was a severe bilateral serofibrinous arthritis and synovitis in most limb joints. This was particularly marked in the knee joints of the hind limb. Synovial membranes were inflamed and thickened, while the articular surfaces were pitted, eroded and indurated.

The kidneys of 3 of the cases, showed evidence of subacute nephritis, while small focal areas of consolidation of the lungs were identified in 2 of the horses.

Severe lymphocytic synovitis was the most consistent finding in all cases examined and in one case, there was mild subsynovial infiltration by neutrophils. Affected kidneys showed subacute, multifocal, interstitial lymphocytic nephritis while the lungs manifested a focal pulmonary necrosis and peribronchitis.

Routine microbiological tests of synovial fluid and organs for bacteria, mycoplasmas and viruses were negative; 8/39 horses tested for chlamydia antibodies were positive, but showed titres of less than 24.

In 1988, all domestic animals at the riding school were tested for antibodies to *Borrelia burgdorferi*, following the increasing number of reports of Lyme disease in domestic animals in the literature. Serum samples from horses and dogs on the property were subsequently tested against *B. burgdorferi* antigen, using the indirect fluorescent anitbody test (IFAT). Positive titres of 1/256 and higher were found in 71/117 (61%) horses and 6/11 (55%) dogs. Although chronic stiffness and lameness occurred in 15 of the horses tested, these cases could not be correlated with positive titres. There was no relationship between the seropositive dogs and any undiagnosed clinical symptoms, except for one dog which had a recent history of pyrexia of unknown origin, which was only responsive to a prolonged course of tetracycline.

In October 1988, the 38-year-old owner of the riding school developed severe headache following a tick bite, but failed to respond to a course of tetracycline, following the diagnosis of tick bite fever. Her condition deteriorated over the following few weeks during which time she developed severe arthralgia, especially of the neck and knees, depression, vertigo and slurred speech. Serological tests conducted by the department of Medical Microbiology, University of the Orange Free State, Bloemfontein, were negative, except for a positive I F A test for *Borrelia burgdorferi*. The serum was referred to a reference centre, Hygiene-Institut der Universität, Vienna, for confirmation as a previous report from Vienna had described a case of Lyme borreliosis in a tourist who had recently returned from a visit to Natal[6]. Enzyme-linked immunosorbent assay (ELISA) and Western blot results, confirmed the I F A T with the 39,5 KD blot, indicating a recent infection.

The treatment was changed to 6-hourly intravenous injections of 2 million units of penicillin for 5 d, followed by a single long-acting intramuscular penicillin injection on the sixth day. The patient made a prompt and uneventful recovery.

Subsequently, 3 more adults at the riding school have presented with similar symptoms of headache, lethargy and arthralgia. A clear history of tick bite, was recorded in only one case. Two cases had developed an erythematous rash. All cases were I F A T positive for *B. burgdorferi* and clinical improvement followed after high doses of penicillin therapy.

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DISCUSSION

There is a need to exercise caution in diagnosing Lyme disease on symptoms alone, in view of the multi-organ involvement of the disease. The definitive diagnosis of Lyme disease is based on the isolation of the causative organism and the demonstration of rising titres of specific *B. burgdorferi* antibodies. However, the occurrence of polyarthritis in all the horses and nephritis and pulmonary involvement in some of the horses examined after euthanasia, was very unusual but in keeping with the symptomatology of Lyme disease described elsewhere[2,3].

No attempts were made to isolate *Borrelia* organisms in joint fluid aspirates and organs because the authors were unaware of Lyme disease at the time and a successful isolation of the causative organism would have been unlikely with the use of routine bacteriological tests. Moreover the joint involvement had become chronic by the time the horses were euthanased and in any case the joint pathology is regarded as immune-mediated, rather than being due to the direct effects of the organism per se[7].

Acute and convalescent sera from affected horses were unfortunately discarded in 1985, thereby eliminating another possibly valuable indicator of Lyme infection.

Perhaps the strongest evidence for the possible involvement of *B. burgdorferi* infection in the horses, was the occurrence of the disease in the 4 humans associated with the riding school. It is regrettable that cerebrospinal fluid taken from the first patient, was not submitted for bacteriological examination prior to commencement of the penicillin therapy.

It is notable that a recent report from Belgium, discusses the possible role of horses as reservoirs of *B. burgdorferi* infection and cites a case of Lyme borreliosis which occurred in a stable hand who was tending sick horses which were found to be seropositive for *B. burgdorferi*[4].

It could be argued that the seropositive tests in the horses and dogs reported here, were not sufficiently specific as the sera were not screened against other *Borrelia* organisms which occur in Africa. For example, nothing is known of the antigenic relationship between *B. burgdorferi, B. theileri* and *B. duttoni,* the cause of relapsing fever in humans.

It would be logical to attempt to isolate the causative organism from ticks on the property. Large numbers of spinose ear ticks *Otobius megnini* and red-legged ticks *Rhipicephalus evertsi evertsi* occur on horses on the property, but a perliminary attempt failed to isolate *Borrelia* from a batch of dissected ticks and whole tick homogenates.

Finally, an intriguing finding on the property was the regular occurrence of febrile reactions in many of the horses during the summer. The temperature reactions would ordinarily remain undetected, except that the daily temperature of every horse is routinely recorded. Renewed attempts are being made to isolate the causative organism from febrile cases. It is notable that the 7 horses described in this paper, had manifested high febrile reactions for varying periods prior to their death. A single intramuscular injection of long acting antibiotic would have been insufficient to eliminate *B. burgdorferi*[7].

The occurrence of Lyme disease in domestic animals in South Africa awaits confirmation. This report highlights the possibility that this infection may be estalbished in the domestic animal population and there is a need for veterinarians and medical practitioners to be aware of that possibility.

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Case report/Gevalverslag

ELECTROCARDIOGRAPHIC CHANGES ASSOCIATION WITH ALTERED THYROID FUNCTION IN TWO DOGS

J.M. WYSOKE* and J. VAN HEERDEN*

ABSTRACT

Two dogs with altered serum thyroid hormone concentrations and electrocardiographic changes are presented: low voltage QRS complexes and low amplitude, inverted T-waves associated with hypothyroidism; and tachyarrhythmia and increased amplitude QRS complexes in all leads, associated with hyperthyroidism.

Key words: Electrocardiogram, hyperthyroidism, hypothyroidism, dog

Wysoke J.M.; Van Heerden J. **Electrocardiographic changes associated with altered thyroid function in the dog.** *Journal of the South African Veterinary Association* (1990) 61 No. 3, 130-132 (En.) Department of Companion Animal Medicine and Surgery, Faculty of Veterinary Science, Medical University of Southern Africa, 0204 Medunsa, Republic of South Africa.

INTRODUCTION

Electrocardiographic (ECG) changes associated with thyroid disorders have received scant mention in the veterinary literature. Although the numerous other clinical signs should be indicative of a possible thyroid disorder, ECG changes may lead to incorrect suspicion of some primary cardiac pathology. Awareness of the ECG changes will allow for earlier, correct diagnosis and treatment without unnecessary investigation of the cardiac manifestations.

CASE I

A 9-year-old female Bull Mastiff-cross was presented with a complaint of weakness and malaise of a few weeks duration. At the time of presentation, the dog was recumbent and had been anorexic for 3 d.

Clinical examination revealed a severely obese dog with a rectal temperature of 37,5°C and a coarse, sparse haircoat. The facial skin appeared thickened and puffy, resulting in a so-called "tragic" facial expression. The heart sounds and the pulse were extremely faint with a rate of 82 beats per min. Abdominal palpation indicated an abdominal mass and a distended bladder.

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The urine had a low specific gravity (1,013). Subsequent laboratory data excluded an azotaemia. Haematological examination revealed a non-regenerative, normocytic, normochromic anaemia (Table 1).

The electrolyte status of the dog was normal (Table 1). Serum thyroid determination revealed a profound hypothyroidism (Table 1). On sequential ECG examinations, the heart rate fluctuated between 90 and 120 beats per min. This rate persisted despite the presence of atrial fibrillation (absent P-waves and the presence of F-waves). The maximum amplitude of the QRS complex was 0,7 mV (lead II) with a duration of 0,04 s. The T-wave was indistinct but tended to be inverted in leads I, II, AVR and AVF. Thoracic radiographs did not indicate any change in the size of the cardiac silhouette.

Treatment with T3 and T4 supplementation (Diotroxin, Lilly) at a dose rate of 20 ug $kg^{-1}day^{-1}$ divided into 2 equal dosages was initiated. By Day 2 the habitus and appetite had improved slightly. The dog died 2 d later.

On post-mortem examination, a severe megacolon filling the abdomen and pelvis was found. Histopathology revealed a chronic, atrophic, lymphocytic thyroiditis. Marked distention of scattered myelin sheaths was observed in the cauda equina, with no inflammatory reaction associated with these lesions. The axons were histologically normal. No other significant findings were reported.

CASE II

An 8,5-year-old male Pointer was presented with a complaint of polyphagia, restlessness and loss in body condition. Clinical examination revealed a dull haircoat, a strong rhythmic pulse with a rate of 132 beats per min, congested mucous membranes and the presence of a firm localised nodule, approximately 3x2 cm in size, situated subcutaneously at the midventral aspect of the neck.

Urine analysis revealed a specific gravity of 1,013, a proteinuria and the presence of leukocytes and red blood cells in the stained sediment. The results of blood chemical and hormonal assays are presented in Table 1.

Electrocardiographic examination revealed a sinus rhythm with a heart rate of 132 beats per min. High-amplitude R waves were seen in Leads 1 (2 mV), Lead II (3 mV), Lead III (1,7 mV), and aVF (2,3 mV). Prominent Q-waves occurred in Leads I (0,8 mV), II (0,9 mV) and aVF (0,8 mV). Prominent T-waves were observed in Leads II, III, aVR and aVF. The average duration of the QRS-complexes was 0,06 s.

The nodule was excised and subsequent histological examination confirmed it to be a well-encapsulated mass of thyroid tissue, i.e. an adenoma of ectopic thyroid tissue. The dog made an uneventful recovery and its physical condition gradually returned to normal.

DISCUSSION

In human medicine, there are numerous reports on hypothyroid-associated ECG changes, including sinus bradycardia, conduction disturbances such as bundle branch blocks, low voltage, axis deviations, prolongation of the QRS interval and flattened or inverted T-waves[9]. The ECG findings in Case 1 are consistent with the most common hypothyroid-associated ECG changes, namely, low voltage complexes and depressed or inverted T-waves[7]. A list of differential diagnoses for low-voltage QRS-complexes is provided in Table 2. Experimental studies have indicated that thyroid hormones prolong the refractory period and the at-

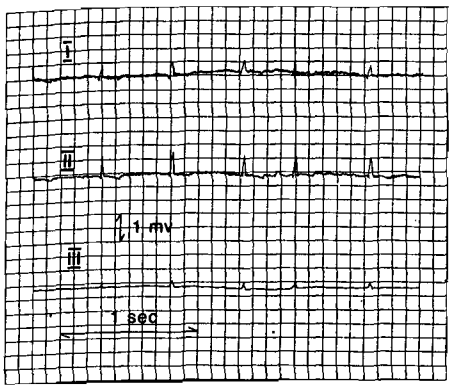

Fig. 1: **Electrocardiographs of the dog with hypothyroidism (Case 1)**

Table 1: **Laboratory findings in a dog with hypothyroidism (Case I) and a dog with hyperthyroidism (Case II)**

	Case I	Case II	Normal Range
Haematocrit	0,31	0,43	0,37-0,55
MCV (fl)	64,7	65	60-77
MCHC (g $d\ell^{-1}$)	35,8	38,3	32-36
Sodium (mmol ℓ^{-1})	150,0	152	126-157
Potassium (mmol ℓ^{-1})	5,0	4,4	3,6-5,1
Urea (mmol ℓ^{-1})	4,0	6,0	3,6-8,9
Creatinine (μmol ℓ^{-1})	78	107	<133
Total T4 (nmol ℓ^{-1})	<10,0	55,96	10-40
Free T4 (pmol ℓ^{-1})	<2,8	28,72	7-20
Total T3 (nmol ℓ^{-1})	<0,5	3,17	0,5-1,5

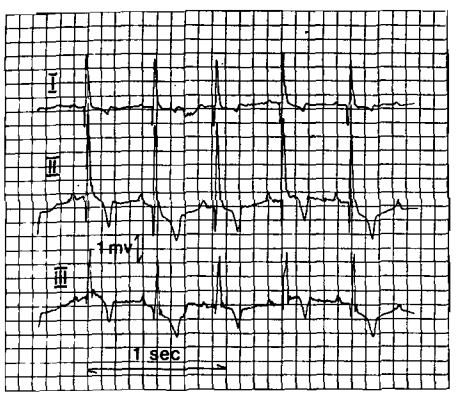

Fig. 2: **Electrocardiographs of the dog with hyperthyroidism (Case II)**

rioventricular conduction time of the heart[4]. The influence on nerve conduction is not restricted to the cardiac system as there are reports on hypothyroid-associated nerve conduction disturbances manifesting as neurological[1] and neuromuscular disturbances[5]. A dynamic ileus, resulting in a megacolon, is further evidence of nerve conduction disturbances[5].

Histological studies of the myocardium of hypothyroid humans revealed interstitial oedema, basophilic degeneration, myofibrillar swelling, loss of striations, fibrosis and mucinous vacuolisation with a positive periodic acid-Schiff reaction[8 9]. Myelin degeneration resulting in denervation atrophy of muscles, was detected in one study on hypothyroid-associated neuromuscular disorders[5].

It therefore appears that the cardiac manifestation of hypothyroidism may contain components of both neurological and myocardial changes. Despite these changes, congestive heart failure, in the absence of underlying cardiac pathology, is uncommon. All these manifestations are reversible with the supplementation of thyroid hormones[1 5 7].

Table 2: **Conditions associated with low-voltage QRS complexes***

1. Normal variation
2. Incorrect standardisation
3. Pericardial effusion
4. Severe myocardial damage (infarction, cardiomyopathy, fibrosis, neoplasia)
5. Pulmonary disease (oedema, emphysema, pneumonia)
6. Obesity
7. Pneumothorax
8. Pleural effusion
9. Cardiomyopathy after adriamycin chemotherapy
10. Space-occupying intrathoracic masses
11. Hypothyroidism

*Adapted from Tilley[10]

Due to the frequency of its occurrence, the ECG changes associated with hyperthyroidism in cats are more frequently reported than in dogs. The incidence and clinical signs of this condition in humans have also been widely documented. It is perhaps due to the reliability of the cardiac manifestation of canine hyperthyroidism, that these signs are more readily recognised and correctly associated with a thyroid disorder. Table 3 lists conditions associated with high-voltage QRS-complexes.

The tachycardia associated with canine hyperthyroidism is attributed to an increase in β-adrenergic reseptors, increased receptor activity and an increase in free catecholamine levels in the tissues[2 3 4]. Abnormal parasympathetic restraint of sinus node automaticity has also been documented[11]. Thyrotoxicosis causes an increase in cardiac rate and output[2]. The tachycardia may be associated with a supraventricular arrhythmia, atrial fibrillation or a more forceful apical beat and arterial pulse[3]. As this is sometimes associated with decreased peripheral resistance, high output cardiac failure may result[2]. Major ECG findings are an increased rate and amplitude of the QRS complex in all leads as seen in Case 2. Ventricular ectopic beats and arrhythmias are sometimes seen[2]. In cats, symmetric hypertrophy of the ventricular septum and left ventricular free wall have been found in conjunction with hyperthyroidism[6]. The hypermetabolic state of hyperthyroidism and subsequent demand on the heart for increased tissue perfusion with resultant increases in myocardial contractility, myocardial oxygen consumption, cardiac output and energy turnover, are the proposed mechnisms which could result in compensatory myocardial hypertrophy[6]. Histopathological findings in the myocardium of these cats included large, hyperchromatic nuclei, interstitial fibrosis, endocardial fibroplasia, fibrosis of the atrioventricular node and disorganisation of cardiac muscle cells[6]. These changes are reversible when serum thyroid levels are reduced to euthyroidism[6].

Thyroid disorders represent some of the most common endocrine conditions pre-

Table 3: **Conditions associated with high-voltage QRS complexes***

1. Eccentric hypertrophy secondary to volume overload (mitral insufficiency, aortic insufficiency, ventricular septal defect, patent ductus arteriosus)
2. Concentric hypertrophy secondary to pressure overload (aortic stenosis)
3. Primary myocardial disease (dilated form of cardiomyopathy)
4. Normal variation
5. Incorrect standardisation
6. Thin-chested breeds
7. Young animals
8. Emaciated animals
9. Hyperthyroidism

*Adapted from Tilley[10]

sented to the veterinarian. Awareness of the cardiac and electrocardiographic manifestations of hyper- and hypothyroidism will provide a more readily accessible means of confirming one's suspicion of a thyroid disorder before definitive thyroid hormone determinations are embarked upon. Prior knowledge will also prevent the unneccessary investigation of the cardiac disorder and allow one to emphasise the underlying metabolic condition.

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PRACTICE ON THE FRINGE : A LEGAL PERSPECTIVE

The last 2 decades have seen a growing acceptance in South Africa of many of the "alternative" or "fringe" varieties of medical therapy, notably homeopathy, herbalism, naturopathy, acupuncture, chiropractics and physiotherapy[a]. As far as the treatment of humans is concerned, these "alternative" practices have to a greater or lesser extent been officially recognised and are now regulated by statute[b].

As far as animals are concerned, a similar rapid growth in the acceptance and availability of "alternative" veterinary therapy has occurred, and a substantial number of veterinary physiotherapists and osteopaths, together with homeopaths, herbalists and acupuncturists who have extended the ambit of their practices to cater for veterinary patients, are now practising in South Africa. The law, however, has by and large failed to keep pace with these developments, and as it stands, is unable to accommodate such practitioners and so to cater for the needs of the animal-owning public in general.

The diagnosis and treatment of pathological conditions in animals in South Africa is regulated by the Veterinary and Para-Veterinary Profession Act, 1982, as amended by the Veterinary and Para-Veterinary Professions Amendment Act, 1989[d].

It would seem logical to suggest that such legislation should serve a dual purpose: on the one hand, to protect animals and the animal-owning public from charlatans and incompetent practitioners, and on the other hand, in order to further the welfare of the animals concerned, to facilitate and regulate the provision of as wide a range of veterinary treatments as possible. The Act, however, like so many of its genre, simply creates a monopoly of the treatment of animals for registered veterinarians and para-veterinarians, thereby achieving the first objective, but failing entirely to achieve the second.

The Act divides the world into 3 classes of people:

(i) registered veterinarians;
(ii) registered para-veterinarians; and
(iii) unregistered persons.

and then proceeds to prohibit the practising of any aspect of veterinary medicine by unregistered persons as follows:

23(1)(a) "No person shall in any manner whatsoever practise a veterinary profession or para-veterinary profession unless he is registered or deemed to be registered in terms of this Act to practise the profession concerned..."

Subsection (2) as read with subsection (3) of section 23 defines what, for the purposes of the Act, constitutes the practice of a veterinary or para-veterinary profession:

"[F] or gain, directly or indirectly, whether for own account or within the scope of employment with any employer, ... performing any act which has as its purpose diagnosing, treating or preventing any pathological condition in any animal ... and is deemed in terms of the rules to pertain specifically to a veterinary [or para-veterinary] profession... .

Rule 2 of the rules relating to the practising of the veterinary profession[e] reads as follows:

"For the purposes of the Act -

2.1 the diagnosis, treatment or prevention of an infectious disease or organic disease or a pathological condition in an animal;

2.2 a surgical operation on an animal; and

2.3 the prescribing or administration of a veterinary medicine to an animal

shall be deemed to be services which pertain specially to a veterinary profession"

The word "pathological" is defined in the Oxford English Dictionary[f] as follows: "pertaining to or dealing with the causes and nature of diseases, or abnormal bodily affections or conditions". Thus the treatment of conditions caused by both illness and injury are brought within the ambit of the Act.

Section 41 of the Act renders the contravention of section 23 a criminal offence. A person alleged to have contravened the section is therefore liable to be arrested by the police and tried before a magistrate's court, and if found guilty, on a first conviction, to a fine not exceeding R2 000 or to imprisonment for a period not exceeding one year, or to both such fine and such imprisonment.

The exclusionary effect of section 23(1)(a) and the Rules promulgated in terms of it, would seem to be quite extraordinarily broad, in that the treatment for gain of any ailment in an animal by any unregistered person is outlawed. But this broadness is itself problematic. If the words of the Act and the Rules are given their plain and ordinary meaning in accordance with the normal conventions by which statutes are interpreted, then a groom who notices that a horse has a stiff leg and applies liniment to it to make it better, falls foul of the Act. Similarly, a boarding kennel owner who notices that one of the dogs in his care is off-colour and gives it a condition tablet, renders himself liable to prosecution. It seems unlikely that this is what the legislature intended, but it is what the Act says.

The legislation as it stands therefore places 2 categories of people in a quite invidious position. The first is comprised of persons such as grooms, servants and kennel keepers who must care for animals in the course of their ordinary employment, and whose treatment of such animals is unlikely to amount to much more than that of maintaining them in a reasonable condition and, in the case of an accident, of rendering first aid. The second consists of the substantial number of practitioners providing the various forms of "alternative" medical treatment for animals mentioned above.

As regards the first category, although the relevant sections of the Act clearly

a. Although the practice of physiotherapy on humans has become so widely accepted that it may no longer seem appropriate to refer to it as an "alternative" treatment, the use of the term, it is suggested, draws attention to the fact that the therapy came to be regarded as "conventional" by way of a process of acceptance, and is quite appropriate in describing the present status of physiotherapy in the context of veterinary medicine.
b. The Medical, Dental and Supplementary Health Service Professions Act No 56 of 1974 and the Rules promulgated in terms of it, regulate the practice of physiotherapy, while the Associated Health Service Professions Act No 63 of 1982 regulates the practice of homeopathy, osteopathy, herbalism and chiropractics.
c. Act No 19 of 1982.
d. Act No 19 of 1989. Although the commencement of this Act has to date not been gazetted, its provisions serve only to emphasise the points made in this article and so the amended versions of these are employed throughout.
e. Government Gazette 8402 1/10/82 and Government Notice R2086.
f. 1978 Ed: Murray, Bradley, Craigie and Onions, Clarendon Press, Oxford.
g. Government Gazette 8402 1/10/82, Government Notice R2085 and Government Notice R397.
h. Act No 101 of 1965.
i. Act No 36 of 1947.
j. Act No 101 of 1965.
k. Act No 56 of 1974.
l. 16 September 1977, Government Gazette 5741.
m. by para 2 of the schedule to Regulation R1731, 9 August 1985, Government Gazette 9886.

need to be reworded in order to remedy the illogicality inherent in them, it is quite possible that in order to circumvent the most obvious difficulties, a court might interpret the legislation restrictively so as to include only those instances in which the treatment of an animal is central rather than peripheral to the gainful employment of the person concerned. However, as the persons in this group fall neither into the category of charlatans from whom the animal-owning public need to be protected, nor of practitioners to whom access by the public should be facilitated and regulated, their position need not be considered further here.

As regards the second category, the question arises as to what avenues are open to these practitioners to bring themselves within the ambit of the Act. Would it avial them not to charge a fee for their services, but merely to receive a donation at the discretion of the owners of the animals which they treat? This avenue is not open to them, as the receiving of donations is as firmly excluded by the Act as the receipt of fees: section 23(d) outlaws any activity "by virtue of which any advantage, whether for a person himself or any other person, can be obtained by means of... a donation or gift, or by means of the provision of accommodation, or by means of any other profit whatsoever, whether direct or indirect.

May they register as para-veterinarians in terms of the Act? Section 21(1) empowers the Minister, on the recommendation of the Veterinary Council, to declare by notice in the Government Gazette that the provisions of the Act shall be applicable to any profession which has as its object the rendering of services supplementary to the services, which in terms of the rules, are deemed to pertain specifically to the veterinary profession. In other words, he may declare any such profession a para-veterinary profession. To date, only 2 professions have been so declared: these are those of veterinary nurses and veterinary technologists[g]. In order to register as a para-veterinarian, a person is required by section 24 of the Act to hold a Dip. Cur. Anim, a Dip. Vet. Nur. or a national Diploma in Veterinary Technology, or, if he is not a holder of any of these, to have applied for registration within 6 months of the dates of the above Government Gazettes, providing proof that he had practised the para-veterinary profession concerned for a continuous period of 5 years, prior to the date of publication of the abovementioned Gazettes, and had passed an examination determined by the Council. The practitioners concerned, fall into neither of these categories of person and so would not be entitled to register as para-veterinarians.

May they practise in conjunction with, or under the supervision of a registered veterinarian? The answer to this question would appear to turn on the issue of who in fact would under such circumstances be making the ultimate decision as to the treatment which the animal should receive. If their function could be construed as being no more than that of assisting a veterinarian in applying the treatment prescribed by him in pursuance of his own diagnosis, it would seem unexceptionable. But where treatments such as homeopathy or acupuncture are concerned, which require expert knowledge not necessarily held by a conventionally trained veterinarian, the "alternative" practitioner would, irrespective of any amount of supervision by the veterinarian concerned, of necessity have to operate by applying his own expert knowledge to the treatment of the animal, and so would in fact continue to operate independently of the registered veterinarian and thus fall foul of the Act. However, this solution would in any event prove unsatisfactory from the point of view of the "alternative" practitioners who could rightly maintain that such direct "supervision" was pointless, and of the animal-owning public, who would be required to incur the additional expense and inconvenience of a superfluous veterinary consultation whenever they sought to avail themselves of the services of an "alternative" practitioner.

One possible route out of this dilemma is contained in the wording of the Act itself. Section 23(1)(c) reads as follows:

"(c) The [Veterinary Council of South Africa] may, after consideration of an application by a person not registered or deemed to be registered in terms of this Act, authorise him in writing to render for gain a particular service deemed in terms of the rules to pertain specifically to a veterinary profession or para-veterinary profession."

This section would appear to make provision for a person who would not be eligible to be registered as either a veterinarian or a para-veterinarian, but who is competent to perform one of the number of services usually performed by them, to be authorised by the Council to perform that specific service for gain.

However, the section stands alone in the Act and no reference has been made to it in the Rules promulgated in terms of the Act to date. It is therefore far from clear quite how the legislature intended this section to be put into effect. Nonetheless the section exists, and, if necessary, could be relied on by such a person to require the Veterinary Council to formulate some manner of dealing with his application. It is further trite law that when an Act of Parliament provides the means by which a statutory body may regulate the provision of certain services, that body is obliged to do so, and may not merely hold that no such services may be provided at all.

Placing reliance on this section, however, would not be without risk for persons presently practising "alternative" veterinary medicine, in that, in the absence of any legislated guidelines, the Veterinary Council would be at liberty to decide on the criteria by which such applications would be judged, and may well set these at a level which certain practitioners would be unable to meet. However, if the legislation is to serve the function of protecting members of the public against persons who are not competent to treat their animals, the exclusion of practitioners who could not meet such requirements may well be desirable. A further problem, however, is that given the unconventional nature of the "alternative" treatments under discussion, it is far from clear whether the Veterinary Council would be in any position to properly examine or assess the competence of the "alternative" practitioners in the first place. It may well be possible that an examining body comprised of persons familiar with these treatments could be appointed, but quite what form an examination would need to take to cater for the individualistic nature of "alternative" practice, remains open to question.

An additional complication exists in respect of homeopaths administering homeopathic medicines to animals. As was set out above, in terms of Rule 2,3 the prescription or administration of a veterinary medicine to an animal, is deemed to be a service which pertains especially to the veterinary profession and so may not be performed by an unregistered person. But what is a veterinary medicine? Rule 1 of the Rules, which contains the definitions of the terms used in them states:

> "veterinary medicine" means a veterinary medicine as defined in section 1 of the Medicine and Related Substances Act, 1965."[h].

Section 1 reads as follows:

> "veterinary medicine' means any substance or mixture of substances, other than an stock remedy or farm feed to be registered in terms of the Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act, 1947[i], used or purporting to be suitable for use... in connection with vertebrates, for the treatment, diagnosis, prevention or care of any disease, infection or other unhealthy condition..."

In terms of the Act:

> "stock remedy' means a substance in-

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tended or offered to be used in conjunction with domestic animals, livestock...[etc] for the diagnosis, prevention treatment or cure of any disease, infection or other unhealthy condition..., but excluding any substance insofar as it is controlled under the Medicine and related Substances Control Act, 1965"[j].

The definition is thus entirely circular and it remains far from clear which remedies may be administered by an unregistered person and which not.

What then is the solution to the problem posed by the wording of the Act? It is suggested that it may lie in the adoption of some of the provisions relating to the practice of physiotherapy on human patients contained in the Medical, Dental and Supplementary Health Service Professions Act 1974[k] and the Regulations and Rules made in terms of it.

Regulation R1838[l] issued in terms of section 50(1) of the Act, specified a number of acts or omissions by physiotherapists in respect of which disciplinary steps may be taken against them by the Professional Board of Physiotherapy and the South African Medical and Dental Council. Rule 21 in its original form dealt with the performance of forbidden professional acts by physiotherapists and included among them:

"(1) the treatment of any patient unless that patient has been referred by a registered medical practitioner...except in an emergency."

The effect of this provision was strongly contested by practitioners of physiotherapy who saw the requirement that patients be referred to them by a medical practitioner as an unnecessary restriction. Their arguments prevailed and the rule was finally amended[m] to read as follows:

"(1) The treatment of any patient, except in an emergency-

(a) where such patient has not been referred by a registered medical practitioner...; or

(b) where such treatment, in the case of a patient not so referred, is given otherwise than in close collaboration with a registered medical practitioner.

...

Provided that the expression 'in close collaboration' in this subrule shall mean that the physiotherapist at one or other stage of the physiotherapy treatment, though not necessarily before undertaking such treatment, consults a registered medical practitioner ... on the case concerned and at the end of such treatment furnishes him with a report on such treatment."

It is suggested that the interests of the animal-owning public might best be served by the establishment of a register of "alternative" practitioners by the Veterinary Council, upon which the name of any person wishing to practise as such, would be entered upon their making application to the Veterinary Council in terms of section 23(1)(c). Such enrolment should be allowed without the need for the practitioner to undergo any examination as to his competence or to establish any formal qualifications, but it would mean that any such enrolled practitioner would then fall under the jurisdiction of the Veterinary Council, and as such could be made subject to a disciplinary enquiry into any allegations of dishonesty or malpractice or of causing harm to animals brought against him by members of the public or of the veterinary or para-veterinary professions. In terms of this arrangement, were an "alternative" practitioner to be found guilty of such a charge, the Council would be entitled to strike his name off the register, thereby rendering his continuing to practise illegal and subject to the penalties prescribed by section 41 of the Act.

Furthermore, if this system were coupled with the promulgation of a Rule similar to the amended Rule 21, relating to the practice of physiotherapy on humans, then the animal-owning public would be further protected without incurring unnecessary expense, by the requirement that all "alternative" practitioners should at least consult with a registered veterinarian during the course of administering treatment and by the element of indirect, but qualified veterinary supervision inherent in that provision.

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A REVIEW OF CHEMICAL METHODS AVAILABLE FOR THE CONTROL OF GASTROINTESTINAL NEMATODES OF SHEEP AND CATTLE

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The modern anthelmintic is the most potent aid avialable for the control of the gastrointestinal nematodes of sheep and cattle. These modern drugs have vastly improved in efficacy, safety, ease of administration and applicability.

For the past 2-3 decades the anthelmintic has had a far-reaching effect on the approach to worm control, often replacing other methods completely[6].

In the past, researchers often had unwarranted confidence in the ability of the various drugs to control or possibly even eradicate worms, even when these drugs were far less effective than the modern anthelmintics[8 24]. Optimism grew, until resistance spread and brought about the realisation that research into alternative methods of control was urgently required[29 30 33].

Sporadic use of anthelmintics without additional management practices aimed at prevention or retardation of reinfection after treatment, is not to be recommended. Hence, for the purposes of the following discussions, it is accepted that anthelmintics are not applied in isolation, but only in the context of fully-integrated worm control. It is essential to monitor the efficacy of treatment, otherwise heterozygotic-resistant worms survive after treatment and safe pastures become populated with their offspring, thus leading to very severe selection for resistance[14].

Certain general considerations are important when deciding on a drenching programme:

- Poor growth rates[3] with the advent of winter commonly result from a combination of malnutrition and nematode infection;
- The effect of a given control programme is very dependent on the type of farming enterprise practised;
- Management practices are critical;
- Initial production advantages in treated versus control animals are often lost at a later stage through compensatory growth in the controls.
- Excessive drenching increases the threat of resistance to the drugs used, and may delay the development of immunity to reinfection in the hosts, leaving them susceptible to worm infection when adult.

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Anthelmintic drenching may be empirical, curative or preventive. Drenching is called empirical when it is not based on any strategy. In curative drenching, treatment is often delayed until pastures are heavily infested and clinical signs or even deaths occur[9]. It has the disadvantage that considerable production losses have already been incurred by the time clinical signs are visible in the host[15], and reinfection takes place directly after drenching unless the animals are removed from the infested pasture at the time of treatment. Despite the disadvantages, curative drenching is favoured by some, as it causes a relatively low selection pressure for resistance, and because it is considered unnecessary to drench adult sheep routinely[4].

Preventive drenching is most important for forestalling excessive contamination of the pasture with free-living stages of the worms, and thus minimising the exposure of susceptible hosts to verminosis. Preventive drenching may be applied in the form of strategic or tactical drenching.

STRATEGIC DRENCHING

Strategic drenching comprises treatment at predetermined intervals, based on seasonal fluctuations in the prevalence of specific worm species; on managerial considerations such as mating, lambing or weaning; or on combinations of these. Thus it can be regarded as a fixed or regular drenching programme, in contrast to other systems where decisions on drenching are made with regard to changes in climate and in the worm burdens of the hosts.

When the fixed drenching programme is applied in conjunction with other methods of control such as pasture spelling, the system can be termed integrated strategic worm control.

Most often, strategic drenching consists of a series of drenches at the start of the worm season, when the worm species concerned commence egg production, and conditions become favourable for the development of free-living worm stages on the pasture. This ensures that worms do not accumulate excessively at the beginning of the season, and constitute a threat to susceptible animals later.

Strategic drenching in the "off-season" when conditions are unsuitable for worm development on pasture and the worms that do occur in the animal are usually hypobiotic, is referred to as offensive or "extended" drenching.

At that stage, it is reasoned, drenching will have the most far-reaching effect. As the worm is practically non-viable outside its host on the pasture, it is "cornered" in the host where it is at its most vulnerable. This system of dosing is recommended by some of the most experienced contemporary helminthologists[6 10 21].

However, there are also negative consequences. In the first place, many worm species can survive the winter on pasture, in which case they are not exposed to the offensive drenching. Furthermore, the majority of the common worm species are hypobiotic in the host when conditions are unfavourable for survival on pasture. These hypobiotic larvae are commonly less susceptible to anthelmintics than normally developing larvae that are not retarded in development. For example, drugs such as closantel, disophenol and rafoxanide (which have an extended residual effect on reinfection with *H. contortus* after drenching) have practically no effect on hypobiotic larvae in the host[12 23].

In my opinion, it is unnecessary to run the risk that the worms will not be susceptible to drugs used offensively, since treatment can be delayed for a short while until the larvae resume development once conditions on pasture have again become favourable (usually in spring in South Africa). Reinecke[21], for instance, recommends that *H. contortus* be removed by drenching in July, in the winter. But if the drenching is delayed until August/September, the retarded larvae will have resumed development, and there is almost no risk of reduced susceptibility to treatment. By then, some of the larvae will already have matured and started laying eggs, but there are indications at present that, at least on the Transvaal Highveld, these ova will either not develop at all, or else be delayed in development and not give rise to infective larvae before the beginning of summer[26].

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Another variation of preventive treatment is suppressive drenching, also termed "protective" drenching. In this approach, verminosis is suppressed when it becomes an immediate threat to the animal. The most important difference from other methods of strategic drenching, is that treatment is delayed until the worms have substantially contaminated the pasture and are accumulating in the host. Treatment therefore suppresses the parasite in the host, before it can do significant damage.

The suppressive treatment is commonly applied as continuous low-level administration of the drugs (in licks, or by means of slow-release devices) or as repeated drenchings at intervals as short as every 2-3 weeks while the worm threat remains.

This form of control can be very effective[2], but is dependent on the intensive use of drugs, thus considerably increasing the chances of selection for anthelmintic resistance[13].

The purpose of drenching particularly ewes before introduction of the rams, is to increase their fertility, which may be reflected in an increase in the number of lambs born per ewe, or in the number of animals that conceive, or both.

As discussed by Donald[5], it has been widely accepted that a pre-mating drench will improve the fertility of the animals. However, after reviewing the results of 81 trials, Brunsdon et al[3]. conclude that the results were very erratic, and that, if anything, only the number of twins increased and not the percentage of ewes that lambed. The possibility is mentioned, however, that better results could be expected if the ewes are heavily infected at the time of mating.

For New Zealand, Brunsdon et al.[3] do not recommend a drench at mating at all, unless it is possible to move the animals to safe pastures afterwards. Furthermore, owing to the relatively poor ability of lighter ewes to produce twins, they point out that it will probably also not be economical to drench only these lighter animals in the flock.

Unfortunately, we have insufficient local data to indicate whether a pre-mating drench would be beneficial in South Africa. However, *H. contortus* (the predominant helminth in most of the summer-rainfall regions of South Africa) has a far greater ability to propagate itself than the *Ostertagia* (= *Teladorsagia)* spp. that predominate in New Zealand. Therefore, it seems unlikely that we in South Africa shall have any better results if the ewes remain on contaminated pasture after having been drenched.

As discussed by Brunsdon[2], young suckling lambs are exposed to larvae from 2 main sources, namely infection originating from contamination of pastures by the ewe, and from residual larvae on pasture, e.g. from those which have survived the winter. After weaning, outo-infection also occurs, owing to the development of worm ova voided by the lambs themselves.

The sheep ewe is the main source of infection of the lamb. Owing to the phenomenon of peri-parturient relaxation of resistance, the ewe becomes more susceptible to infective larvae on pasture, adult worms are expelled more slowly, and mature worms also produce more ova than in less susceptible animals[15]. Hence, in the past it was reasoned that peri-parturient drenching would pay dividends both on account of a decrease in the likelihood that lambs would become heavily infected, and in improved milk production by the ewe, which in turn could lead to improved production in the lamb. However, at least for New Zealand, it has been found that these advantages are not realised unless the animals can be spelled to safe pasture at drenching[3,6].

In the absence of specific investigations, the situation is unclear in South Africa. However, wireworm is such a prolific egg-layer and it is so pathogenic in the summer-rainfall region, that sheep may die unless salvage drenching is applied to animals that cannot be moved to safe pasture.

On condition that lambs are not weaned late, drenching trials involving suckling lambs have thusfar shown almost no advantage for drenching, compared to lambs left undrenched. Brunsdon et al[3] go so far as to say that, irrespective of the extent of the peri-parturient rise in faecal egg count in the ewe, worm infection will not affect the production of the suckling lamb if it is weaned no later than the age of 12 weeks. However, these recommendations are also based on trials in New Zealand, where brown stomachworm predominates. The more pathogenic wireworm of South Africa, may necessitate drenching to prevent ruinous losses in those instances where the ewes and their lambs cannot be spelled to safe pasture.

Weaners, usually the most susceptible class of animals on a farm, must be drenched and moved to safe pastures for optimal production. In New Zealand, susceptible young lambs and calves contribute 5-10 times as much as adult animals to the total pasture contamination in autumn, when heaviest contamination of pastures occurs. Despite this fact, Brunsdon et al.[3] recommend no drenching at weaning to New Zealand farmers, unless a move to safe pastures is possible. Instead, if the sheep cannot be moved, 3 drenches are recommended after weaning, commencing at the start of the worm season and not necessarily at weaning.

Once again, in the summer-rainfall regions of South Africa it may be necessary to dose particularly spring lambs at weaning, even if the animals cannot be spelled, or else run the risk of heavy losses.

Owing to the risk of anthelmintic resistance, intensive suppressive drenching of set-stocked weaners is to be avoided, if at all possible.

TACTICAL DRENCHING

Tactical drenching ("drenching by the weather")[7] consists of preventive drenching when an excessive accumulation of worms is to be expected, e.g. after good, soaking rains when the climate is suitable for development of the free-living worm stages on pasture.

Usually, tactical drenching is used to support the strategic drenching programme for those periods when the set drenches are not sufficient for the expected worm challenge.

With an erratic rainfall (as occurs in most parts of South Africa) the fixed strategic programme cannot be conprehensive enough to allow for substantial worm challenge after spells of good rain, unless drenching is so intensive that a large risk is run regarding the development of anthelmintic resistance.

Depending on the timing, tactical drenching can be either preventive (e.g. at the time that the climate first becomes favourable for the accumulation of worms on pasture), or suppressive, after considerable numbers of infective larvae have already become available on pasture.

No hard and fast rule can be laid down for the timing of tactical drenches. For instance, rainfall over a number of days, is more dangerous for worm infection than a similar amount of rain on a single day. Local conditions, farming types and managerial practices also play a role, e.g. the species and class of animal concerned, the possibility of spelling pasture, etc. A severe drought is often followed by an abundance of infective larvae on pasture after the first good rains. In general, it is advisable to drench tactically after good rains have fallen over a period of 15 to 30 d and then to move the animals to safe pastures, if possible. The drenching should commence about 3 to 6 weeks after the start of the good rains, and the course of the infection in the animals should be monitored by means of the faecal worm egg counts, to guard against overwhelming infections.

In time, experience should indicate the best control systems for each farming enterprise and managerial system.

DRENCHING PROGRAMMES (SHEEP)

It seems likely that in the more extensive

Table 1 **Drenching programmes suggested by 3 authors for sheep in the non-seasonal rainfall regions of the RSA**

Rossiter (22)	Muller (17)	Reinecke (21)
July	-	-
August	August	-
September	-	-
-	-	November
December	December	-
March	March	March

Table 2: **Drenching programmes suggested by Reinecke [19 20 21] for sheep in the winter-rainfall region**

Programme 1	Programme 2	Programme 3	Programme 4 **
-	January	-	-
March	March	March	March
May	-	-	-
July	-	-	-
-	October	October	-
-	-	-	November

** - This applies to adult sheep; lambs should be dewormed when 4 months of age and in November/December, but not in March; Nasal worm should be controlled in May and September

farming areas, multiple camps may be an important aid to worm control, if the animals need not return to a given camp for at least 8 to 10 weeks. Under such conditions, it may be sufficient to drench 2 or 3 times at the time of pasture spelling during the worm season, if sufficient camps are available. On the other hand, given fewer camps, it may be necessary to drench more often. Integrated control systems have however, not been tested in South Africa.

Take note that, although not supported by a recent report[30], some investigators maintain that selection for worm resistance may be very severe in the drench-and-move control system unless the drenching is extremely effective[6 11 13]. The solution is to monitor regularly the efficacy of drenches used at the time of pasture spelling.

1. SUMMER-RAINFALL REGION

Conventional drenching programme[19]

Drench in:

May (before winter)
September (after winter)
December (mid-wireworm season)
January (mid-wireworm season)

SUMMER-RAINFALL REGION

Programme containing drugs with a residual action:

Drench in:

May	: Drug with short action
August/September	: Drug with short action
End November	: Drug with residual action
December/January	: Drug with short action
End of January	: Drug with residual action

For more intensive conditions, a modified programme is suggested in which both short- and long-acting drugs are drenched in September, November and at the end of January, and a short-acting drug alone at the end of March.

Drugs with residual efficacy against wireworm are e.g. closantel or disophenol, each at 10 mg kg^{-1}. These drugs continue to remove incumbent worm infections for at least 7 weeks after having been administered to the animals. If closantel is used at 5 mg kg^{-1}, or if the animals are anaemic, it will be necessary to drench more frequently in mid-summer.

2. NON-SEASONAL RAINFALL REGIONS

The most important worm species in these regions are *Ostertagia* (= *Teladorsagia)* spp. and *Trichostrongylus* spp. Although *H. contortus* is also present, it is less important than in the summer-rainfall region[17].

Drenching programmes have been suggested by Rossiter[22], Muller[17] and Reinecke[21] (Table 1).

3. WINTER-RAINFALL REGIONS

As in the non-seasonal rainfall region, brown stomachworm and bankruptworm are the dominant species, and in general, wireworm is usually less important. However, there has been a recent report of marked losses in sheep production in this region when a strain of wireworm, but not brown stomachworm, became resistant to ivermectin (unpublished data). In this case, the removal of competition from brown stomachworm apparently favoured development of the wireworm.

Reinecke has suggested 4 different drenching programmes for the winter-rainfall region (Table 2). One possible reason for his drawing up so many different programmes, is the dearth of information regarding the epidemiology of gastrointestinal nematodes in this region.

4. SEMI-ARID REGIONS

a) **Karoo** While wirewom, long-necked bankrumptworm and, possibly, nodular worm are the most prevalent worm species in the eastern Karoo, only bankruptworm and long-necked bankruptworm are common towards the west. It appears that long-necked bankruptworm is suppressed by wireworm; as the latter increases progressively from west to east, the occurrence of the former decreases[27 28].

Viljoen[27 28] suggested 2 different drenching programmes for routine use in this region (Table 3), but particularly in the drier western part of the Karoo it is probably not necessary to follow a routine drenching programme at all (except in times of particularly good rainfall) unless 2 or more relatively good rainy seasons should occur consecutively.

Table 3: **Drenching programmes suggested by Viljoen[27 28] for sheep in the semi-arid rainfall regions in the Karoo**

Programme 1	Programme 2
March	-
-	April
July	-
-	-
-	September
March	December

b) **Kalahari** In a survey by Biggs & Anthonissen[1], wireworm and nodular worm were found to be the most prevalent, but relatively few worms were encountered, possibly owing to a control programme followed before the survey on the farm commenced.

They suggested drenching in: October (for worms and *Oestrus ovis)*, and in April/May, after the first frost.

DRENCHING PROGRAMMES FOR CATTLE

It should be borne in mind that, in general, cattle are better able than sheep to develop immunity to reinfection by most worm species. Therefore, particularly for adult cattle, drenching programmes are generally not as necessary as for sheep, as the cattle are, to a large extent, able to control worm infection without being drenched.

On the other hand, young beef and dairy cattle may acquire heavy worm burdens during their first year at pasture[9]. Newly-weaned calves are considered to be the most important source of pasture contamination in a beef herd[9].

1. SUMMER-RAINFALL REGIONS

The most important worm species are wireworm, cattle bankruptworm, nodular worm, and, to a certain extent, hookworm[18].

Although Reinecke[21] suggested drenching in March, May and September, (except for the more susceptible classes of cattle, e.g. weaners) it may not be necessary to drench adult cattle at all if they are in good condition and gaining weight satisfactorily. Faecal egg counts should be routinely monitored to ensure that the cattle are not subjected to unacceptable levels of parasitism.

Weaners and Dairy Replacement Heifers

Worm control in newly weaned beef calves should focus on prevention of infection in the immediate post-weaning period, as a small number of strategic treatments at this time can reduce pasture contamination and the consequent accumulation of larvae on pasture[9].

Replacement dairy heifers also merit special consideration in worm control[9]:

Owing to shrinking profit margins and increasing costs of drenching cattle, faecal egg counts will most probably become progressively more important as an aid to gauging the necessity for drenching. The practitioner should therefore be prepared to supply this service to his clients.

2. WINTER- AND NON-SEASONAL RAINFALL REGIONS

For the winter-rainfall region Reinecke[21] recommends drenching in: April, July and November.

Once again, the practitioner should use routine faecal worm egg counts in order to decide on the necessity of drenching at such a high frequency. Infections with particularly brown stomachworm, may reach important levels.

GENERAL FACTS ON THE USE OF ANTHELMINTICS

It is essential that the practitioner is completely conversant with the properties of the anthelmintics in order to advise the clients properly.

It is important also to know the different anthelmintic groups (based on their modes of action), in order to be able to give advice on the correct alternation of anthelmintics.

As important as knowing the spectrum of efficacy of a given drug, is knowledge of those worm species that are not controlled. For example, the drugs that have a residual action against wireworm and hookworm, are very valuable in any drenching programme, but they are unable to control bankruptworm and nodular worm, as well as hypobiotic larvae of wireworm.

OTHER FORMS OF WORM CONTROL

Some successes have been obtained with worm control by vaccines, and by breeding animals that are genetically able to resist infection more effectively than the average member of a given breed. However, none of these methods can as yet be used in practice for control of gastrointestinal nematodes in sheep and cattle.

CONCLUSION

In South Africa little work has been done to determine the efficacy of integrated worm control in practice. In fact, it is not even known which, if any, of the basic principles apply to the prevalent worm species in this country. On the other hand, much time and labour will be required to test even the most important principles, and meanwhile there are reasonable indication that the system can be applied to good effect.

The solution to worm control lies in giving an intensive service to the client.

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INTEGRATED WORM CONTROL AS A STRATEGY IN THE CONTROL OF GASTROINTESTINAL NEMATODES OF SHEEP AND CATTLE

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Over the past 3 decades a great deal of information has accumulated on alternative methods of control of helminth infections that could extend the useful life of anthelmintics.

In this paper the use of various managerial practices for worm control is considered.

Most nematode species of domesticated ruminants are reasonably well-adapted to their natural hosts, and large-scale deaths of animals are uncommon in nature. Increased production of production animals has often resulted in an upset in the balance of the host-parasite relationship, usually in favour of the parasite[11], and decreased the ability of the farmer to incur indirect losses from suboptimal farming. Improvements of pasture through irrigation increases the chances of survival of the free-living stages of the parasitic helminths, while increased grazing pressure increases the rate of pasture contamination with worm eggs, and the degree of reinfection of the grazing host. Practices such as farming exclusively with either sheep or cattle have further added to the problem of worm infection. Furthermore, animals have been bred for increased production without consideration being paid to their susceptibility to worms, and breeds of animals have been introduced to regions where they have not occurred previously. These potential dangers were unrecognised because of the expectations raised by an increasing number of drugs that were highly effective against a growing number of worm species.

Anthelmintic resistance, however, soon developed and increased to the extent that today some researchers fear that we may return to the era before the advent of safe and effective drugs[3].

PROBLEMS IN WORM CONTROL

Almost all sheep and cattle must be regarded as being continually infected with helminths, and contamination of the environment is continuous[12]. Both sheep and cattle develop immunity to reinfection, but particularly in sheep it is by no means solid. It may fluctuate due to changes in the availability of larvae on pasture and to periods of reduced resistance, such as the so-called "PPRR" or peri-parturient relaxation of resistance[13].

This situation of continuous, but fluctuating levels of infection complicate attempts at worm control, since prevailing weather conditions may cause a flare-up in the infectivity of the pasture within a short time. Secondly, the day-to-day decisions on both the timing and the type of worm control measures to take become extremely difficult for any person not well-versed in helminth epidemiology.

CONTROL POSSIBILITIES

Basically, worm control implies separation of the host from the parasite. This can be achieved by means of the following possibilities:

removal of the hosts from the infested pasture;
removal of the worms by drenching the host; or by
making the host biologically inaccessible to the parasite, e.g. by breeding for resistance to infection or stimulating immunity to reinfection, resulting in the host rejecting the parasite.

INTEGRATED WORM CONTROL AND THE ROLE OF MANAGERIAL PRACTICES

The term "integrated worm control" has a special connotation today, namely different forms of rotational grazing, with or without anthelmintic drenching at the time of withdrawal of the livestock from the pasture. It is mainly based on 2 phenomena: the adult worm does not have a long lifespan in the host, and the worms' free-living stages on pasture, develop at different rates during the various seasons of the year.

1. Short life expectancy of the adult worms

With the aid of a series of trials, it has been estimated[19 20] that adult brown stomachworms of cattle (*Ostertagia ostertagi)* have a mean life expectancy of only 28 d under the conditions of reinfection that usually prevail in the field. To what extent these findings can be extrapolated to other worm species is uncertain, as insufficient work has been done to confirm this observation. However, as reviewed by Donald & Waller[10] and Behnke[6], it appears that adult *Ostertagia circumcincta* (= *Teladorsagia circumcincta,* the adult brown stomachworm of sheep) and also *Haemonchus contortus,* the wireworm of sheep, are possibly similar, and that adult bankruptworm *(Trichostrongylus* spp.) may have a longer life expectancy.

The rapid rejection of adult worms has the effect that drenching with anthelmintics merely removes worms that would have died soon in any case. The epidemiological effect of drenching is therefore very small, except in the case of long-lived worms. Furthermore, unless the hosts are removed from the infested pastures when they are dewormed, reinfection usually takes place rapidly, with the result that drenching is of limited value. In the case of heavy infections, however, drenching may be essential in order to save the lives of the animals. But it should be kept in mind that by the time the worm burden becomes life-threatening, a substantial, unacceptable loss in productivity has already occurred and the pastures are heavily contaminated. This should be avoided by initiating control measures much earlier. The solution is to remove the animals from the infective pasture at the time of drenching, as discussed in greater detail below.

2. The "concerting effect" of development of free-living worm stages on pasture

It has been known at least since the turn of the century that free-living worm stages on pasture develop at different rates during the different seasons of the year[1].

3. Hypobiosis, or retarded development of worms in the host

Retarded development is another phenomenon that plays an important role in the annual cycling of worm generations between the pasture and the host.

In the presence of unfavourable conditions for the free-living stages of worms on pasture (e.g. low temperatures, particularly when accompanied by low moisture), the larvae ingested by the host do not develop as usual to adulthood, but become retarded until conditions on pas-

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ture are more favourable. Horak[16] for example found that more than 70% of the wireworm larvae that became established in the host from February until the end of the winter were hypobiotic, and resumed development only with the advent of spring.

The combined effect of the concertina phenomenon during winter and spring, together with hypobiosis in autumn, is that *H. contortus* and *O. circumcincta* cycle much more slowly than was previously believed. Consequently, far fewer worm generations occur annually than the theoretical minimum estimated from the prepatent period and laboratory experimental work. Even at the height of the worm season, development of the majority of free-living worm stages on pasture is not nearly as rapid as the theoretical minimum obtained in the laboratory. In the case of *O. ostertagi,* Michel[19 20] estimated from an extensive series of trials, that only one main worm generation occurs annually in cattle in Britain. Michel[19 20] also realised that, despite the fact that worm ova accumulate on pasture during times of slow development (e.g. spring), the pasture is not then infective to the host. Thus the pasture is **contaminated,** but **not infective** in spring, and can at this time be used with almost complete safety for even the most susceptible of animals. Furthermore, in the relatively stable climate of Europe and Britain, the pasture becomes "dangerous" (infective) at much the same time from year to year.

In atypical seasons (such as those with abnormally high rainfall or when drought prevails or when unseasonal changes in temperature occur), the routine control programme must be adapted, e.g. by making more or less use of anthelmintics at the time of removal of the livestock to safe pasture, or by spelling earlier than in "normal" years. Control also needs to be adjusted in regions where more than one main worm generation occur annually, usually by spelling more than once to safe pasture during the worm season.

In the warmer climate of the summer-rainfall regions of South Africa, integrated worm control has not been sufficiently investigated, but there are indications that more than one main worm generation may be expected to occur. On the other hand, it seems unlikely that more than 2 or at most 3 main generations will occur here, except in the warmer, relatively moist regions such as the Transvaal Lowveld. On the Highveld of the Transvaal, for instance, there is a substantial degree of hypobiosis in autumn and winter. Reinecke[25] showed slow development of *Haemonchus placei* in faecal pats of cattle during autumn and winter in the northern Cape. In addition, it has been shown repeatedly that, as in Britain, the pastures on the Highveld of the Transvaal are uninfective in spring[15 16], despite substantial differences in the climate and the principal worm species. Thus, there is only a short period during which development takes place "unhindered", and it can be expected that no more than 2 main worm generations will occur.

PASTURE SPELLING, THE CORNERSTONE OF INTEGRATED CONTROL

Pasture spelling, also called rotational grazing, comprises the resting of pasture until the free-living worm stages no longer constitute an immediate threat to the host.

There are various ways in which this reduction in pasture infectivity can be achieved:

classical pasture spelling;
alternation of different host species on pasture;
alternation of susceptible and insusceptible hosts of the some species;
alternation of pasture and crop aftermaths;
combined alternation of crops and different animal species; and
creep grazing for young animals.

A. CLASSICAL PASTURE SPELLING[27]

In its most elementary, original form, worm control by means of rotational grazing comprises the withdrawal of susceptible hosts from the pasture until the free-living stages of the worms have succumbed to aging and exposure, before the animals are replaced.

The system is almost universally rejected today as of no practical significance for worm control[19 20 24]. It should, however, be kept in mind that condemnation of the system was based mostly either on trials or on theoretical considerations that apply under intensive farming conditions.

The possibility remains that classical pasture spelling may be a practical method of control in the more extensive farming conditions of large tracts of the summer-rainfall regions of South Africa. Factors favouring worm control by means of classical pasture spelling under such extensive conditions, are a low and very erratic rainfall and therefore slow pasture growth and sparser plant cover. Under these conditions the free-living stages of the worms, which are largely dependent upon both moisture and shade for survival, are more exposed to adverse climatic conditions and can be expected to succumb sooner than under more intensive conditions. Furthermore, for optimum production, the vegetation requires long rest periods which can probably be put to very good use for worm control.

IMPROVED PASTURES

It is understandable that simple rotational grazing cannot be practical under intensive farming conditions. Withdrawal of animals for longer than 3 weeks, causes the pasture to grow too vigorously and this is not economical, since the animals then trample and destroy more than they can eat. Also, the pasture production becomes reduced and therefore suboptimal if the foliage becomes overdeveloped. Add to this the fact that free-living worm stages live for months in the near-ideal conditions created by the improved pastures, and it becomes obvious that resting of the pasture for periods long enough to promote worm control under intensive conditions, leads to suboptimal use. It should also be kept in mind that when considered agronomically, optimum use of pasture is usually more important than worm control, as well-fed animals usually have a relatively strong ability to withstand the effects of worm infection[12].

Droughts

Illogical as it may seem, extreme droughts may, under certain circumstances, also favour survival of the worms on pasture.

The bovine faecal pat, and to a lesser extent the sheep pellet, offer the free-living worm stages protection in the form of moisture and shade. Under "normal" rainfall conditions, there is little accumulation of faecal pats, as there is sufficient regular rain to soak the faecal pats that escape the attention of dung beetles, causing them to soften and disintegrate. The entrapped worm larvae are set free and so lose their shelter. However, in the absence of rain, faecal pats accumulate and entrap large numbers of free-living worm stages that are unable to escape. With the advent of the first good rains after the drought, very large numbers of larvae may be set free within a short period of time, often with dire consequences. The hosts are usually in poor condition and therefore more susceptible to worm infection and the losses may be serious. Over a particularly dry period in Australia, larvae from eggs that had been deposited on pasture under natural conditions by infected calves, survived for as long as 18 months, appearing on pasture in large numbers after the drought had been broken by good rains[5]. In South Africa some of the most serious outbreaks of verminosis have also been experienced after long periods of drought[25].

B. ALTERNATION OF ANIMALS OF DIFFERENT SPECIES

The most obvious approach in the search for alternatives, is the alternate use of pasture for animals of different species which are not susceptible to one another's worm parasites.

For such a system, the available pasture is divided into 2, each half of which is used alternately for grazing of e.g. sheep and cattle or horses. Alternation of the animals occurs infrequently, e.g. anually as in Europe[2]. If sufficient camps are available, rotational grazing can be applied on both halves.

In effect, this system provides for the pastures to be utilised optimally, while at the same time allowing sufficient time for the free-living worm stages to become reduced in numbers. Parasites die from aging and exposure to adverse conditions on pasture, while larvae that are ingested with the grazing by the alternate host species are unable to develop and also die. It should be noted, however, that this process cannot be likened to a vacuum cleaner: larvae are ingested in relation to the amount of foliage ingested, and are by no means selectively removed[19 20]. It may even happen that proportionately fewer larvae are removed if the pasture is well-developed. The infective worm larvae may occur in higher concentrations close to the ground than higher up on the foliage and if cattle (for instance) do not graze close to the ground, they will remove proportionately fewer larvae than when forced to do so, as on close-cropped pasture.

Most of the common worm species of sheep and cattle are reasonably host-specific, with the result that alternating grazing is certainly practical under certain circumstances[24]. Morley & Donald[24] maintain that, while there is almost no cross-infection in the case of the genera *Ostertagia, Oesophagostomum, Nematodirus, Bunostomum,* and *Cooperia* and while intestinal *Trichostrongylus* spp. are less infective for the alternate hosts, or live for shorter periods of time, there is little difference in the infectivity of *Haemonchus* spp. and *Trichostrongylus axei* for sheep and cattle. Helle[14] showed that, while alternation of sheep and cattle as seldom as once per year had a dramatic control effect on *Ostertagia* and *Nematodirus,* in Norway the genera *Haemonchus, Trichostrongylus* and *Cooperia (C. curticei)* were hardly affected.

H. contortus (wireworm of sheep) is by far the most important of the gastrointestinal roundworms of sheep in the summer-rainfall regions of South Africa. Thus the opinion of Morley & Donald[24], shared also by Gordon[13], that alternation of sheep and cattle is unlikely to be of practical use for the control of wireworm, is of paramount importance to us.

It is however, by no means a foregone conclusion[7] that alternation of sheep and cattle will not be of practical significance for worm control in South Africa and this aspect should receive a high priority in local research.

Resting periods required for the pasture

Trials at Armidale in Australia, which has a rainfall pattern with no overall seasonal effect, showed that residual infestation on pasture was substantially reduced after 6 weeks in the case of *Haemonchus* and *Trichostrongylus* spp. However, 12 weeks were required for *Ostertagia* spp. and as long as 24 weeks for *Nematodirus,* in order to obtain a similar effect[7].

Very little is known of resting periods necessary for worm control in South Africa, and withdrawal periods on improved pastures will probably need to be at least as long as those at Armidale.

C. ALTERNATION OF SUSCEPTIBLE AND MORE RESISTANT ANIMALS OF THE SAME SPECIES

It is known that cattle in particular, but also sheep to a certain extent, develop resistance to worm infection. Older animals are usually less susceptible to worm infection than younger ones, as demonstrated by lower percentages of development of worm larvae that are ingested, as well as by lower egg production in those worms that do manage to develop to adulthood[19 20]. Consequently, it has been shown to be beneficial for worm control to alternate susceptible and more resistant animals of the same species on pasture. The results are not as dramatic as those obtained with different host species, but the system has been demonstrated to be useful in New Zealand[7]. This difference in susceptibility is not necessarily related to age, as is shown by the heavily pregnant and lactating ewe, that temporarily becomes susceptible to infection again[7].

In practice, lactating ewes and lambs, which are very susceptible, often form the largest proportion of the stock on the farm, with the result that there are insufficient "resistant" animals for optimal utilisation of the available grazing which has become unsafe for susceptible animals. For example, in Australia it has been stated that breeding ewes are responsible for 60 to 90% of the total sheep grazing pressure, and the only way in which safe grazing can be provided, is by reducing the grazing pressure to suboptimal levels[24]. It may then be necessary to manipulate the proportions of young and older animals, e.g. by keeping more wethers or by marketing beef cattle at a later stage[24]. In South Africa, fat lamb production may contribute to effective integrated worm control, as the lambs are often marketed from the dams at weaning, with the result that they are removed from the pasture before they are exposed to excessive levels of infection in the post-weaning period. Weaners are possibly the most susceptible class of sheep on the farm and they constitute an important source of pasture contamination. However, under intensive farming conditions (where conditions are optimal for propagation of gastrointestinal nematodes) or with delayed weaning, worm burdens may overwhelm the lambs while still suckling[20], unless timely remedial measures are instituted. The sooner lambs can be marketed, the less the pastures will be contaminated, the less anthelmintics will have to be used, and correspondingly the less selection pressure for anthelmintic resistance should occur.

D. ALTERNATION OF PASTURE AND CASH CROPS

It has been shown in Australia that *Ostertagia* spp. can be effectively controlled in calves by drenching at weaning, and a move to pastures that were spelled or only lightly grazed during the preceding autumn and winter[24]. But at this time of the year there is a critical shortage in feed flow, making it almost impossible to rest pastures. Much the same conditions can probably be expected in the winter-rainfall regions of South Africa.

A possible solution is to use crop aftermaths (stubble lands) as safe grazing. Indeed, such aftermaths have been found to be practical for worm control, but the following points need to be kept in mind[24]:

a) There is seldom sufficient crop aftermath to accommodate all the susceptible animals. It also requires most careful planning to have this pasture available when required to move susceptible animals from other pastures that have become helminthologically unsafe. Furthermore, the requirement for safe pasture is dependent on the type of farming enterprise applied. For example, pastures that are ample for dairy calves, may not be sufficient for beef calves that run with their dams.

b) Not only the **quantity**, but also the **quality** of the stubble pasture is of paramount importance. The young, highly susceptible animals are also those that require the best quality grazing for optimum production. After all, the system is useless if the susceptible stock is effectively protected from worm infection, but do not grow satisfactorily due to malnutrition.

E. COMBINED ALTERNATION OF ANIMAL SPECIES AND CASH CROPS

Excellent worm control can be achieved by dividing a farm into 3 parts[2], for annual rotation of sheep, cattle and either cash crops or veld conservation. In this way it is ensured that sheep and cattle move annually to pasture that should be practically completely safe.

Given the relatively dependable rainfall

in Europe, this system will probably hold at least as much promise under warmer climatic conditions with more erratic rainfall, as in South Africa. On the other hand, particularly in the summer-rainfall region of South Africa, important differences in prevalent worm species and in the length of the worm season occur, and extensive investigations are needed before this system can be recommended locally.

F. SIDEWAYS AND FORWARDS CREEP GRAZING

Two further refinements of classical pasture spelling are the so-called "forwards creep grazing" (where lambs or calves are grazed ahead of the dams, which follow them directly on the same pasture); and "sideways creep grazing", in which young animals have access to adjacent pasture that is not accessible to the dams. In the latter system, it is accepted that the young animals will prefer the creep grazing, and will therefore not graze together with their dams[19].

Both forms of creep grazing have the theoretical advantage that the young animals can graze the pasture when the foliage is still intact and most nutritious, and are exposed to relatively low levels of worm infection. On the other hand, a disadvantage is that the system is managerially complex and therefore relatively difficult to apply.

INTEGRATED WORM CONTROL IN PRACTICE

Integrated worm control consists of combinations of different control systems, usually including drenching with anthelmintics and different forms of pasture spelling. The animals are usually drenched at the time of changing of the pasture, and it is advisable to keep them overnight in a kraal before the move, so that most worm ova may be excreted in the kraal and not on the safe pasture.

A system that is dependent on rotational grazing, can only be applied if sufficient camps are available. A potential problem is that integrated worm control is generally difficult to apply. Worldwide, researchers and advisers to the farmer have complained that farmers either refuse or are unable to apply systems of control that are developed by helminthologists[17 18]. This is understandable, however, since the majority of the control strategies devised for worm control, require a considerable effort on the part of the former and they are usually too complex for the poorly-informed person to comprehend. After all, it is much easier to drench animals with readily available anthelmintics than to apply management practices that require insight and meticulous planning.

The recent practice whereby farmers are intensively advised on the whole spectrum of farm and disease management by private practitioners in association with pasture scientists, may present a solution to the problem Even though these practitioners may not be able to remain sufficiently well-informed in the field of helminthology to render a fully satisfactory service (especially as multiple drug resistance makes worm control more problematical), it is much more practical for the few helminthologists to advise these consultants, than to attempt to give a comprehensive service to every farmer. A growing number of practitioners could reach more and more farmers with sound advice on worm control. As existing practitioners become better-versed in the intricacies of modern worm control methods, only newcomers in this field need be trained intensively.

In general, the helminthologist knows too little about farm management systems to apply the available knowledge on worm control to the best advantage. The modern practitioner in preventive medicine, by contrast, has a very good working knowledge of farm management systems to apply the available knowledge on worm control to the best advantage. The modern practitioner in preventive medicine, by contrast, has a very good working knowledge of farm management, but lacks specialised knowledge of helminthology. Their combined efforts should supply the farmer with the necessary practical advice for effective worm control, without undue risk of the development of drug resistance.

Perhaps computer technology, such as is already available to a limited extent in tick control, will supply the necessary support for this approach. In time it may be possible to develop worm control programmes which will allow the practitioner to key in particulars about the farm management systems, the animals species, breed and class of animals, climate, vegetation, pasture availability etc., and then receive a printout of a suggested worm control programme. Unfortunately, at present this is not possible, due to inadeuqate information. None of the worm control programmes at present propagated in South Africa has ever been tested under realistic field conditions[26].

SPECIAL CONSIDERATIONS FOR WORM CONTROL

Certain aspects of worm control in practice merit special consideration:

1. **Earth dams.** Cobb[9] recommended that earth dams should not be used as watering points for animals, but that the dams should be fenced off and the water be piped to drinking troughs. In South Africa, this has also been the standard recommendation for more than half a century, because the water in the dams or pans often contains worms, the soil bordering on the dams or pans is always wet, and conditions are exceptionally favourable for the hatching of worm eggs and survival of the larvae. Sheep should be watered from suitable troughs, preferably fed by bore-holes or springs; otherwise dams should be fenced in, and the water led from them through pipes[28]. Sadly, this advice has too often fallen on deaf ears, and has not been implemented.

2. **Vleis.** These marshes that are quite common in certain regions in South Africa, jeopardise control of parasitic helminths, unless they are properly managed. The vlei is often valuable pasture, but it provides an ideal environment for trematodes, as well as nematodes, such as *H. contortus,* which is the most important nematode in the summer-rainfall regions.

On most properties, the vleis cover only a small proportion of the available pasture. This makes it possible to put this grazing to good use, without creating insurmountable helminthological problems.

The vlei should be fenced off and included in the rotational grazing system, for alternative use by different host species; or for susceptible/insusceptible animals of the same species; or even for different flocks or herds of a given species. Careful selection of the time of alternation of the animals (e.g. at the end of spring on the Highveld of the Transvaal) should faciliatate nematode control without having to rely too heavily on drugs. At the end of spring, the pasture is heavily contaminated with free-living worm stages, and is on the point of becoming dangerously infective, and an alternation at that time will remove the susceptible hosts before they are exposed to heavy infection.

3. **Intensive grazing.** Intensive grazing does not invariably lead to larger worm burdens, because the improved nutrition, associated with improved pastures, reportedly leads to greater resistance in the animal to the worms and their harmful effects[11 12]. However, in South Africa it can safely be said that improved pastures under irrigation have had a far-reaching effect on the development of worm resistance to anthelmintics. Most of the cases of resistance to the modern drugs, originated on improved pastures, mostly under irrigation[28 29 30].

Improved pastures cannot be left ungrazed for long periods under intensive farming conditions, and the optimal resting time for these pastures between grazing spells, is too short for the control of the common nematodes of ruminants. Consequently, worm control on such pastures is totally dependent on drugs,

and selection pressure for resistance becomes excessive. However, there is a further complicating factor: the improvement of pastures is capital intensive, and the farmer, anxious to protect his investment, is inclined to drench sheep excessively. There are instances where the animals are drenched every 3 weeks throughout the year, leading to a most severe selection pressure for resistance[30]

At present there is no easy solution to this problem, but the alternation of sheep and cattle or susceptible/relatively insusceptible animals of the same species on the pasture may be practical.

4. **The burning of pasture as a method of worm control.** While it seems logical that the heat of burning should reduce the numbers of free-living stages, the author has as yet not been able to find any experimental proof of this theory. Larvae apparently migrate up and down the vegetation, in the presence of moisture and light, and therefore many of them should be destroyed by fire[4]. On the other hand, larvae are also found in the mat under the foliage and in the soil, where they are unlikely to be reached by the heat.

5. **Game as a possible complicating factor in worm control.** Many of the common gastrointestinal nematodes of sheep and cattle are also encountered in game[8 16 21 22]. The most important of the worm species involved, are the wireworm *(H. contortus),* nodular worm *(Oesophagostomum columbianum),* hookworm *(Gaigeria pachyscelis),* bankruptworm *(Trichostrongylus* spp.), white bankrumptworm *(Strongyloides papillosus)* and certain tapeworm species that are encountered e.g. in blesbok and/or impala[16]. These worm species are sometimes maintained in game in the absence of sheep.

In every worm control programme that is drawn up, it is essential to consider the presence of game that can serve as a reservoir of infection, and may ostensibly jeopardise an otherwise effective control programme.

CONCLUSION

Some of the methods of integrated worm control, appear to hold much promise, both for limiting the harmful effects of worm infection and for slowing down the development of worm resistance to the available anthelmintics. However, it is obvious that a great deal of work needs to be done to gauge the applicability of the most promising methods of control under our conditions, and to fully adapt them to the different regions of the country.

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