SA ISSN 0038-2809

# Journal of the South African Veterinary Association

# Tydskrif van die Suid-Afrikaanse Veterinêre Vereniging



December/Desember 1989

Volume • Jaargang 60 No. 4

Deticking black rhinoceros

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**December/Desember 1989** **Volume • Jaargang 60 No. 4**

**SA ISSN 0038-2809**
Dewey Cat No. 636.089



**All correspondence:**
The Director,
SAVA, JI S. Afr. vet.Ass.,
P.O. Box 25033,
Monument Park,
0105 Pretoria.
Tel. (012) 346-1150

**Alle briefwisseling:**
Die Direkteur,
SAVV, Tydskr.S Afr.vet.Ver.,
Posbus 25033,
Monumentpark,
0105 Pretoria.
Tel. (012) 346-1150




**Front page/Voorblad:**

The use of a pour-on preparation to detick captive black rhinoceros prior to translocation in Zimbabwe


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# Contents • Inhoud




Geldelike steun deur die Departement Nasionale Op[illegible]ding word met dank erken.
Financial subvention by the Department of National Educ[illegible]on is gratefully acknowledged.

# DIAGNOSING *STILESIA HEPATICA* INFESTATION IN SHEEP

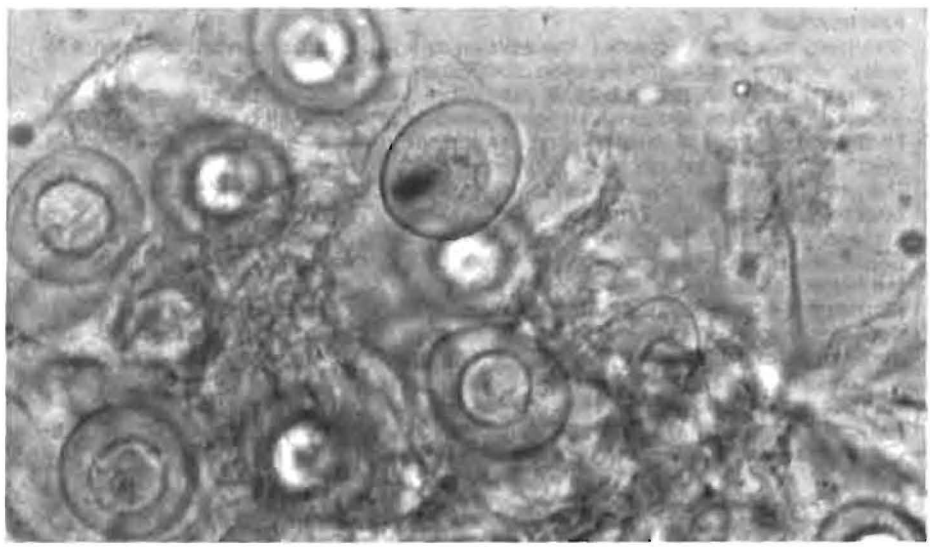
The liver tapeworm, *Stilesia hepatica*, causes economic losses to sheep producers in this country that are difficult to quantify because losses are probably not confined only to the condemnation of infested sheep livers at abattoirs.

The number of sheep livers actually condemned varies from 21,6% at Cato Ridge abattoir during July 1986 (Visser E L, Veterinary Research Institute, Onderstepoort; personal communication), to 43,9% of which 4% were infested with *Stilesia hepatica* at Kuruman abattoir in October of the same year (Bayer Animal Health, unpublished data).

We know little or nothing about the seasonal incidence, host age preference, geographical distribution, life cycle, or pathophysiology (and hence the possible production losses the live animal suffers as a result) of this parasite. There is at present no known cost-effective treatment: praziquantel is effective at high dosages[1] which may be economically justifiable if we knew the opportunity cost (i.e. the cost of not treating).

One of the problems in studying this parasite is the difficulty of diagnosing the infestation in the live animal. In the course of performing efficacy trials, one of us (AvA) succeeded in demonstrating *Stilesia hepatica* eggs in faeces. The technique was as follows:

Approximately 60 g faeces (filling a 100 ml specimen jar) was blended with 200 ml 40% sugar solution. This mixture was centrifuged for 1 minute (centrifuge speed not recorded). The eggs were extracted from the centrifuge tube by touching the meniscus of the liquid with the bottom of a test tube and transferring this drop to a microscope slide. This drop was examined under a coverslip at a 400x magnification. The eggs resemble those of *Avitellina* spp. (see photograph), but the middle albuminous coat which surrounds the embryo, is slightly thicker. At post mortem the sheep from which the faeces had been collected were found to harbour no other cestodes than *Stilesia hepatica*. It is intended to refine the technique.



A F van Amelsfoort and J Schröder; Bayer (SA) Animal Health, P O Box 143 1600 Isando

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1. Schröder J, Van Amelsfoort A F 1988 The anthelmintic efficacy of praziquantel in sheep. Paper read at the Congress of the South African Veterinary Association, 11-15 July, Pietermaritzburg

# HYDROPS FOETALIS IN A MUTTON MERINO EWE

A pregnant ewe (one of a flock of 250 Mutton Merino ewes which were kept in pens and fed silage and a pelleted balanced concentrate with limited access to kikuyu pastures (*Pennisetum clandestinum*)) showed signs of an abdominal distention. The animal became recumbent and died before any surgical treatment could be instituted.

A post mortem examination revealed a grossly enlarged uterine horn and oedema of the placenta. The right uterine horn contained remnants of a reabsorbed foetus. The left horn contained an abnormal male lamb characteristic of *hydrops foetalis*. No other abnormal macroscopical lesions were noted elsewhere in the reproductive tract.

The foetus was approximately 3 months old and showed severe generalised oedema with fluid accumulation in all of the serous cavities. The abdomen was grossly distended and contained a large amount of clear fluid. (Fig. 1) There was severe oedema of the scrotum, head and legs. The lungs were enlarged and oedematous. The liver was congested, enlarged and friable with an irregular surface. The skeletal muscles were gelatinous. On histopathological examination, the kidneys showed bilateral cortical necrosis. No signs of any primary infectious condition were observed.

*Hydrops foetalis* is uncommon in sheep, but has been observed in several cattle breeds. A recessive gene has been identified as the cause in some cases observed in Ayrshires, Swedish Lowland and Fresian cattle. In 1987 Plant et al[1] reported cases of *hydrops foetalis* in sheep in New South Wales, Australia. Over a 4-year period, a total of 39 cases were observed in 4 flocks. The flocks consisted of crossbred ewes mated either to Poll Dorset or Dorset rams. Following replacement of the rams, no new cases were observed. The authors suggested that genetic factors may have been involved.

It can be speculated that a genetic disorder could have played a role in this case, possibly resulting in disturbance in tissue fluid drainage or production. The bilateral renal cortical necrosis may be part of the condition, although agonal shock may also be responsible for this pathological change.

J.A. d'Assonville, Department of Production Animal Medicine; Faculty of Veterinary Science, Medical University of Southern Africa, 0204 Medunsa

**REFERENCES**

1. Plant J W, Lomas S T, Harper P A W, Duncan D W, Carroll S N 1987 Hydrops foetalis in sheep. Australian Veterinary Journal 64: 308-310

Fig. 1: **Foetus from a Mutton Merino ewe with severe generalised oedema and fluid accumulation in the abdomen**

# OVERBERG RESEARCH PROJECTS. I. THE EPIDEMIOLOGY OF PARASITIC NEMATODES IN EWES, SUCKLING LAMBS AND WEANERS

R.K. REINECKE* and J.P. LOUW

**ABSTRACT**

**Total differential worm counts were done on sheep slaughtered from 7 May 1987 to 19 May 1988 at Boontjieskraal Estate in the Overberg, Republic of South Africa. It was found that winter lambs became infested with *Nematodirus spathiger* at 5 to 7 weeks of age. At weaning in October 1987 this species was superseded by *Teladorsagia circumcincta* and *Trichostrongylus rugatus*. Small numbers of *Trichuris skrjabini* and *Oesophagostomum venulosum* were also present. From July to October, 3rd and 4th stage larvae exceeded adult *Teladorsagia* in ewes, and from July to December 1987 and in May 1988 in lambs and weaners. Juveniles exceeded adult *Nematodirus* in ewes from July to October 1987 and in suckling lambs in July 1987 and May 1988.**

**Infective larvae aestivate in the faeces or in the soil of the lucerne pastures in the dry, hot summer months and migrate on to the herbage during the cool, wet autumn. Grazing in summer on wheat stubble and even newly sprouted lucerne is safe, in paddocks ranging from 40 to 60 ha in extent, despite massive daily contamination by weaners with more than 60 million worm eggs. Previously infected weaners underwent spontaneous cure within 6 weeks to 6 months of starting to graze safe pastures, *Teladorsagia* being reduced by 77 to 98%, *Nematodirus* by 9 to 94% and *Trichostrongylus* by 34 to 40%.**

**Key words:** *Teladorsagia, Nematodirus, Trichostrongylus,* **larval aestivation in lucerne pastures, safe wheat stubble, spontaneous cure.**

**Reinecke R.K.; Louw J.P. Overberg Research Projects. I The epidemiology of parasitic nematodes in ewes, suckling lambs and weaners.** *Journal of the South African Veterinary Association* **(1989) 60 No. 4, 176-185 (En) Overberg Research Projects, Department of Parasitology, University of Pretoria, P.O. Box 680, 7200 Hermanus, Republic of South Africa.**

## INTRODUCTION

The only data based on systematic slaughtering of sheep to diagnose the presence of helminths in the winter rainfall areas of the southern hemisphere have been obtained in western Victoria and South Australia[1,2,11] and at Elsenberg in the Republic of South Africa[12].

An experiment was planned at Boontjieskraal, a farm in the Overberg region of the Western Cape Province, to study the epidemiology of nematode parasites, wool production and mass gains of sheep. Comparisons were made between two flocks of Merino sheep and their progeny ($F_1$ and $F_2$), one of which was untreated and the other treated with anthelmintics to reduce worm burdens to the lowest possible level.

The present report is confined to the epidemiology of parasites in the untreated ewes from advanced pregnancy (6 May 1987) until weaning in October 1987, and their suckling lambs and weaners as well as weaners of the treated ewes until 19 May 1988. Tracer sheep, which ran with the weaners of both the untreated and treated ewes, were also examined.

## MATERIALS AND METHODS

The experiment was carried out at Boontjieskraal Estate (34°12'S, 19°21'E, altitude 120 m), a mixed wheat and sheep farm consisting of 1 000 ha dryland lucerne, 1 200 ha wheat and 150 ha natural fynbos.

Merino ewes (n=2 033) were dosed with ivermectin (Ivomec, Logos Agvet) on 1 December 1986. (Ivermectin was always administered orally at a dose of 0,2 mg $kg^{-1}$.). Mating took place during the period 6 January - 27 February 1987. From 15 to 18 March 1987 the ewes were dosed orally with 18 ml of a mixture of closantel and albendazole (Valbantel, Smith Kline). On 8 April 1987 the flock was scanned for pregnancy and 500 ewes with single foetuses were selected. On 22 April 1987 the selected ewes were randomly allocated to 2 flocks of 250 ewes each, one to be treated and the other left untreated.

Management of the untreated flock is summarised in Table 1.

Lambs of treated ewes were compared to those of untreated ewes, but the ewes themselves were excluded from this trial and are discussed elsewhere[9]. Management of these lambs after weaning is summarised in Table 2.

Merino wethers, 18 months old, serving as tracers ran with both groups of weaners. They were dosed with ivermectin immediately prior to introduction to both weaner groups. Six tracers were removed from grazing after 42 d and slaughtered 3 d later. Each subsequent group of 6 tracers was dosed with ivermectin, grazed for 42 d and slaughtered 3 d later.

### Necropsy

Water was freely available but ewes were starved for 48h and lambs for 24h before slaughter. The entire pluck and gastrointestinal tract were removed on the farm and the rumen and reticulum opened and examined for *Paramphistomum* spp. The omentum and mesentery were stripped and the abomasum and duodenum, small intestine, large intestine, liver and lungs placed in separate, labelled plastic bags for transportation to the laboratory.

Three modifications of described necropsy procedures[12] were used:

(i) Abomasum and duodenum: On arrival at the laboratory the abomasum and duodenum were cut open and the ingesta washed into a bucket. The abomasal wall was cut in half and each half divided into 5 or 6 pieces. These pieces and the duodenum were placed in 2 separate, labelled 1 ℓ glass jars in 3% commercial HCl solution (± 800 mℓ) and incubated at 40°C for 20 to 24h. The following morning, the gut wall was thoroughly washed off, the washings fixed with formalin and residues on the 38 μm sieve's surface collected[12].

(ii) The entire caecal and colonic ingesta were examined macroscopically for *Oesophagostomum* and *Trichuris*.

(iii) Aliquots: The volume of ingesta in the collection jars, either of the abomasum or of the small intestine, was adjusted to the nearest 100 mℓ, e.g. 700 mℓ. The ingesta were vigorously mixed with air provided by a small compressor, 1% of the mixed suspension collected with a 100mℓ graduated pipette and transferred to a small vial. After staining with a concentrated $I_2$, KI mixture, worms were counted and the aliquot returned to the original specimen jar. If less than 20 worms were counted in the 1% sample, 4 x 5% specimen aliquots were subsequent-

* Overberg Research Projects, University of Pretoria, P.O. Box 680, 7200 Hermanus, Republic of South Africa

Received: July 1988 Accepted: June 1989

Table 1: **Management of 250 untreated Merino ewes and their progeny. Dates on which lambing, weaning, changes in pastures, faecal sampling and slaughter for differential worm counts took place are indicated**

| Date | Procedure |
|---|---|
| 1987<br>22 April | Ewes eartagged; grazed on dry-land lucerne (Camp 22). |
| 5 May | 12 ewes chosen at random; faeces sampled for worm egg counts (e.p.g.) |
| 6 May | 6 ewes slaughtered for differential worm counts |
| 1 June | Remaining ewes transferred to lucerne paddock |
| 6 June-30 July | Lambing. Lambs eartagged on left ear with same number as dam. |
| 15 June | 12 ewes + their 12 ewe lambs (blue tags) sampled for e.p.g. |
| 16 June | 6 ewes + their 6 ram lambs slaughtered for differential worm counts |
| 22 July | Faecal sampling of ewes and ewe lambs for e.p.g. |
| 27 July | 6 ewes + their wether lambs slaughtered |
| 4 September | Faecal sampling ewes and ewe lambs for e.p.g. |
| 10 September | 6 ewes + their 6 wether lambs slaughtered |
| 27 September | Flock moved to another lucerne paddock (Camp 29) |
| 15 October | Faecal sampling of ewes and ewe lambs for e.p.g. (blue tags) |
| 21 October | 6 ewes + their 6 wether lambs slaughtered |
| 17 November | Weaning - ewes discharged |
| 27 November | Weaners transferred to wheat stubble (Camp 38). |
| 30 November | Faecal sampling of 12 weaned ewes for e.p.g. (blue tags). Tracers (T1) introduced and treated with ivermectin |
| 2 December | 6 weaned wethers slaughtered |
| 21 December | Flock transferred to wheat stubble (Camp 25) |
| 1988<br>11 January | Faecal sampling of 12 weaned ewes for e.p.g; 6 tracers (T2) dosed with ivermectin |
| 13 January | 6 weaner wethers slaughtered |
| 14 January | 6 tracers (T1) slaughtered |
| 11 February | Flock received enriched barley (molasses + barley) 120g per sheep per d |
| 22 February | Faecal sampling of 12 weaned ewes for e.p.g; 6 tracers (T3) dosed with ivermectin. |
| 24 February | 6 weaned wethers slaughtered |
| 25 February | 6 tracers (T2) slaughtered. Balance of flock transferred to newly sprouted lucerne (Camp 38) |
| 21 March | Flock fed lucerne 1 kg + 300g enriched barley per sheep per d |
| 25 March | Flock returned to wheat stubble |
| 29 March | Faecal sampling of 12 weaned ewes for e.p.g; 6 tracers (T4) dosed with ivermectin |
| 11 April | 6 weaned wethers slaughtered |
| 12 April | 6 tracers (T3) slaughtered |
| 6 May | Flock transferred to lucerne (Camp 38) |
| 16 May | Enriched barley increased to 500g per d. Faecal sampling of 12 weaned ewes for e.p.g. (blue tags) |
| 18 May | 6 weaned wethers slaughtered |
| 19 May | 6 tracers (T4) slaughtered |

ly removed for counting and identification of worms; if more than 20 worms were present, 4 x 1% aliquots were taken[4].

**Graphs**

When plotting graphs, negative worm counts were given a value of 10 and transformed to Log 1 in order to estimate the geometric mean (G) of the counts of the dominant genera (*Teladorsagia, Nematodirus* and *Trichostrongylus*).

**Statistical tests**

The Kruskal-Wallis test was used to compare worm counts within groups, e.g. when larvae were compared with adults, or when data from more than 1 group were compared with other ($P<0,05$). The Mann-Whitney U test was used when the group was compared with another and the significance is given in the results below[13].

## RESULTS

The following helminths were recovered:
*Teladorsagia circumcincta, and T. trifurcata*
*Nematodirus spathiger* and, more rarely, *N. abnormalis*
*Trichostrongylus rugatus* were always dominant, with *T. colubriformis, T. falculatus* and *T. pietersei* rarely present
*Oesophagostomum venulosum*
*Trichuris skrjabini*
*Avitellina* was the only cestode present, in 9/36 tracers (Tables 7 and 8).

**Total worm burdens - Ewes** (Tables 3 and 4, Fig. 1)

Few worms were present in May but worm burdens increased markedly in June, to exceed 12 000 in July, remaining at a high level until October when the ewes were discharged.

*Teladorsagia*

*Teladorsagia* burdens were compared with each other in the 5 groups of ewes slaughtered. The burdens recorded in May were less than in any other group ($P<0,05$). Numbers in June were less than either July or September ($P<0,05$). Differences elsewhere were not significant.

The peak in July was abnormally high (G mean 7 961) due to the burden of Ewe 66 (Table 3). The G mean of 5 704 of the other 5 ewes is probably a more accurate reflection of the worm burdens at that time. This is indicated by a break in the histogram (Fig. 1).

*Nematodirus*

*N. spathigher* was recovered from all animals expect Ewes 86 and 125. *N. abnormalis* was only recovered from Ewe 107. Only 5/12 ewes killed had more than 2 000 worms, in September and October. There were significantly fewer worms in sheep slaughtered during May than in any subsequent slaughter group ($P<0,05$). In June there were less worms than in either July or September ($P<0,05$). Differences between July, September and October were not significant.

*Trichostrongylus*

*T. rugatus* ranged from 0 to 2 349 in autumn and winter, rising to 25 to 6 143 worms in spring. *T. falculatus* was only present in 5 ewes from July to October. There was no significant difference between

June and July but elsewhere all groups differ from one another ($P<0,05$).

*Oesophagostomum venulosum*
In October all 6 ewes killed were lightly infested (1 - 15 worms). Only 3 of the 24 ewes killed from May to September had *O. venusolum* (1 - 3 worms).

*Trichuris skrjabini*
There were 4 and 12 worms in Ewes 5 and 11 respectively, both of which were killed in October.

**Larvae compared with adults**
The numbers of 3rd stage ($L_3$) and 4th stage ($L_4$) larvae recovered from the animals were compared with adult worm burdens within experimental groups.

*Teladorsagia*
There were more larvae than adults in groups killed from July to October and more adults than larvae in June. These differences were significant ($P<0,05$) in June, September and October.

*Nematodirus*
There were more larvae than adults in May and July ($P<0,05$).

**Total worm burdens - lambs** (Tables 5 and 6; Fig. 2)

No worms were recovered from any of the 8-10 d-old lambs killed on 16 June. These animals have been excluded from Table 5.

Worms recovered in July were less than those in September and peak worm counts were recorded in October and December 1987, followed by a dramatic fall in January which continued until May 1988.

*Teladorsagia*
After a slow start in July and September this genus reached a peak in December. Within 6 weeks of weaners grazing on wheat stubble there was a 77% decrease in worm numbers, compared with the G mean in December, and this continued until May 1988 when 98,8% had been lost.

Third stage larvae ($L_3$), third Moult ($M_3$) and early fourth stage ($EL_4$) comprised 62,5 - 64,2% of total numbers from July to October and 57,1 and 50,5% in December and January respectively. Thereafter, adults were dominant. The larval dominance was statistically significant only in lambs killed from September to December ($P<0,05$).

*Nematodirus*
This was the first genus to exceed a G mean of 1 200 worms in July, rising to a peak of 7 208 in September before falling below the level of *Teladorsagia* from October onwards. *N. spathigher* was always present; *N. abnormalis* was recovered from 5 lambs only (Table 6). When compared with worm burdens in December 1987, the losses of *Nematodirus* from January to May were 9 - 94%. Larvae only exceeded adults in July (Group 7).

*Trichostrongylus*
Initially, this genus was either absent or present in small numbers. It was consistently present from September and

Table 2: **Management of weaned lambs of 250 treated Merino ewes and tracer wethers**

| Date | Procedure |
|---|---|
| 1987<br>17 November | Weaning |
| 26 November | Transferred to wheat stubble (Camp 21) |
| 27 November | Dosed with ivermectin |
| 21 December | Transferred to lucerne and wheat fallow (Camp 22) |
| 1988<br>22 February | 6 tracers (R3) treated with ivermectin |
| 26 February | Transferred to barley stubble (Camp 16) |
| 29 March | 6 tracers (R4) treated with ivermectin |
| 11 April | 6 weaners (Group 13) slaughtered |
| 12 April | 6 tracers (R3) slaughtered |
| 26 April | Transferred to dry-land lucerne (Camp 19) |
| 18 May | 6 weaners (Group 14) slaughtered |
| 19 May | 6 tracers (R4) slaughtered |

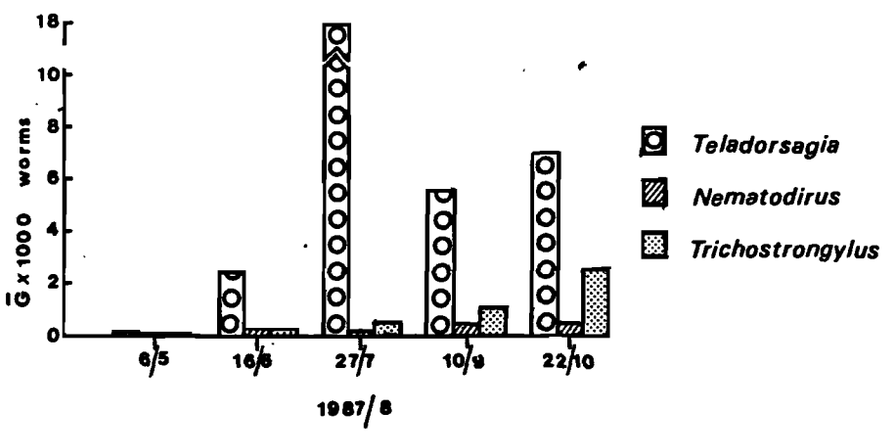


Fig. 1: **Variations in the geometric mean (G) worm burdens of** *Teladorsagia, Nematodirus* **and** *Trichostrongylus* **in ewes from May to October 1987 at Boontjieskraal. The break in this histogram for** *Teladorsagia* **includes the G mean of 5/6 ewes slaughtered (see text)**

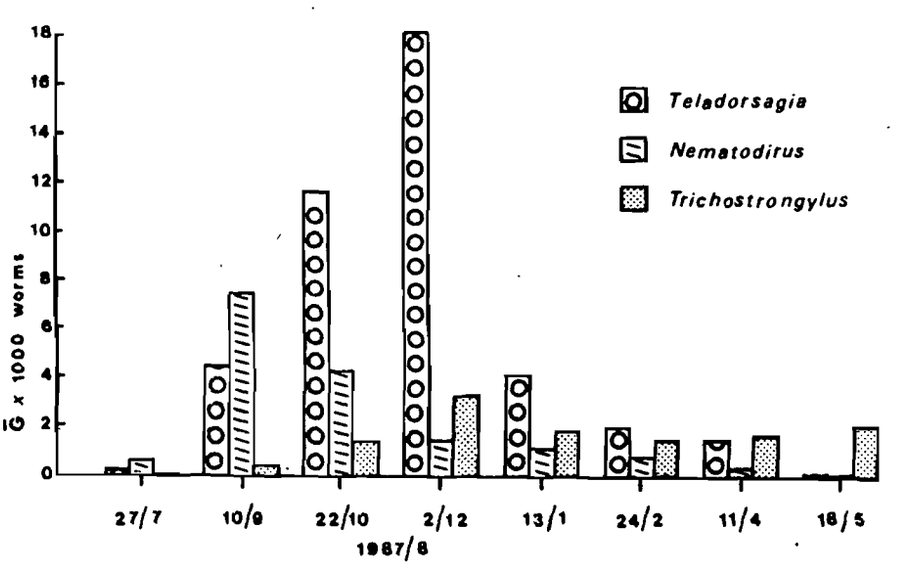


Fig. 2: **Variations in the G mean worm burdens of** *Teladorsagia, Nematodirus* **and** *Trichostrongylus* **in suckling lambs and weaners from January 1987 to May 1988 at Boontjieskraal**

Table 3: **Numbers of nematodes consistently recovered from ewes at Boontjieskraal**

| Group | Day killed | Ewe No. | *Teladorsagia* | | *T. circumcincta* | *T. trifurcata* | *Nematodirus* | | *N. spathigher* | *Trichostrongylus* | | *T. rugatus* | *Others (see Table 4)* | **All nematodes** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | $L_3$ | $L_4$ | | | $L_3$ | $L_4$ | | $L_3$ | $L_4$ | | | $L_3+L_4$ | **Adults** | **Total** |
| 01 | 6 May 87 | 136 | 0 | 10 | 52 | 0 | 8 | 132 | 47 | 0 | 0 | 78 | 0 | 150 | 177 | 327 |
| | | 139 | 0 | 19 | 23 | 23 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 21 | 47 | 68 |
| | | 172 | 6 | 16 | 1 | 0 | 0 | 431 | 29 | 0 | 0 | 0 | 0 | 453 | 30 | 483 |
| | | 184 | 7 | 18 | 18 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 26 | 19 | 45 |
| | | 185 | 0 | 2 | 33 | 0 | 0 | 9 | 8 | 0 | 6 | 43 | 0 | 17 | 84 | 101 |
| | | 234 | 0 | 9 | 12 | 0 | 0 | 1 | 1 | 0 | 0 | 10 | 0 | 10 | 23 | 33 |
| 02 | 16 Jun 87 | 12 | 16 | 88 | 796 | 0 | 0 | 1 | 1 | 0 | 0 | 120 | 0 | 105 | 917 | 1022 |
| | | 88 | 35 | 319 | 1021 | 232 | 0 | 1 | 5 | 0 | 20 | 455 | 1 | 375 | 1714 | 2089 |
| | | 107 | 31 | 42 | 880 | 77 | 0 | 7 | 480 | 0 | 0 | 533 | 120 | 80 | 2090 | 2170 |
| | | 117 | 28 | 562 | 2693 | 647 | 150 | 160 | 345 | 0 | 0 | 0 | 0 | 900 | 3685 | 4585 |
| | | 128 | 292 | 687 | 1882 | 625 | 430 | 590 | 120 | 0 | 0 | 205 | 0 | 1999 | 2832 | 4831 |
| | | 183 | 91 | 600 | 6296 | 812 | 287 | 228 | 113 | 0 | 0 | 648 | 0 | 1206 | 7869 | 9075 |
| 03 | 27 Jul 87 | 37 | 1842 | 10007 | 731 | 0 | 70 | 275 | 30 | 0 | 0 | 1613 | 0 | 12194 | 2374 | 14568 |
| | | 43 | 4023 | 8994 | 2423 | 241 | 20 | 30 | 10 | 0 | 5 | 567 | 68 | 13072 | 3309 | 16381 |
| | | 64 | 5060 | 10477 | 7217 | 696 | 27 | 13 | 1 | 0 | 0 | 0 | 0 | 15577 | 7914 | 23491 |
| | | *66 | 1870 | 10571 | 18832 | 2161 | 95 | 535 | 65 | 0 | 0 | 2349 | 0 | 13071 | 23407 | 36478 |
| | | 127 | 2384 | 7774 | 1880 | 63 | 15 | 7 | 1 | 0 | 0 | 120 | 0 | 10180 | 2064 | 12244 |
| | | 220 | 4647 | 7976 | 4644 | 686 | 0 | 5 | 5 | 0 | 0 | 325 | 0 | 12628 | 5660 | 18288 |
| 04 | 10 Sep 87 | 27 | 497 | 1000 | 15 | 0 | 10 | 0 | 1 | 0 | 0 | 25 | 0 | 1507 | 41 | 1548 |
| | | 45 | 0 | 121 | 45 | 0 | 13 | 573 | 13 | 0 | 27 | 557 | 157 | 734 | 772 | 1506 |
| | | 118 | 26990 | 2400 | 1737 | 576 | 0 | 1 | 1 | 0 | 33 | 4132 | 0 | 29424 | 6446 | 35870 |
| | | 198 | 3662 | 896 | 366 | 0 | 0 | 2000 | 1 | 0 | 0 | 910 | 0 | 6558 | 1277 | 7835 |
| | | 242 | 15156 | 8028 | 1980 | 220 | 0 | 766 | 3000 | 0 | 67 | 6143 | 674 | 25017 | 12017 | 37034 |
| | | 502 | 23222 | 4450 | 7800 | 1683 | 0 | 1733 | 633 | 0 | 66 | 3400 | 3 | 29471 | 13519 | 42990 |
| 05 | 21 Oct 87 | 5 | 17372 | 1930 | 6970 | 580 | 0 | 1367 | 3200 | 0 | 0 | 3633 | 15 | 20669 | 14398 | 35067 |
| | | 11 | 5133 | 3367 | 400 | 0 | 0 | 133 | 100 | 0 | 0 | 2973 | 740 | 8633 | 4213 | 12846 |
| | | 86 | 385 | 604 | 175 | 0 | 0 | 133 | 0 | 0 | 0 | 8708 | 15 | 1122 | 8898 | 10020 |
| | | 106 | 582 | 437 | 75 | 0 | 67 | 2233 | 33 | 0 | 33 | 2550 | 5 | 3352 | 2663 | 6015 |
| | | 125 | 11003 | 4933 | 6539 | 594 | 0 | 0 | 0 | 0 | 0 | 167 | 2 | 15936 | 7302 | 23238 |
| | | 238 | 10104 | 4708 | 2250 | 0 | 33 | 5833 | 67 | 0 | 100 | 5866 | 1047 | 20778 | 9230 | 30008 |

*_Teladorsagia_ total = 33 434 : abnormally high

reached a peak in December, numbers falling by only 34% - 40% in January and May 1988 respectively. *T. rugatus* was always dominant, except in October when 393 adult *T. colubriformis* were present in Lamb 238. *T. falculatus* was present once, in December and *T. pietersei* was found in 2 lambs in September (Table 6).

*Oesophagostomum venulosum*
One to 6 worms were present in 2, 5 and 3 lambs slaughtered in September, October and January respectively.

*Trichuris skrjabini*
In September only Lamb 118 was infested with 2 parasites; thereafter, all lambs had from 3 to 71 worms.

**Tracers in the untreated flock (Table 7)**
While tracers were grazing on wheat stubble only *Nematodirus* was consistently recovered (17/18 tracers) in small numbers (10 - 840); 5 tracers had 5 - 30 *Trichostrongylus* and only 1 tracer had 1 $L_4$ of *Teladorsagia*. Within 10 days (6 - 16 May 1988) of tracers grazing on lucerne, there was a highly significant increase ($P<0,001$) in *Teladorsagia* and a significant increase ($P<0,039$) in *Trichostrongylus*, but fewer *Nematodirus* ($P<0,242$) than in April, despite the heavy worm burdens in Tracer 2051 (Table 7).

**Weaners and tracers in the treated flock** (Table 8)
The data for weaners showed a highly significant increase ($P<0,001$) in all the major genera when Group 14, killed on 18 May, was compared with those slaughtered on 11 April. This was confirmed by the results of the tracers. With the exception of Sheep No. 2089 which was negative for both *Teladorsagia* and *Trichostrongylus*, all weaners and tracers had recently acquired infestation of both these genera prior to slaughter in May.

**Worm egg counts - Ewes** (Table 9)
Faecal samples were collected from 9 to 12 ewes every 37 - 43 d between May and October 1987: all of them were negative during May; thereafter, only 1 -10 ewes were positive for *Teladorsagia*, counts ranging from 66 to 266 e.p.g. (eggs per gram). Combined cultures from pooled faeces consistently had larvae of *Teladorsagia* and 1-3 larvae of *Trichostrongylus*. In October, 2 *Oesophagostomum* were present. *Nematodirus* eggs were found whenever *Teladorsagia* were present, albeit in fewer animals (i.e. lower frequency), only 1-6 animals being positive with 66 to 400 e.p.g.

**Worm egg counts - Lambs** (Table 9)
The frequency of positive egg counts ranged from as low as 1/14 (7,1%) to all lambs sampled (100%). Worm egg counts ranged from 66 to 1 133 e.p.g. Larvae of *Teladorsagia* were present in all pooled cultures, *Trichostrongylus* in 2 and

Table 4: **Numbers of nematodes occasionally recovered from ewes at Boontjieskraal**

| Group | Date killed | Ewe No. | *Nematodirus abnormalis* | *Oesophagostomum venulosum* | *Trichostrongylus falculatus* | *Trichostrongylus pietersei* | *Trichuris skrjabini* | Total |
|---|---|---|---|---|---|---|---|---|
| 02 | 16 Jun 87 | 88 | 0 | 1 | 0 | 0 | 0 | 1 |
| | | 107 | 120 | 0 | 0 | 0 | 0 | 120 |
| 03 | 27 Jul 87 | 43 | 0 | 0 | 68 | 0 | 0 | 68 |
| 04 | 10 Sep 87 | 45 | 0 | 0 | 157 | 0 | 0 | 157 |
| | | 242 | 0 | 1 | 673 | 0 | 0 | 674 |
| | | 502 | 0 | 3 | 0 | 0 | 0 | 3 |
| 05 | 21 Oct 87 | 5 | 0 | 11 | 0 | 0 | 4 | 15 |
| | | 11 | 0 | 1 | 727 | 0 | 12 | 740 |
| | | 86 | 0 | 15 | 0 | 0 | 0 | 15 |
| | | 106 | 0 | 5 | 0 | 0 | 0 | 5 |
| | | 125 | 0 | 2 | 0 | 0 | 0 | 2 |
| | | 238 | 0 | 13 | 467 | 567 | 0 | 1047 |

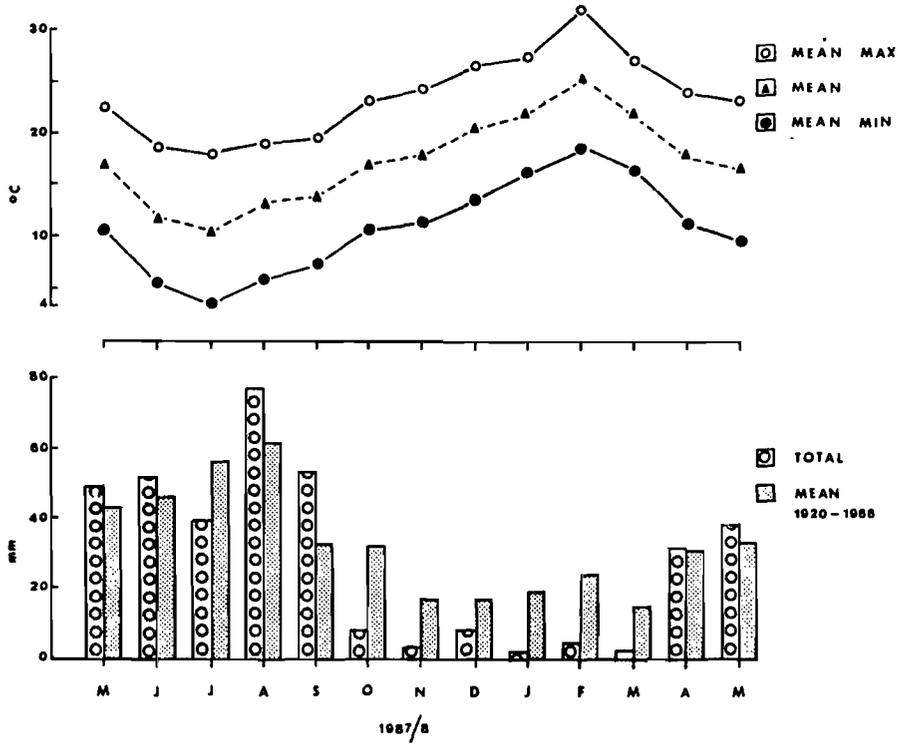


Fig. 3: **Monthly temperature and rainfall recorded from May 1987 to May 1988 at Boontjieskraal**

*Oesophagostomum* in 1.

On 4/7 occasions no faecal samples had *Nematodirus* eggs. Twice only 1 ewe lamb had 66 e.p.g., in September and October, when egg counts ranged from 66 to 1 333 and 66 to 266 e.p.g. respectively.

**Weaner ewes in the treated flock**

There was only 1 positive egg count (66 e.p.g.) during summer and combined cultures yielded as few as 1 to 106 *Teladorsagia* larvae throughout the summer and autumn.

**Climate** (Fig. 3)

Normal rainfall (39,6 - 77,0 mm/month) occurred during April to September while ewes grazed on lucerne, but in October and November only 8,4 and 2,3 mm rain was recorded, compared with the mean rainfall of more than 30 and 15 mm for these months. While weaners and tracers grazed on wheat stubble from November 1987 to March 1988, rainfall ranged from 0,9 to 13,2 mm per month, compared with the average of 15 to 20 mm per month, and rose to the normal rainfall of 31,7 mm in April. Only 1 mm of rain fell during the period 6 - 16 May, when weaners and tracers were taken off the grazing.

Monthly mean temperatures during summer exceeded 20°C from December to March, falling to 17,2 and 15,05°C in April and May respectively.

## DISCUSSION

### Aestivation of larvae in dry-land lucerne pastures

At Boontjieskraal, by far the most important source of infestation by larvae of *Teladorsagia, Trichostrongylus* and *Nematodirus* is dry-land lucerne pasture in autumn, winter and spring. The following facts, revealed by Poinar[10] are relevant to this discussion:

"There are possibly 500 000 nematode species in the world, of which some 15 000 have been described. Most are marine nematodes, or live in the soil and fresh water. Free-living nematodes (Rhabditidae) found their way into the intestines of vertebrates fairly soon after the latter appeared on earth".

The nematode parasites *Teladorsagia, Nematodirus,* and *Trichostrongylus* spend only part of their lives in sheep and their free-living stages are well adapted to the soil. When the autumn and winter rains stimulate migration of infective larvae, they infest ewes and lambs grazing dry-land lucerne pasture. Climatic conditions at Boontjieskraal were only suitable for the free-living stages to develop to the infective stage in the previous autumn, winter and spring. In the dry, hot summer period few, if any, pre-infective larvae would survive to develop to the infective stage in the faeces.

Infective larvae probably migrate into the soil, according to observations on *Ostertagia ostertagi*[3] which showed that they survive in the soil to a depth of at least 10 cm, then migrate on to the pasture to infest sheep when the rainfall exceeds 30 mm per month. Such was the case at Boontjieskraal in April (Fig. 3). *Nematodirus* buried to a depth of 60 cm returned to the surface (Michel citing Everett in Armour *et al.*[3]). Moreover, *Nematodirus* eggs and hatched infective larvae are extremely resistant to desiccation, having been observed to survive on pastures despite ploughing, reseeding and practically no grazing (and thus very little egg contamination) for a period of 3 years[14]. This would account for their presence on stubble lands at Boontjieskraal, albeit in small numbers, throughout the summer months.

**Worm egg contamination of stubble pastures**

Sheep excrete 3% of their mass as faeces every day. The mean faecal output of weaners on 22 February and 29 March was 948 and 1 008g per day. The mean faecal worm egg counts, multiplied by these figures, showed that each weaner deposited 373 512 and 551 376 worm eggs, respectively, on these days. There were 166 and 160 infested sheep on the pasture, so the total number of eggs deposited on the pasture by the flock was 62 002 992 and 88 220 160 respectively.

Although many millions of eggs were deposited on the pasture every day during this period, none of the *Teladorsagia* nor *Trichostrongylus* developed into infective larvae capable of infesting sheep. Worm recovery data in Tables 5 and 7 showed that neither *Teladorsagia* nor *Trichostrongylus* were acquired by grazing animals. *Nematodirus* were only present in small numbers throughout this period. Apart from the unsuitable physical conditions in the stubble, the monthly mean temperature was 23,6°C in February and 21,0°C in March. Only 3,3 and 13,2 mm rain fell in these months. In April and May, however, the mean monthly temperatures fell to 17,2 and 16,05°C; April rainfall increased to 31,7 mm but only 1 mm of rain fell in the first 16 days of May, while the animals due for slaughter were still grazing. The data has conclusively shown that these animals acquired their first infestation of *Teladorsagia* and *Trichostrongylus* after they had returned to the lucerne on 6 May. Those infective larvae must have been deposited on the lucerne during the previous winter and spring and aestivated there throughout the summer, to migrate on to the grazing in April. It can be argued that the eggs deposited on the lucerne in February and March were responsible for the increased infestation in the same paddock when the flock returned there in May but this is nullified if the results are compared with those from the treated flock, described below.

Data gained from the treated flock (Table 8) show that those animals acquired no appreciable infestation until 9 April (2 days prior to slaughter when they were transferred to pens). The treated flock and their tracers, however, were transferred to lucerne on 25 April (Camp 19) instead of 6 May (controls) and the former showed more worms than the undosed control flock. (Compare Tables 5 and 7 with Table 8). Most of these weaners, treated on 27 November 1987, had negative egg counts and the pasture grazed by the treated group was not contaminated by the grazing flock. The only possible source of infestation was the infective larvae which had survived over the summer in faeces or soil in the lucerne pastures.

*Teladorsagia* **larvae in ewes, lambs and weaners**

The total number of $L_3$ and $L_4$ in May and June, in ewes, was less than 1 000 and probably only an indication of newly acquired infestation. From July onwards, the mean number of larvae exceeded 10 000, representing 66 - 68% of *Teladorsagia* present. Most of the $L_4$ were 1,6 mm long which Donald et al.[6] classified $EL_4$ (early fourth stage larvae). Denham[5] classified $EL_4$ as Phase 3, basing his description on the development of the genitalia which is a compact ball of cells in the male and an elongated row of cells, twice as long as the body width in the female. The characteristic length is 1 -1,2 mm (according to Waller, McMaster Laboratory, Glebe, Sydney, personal communication 1988). Most of the $L_4$ we saw fell into this classification and were $EL_4$. A new finding was the presence of $L_3$, both in ewes and lambs, from July to October and in weaned lambs slaughtered thereafter. Most of these larvae were in the third moult ($M_3$) which Hyman[8] states is part of the third stage and therefore classified as $L_3$. Douvres[7] described changes in the cephalic end (head) of $L_3$ and the third moult ($M_3$) and we grouped $L_3$ + $M_3$ as distinct from the head of $L_4$ in this study.

**Death of** *Teladorsagia* **and** *Nematodirus* **in weaners**

Weaners grazing on wheat stubble from 2 December to 13 January 1988 showed a G mean loss of 14 991 *Teladorsagia* and the death of these worms continued until May when only 230 (G mean) were left. This represents 98,8% of worms of this genus. During the same period 94% of *Nematodirus,* but only 40% of *Trichostrongylus* died. This indicates that *Teladorsagia* does not live very long in this host; *Nematodirus* survives for a longer period initially, but in time most of them die, and that *Trichostrongylus* survives for a longer period (Fig. 2).

This has very interesting practical implications. Neither *Teladorsagia* no *Nematodirus* live very long in the absence of reinfestation and therefore safe pastures can be used to augment the loss of worms. If the flock is treated in November with a highly effective anthelmintic such as ivermectin, prior to being placed on wheat stubble, this can be translated into more wool and an increase in live mass. Louw[9] dosed the treated flock with ivermectin (0,2 mg $kg^{-1}$) on 27 November 1987 and the flock was sheared at that time. Nine months later, on 6 September 1988, the wool mass was on average 960g more than that of the control flock, and the mean mass of the treated flock was 50 kg compared with 38 kg in the control flock.

**ACKNOWLEDGEMENTS**

Our sincere thanks are due to Mr Uwe Kersandt, owner, and to Mr Piet de Wet, sheep manager of Boontjieskraal; Drs Ian Herbst and Ricky Wilson, veterinary practitioners of Caledon, who assisted us in many ways; the Foundation for Research Development, C.S.I.R., the Department of Agriculture and Water Supply and the S.A. Wool Board for financial assistance; Mrs Norah Reinecke who typed the manuscript and Mrs Johanna Mathewson for tracing the graphs.

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Table 5: **Numbers of nematodes consistently recovered from lambs and weaners at Boontjieskraal**

| Group | Date killed | Lamb No | *Teladorsagia* $L_3$ | *Teladorsagia* $L_4$ | *T. circumcincta* | *T. trifurcata* | *Nematodirus* $L_3$ | *Nematodirus* $L_4$ | *N. Spathiger* | *Trichostrongylus* $L_3$ | *Trichostrongylus* $L_4$ | *T. rugatus* | Others (see Table 5) | $L_3+L_4$ | Adults | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO7 | 27 Jul 87 | 37 | 527 | 105 | 200 | 15 | 117 | 3333 | 0 | 0 | 17 | 117 | 0 | 4099 | 332 | 4431 |
| | | 43 | 16 | 14 | 71 | 3 | 10 | 145 | 80 | 0 | 0 | 10 | 0 | 185 | 164 | 349 |
| | | 64 | 55 | 83 | 220 | 2 | 173 | 945 | 67 | 0 | 0 | 0 | 0 | 1256 | 289 | 1545 |
| | | 66 | 395 | 229 | 217 | 31 | 85 | 925 | 0 | 0 | 0 | 0 | 0 | 1634 | 248 | 1882 |
| | | 127 | 104 | 70 | 149 | 49 | 125 | 925 | 675 | 0 | 0 | 35 | 0 | 1224 | 908 | 2132 |
| | | 220 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 5 | 5 |
| C08 | 10 Sep 87 | 27 | 1548 | 2183 | 1615 | 175 | 80 | 1240 | 6160 | 0 | 40 | 190 | 0 | 5091 | 8140 | 13231 |
| | | 45 | 1309 | 2121 | 1345 | 199 | 150 | 1350 | 14425 | 0 | 50 | 7 | 106 | 4980 | 16082 | 21062 |
| | | 118 | 915 | 3667 | 2924 | 729 | 200 | 2333 | 9033 | 0 | 0 | 433 | 2 | 7115 | 13121 | 20236 |
| | | 198 | 147 | 1333 | 1167 | 206 | 167 | 747 | 100 | 0 | 0 | 40 | 0 | 2394 | 1513 | 3907 |
| | | 242 | 383 | 1507 | 185 | 35 | 167 | 1867 | 4380 | 0 | 0 | 467 | 554 | 3924 | 5621 | 9545 |
| | | 502 | 1087 | 1633 | 1347 | 0 | 200 | 2300 | 12050 | 0 | 0 | 497 | 3 | 5220 | 13897 | 19117 |
| C09 | 21 Oct 87 | 5 | 4875 | 1850 | 8347 | 928 | 0 | 660 | 10940 | 0 | 20 | 3830 | 5 | 7405 | 24050 | 31455 |
| | | 11 | 7550 | 3507 | 10580 | 1307 | 0 | 390 | 8770 | 0 | 0 | 1200 | 22 | 11447 | 21879 | 33326 |
| | | 86 | 9007 | 6020 | 1513 | 0 | 0 | 500 | 287 | 0 | 7 | 2547 | 9 | 15534 | 4356 | 19890 |
| | | 106 | 3746 | 4333 | 3603 | 400 | 7 | 380 | 540 | 0 | 13 | 1140 | 16 | 8479 | 5699 | 14178 |
| | | 125 | 2354 | 2020 | 1803 | 0 | 10 | 70 | 11670 | 10 | 0 | 840 | 7 | 4464 | 14320 | 18784 |
| | | 238 | 2534 | 2650 | 100 | 0 | 0 | 2340 | 2906 | 87 | 20 | 0 | 403 | 7631 | 3409 | 11040 |
| C10 | 2 Dec 87 | 2 | 2501 | 3451 | 4975 | 0 | 0 | 50 | 50 | 0 | 0 | 2475 | 35 | 6002 | 7535 | 13537 |
| | | 46 | 5500 | 7333 | 5433 | 0 | 0 | 1650 | 4275 | 0 | 0 | 3800 | 12 | 14483 | 13520 | 28003 |
| | | 69 | 6650 | 8500 | 15916 | 1384 | 0 | 725 | 2975 | 0 | 0 | 5275 | 2267 | 15875 | 27817 | 43692 |
| | | 82 | 5169 | 7602 | 8209 | 1226 | 0 | 625 | 1375 | 0 | 0 | 3450 | 1816 | 13396 | 16076 | 29472 |
| | | 163 | 5601 | 8234 | 6736 | 430 | 0 | 50 | 50 | 0 | 0 | 2300 | 20 | 13885 | 9536 | 23421 |
| | | 170 | 1635 | 4335 | 4589 | 1077 | 0 | 425 | 3575 | 0 | 0 | 2520 | 641 | 6395 | 12402 | 18797 |
| C11 | 13 Jan 88 | 49 | 1 | 366 | 2139 | 0 | 0 | 130 | 205 | 0 | 5 | 900 | 4 | 502 | 3248 | 3750 |
| | | 55 | 0 | 450 | 1851 | 0 | 0 | 195 | 1075 | 0 | 0 | 1475 | 15 | 645 | 4416 | 5061 |
| | | 188 | 427 | 4515 | 4042 | 450 | 0 | 255 | 1085 | 0 | 0 | 2740 | 19 | 5197 | 8336 | 13533 |
| | | 191 | 669 | 6373 | 3506 | 0 | 0 | 567 | 5700 | 0 | 0 | 5199 | 26 | 7609 | 14431 | 22040 |
| | | 196 | 3 | 315 | 1568 | 275 | 0 | 33 | 586 | 0 | 0 | 1273 | 100 | 351 | 3802 | 4153 |
| | | 197 | 367 | 2075 | 1435 | 0 | 0 | 140 | 918 | 0 | 0 | 2400 | 114 | 2582 | 4867 | 7449 |
| C12 | 24 Feb 88 | 25 | 0 | 265 | 801 | 24 | 0 | 10 | 330 | 0 | 0 | 1030 | 24 | 275 | 2209 | 2484 |
| | | 75 | 17 | 1896 | 2091 | 179 | 0 | 200 | 9900 | 0 | 0 | 3200 | 42 | 2113 | 15412 | 17525 |
| | | 96 | 0 | 8 | 1806 | 193 | 0 | 13 | 680 | 0 | 0 | 1187 | 8 | 21 | 3874 | 3895 |
| | | 124 | 2 | 1837 | 1761 | 177 | 0 | 47 | 747 | 0 | 0 | 2053 | 26 | 1886 | 4764 | 6650 |
| | | 150 | 0 | 196 | 883 | 0 | 0 | 30 | 200 | 0 | 0 | 1907 | 16 | 226 | 3006 | 3232 |
| | | 190 | 0 | 43 | 2884 | 0 | 0 | 187 | 199 | 0 | 0 | 853 | 10 | 230 | 3946 | 4176 |
| C13 | 11 Apr 88 | 505 | 0 | 164 | 1487 | 0 | 0 | 10 | 130 | 0 | 0 | 1320 | 29 | 174 | 2966 | 3140 |
| | | 92 | 0 | 85 | 1551 | 130 | 0 | 20 | 1013 | 0 | 0 | 1840 | 27 | 105 | 4561 | 4666 |
| | | 131 | 0 | 120 | 661 | 0 | 0 | 27 | 1333 | 0 | 0 | 1433 | 19 | 147 | 3446 | 3593 |
| | | 132 | 0 | 272 | 2345 | 171 | 0 | 20 | 113 | 0 | 0 | 2254 | 29 | 292 | 4912 | 5204 |
| | | 139 | 0 | 112 | 788 | 0 | 0 | 20 | 260 | 0 | 0 | 2360 | 21 | 132 | 3429 | 3561 |
| | | 166 | 0 | 279 | 1707 | 90 | 0 | 47 | 760 | 0 | 0 | 1060 | 19 | 326 | 3636 | 3962 |
| C14 | 18 May 88 | 39 | 0 | 509 | 62 | 0 | 20 | 4973 | 60 | 0 | 300 | 1160 | 14 | 5802 | 1296 | 7098 |
| | | 71 | 0 | 457 | 2 | 0 | 0 | 20 | 0 | 0 | 127 | 3994 | 71 | 604 | 4067 | 4671 |
| | | 87 | 0 | 1 | 1 | 0 | 0 | 40 | 0 | 0 | 87 | 3287 | 33 | 128 | 3321 | 3449 |
| | | 104 | 6 | 500 | 81 | 0 | 0 | 513 | 780 | 0 | 60 | 1580 | 24 | 1079 | 2465 | 3544 |
| | | 144 | 10 | 347 | 707 | 0 | 0 | 20 | 20 | 0 | 40 | 787 | 23 | 417 | 1537 | 1954 |
| | | 146 | 0 | 433 | 21 | 0 | 23 | 100 | 40 | 0 | 60 | 3626 | 30 | 616 | 3717 | 4333 |


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Table 6: **Numbers of nematodes occasionally recovered from untreated lambs and weaners at Boontjieskraal**

| Group | Date killed | Sheep No. | *Nematodirus abnormalis* | *Oesophagostomum venulosum* | *Trichostrongylus colubriformis* | *Trichostrongylus falculatus* | *Trichostrongylus pietersei* | *Trichuris skrjabini* | Total |
|---|---|---|---|---|---|---|---|---|---|
| C08 | 10 Sep 87 | 45 | 0 | 6 | 0 | 0 | 100 | 0 | 106 |
| | | 118 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| | | 242 | 487 | 0 | 0 | 0 | 67 | 0 | 554 |
| | | 502 | 0 | 3 | 0 | 0 | 0 | 0 | 3 |
| C09 | 21 Oct 87 | 5 | 0 | 2 | 0 | 0 | 0 | 3 | 5 |
| | | 11 | 0 | 1 | 0 | 0 | 0 | 21 | 22 |
| | | 86 | 0 | 0 | 0 | 0 | 0 | 9 | 9 |
| | | 106 | 0 | 2 | 0 | 0 | 0 | 14 | 16 |
| | | 125 | 0 | 4 | 0 | 0 | 0 | 3 | 7 |
| | | 238 | 0 | 4 | 393 | 0 | 0 | 6 | 403 |
| C10 | 02 Dec 87 | 2 | 0 | 0 | 0 | 0 | 0 | 35 | 35 |
| | | 46 | 0 | 0 | 0 | 0 | 0 | 12 | 12 |
| | | 69 | 2250 | 0 | 0 | 0 | 0 | 17 | 2267 |
| | | 82 | 1800 | 0 | 0 | 0 | 0 | 16 | 1816 |
| | | 163 | 0 | 0 | 0 | 0 | 0 | 20 | 20 |
| | | 170 | 0 | 0 | 0 | 630 | 0 | 11 | 641 |
| C11 | 13 Jan 88 | 49 | 0 | 0 | 0 | 0 | 0 | 4 | 4 |
| | | 55 | 0 | 0 | 0 | 0 | 0 | 15 | 15 |
| | | 188 | 0 | 2 | 0 | 0 | 0 | 17 | 19 |
| | | 191 | 0 | 0 | 0 | 0 | 0 | 26 | 26 |
| | | 196 | 80 | 4 | 0 | 0 | 0 | 16 | 100 |
| | | 197 | 102 | 2 | 0 | 0 | 0 | 10 | 114 |
| C12 | 24 Feb 88 | 25 | 0 | 0 | 0 | 0 | 0 | 24 | 24 |
| | | 75 | 0 | 0 | 0 | 0 | 0 | 42 | 42 |
| | | 96 | 0 | 3 | 0 | 0 | 0 | 5 | 8 |
| | | 124 | 0 | 1 | 0 | 0 | 0 | 25 | 26 |
| | | 150 | 0 | 2 | 0 | 0 | 0 | 14 | 16 |
| | | 190 | 0 | 0 | 0 | 0 | 0 | 10 | 10 |
| C13 | 11 Apr 88 | 505 | 0 | 0 | 0 | 0 | 0 | 29 | 29 |
| | | 92 | 0 | 0 | 0 | 0 | 0 | 27 | 27 |
| | | 131 | 0 | 0 | 0 | 0 | 0 | 19 | 19 |
| | | 132 | 0 | 0 | 0 | 0 | 0 | 29 | 29 |
| | | 139 | 0 | 0 | 0 | 0 | 0 | 21 | 21 |
| | | 166 | 0 | 0 | 0 | 0 | 0 | 19 | 19 |
| C14 | 18 May 88 | 39 | 0 | 0 | 0 | 0 | 0 | 14 | 14 |
| | | 71 | 0 | 0 | 0 | 0 | 0 | 71 | 71 |
| | | 87 | 0 | 5 | 0 | 0 | 0 | 28 | 33 |
| | | 104 | 0 | 0 | 0 | 0 | 0 | 24 | 24 |
| | | 144 | 0 | 0 | 0 | 0 | 0 | 23 | 23 |
| | | 146 | 0 | 1 | 0 | 0 | 0 | 29 | 30 |

Table 8: **Numbers of helminths recovered from weaners in the treated flock and tracers grazing with them at Boontjieskraal**

| Group | Date dosed with ivermectin | Date killed | Sheep No. | *Nematodirus* $L_3$ | *Nematodirus* $L_4$ | *N. spathiger* | *Teladorsagia* $L_4$ | *T. circumcincta* | *Trichostrongylus rugatus* | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Weaners 13 | 27 Nov 87 | 11 Apr 88 | 298 | 0 | 0 | 30 | 0 | 0 | 0 | 30 |
| | | | 305 | 0 | 0 | 0 | 0 | 13 | 0 | 13 |
| | | | 337 | 0 | 0 | 10 | 0 | 0 | 0 | 10 |
| | | | 361 | 0 | 0 | 0 | 2 | 0 | 0 | 2 |
| | | | 456 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| | | | 459 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| Tracers R3 | 22 Feb 88 | 12 Apr 88 | 2056 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | 2059 | 0 | 0 | 10 | 2 | 11 | 0 | 23 |
| | | | 2061 | 0 | 0 | 10 | 0 | 0 | 0 | 10 |
| | | | 2079 | * | 0 | 10 | 1 | 1 | 10 | 22 |
| | | | 2094 | * | 0 | 0 | 0 | 1 | 0 | 1 |
| | | | 2102 | * | 10 | 20 | 0 | 0 | 0 | 30 |
| Weaners 14 | 27 Nov 87 | 18 May 88 | 276 | 0 | 120 | 80 | 0 | 53 | | |
| | | | 287 | 0 | 47 | 333 | 1 | 28 | 80 | 333 |
| | | | 357 | 40 | 160 | (1)420 | 2 | 53 | 0 | 409 |
| | | | 397 | 0 | 73 | 7 | 13 | 0 | 60 | 735 |
| | | | 413 | 0 | 260 | 53 | 2 | 30 | 0 | 93 |
| | | | 455 | 0 | 127 | 40 | $L_3$ $L_4$ 2 7 | 120 | 27 253 | 372 549 |
| Tracers R4 | 29 Mar 88 | 19 May 88 | 2065 | 0 | 273 | 313 | 2 | 20 | (2)54 | 662 |
| | | | 2074 | 0 | 93 | 26 | 0 | 33 | 0 | 152 |
| | | | 2076 | 0 | 320 | 0 | 0 | 26 | (4)7 | 353 |
| | | | 2089 | 0 | 213 | 40 | 3 | 93 | 20 | 369 |
| | | | 2098 | 0 | 153 | 0 | 0 | 0 | 0 | 153 |
| | | | 2103 | 0 | 260 | (3)854 | 1 | 60 | 20 | 1195 |

* *Avitellina*
(1) Including 84 *N. abnormalis*
(2) " 27 $L_4$ *Trichostrongylus*
(3) " 170 *N. abnormalis*
(4) All 7 $L_4$ *Trichostrongylus*

Table 9: **Fluctuations in faecal worm egg counts of *Teladorsagia* and *Nematodirus* in grazing ewes and ewe lambs at Boontjieskraal**

| Date | No. of faecal specimens | *Teladorsagia* Mean | *Teladorsagia* Range | *Teladorsagia* No. positive | *Nematodirus* Mean | *Nematodirus* Range | *Nematodirus* No. positive |
|---|---|---|---|---|---|---|---|
| Ewes | | | | | | | |
| 05 May 1987 | 12 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15 June | 9 | 37 | 66-66 | 5 | 15 | 133 | 1 |
| 22 July | 12 | 100 | 66-266 | 10 | 28 | 133-200 | 2 |
| 04 September | 12 | 39 | 66-133 | 6 | 28 | 333 | 1 |
| 15 October | 12 | 5 | 66 | 1 | 78 | 66-400 | 6 |
| Lambs | | | | | | | |
| 22 July 1987 | 14 | 5 | 66 | 1 | 0 | 0 | 0 |
| 04 September | 12 | 200 | 66-733 | 3 | 366 | 66-1333 | 7 |
| 15 October | 12 | 111 | 66-400 | 9 | 66 | 66-266 | 6 |
| 30 November | 9 | 503 | 66-1000 | 9 | 7 | 66 | 1 |
| 11 January 1988 | 12 | 339 | 133-866 | 11 | 0 | 0 | 0 |
| 22 February | 11 | 394 | 200-800 | 11 | 6 | 66 | 1 |
| 29 March | 12 | 547 | 66-1133 | 10 | 0 | 0 | 0 |
| 16 May | 12 | 110 | 66-333 | 9 | 0 | 0 | 0 |


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Table 7: **Numbers of helminths recovered from tracers grazing with the untreated flock at Boontjieskraal**

| Group | Date dosed with ivermectin | Date killed | Sheep No. | *Nematodirus* $L_3$ | *Nematodirus* $L_4$ | *N. spathiger* | *Teladorsagia* $L_3$ | *Teladorsagia* $L_4$ | *T. circumcincta* | *Trichostrongylus rugatus* | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| T1 | 30 Nov 87 | 14 Jan 87 | 2015 | 0 | 15 | 35 | 0 | 0 | 0 | 5 | 45 |
| | | | 2016 | 0 | 0 | 15 | 0 | 0 | 0 | 10 | 25 |
| | | | 2017 | 0 | 70 | 260 | 0 | 0 | 0 | 0 | 330 |
| | | | 2018 | 10 | 0 | 20 | 0 | 0 | 0 | 0 | 30 |
| | | | 2019 | 0 | 15 | 5 | 0 | 0 | 0 | 0 | 20 |
| | | | 2020 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 10 |
| T2 | 11 Jan 88 | 25 Feb 88 | *2010 | 0 | 13 | 133 | *Avit. | 0 | 0 | 0 | 146 |
| | | | *2025 | 6 | 13 | 80 | *Avit. | 0 | 0 | 0 | 99 |
| | | | 2026 | 6 | 13 | 160 | 0 | 0 | 0 | 0 | 179 |
| | | | 2034 | 0 | 0 | 20 | 0 | 0 | 0 | 0 | 20 |
| | | | 2043 | 0 | 33 | 160 | 0 | 0 | 0 | 0 | 193 |
| | | | 2046 | 0 | 0 | 253 | 0 | 0 | 0 | 6 | 259 |
| T3 | 22 Feb 88 | 12 Apr 88 | 2001 | 0 | 20 | 100 | 1 | 0 | 0 | 0 | 121 |
| | | | 2055 | 0 | 30 | 130 | 0 | 0 | 0 | 0 | 160 |
| | | | 2066 | 0 | 0 | 160 | 0 | 0 | 0 | 0 | 160 |
| | | | 2036 | 0 | 40 | 800 | 0 | 0 | 0 | 20 | 860 |
| | | | 2053 | 0 | 10 | 100 | 0 | 0 | 0 | 0 | 110 |
| | | | *2054 | 0 | 0 | 0 | *Avit. | 0 | 0 | 30 | 30 |
| T4 | 29 Mar 88 | 19 May 88 | 2021 | 0 | 13 | 0 | 0 | 0 | 93 | 0 | 106 |
| | | | 2028 | 0 | 67 | 0 | 12 | 121 | 94 | 20 | 106 |
| | | | *2032 | 0 | 20 | 107 | *Avit. | 164 | 1206 | [1]600 | 2097 |
| | | | *2041 | 0 | 60 | 0 | *Avit. | 47 | 260 | 7 | 374 |
| | | | *2044 | 0 | 20 | 0 | *Avit. | 32 | 34 | [2]53 | 139 |
| | | | 2051 | 0 | 5333 | 15533 | 1 | 130 | 381 | [3]900 | 22278 |

**Avit.* = *Avitellina*

[1] *includes 153 $L_4$*
[2] includes 13 $L_4$
[3] includes 300 $L_4$

**Book Review/Boekresensie**

## CLINICOPATHOLOGIC PRINCIPLES FOR VETERINARY MEDICINE

(EDITORS) W F ROBINSON and C R R HUXTABLE

**1st Edn. The Press Syndicate of the University of Cambridge, Cambridge CB2 1RP. 1988 pp viii and 419, Price not given. (ISBN 0 521 30883 6)**

The aim of this book is to correlate the clinical signs of disease with the pathophysiology involved.

The systems covered in the book are the immune, haematopoietic, respiratory, cardiovascular, alimentary, urinary, endocrine, skeletal, integument, nervous and reproductive systems with additional chapters on acid base and metabolic diseases. Although some aspects are not covered in any great depth, references for additional reading are listed at the end of each chapter.

The book is easy to read, well-illustrated with a minimum of errors. This book could be of general interest to undergraduate students, but would be of greater benefit to the qualified veterinarian wanting to keep abreast of the latest developments in the pathophysiology of disease.

**N.M. Duncan**

# OVERBERG RESEARCH PROJECTS: III. A PREVENTIVE WORM CONTROL PROGRAMME FOR SHEEP IN THE RÛENS, IN THE WINTER RAINFALL REGION OF SOUTH AFRICA

J P LOUW*

**ABSTRACT**

The mass gains and internal parasite burdens of a flock of untreated ewes and lambs were compared with those of a similar flock of treated ewes and lambs. These data, combined with climatic data, were used to compile a nematode parasite control programme for sheep in the Rûens, a sub-region of the winter rainfall area of South Africa. *Teladorsagia* were the most numerous parasites in the ewes and later in the season, also in the lambs. From July onwards, the development of *Teladorsagia* was inhibited regardless of previous exposure to worms, the number of worms present or the age of the host. Initially, *Nematodirus* dominated in the lambs and its development was not inhibited. Low numbers of *Nematodirus*, mainly inhibited, were found in the ewes. Both parasites were rife in winter but disappeared from the pasture during spring, while *Trichostrongylus rugatus*, the dominant species of *Trichostrongylus*, infested the lambs in spring and persisted in them throughout summer.

Anthelmintic treatments had no significant effect on the live mass gains of ewes and suckling lambs while they were on lush, but heavily infested lucerne pastures for 5,5 months, but after a further 6 months on safe wheat stubble pastures, the overall mean live mass gain of the treated lambs was a significant 4,7 kg more than that of the untreated lambs.

The integrated, preventive worm control programme recommended consists of pre-winter, pre-spring and pre-summer treatments with broad spectrum anthelmintics, but transfer to safe pastures after each treatment is essential.

Key words: Preventive worm control programme, sheep, winter rainfall region, live mass gains, hypobiosis

Louw J.P. **Overberg research projects: III. A preventive worm control programme for sheep in the Rûens, in the winter rainfall region of South Africa.** *Journal of the South African Veterinary Association* **(1989) 60 No. 4, 186-190 (En.) Overberg Research Projects, University of Pretoria, P.O. Box 680, 7200 Hermanus, Republic of South Africa.**

## INTRODUCTION

Judging from the variation in recommendations and the recommended frequency of anthelmintic treatment within the Rûens region (R.K. Reinecke, 1988, personal communication), basic regional epidemiological information is inadequate and consequently, protective rather than preventive worm control is practised. This may not be cost effective.

For a parasite control programme to be successful, it must be based on knowledge of larval ecology, parasite epidemiology, climatic conditions and husbandry practices[7] as well as the dynamics of the parasite population[8].

* Overberg Research Projects, University of Pretoria, P.O. Box 680, 7200 Hermanus, Republic of South Africa

Received: December 1988 Accepted: June 1989

The seasonal incidence of parasites can be determined either by means of a survey of infective larvae on pastures, or from the incidence and pathogenic effects of parasitic stages in the host. The former is often used in simulation models and outbreak alert systems. The ultimate worm burden of the host, however, is determined by grazing behaviour, susceptibility and breed of the host and by the viability and conditioning of the infective larvae[1,9]. The present study was based on the aetiology and seasonal incidence of verminosis in the host, determined by regular necropsies, live mass studies and climatic observations on a typical Rûens sheep farm. The object was to develop a unique worm control programme for sheep in the Rûens.

## MATERIALS AND METHODS

**Locality:** The Rûens is a sub-region of the winter rainfall area of South Africa, along the southern Cape coast. It lies between the Lange and Riviersonderend mountain ranges in the north and the coastal plains in the south (34° 5'S to 34° 20'S), spanning the districts of Caledon, Swellendam, Heidelberg and the northern section of Bredasdorp (19° 15'E to 21°E). Extensive and integrated wheat and sheep farming is practised in this region. The farm Boontjieskraal (34° 12'S, 19° 21'E) lies 10 km west of the town Caledon. The annual carrying capacity of 6 small stock units per hectare is representative of the region (I.A. Herbst, 1988, unpublished data) and is the calculated average of a stocking rate of 12 small stock units per hectare of permanent pasture grazed in winter and a stocking rate of 12 small stock units per hectare of wheat stubble grazed in summer.

**Climate:** Daily rainfall as well as maximum and minimum atmospheric temperatures were obtained from the Agrometeorology Section of the Department of Agriculture and Water Supply, which records weather data at Boontjieskraal. The trial was carried out 2-3 km from the weather recording station.

**Nutrition:** Permanent pastures consist of lucerne but are only productive in the rainy season from May to November. Sheep graze on wheat stubble, supplemented with oats, vitamins, minerals and trace elements, for the remainder of the year.

**Animals:** A flock of adult Merino ewes raised on the farm and mated during January and February 1987, were scanned ultra-sonically in April and 500 pregnant ewes each carrying a single foetus were selected. These ewes were divided randomly into 2 equal groups by allocating every second ewe which passed through a sheep race, to the control group and the remaining 250 ewes to the treated group. One group (controls) received no further anthelmintic treatment while the other group (treated) were treated as described below. The 2 groups grazed on similar paddocks. The treated animals remained on the same pasture till weaning on 17 November, but on 27 September the control animals were moved to a camp which had been spelled for a period of 10 months. Shearing took place on 26 November 1987, after which the ewes were discharged and the 2 groups of lambs moved to 2 separate wheat stubble fields. However, during March 1988 the control lambs had to be moved because they were in very poor condition and mortalities on the stubble were imminent. They were moved to a lucerne pasture which had been spelled for a period of 3 months. After 4 weeks these lambs were returned to the wheat stubble fields.

**Pasture and Stock management:**

1 December 1986 - Treated all ewes with a therapeutic dose of ivermectin.
6 January - 27 February 1987 - Mated ewes.
8 April 1987 - Scanned ewes and selected 500 ewes, each having a single foetus.
22 April 1987 - Divided ewes into 2 groups and numbered control ewes with eartags from 1-250 and the treated ewes from 251-500. Placed ewes in separate paddocks at stocking rates of 12/ha.
11 May 1987 - Moved treated as well as control ewes to lucerne pastures at stocking rates of approximately 12 ewes per hectare.
6 June 1987 - Lambing commenced.
27 September 1987 - Moved control animals to rested lucerne pasture at a stocking rate of approximately 12 animals per hectare.
17 November 1987 - Weaned lambs and discharged all ewes
26 November 1987 - Sheared all lambs and moved to wheat stubble lands at stocking rates of approximately 12 lambs per hectare.
25 February 1988 - Moved control lambs to lucerne pasture.
24 March 1988 - Returned control lambs to wheat stubble. All lambs received lucerne hay and grain supplements daily.
25 April 1988 - Moved treated group to lucerne pasture at a stocking rate of approximately 12 animals per hectare.
6 May 1988 - Moved control group to lucerne pasture at a stocking rate of approximately 12 animals per hectare.

**Anthelmintic treatments:**

Ewes: 18 March 1987 - albendazole + closantel; 21 May 1987 - albendazole; 21 July 1987 - albendazole; 28 September 1987 - ivermectin.
Lambs: 21 July 1987 - niclosamide; 09 August 1987 - albendazole; 28 September 1987 - ivermectin; 26 November 1987 - ivermectin.

**Live Mass:** The first 20 ewe lambs born in each group received eartags with the some numbers as their dams and the live mass of these ewes and lambs were recorded every 6 weeks between 23 July 1987 and 17 November 1987, after which the ewes were discharged.

From 30 November 1987 until 16 May 1988, the live mass of the lambs was recorded every 6 weeks. At weaning on 17 November 1987, the live mass of the control group of lambs was compared with that of the treated group of lambs and the difference subjected to Student's t-test for significance. This analysis was also carried out on the ewes at weaning and repeated on the lambs on 16 May 1988.

**Recovery of Parasites:** Six pregnant ewes were slaughtered from each group on 6 May 1987. From 16 June 1987 until 22 October 1987, 6 ewes with their ram lambs and thereafter, until 18 May 1988, 6 wethers were slaughtered from each group every 6 weeks. Animals selected for necropsy were starved for 24 hours, slaughtered and the gastro-intestinal organs and heads removed. The abomasum, small intestine and large intestine were each tied off with string, separated, placed in labelled plastic bags and transported to the laboratory for processing according to the following procedure:

**Abomasum:** The ingesta and washings of the abomasum wall were collected in a bucket, fixed with formalin, washed on a sieve with apertures of 38 micron and preserved in a labelled glass jar. The wall of the abomasum was then cut in half and each half placed in a labelled glass jar containing 3% HCl, incubated at 40°C for 20 to 24 h and washed on a 38 micron sieve and preserved in a labelled jar.

**Small intestine:** The ingesta and washings of the small intestinal wall were collected in a bucket, fixed with formalin, washed on a 38 micron sieve and preserved in a labelled glass jar.

**Large intestine:** The ingesta and washings of the wall of the large intestine were collected in a bucket, washed on a 150 micron sieve and preserved in a labelled glass jar.

**Counting and identification of worms:** Rough estimates of the total number of worms present in the abomasa and small intestines were made. If more than 2 000 worms were found in an organ, 4 aliquots of 1% were collected, otherwise 4 aliquots of 5% were taken. These aliquots were examined under a stereo microscope, the worms counted and approximately 30 males and 30 immatures removed for identification. The ingesta of the large intestines were examined macroscopically in total and the worms counted and identified. These counts were then used to compute the total worm burdens.

*Oestrus ovis* larvae were recovered from the slaughtered animals after the heads had been cut open with the aid of a bone saw and cutter and the nasal cavities and sinuses examined macroscopically.

## RESULTS

### Climatic data

Total rainfall recorded during 1987 was 366 mm, while the mean annual rainfall is 414 mm (Fig. 1). The first substantial downpour of the season was recorded on 14 April 1987. The highest mean maximum and mean minimum temperatures were recorded from November to March, with a peak in February and the lowest from June to August (Fig. 2). The lowest mean temperatures were recorded in July, but frost was rare.

### Total parasite burdens

Geometric means of nematode burdens are presented in Fig. 3-6 and the group burdens of *Oestrus ovis* in Table 1. Cestodes were found in 3/36 treated lambs, but none were present in the 36 control lambs or the 60 ewes slaughtered. No trematodes were present.

### Parasite dynamics in the ewes and lambs

The proportions of the *Teladorsagia*, *Nematodirus* and Trichostrongylus populations still in the third (L3) or fourth (L4) larval stages at slaughter, are expressed as percentages of the total populations of the 3 genera respectively (Fig. 3-6). Where fewer than 10 worms were recovered, counts were ignored.

In all the necropsies done on ewes from 27 July 1987 onwards, large proportions of immature worms were present. The percentage of immature worms remained high until the ewes were discharged on 22 October 1987 (Fig. 4 and 6).

Even though the worm burdens in lambs were initially low, a large percentage of immature *Teladorsagia* were present from 27 July 1987 until 22 October 1987, after which they declined. In the lambs, *Nematodirus* developed into adults (Fig. 3 and 5).

### Live mass gain of lambs and ewes

From birth until 18 October 1987, the control lambs maintained growth equal to that of the treated lambs, but during the following 6 weeks, gained 1,79 kg less. This difference was, however, not significant ($P < 0,05$). All lambs were shorn on 26 November 1987, accounting for the general reduction in live mass recorded on 30 November 1987. At the conclusion of the trial on 16 May 1988, the treated lambs had gained a significant ($P < 0,05$) 4,7 kg greater mass than the control lambs (Fig. 7). When all ewes were discharged on 17 November 1987, the treated ewes had gained 0,5 kg greater mass than the control ewes, but the difference was not significant ($P < 0,05$).

## DISCUSSION

### Climate and pasture infectivity

In the winter rainfall regions of Australia and South Africa peak larval availability was recorded during the cool months, until September, when mean monthly temperatures are between 14,6°C and 18,2°C and rainfall is in excess of 20 mm per fortnight[1 2 16 17]. This climatic profile prevailed in the Rûens (Fig. 1 and 2). The validity of these meteorological parameters was confirmed by the worm burdens of slaughtered animals in the present study.

In this study very few nematodes were recovered (Fig. 4 and 6) 3 weeks after the first good rains, indicating that the permanent pastures are not infective immediately after climatic conditions turn favourable, but require time for either the nematode eggs deposited by carriers to be translated to infected larvae or for upward migration of larvae residing in the soil.

During the period when the mean daily temperature was consistently above 16°C (Fig. 2) and the monthly rainfall below 20 mm (Fig. 1), conditions prevailing on the wheat stubble pastures were unfavourable for the development of nematodes and pastures were regarded as safe.

### Live mass

The parity in the live mass gains of the 2 groups of lambs until 18 October 1987 may either be the result of severe reinfestation negating the benefit derived from treatment if lambs are not moved to a safe pasture, or else, it may indicate that the pathogenic effect of the worm burdens in the control lambs was offset by the high plane of nutrition on the lucerne lands. Until weaning, the treated lambs gained 1,79 kg more than the control lambs, but the difference was not signifi-

Table 1: **Total *Oestrus ovis* larvae recovered from 6 control ewes and lambs slaughtered every 6 weeks.**

| Group / Date slaughtered | *Oestrus ovis* $L_1$ | $L_2$ | $L_3$ | Total | Flock Incidence |
|---|---|---|---|---|---|
| Ewes | | | | | % |
| 06/05/87 | 12 | 0 | 0 | 12 | 17 |
| 16/06/87 | 19 | 0 | 1 | 20 | 33 |
| 27/07/87 | 81 | 6 | 7 | 94 | 100 |
| 10/09/87 | 54 | 16 | 29 | 99 | 100 |
| 21/10/87 | 1 | 5 | 8 | 14 | 80 |
| Lambs | | | | | |
| 27/07/87 | 0 | 0 | 0 | 0 | 0 |
| 10/09/87 | 0 | 0 | 0 | 0 | 0 |
| 22/10/87 | 0 | 1 | 5 | 6 | 17 |
| 02/12/87 | 0 | 0 | 0 | 0 | 0 |
| 13/01/88 | 2 | 12 | 16 | 30 | 67 |
| 24/02/88 | 0 | 18 | 31 | 49 | 33 |
| 11/04/88 | 11 | 2 | 3 | 16 | 50 |
| 18/05/88 | 49 | 6 | 0 | 54 | 100 |

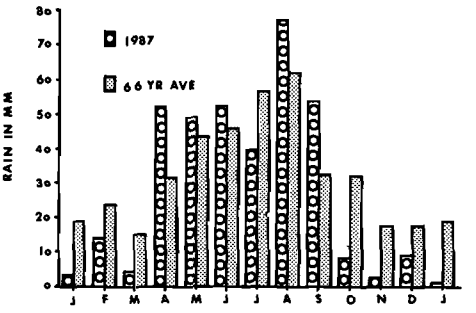


**Fig. 1: Monthly rainfall of 1987 and January 1988 compared to a 66 year average measured on the farm Boontjieskraal**

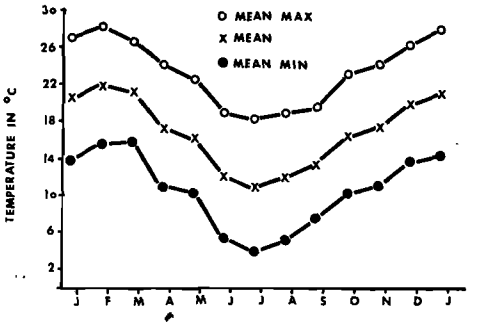


Fig. 2: **Monthly mean maximum, mean minimum and calculated mean atmospheric temperature of 1987 and January 1988 measured on the farm Boontjieskraal**

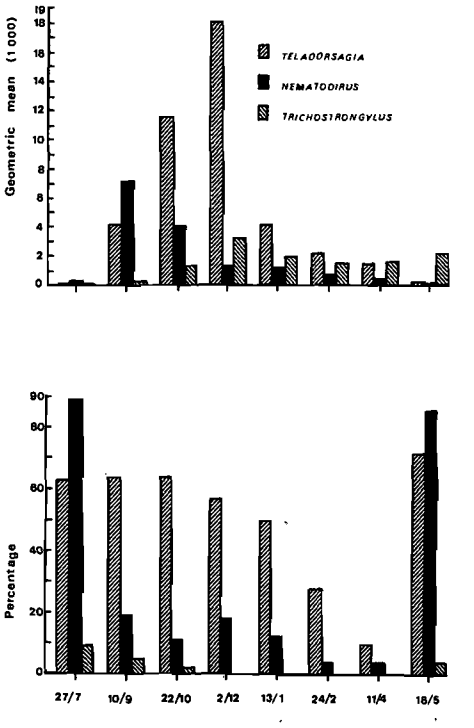


Fig. 3: **Geometric means of the major genera of nematodes and the larval population of each genus, expressed as a percentage of the total population of that genus, recovered from 6 control lambs slaughtered every 6 weeks during 1987 and 1988**

cant ($P<0,05$). Treatment, followed by transfer to a safe pasture on 26 November 1987, resulted in a significant ($P<0,05$) difference of 4.7 kg in favour of the treated group (Fig. 7). Similar observations were made by other workers[1 3 6], while still others reported similar results from animals kept worm-free on contaminated pastures by daily doses of anthelmintics[20].

Weaning onto wheat stubble resulted in the stagnation of further mass gains by the lambs, a trend that was further exacerbated in the control lambs by their residual worm burdens (Fig. 7). The increase in live mass seen in the control lambs during March could be the result of their temporary transfer to lucerne pasture. This also demonstrates the importance of the host's nutritional status in the epidemiology of parasites.

**Pathogenicity and the dynamics of the parasite population**

The pathogenicity of a parasite population, rather than parasite numbers per se, should determine the need for treatment. The accumulation of hypobiotic *Teladorsagia* larvae in sheep in this area, an important observation of this study, has to receive special attention in a control programme. Hypobiotic larvae are relatively harmless[4] and less susceptible to anthelmintics[9 19] but may become pathogenic and are a source of pasture contamination when they mature.

Hypobiosis or retarded parasite development in the host may be the result of host immunity, parasite population pressure, environmental stimuli, genetic factors or a combination of factors[18], parasite progeny conditioning[15] and is similar to diapause as seen in insects[4]. In the present study a number of these factors can be eliminated as possible causes for the development of hypobiosis in the Rûens.

A large percentage (64%) of all *Teladorsagia* recovered from the lambs slaughtered on 27 July 1987 were immature worms. These lambs were only 6 weeks old and therefore immunologically naive, had had no previous exposure to parasites and were therefore not likely to have exerted any immune effect on the development of the parasite. Furthermore, the percentage of immature *Teladorsagia* remained relatively constant for approximately 6 months (Fig. 3 and 5) despite the increasing age of the lambs and their continuous exposure to nematodes. In the ewes an accumulation of hypobiotic *Teladorsagia* larvae was also noticed for the first time on 27 July 1987, when the ewes had already been exposed to *Teladorsagia* infestation for more than 3 months (Fig. 4 and 6). If immunity were responsible for the development of hypobiosis, the ewes, subjected to parasitological challenge for years, rather than the immunologicaly naive lambs, would arrest *Teladorsagia* larvae immediately after infection and increasing proportions of *Teladorsagia* larvae would be arrested by the lambs as their age and the period of exposure to parasitological challenge increased.

As the season progressed, the worm burdens of the lambs increased, but the percentage of *Teladorsagia* larvae remained relatively constant (Fig. 3), indicating the insignificance of parasite population pressure in the development of hypobiosis.

Environmental stimuli affecting the preparasitic stages changed dramatically from July to December, yet the percentage of hypobiotic *Teladorsagia* larvae acquired after treatments during this period remained high (Fig. 5), suggesting that environmental stimuli do not constitute the only trigger mechanisms for hypobiosis. Furthermore, the accumulation of hypobiotic larvae in both ewes and lambs started in July, which coincides with hypobiosis of *Teladorsagia* in the summer[13] and the non-seasonal[16] rainfall regions of South Africa.

Hypobiosis of *Teladorsagia* is therefore either a diapause-like phenomenon, the result of the conditioning of the progeny of environmentally stressed worms or a



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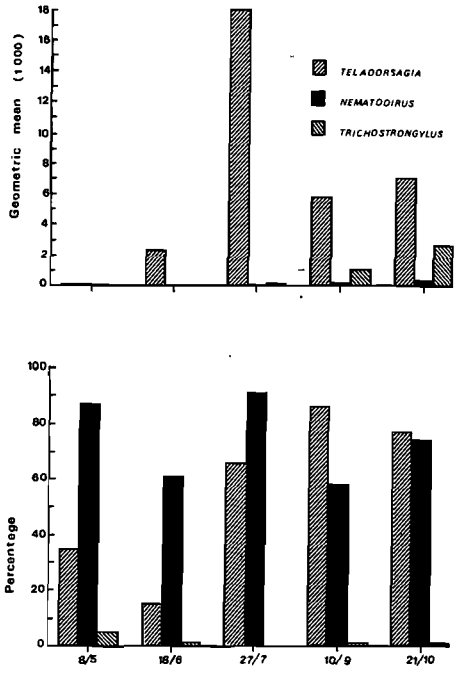


Fig. 4: **Geometric means of the major genera of nematodes and the larval population of each genus, expressed as a percentage of the total population of that genus, recovered from 6 control ewes slaughtered every 6 weeks during 1987**

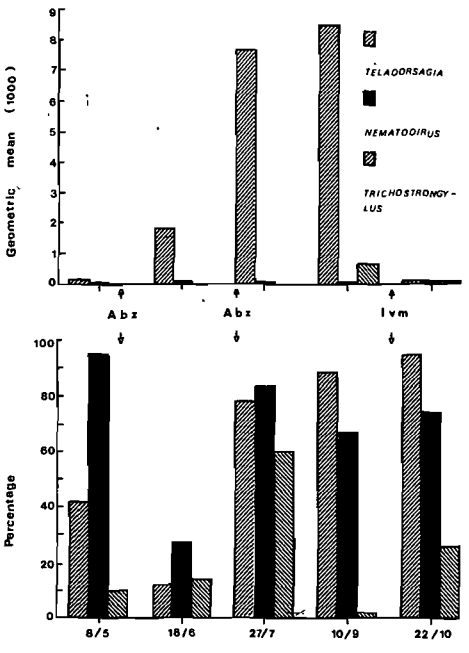


Fig. 6: **Geometric means of the major genera of nematodes and the larval population of each genus, expressed as a percentage of the total population of that genus, recovered from 6 treated ewes slaughtered every 6 weeks during 1987. Albendazole (Abz) and ivermectin (Ivm) treatments are indicated**

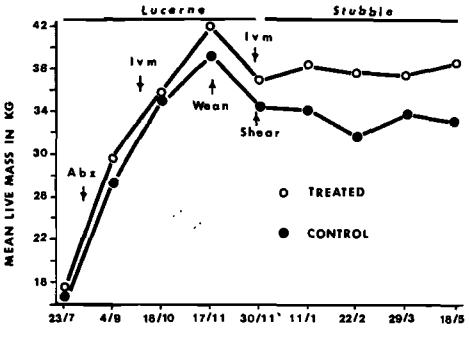


Fig. 7: **The mean live mass of the treated and the control lambs from 23 July 1987 until 16 May 1988. Albendazole (Abz) and ivermectin (Ivm) treatments as well as weaning and shearing dates are indicated**

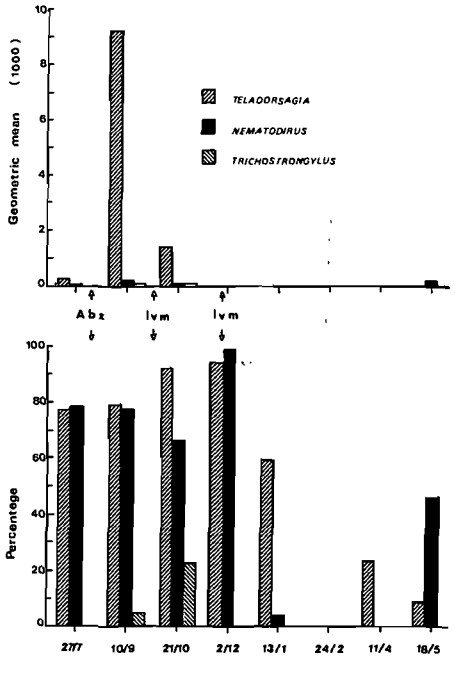


Fig. 5: **Geometric means of the major genera of nematodes and the larval population of each genus, expressed as a percentage of the total population of that genus, recovered from 6 treated lambs slaughtered every 6 weeks during 1987 and 1988. Albendazole (Abz) and ivermectin (Ivm) treatments are indicated**

combination of different factors[18]. Its seasonal predictability, however, simplifies the planning of a preventive control programme.

Donald et al.[9] reported large numbers of hypobiotic larvae in lactating ewes, 7 weeks after parturition, while dry ewes had few hypobiotic larvae. In the present study, the ewes slaughtered on 16 June 1987, 12-14 days after parturition, had very few hypobiotic *Teladorsagia* larvae. *Teladorsagia* developed into adults during the early stages of lactation, but as lactation progressed to 12 weeks, the percentage of hypobiotic larvae in the ewes increased to high levels (Fig. 4 and 6). The rapid development of *Teladorsagia* into adults immediately after parturition could be a manifestation of the periparturient relaxation of resistance in the ewes, an important mechanism for the early contamination of the pasture and a ready source of infection for lambs.

In contrast to observations by Muller[16], *Nematodirus* was not inhibited in the young lambs, but in the ewes, as observed previously in older lambs[22], it largely failed to develop to adulthood.

The emergence of *Trichostrongylus* spp in spring may be an important contributor to the retarded growth of the control lambs, as the combined effect of *Teladorsagia* and *Trichostrongylus* on wool production and live mass gains of lambs is more severe than the effect of either genus on its own[21]. Efforts at reducing *Teladorsagia* populations to low levels may be misplaced, but the control of *Trichostrongylus* infections is essential[21].

Either 8 000 *Trichostrongylus*, 6 000 *Teladorsagia* or 6 000 *Nematodirus* are regarded as economically significant burdens in lambs, while double these worm burdens are regarded as significant and justify treatment in ewes[10,11]. If these parameters are applied in the present study, treatment of the ewes and lambs were justified on economic grounds (Fig. 4 and 5).

The epidemiology of *Oestrus ovis* infections in the Rûens area is similar to that on the Transvaal Highveld in respect of the absence of fly strikes during winter, hibernation of the larvae in the sinuses of the host and infestation which started in October and continued throughout summer and autumn[12]. *Oestrus ovis* infections have an adverse effect on animal health and production[14] and treatment is therefore justified.

## Recommended preventive control programme

### Strategic programme

Strategic treatments are important in order to prevent the synergistic effect of parasitism and poor nutrition on the animals during summer, carriers from contaminating winter pastures, *Teladorsagia* from reaching critical levels in spring and bankrupt worms in summer and *O.ovis* larvae from hibernating in the animals.

May/June: Use broad spectrum drug with action vs *O. ovis*. Exclude lambs under the age of 6 weeks. Move treated animals to winter pastures.

Aug/Sept: Use broad spectrum drug with action vs *O. ovis* and hypobiotic larvae. Move treated animals to safe pastures.

November: Use broad spectrum drug with action vs *O. ovis* and hypobiotic larvae. Move treated animals to stubble lands.

### Choice of anthelmintic

For treatments in August/September and November, the choice of a highly effective anthelmintic is essential. Some compounds are metabolised too rapidly to be effective against hypobiotic larvae[19] and increased or sustained dosages may be required[9]. Ivermectin has a half-life of 157 hours in sheep[5], making it a more suitable choice against hypobiotic larvae in spring and summer, while any anthelmintic effective against *Teladorsagia*, *Nematodirus* and *Trichostrongylus*, combined with a nasal worm remedy, can be used in the pre-winter treatment.

### Tactical programme

Summer rains may necessitate an addi-

tional treatment in autumn. Confirmed cases of cestode infestation may justify tapeworm treatments in lambs.

**Management programme**

From the results of the present study it can be concluded that an effective preventive parasite control programme in the Rûens has to integrate anthelmintic control with management control measures, of which the provision of safe pastures after each treatment is an essential requirement. From a parasitological point of view, safe pastures are pastures which are relatively free of infective helminth larvae and can be produced by a variety of stock and pasture manipulations[7] of which the most practical, for the region, is effective pasture spelling. Brunsdon[7] regards 3 months as the shortest effective spelling period.

The present study proved that wheat stubble lands are naturally safe pastures and can safely accommodate sheep after the recommended anthelmintic treatment in November, while the dryland lucerne pastures which are unproductive and lie fallow during the hot and dry summer months, can be regarded as safe pastures when animals are introduced after the recommended treatment in May. Some of these safe lucerne pastures should, however, be reserved until after the August/September anthelmintic treatment.

**ACKNOWLEDGEMENTS**

Grants received from the Foundation for Research Development of the CSIR, Department of Agriculture and Water Affairs as well as the Wool Board, are gratefully acknowledged.

I wish to thank Mr U. Kersandt, who donated the trial animals and Mr P de Wet manager of the farm; as well as Prof R.K. Reinecke for his support and Mrs J. Mathewson for drawing the graphs.

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# PHARMACOKINETICS OF ASPIRIN AND ITS APPLICATION IN CANINE VETERINARY MEDICINE

D J MORTON* and D C KNOTTENBELT**

**ABSTRACT**

**In preliminary investigation of the pharmacokinetics of aspirin in dogs it became apparent that the drug was well absorbed following oral ingestion with food. Multiple dosing appeared to lead to a substantial increase in half-life; a twice daily dosage regimen would, therefore, be adequate for maintenance of therapeutic levels in dogs. The marked variation in pharmacokinetic parameters observed suggested that therapeutic drug monitoring would be of benefit in the control of canine inflammatory conditions using aspirin. Therapeutic monitoring of dogs (n=20) showed that clinical improvement paralleled plasma salicylate concentrations and the therapeutic concentrations so determined were within the range considered therapeutic in humans. No overt gastric irritation was noted in this study over a period of a year which suggests that aspirin can be successfully used to treat canine inflammatory disorders, routine monitoring of plasma salicylate being recommended to ensure therapeutic success.**

**Key words: anti-inflammatory, arthritis, rheumatoid, aspirin, dog, canine, pharmacokinetics.**

**Morton D.J.; Knottenbelt D.C. Pharmacokinetics of aspirin and its application in canine veterinary medicine.** *Journal of the South African Veterinary Association* **(1989) 60 No. 4, 191-194 (En.) Department of Pharmacy, Faculty of Medicine, University of Zimbabwe, P.O. Box MP 167, Mount Pleasant, Harare, Zimbabwe.**

## INTRODUCTION

Aspirin has for years been the mainstay of treatment of arthritic conditions. In human medicine, aspirin has been shown to be at least as effective, if not superior to the newer non-steroidal anti-inflammatory drugs[9] and this has also been suggested to be true in veterinary medicine[3]. The major problems encountered in the therapeutic use of aspirin are twofold. Firstly the plasma concentrations of the drug regarded as being therapeutic are relatively close to the toxic levels[7] and secondly there are substantial individual variations in plasma concentrations of salicylate resulting from administration of the same dose[1 2] although this was not found in another study where it was suggested that variation might be related to plasma albumin concentration[5]. Considering that variations in plasma aspirin concentrations may exist, it would be advisable to monitor circulating salicylate and make adjustments to dose as and when necessary. The routine use of therapeutic drug monitoring would be expected to improve therapeutic anti-inflammatory success as has been shown with anti-epileptics[8].

*Department of Pharmacy, Faculty of Medicine, University of Zimbabwe, P O Box MP 167, Mount Pleasant, Harare, Zimbabwe
**Department of Clinical Veterinary Studies, Faculty of Veterinary Science

Received: January 1989 Accepted: July 1989

In a number of studies large interspecies differences should be noted[3 4 10] with the half-life of salicylate in dogs after single administration being reported as 8,6 h[4] and 12,2 h after multiple administration[12]. This change in half-life with multiple administration would suggest that twice daily dosing in dogs should be adequate to maintain adequate circulating salicylate levels, although such a regimen has been reported to result in gastric irritation manifesting as emesis[12].

The aims of this study were to determine the pharmacokinetics of single and multiple administration of aspirin in dogs to develop a workable dosage regimen for clinical application. The value of therapeutic drug monitoring in maintaining adequate anti-inflammatory salicylate levels was also evaluated.

## MATERIALS AND METHODS

### Pharmacokinetic studies

Healthy male dogs (cross breeds; n=5), hospitalised for the duration of the study, had access to unlimited water and were fed commercial pet food twice daily (morning and evening). On Day 1 in the morning, aspirin (900mg; 36-69mg $kg^{-1}$) was administered by slow intravenous injection and blood samples collected at 0,25; 0,5; 1; 2; 3; 4; 6 and 8 h post administration. On the evening of Day 1 and then twice daily for 8 d aspirin BP was administered to the dogs as powder mixed with feed at a dose of 50mg $kg^{-1}$. On Day 9 blood samples were collected before feeding and 1; 2; 3; 4; 6; 8 and 16 h after the morning feed/aspirin dose. All blood samples were collected in heparinised tubes, centrifuged and plasma collected for salicylate analysis.

### Referred samples

Plasma samples were referred by practising veterinary surgeons who had been informed of the availability of a service for monitoring salicylate levels. All animals had been on aspirin for a minimum of 7 d before the first sample was taken. The samples were from dogs with a variety of inflammatory disorders and were accompanied by assay request forms which included details of each patient (breed, age, sex, weight, current disease status, hepatic funtion and presence/absence of gastric irritation).

Blood samples were collected just prior to the next drug dose. Changes in dose were recommended on the basis of the plasma salicylate concentration. This information was conveyed to the patients' owners and the importance of compliance with the dosage regimen was stressed. In all cases of dosage change, samples were requested to be taken 7 d following the change and any change in clinical status noted was to be reported.

### Salicylic acid assay

Salicylic acid in plasma was estimated using a modification of a previously reported method[11]. A 500 µl sample of the test plasma was mixed with 2,5 mℓ of Trinders reagent (4g mercuric chloride in 85 mℓ water and 12 mℓ 1N hydrochloric acid. Four grams of ferric nitrate was added and the whole made up to 100 mℓ with water). The reaction mixture was boiled for 15 min, tubes cooled, centrifuged and the absorbance of the supernatant read at 540 nm spectrophotometrically. Salicylic acid concentrations were calculated using a calibration curve constructed using samples of fresh canine plasma spiked with known amounts of salicylic acid. The method obeyed Beers law over the range 10-350 µg/mℓ ($r$ = 0.997) and was specific for salicylate, with no interference by metabolites.

### Data analysis

The plasma salicylate concentrations were used to calculate the peak plasma concentration (Cmax), apparent volume of distribution (Vd), elimination rate constant (Ke), absorption rate constant (Ka), elimination halflife ($t_{\beta}$ 1/2) and percentage oral availability.

## RESULTS

The individual plasma salicylate concentration time curves following multiple oral administration of aspirin revealed that peak concentrations were consistently

Table 1: **Pharmacokinetic parameters determined for 5 dogs given aspirin iv (single administration) and orally (multiple administration).**

| Subject | Body weight (kg) | Dosage (mg) | Vd ($\ell kg^{-1}$) | Ke $(hr^{-1})$ | Ka $(hr^{-1})$ | t 1/2 B $(hr^{-1})$ | % |
|---|---|---|---|---|---|---|---|
| 1 | 23 | 900 iv | 0,5 | 0,14 | --- | 5,1 | --- |
| | | 1150 po | --- | --- | 1,84 | 22,4 | 71 |
| 2 | 13 | 900 iv | 0,6 | 0,11 | --- | 6,3 | --- |
| | | 650 po | --- | --- | 0,90 | 12,6 | 68 |
| 3 | 24 | 900 iv | 0,4 | 0,13 | --- | 5,2 | --- |
| | | 1200 po | --- | --- | 1,74 | 28,3 | 70 |
| 4 | 25 | 900 iv | 0,6 | 0,32 | --- | 2,2 | --- |
| | | 1250 po | --- | --- | 1,65 | 27,3 | 72 |
| 5 | 24 | 900 iv | 0,4 | 0,08 | --- | 8,7 | --- |
| | | 1200 po | --- | --- | 1,77 | 28,9 | 76 |

Vd = apparent volume of distribution
Ke = elimination rate constant
Ka = absorption rate constant
$t_B$ + 1/2 = half-life
% = % oral bioavailability

Table 2: **Details of patients referred from practising veterinarians**

| Patient | Breed | Age (Yrs) | Sex | Body Mass (kg) | Disorder |
|---|---|---|---|---|---|
| 1 | Doberman | 10 | M | 30 | stiffness on rising |
| 2 | Setter | 7 | F | 44 | stiffness on rising |
| 3 | GSD | 5 | M | 30 | limb stiffness |
| 4 | Labrador | 9 | F | 39 | stiffness on rising |
| 5 | GSD | 12 | M | 40 | limb stiffness |
| 6 | Labrador | 11 | F | 28 | stiffness on rising |
| 7 | Boxer | 2 | F | 25 | limb stiffness |
| 8 | GSD | 4 | M | 45 | hip dysplasia |
| 9 | GSD | 8 | M | 30 | limb stiffness |
| 10 | Rottweiler | 4 | F | 41 | stiffness on rising |
| 11 | Labrador | 11 | M | 38 | hip dysplasia |
| 12 | Boxer | 6 | M | 35 | hip dysplasia |
| 13 | GSD | 8 | M | 32 | hip dysplasia |
| 14 | GSD | 12 | F | 48 | limb stiffness |
| 15 | Terrier X | 10 | F | 21 | limb stiffness |
| 16 | Corgi | 7 | M | 15 | limb stiffness |
| 17 | Schnauzer | 9 | M | 10 | limb stiffness |
| 18 | GSD | 5 | F | 20 | hip dysplasia |
| 19 | GSD | 6 | F | 30 | hip dysplasia |
| 20 | Collie | 9 | F | 25 | limb stiffness |

GSD = German shepherd dog

reached about 3 h after dosing although fluctuations in plasma level with time were not great (Fig 1a-1e).

There were substantial inter-patient differences in the pharmacokinetic parameters (Ke; Ka) and an increase in half-life, following multiple dosing, was noted (Table 1).

Of the patients monitored clinically (Table 2), improvement in condition was generally noted with increased aspirin dosages. Satisfactory control was achieved with salicylate concentrations within the range considered therapeutic in humans (Table 3).

## DISCUSSION

Pharmacokinetic analysis of the results was carried out with the assumption that canine absorption of aspirin would be apparent first order and confer the characteristics of a one-compartment model. If this assumption is accepted, then the time course of salicylate in the body can be described as follows[6]:

$$C = \frac{Ka.F.Xo.}{Vd.(Ka-Ke)} (e^{-Ke.t} - e^{-Ka.t}) \quad \text{.....(1)}$$

where C is the plasma concentration of drug at time t following administration of dose Xo (in mg); Vd is the apparent volume of distribution, F the fraction of drug absorbed and Ka and Ke the absorption and elimination rate constants respectively.

Assuming that Ka>Ke equation 1 can be rewritten in terms of common logarithms as follows:

$$\log C = \log \frac{Ka.F.Xo}{Vd.(Ka-Ke)} - \frac{Ke.t}{2.303} \quad \text{.....(2)}$$

and a plot of log (drug concentration) versus time will yield a y-intercept from which Ka and Vd can be determined (through use of the method of residuals)[6] and measurement of the gradient allows determination of Ke. In the case of orally administered drugs the y-intercept is usually determined by extrapolation of the linear portion of the semi-logarithmic plots. The fact that plots of log (drug concentration) versus time following iv administration were linear (Table 1), implied that the absorption of aspirin was first order and that a one-compartment model was appropriate for analysis. By comparison of the plasma salicylate profiles following oral and intravenous administration, it was possible to estimate the percentage availability of oral aspirin and consequently the other pharmacokinetic parameters (Table 1).

The fairly large inter-patient differences noted in aspirin disposition (Table 1, Fig. 1a-1e) suggests that routine monitoring should accompany therapy to ensure that adequate non-toxic salicylate levels ($<300\mu g/m\ell$) are maintained throughout therapy as has been previously suggested[2]. The large differences observed in the case of the biological half-life ($T_B$ 1/2) between the single and multiple treatments (Table 1) may be the result of inadequate numbers of blood samples in the terminal phase of the disposition curve. The lengthening of half-life noted after multiple dosing (Table 1), however, may have resulted in the fairly constant steady state drug profiles (Fig. 1a-1e) which would be expected to result in good anti-inflammatory control using a twice daily dosing regimen.

This twice daily dosing regimen was examined in practice in 20 cases referred from veterinary surgeons which were followed up in order to monitor success (Table 2). The cases examined were mostly elderly dogs with varying degrees of stiffness in the limbs, difficulty in rising, accompanied by pain and hip dysplasias and all were recommended to start on a dosage of 600 mg aspirin twice daily, adjustments in dose being made on the basis of plasma salicylate concentrations until within the presumed therapeutic range and/or when significant clinical improvement had been noted. Evaluation of clinical condition was subjective. At the start of treatment, dogs were classified as being either bad or very bad and subsequently where improvement was noted, it was classified as fair, good or very good, this grading being based essentially on the degree of improvement in patient mobility.

In most cases the initial dose of oral aspirin given was insufficient and one or

| Dog | Clinical status at start | Dose (mg bd) | Salicylate ($\mu g\ ml^{-1}$) | Clinical status at this dose | Recommended dose mg bd |
|---|---|---|---|---|---|
| 1 | bad | 600 | 12 | bad | 1200 |
| | | 1200 | 69 | *fair* | 1500 |
| | | 1500 | 84 | good | hold (50mg $kg^{-1}$) |
| 2 | very bad | 600 | 123 | fair | 1500 |
| | | 1500 | 192 | good | hold (34mg $kg^{-1}$) |
| 3 | bad | 600 | 22 | bad | 1800 |
| | | 1800 | 89 | good | hold (60mg $kg^{-1}$) |
| 4 | very bad | 600 | 60 | fair | 900 |
| | | 900 | 85 | good | hold (23mg $kg^{-1}$) |
| 5 | bad | 600 | 11 | bad | 1200 |
| | | 1200 | 80 | fair | 1500 |
| | | 1500 | 95 | good | hold (38mg $kg^{-1}$) |
| 6 | very bad | 600 | 63 | bad | 900 |
| | | 900 | 99 | fair | 1200 |
| | | 1200 | 153 | fair | 1500 |
| | | 1500 | 230 | good | hold (54mg $kg^{-1}$) |
| 7 | bad | 600 | 37 | bad | 900 |
| | | 900 | 148 | good | hold (36mg $kg^{-1}$) |
| 8 | very bad | 600 | 59 | fair | 1200 |
| | | 1200 | 86 | good | hold (27mg $kg^{-1}$) |
| 9 | bad | 600 | 8 | bad | 900 |
| | | 900 | 61 | fair | 1500 |
| | | 1500 | 104 | good | hold (50mg $kg^{-1}$) |
| 10 | bad | 600 | 8 | bad | 1200 |
| | | 1200 | 71 | good | hold (29mg $kg^{-1}$) |
| 11 | very bad | 600 | 63 | fair | 900 |
| | | 900 | 72 | fair | 1200 |
| | | 1200 | 105 | good | hold (32mg $kg^{-1}$) |
| 12 | very bad | 600 | 15 | bad | 1800 |
| | | 1800 | 194 | very good | hold (51mg $kg^{-1}$) |
| 13 | very bad | 900 | 77 | fair | 1800 |
| | | 1800 | 112 | good | hold (56mg $kg^{-1}$) |
| 14 | very bad | 1200 | 68 | bad | 2400 |
| | | 2400 | 157 | good | hold (50mg $kg^{-1}$) |
| 15 | very bad | 600 | 50 | bad | 1200 |
| | | 1200 | 130 | fair | 1800 |
| | | 1800 | 281 | good | hold (86mg $kg^{-1}$) |
| 16 | bad | 600 | 146 | good | hold (40mg $kg^{-1}$) |
| 17 | bad | 300 | 200 | good | hold (30mg $kg^{-1}$) |
| 18 | bad | 600 | 73 | good | hold (30mg $kg^{-1}$) |
| 19 | very bad | 1200 | 170 | good | hold (40mg $kg^{-1}$) |
| 20 | bad | 1200 | 85 | good | hold (48mg $kg^{-1}$) |

Figures in parentheses indicate the final effective dose given in mg aspirin per kg body mass

more dose increases were made until clinical improvement was considered adequate (Table 3). The dose necessary to achieve adequate control varied from 23 to 86mg $kg^{-1}$ twice daily (with plasma salicylate concentrations resulting, ranging from 71 to 281 $\mu g\ ml^{-1}$; this range being similar to that suggested as being therapeutic in humans (100-250$\mu g\ ml^{-1}$). In all the cases examined, it was possible to achieve good clinical control through dose adjustments, which suggests that aspirin can be successfully employed in dogs for control of various inflammatory disorders. That there was no correlation between dose of aspirin and circulating salicylate concentration (Table 3) could possibly have been due to the fact that the drug was administered with food and this underlines the importance of routine monitoring to ensure therapeutic success and limit the development of toxicity.

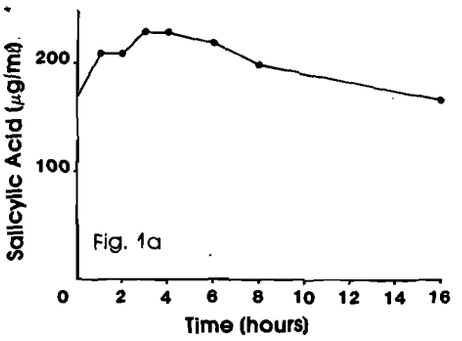
The most striking observation in this study, apart from the therapeutic success derived from oral administration of aspirin, was the absence of overt gastric irritation in all cases, although doses of 50mg $kg^{-1}$ have previously been reported as causing emesis[12]. The apparent lack of gastric irritation noted in the subjects examined in this study, was probably due to the method of administration; aspirin in powder form, mixed with food, would ensure that the drug were evenly distributed throughout gastric contents, reducing the localised irritant effect. When administered as a solid as previously reported[12], the drug would, on disintegration, develop a high concentration in contact with a small area of the gastric mucosa and this could have been responsible for the resultant emesis. It should be noted, however, that gastric ulceration may also be caused by prostaglandin synthetase inhibition although reduction of a directly irritant effect can only be considered beneficial. Aspirin toxicity may also manifest as effects other than gastric irritation and consideration of these effects must also be taken into account when using the drug.

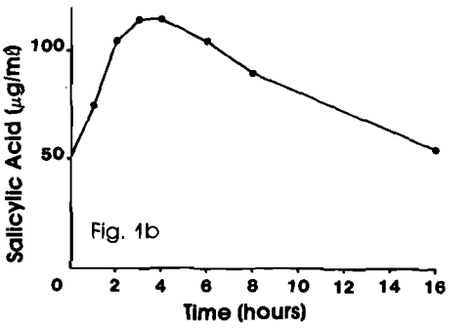
It is apparent, therefore, that aspirin administered twice daily as a powder mixed with food, can be used successfully in the control of canine inflammatory disorders. Dosing should commence at 25mg $kg^{-1}$ twice daily and dose adjustments should be made on the basis of plasma salicylate concentrations until circulating drug levels are between 100-250 $\mu g\ ml^{-1}$ at which point clinical improvement should be optimal. Sampling for salicylate determination, should be done at least a week after a dose change to allow time for attainment of steady state drug levels. Without therapeutic drug monitoring of circulating salicylate levels, these high dosages of aspirin should not, however, be recommended.

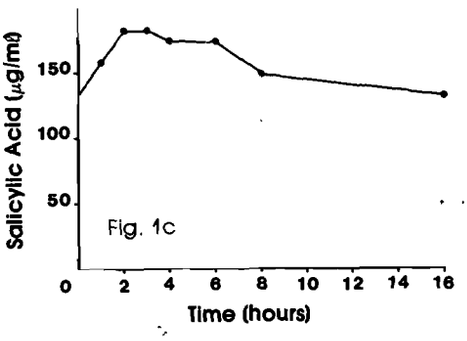
**ACKNOWLEDGEMENTS**

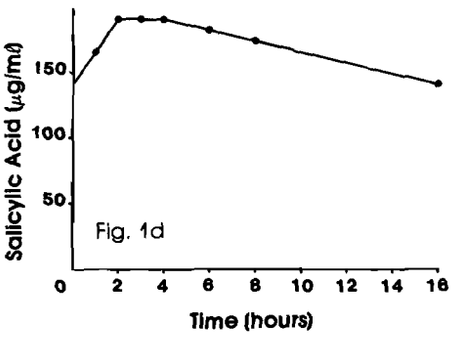
This study was funded by the University of Zimbabwe Research Board. The authors are grateful to the veterinary surgeons, particularly Dr E V Cock, for referring the samples examined.

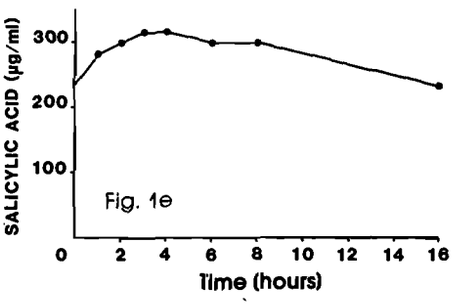
Fig. 1: **Plasma salicylate concentration versus time determined in plasma from dogs given 50 mg kg$^{-1}$ aspirin in feed twice daily for 9 days. (Time 0 = time of administration) a) patient 1; b) patient 2; c) patient 3; d) patient 4; e) patient 5.**





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# THE USE OF FLUMETHRIN POUR-ON FOR DE-TICKING BLACK RHINOCEROS *(Diceros bicornis)* PRIOR TO TRANSLOCATION IN ZIMBABWE

I M DUNCAN*

**ABSTRACT**

The use of flumethrin pour-on in 1.0% and 0,5% concentrations for the purpose of de-ticking black rhinoceros (*Diceros bicornis)* prior to translocation is reported. Both formulations achieved a high level of efficacy within 8 to 12 h following treatment. The 0,5% formulation was found to be more suitable than the 1.0% for use on the dry, hairless skin of the rhinoceros because the increased dose volume resulted in more rapid spreading.

Key words: Rhinoceros, *Diceros bicornis,* tick control, translocation

Duncan I.M. **The use of flumethrin pour-on for de-ticking black rhinoceros** *(Diceros bicornis)* **prior to translocation in Zimbabwe.** *Journal of the South African Veterinary Association* **(1989) 60 No. 4, 195-196 (En.) Agricura (Pvt) Ltd, P.O. Box 2742, Harare, Zimbabwe.**

## INTRODUCTION

The relocation of black rhinoceros (*Diceros bicornis)* from the Mana Pools National Park, and the Sapi and Chiwore Hunting Areas of the Zambezi Valley of nort Zimbabwe, (29° 15'E to 30° 0'E and 16° 15'S), to more centrally situated, safer habitats is part of the Department of National Parks and Wildlife Management's effort to preserve this threatened species from the onslaughts of poachers. In 1988 the rhino capture and translocation took place between mid-June and the end of July. The 20 animals mentioned in this report were relocated in the Zimbabwe Midlands, near Kwe Kwe (18° 59' S, 29° 46' E) and in southern Matabeleland near Gwanda (21° O' S, 29° O' E).

Black rhinoceros are the natural hosts of a number of ixodid tick species, some of which are the vectors of diseases affecting domestic livestock and some wild animals. The species *Amblyomma rhinocerotis* apparently occurs only in the Zambezi Valley and adjacent areas[1]. However, *Amblyomma sparsum* has been reported from other areas of Zimbabwe besides the Zambezi Valley, particularly areas to which black rhinoceros have been relocated[2]. This applies also to *Dermacentor rhinocerinus*[3]. While black rhinoceros appear to be refractory to tick-borne diseases, the role of the tick species they host in the possible transmission of disease to other classes of livestock in relocation areas is largely ignored. The introduction of ticks into these areas by means of translocated black rhinoceros therefore may have important implications. For example the nymphs of *Amblyomma sparsum,* a species hosted by black rhinoceros, are capable of transmitting heartwater (*Cowdria ruminantium)* to sheep[3].

The objectives of the present experiment were to test both the effectiveness and feasibility of using flumethrin pour-on to de-tick black rhinoceros destined for translocation and to prevent the introduction of tick species into relocation areas in which they do not occur naturally.

## MATERIALS AND METHODS

Black rhinoceros (n=20) were carefully examined for tick infestation at the time of capture shortly after immobilisation. Estimates of the tick burdens were made, noting species and attachment sites. Where possible, semi-and fully engorged female ticks were counted and recorded. No sex identification of flat adult ticks was attempted and the numbers of flat ticks were recorded collectively.

Each animal was identified by an ear tag numbered from 01/88 to 20/88. Ticks were collected from each animal. Half of these were placed in 70% alcohol in specimen bottles for identification, while the other half were retained alive for in vitro exposure to flumethrin pour-on.

After capture all animals were transported to holding stockades where they were held for 3 to 7 d prior to crating for transportation by road to their relocation sites. Treatment with flumethrin pour-on took place after crating but before translocation.

The animals numbered 01/88 — 06/88 were treated with a 1,0% pour-on formulation of flumethrin (Drastic Deadline, Bayer) at the rate of 1 mg $kg^{-1}$ live mass (10 mℓ 100 $kg^{-1}$ live mass). The acaricide was applied with an automatic dosing gun, one third of the dose being placed on the dorsal mid-line over the fore quarters, and the remaining two thirds over the hind quarters.

This method of dosage placement was designed to facilitate the rapid spreading of the acaricide to the preferred tick attachment sites of the axilla, groin, udder/scrotum and perineum.

The animals numbered 07/88 — 20/88 were treated in similar fashion with a 0,5% pour-on formulation of flumethrin and the dose volume was doubled to 20 mℓ 100 $kg^{-1}$ live mass to attain the same dosage of active ingredient as for the 1% formulation. This formulation and dose volume were used to achieve faster and more satisfactory spreading of the acaricide.

All 20 animals were checked 30 min and 1 h after treatment and again on arrival at their relocation sites 8-12 h later for tolerance to the treatment. All the animals were inspected for ticks through the sides of the crates before their release into holding stockades, where they were all inspected a second time, to determine the effect of the flumethrin on the ticks, and to note the spreading of the formulations.

In some cases it was possible to pluck ticks off animals by hand, or with specially adapted forceps. The empty translocation crates were searched after the animals were released into the stockades and the dead and live ticks collected. Those already dead were placed in specimen bottles containing 70% alcohol for identification while those still alive were placed in ventilated plastic containers. A small wad of slightly moistened cotton wool was placed to one side on the floor of each container. These containers were placed in an insulated, ventilated box and kept in the shade.

Live ticks collected at the time of immobilisation (before treatment with flumethrin pour-on) were divided into 3 treatment groups as follows: untreated controls, 1,0% flumethrin, and 0,5% flumethrin. Each group consisted of the following ticks:

*Amblyomma rhinocerotis* x 20 (10 male and 10 female)
*Amblyomma sparsum* x 10 (males only)
*Dermacentor rhinocerinus* x 5 (males only)

There were a total of 9 containers, 1 for each species within each treatment group.

In the treated groups, exposure of the ticks to flumethrin took place by means of a 30 mm diameter filter paper placed on the base of a 90 mm diameter Petri dish. One mℓ of the 1,0% and 0,5% formulations of flumethrin was run onto the filter papers prior to the ticks being placed in the containers. Gauze caps were placed over the tops of all containers to prevent the escape of ticks. Each container was checked at two hourly intervals up to 8 h after tick placement and finally at 24 h.

* Agricura (Pvt) Ltd, P.O. Box 2742, Harare, Zimbabwe

Received: February 1989 Accepted: July 1989

Table 1: **Tick infestations on 20 black rhinoceros captured in Zimbabwe during 1988**

| | Estimated numbers of ticks | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | A. rhino | | A. sparsum | | D. rhino | | Hyalomma spp. | | |
| **Animal No.** | **FL** | **S/F** | **FL** | **S/F** | **FL** | **S/F** | **FL** | **S/F** | **TOTALS** |
| 01/88 | 300 | 20 | 25 | 2 | 0 | 0 | 5 | 1 | 353 |
| 02/88 | 100 | 10 | 40 | 3 | 2 | 0 | 1 | 0 | 156 |
| 03/88 | 200 | 15 | 12 | 1 | 0 | 0 | 10 | 0 | 238 |
| 04/88 | 200 | 20 | 10 | 2 | 0 | 0 | 4 | 1 | 237 |
| 05/88 | 500 | 60 | 20 | 4 | 4 | 0 | 15 | 2 | 605 |
| 06/88 | 400 | 20 | 20 | 8 | 7 | 0 | 25 | 8 | 488 |
| 07/88 | 300 | 20 | 15 | 5 | 4 | 0 | 20 | 5 | 369 |
| 08/88 | 150 | 4 | 10 | 2 | 2 | 0 | 20 | 5 | 193 |
| 09/88 | 150 | 4 | 20 | 2 | 0 | 0 | 4 | 1 | 181 |
| 10/88 | 200 | 20 | 15 | 5 | 2 | 0 | 4 | 0 | 246 |
| 11/88 | 250 | 12 | 25 | 4 | 6 | 0 | 20 | 4 | 321 |
| 12/88 | 200 | 5 | 12 | 2 | 2 | 0 | 15 | 2 | 238 |
| 13/88 | 250 | 30 | 20 | 4 | 5 | 0 | 50 | 8 | 367 |
| 14/88 | | | | not counted | | | | | |
| 15/88 | 400 | 20 | 10 | 2 | 4 | 0 | 50 | 10 | 496 |
| 16/88 | 300 | 30 | 50 | 7 | 0 | 0 | 20 | 4 | 411 |
| 17/88 | 300 | 30 | 0 | 0 | 1 | 0 | 20 | 8 | 359 |
| 18/88 | | | | not counted | | | | | |
| 19/88 | 150 | 20 | 50 | 10 | 0 | 0 | 50 | 10 | 290 |
| 20/88 | 200 | 20 | 10 | 0 | 1 | 0 | 15 | 5 | 251 |
| Totals | 4 550 | 360 | 364 | 63 | 40 | 0 | 348 | 74 | 5 799 |
| Combined totals | 4 910 | | 427 | | 40 | | 422 | | |
| Percentage of total infestation | 84,7% | | 7,3% | | 0,7% | | 7,3% | | |

**Key**

| | | |
|---|---|---|
| *A.rhino* | = | *Amblyomma rhinocerotis* |
| *A.sparsum* | = | *Amblyomma sparsum* |
| *D.rhino* | = | *Dermacentor rhinocerinus* |
| FL | = | Flat ticks |
| S/F | = | Semi- and fully engorged female ticks |

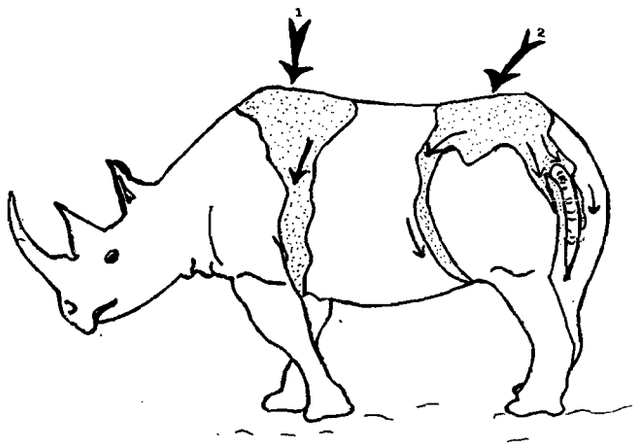


Fig. 1: **Illustration of dosage placement and spread of flumethrin pour-on on black rhinoceros (1 = one third of dose deposited 2 = two thirds of dose deposited)**

**RESULTS**

Estimates made at the time of capture revealed that the black rhinoceros were, at that time, hosting considerable numbers of ticks, mainly of 4 species. These were *A rhinocerotis,* which accounted for roughly 84,7% of the infestations; *A sparsum:* 7,3%; *Hyalomma* spp: 7,3% and *D rhinocerinus:* 0,7%.

No *Rhipicephalus* species were present and members of the genus *Boophilus* are known not to occur in this area. *Amblyomma hebraeum* and *Amblyomma variegatum* could not be found on any of the animals examined. Table 1 summarises the estimated tick burdens of each of 18 animals at the time of capture. It was not possible to estimate the tick numbers on animals 14/88 and 18/88. Tick numbers varied from approximately 156 to 605 adult ticks. Roughly 8,6% of these were semi-and fully engorged female ticks, mainly of the species *A rhinocerotis.* The average tick burden was 322. There was no evidence of tick stress or physical damage on any of these animals.

The main sites of tick attachment for all species were the groin, udder/scrotum, perineum and axilla. A few *A sparsum* were also attached to the dorsal regions of the animals.

**Acaricidal efficacy of flumethrin pour-on**

It was not possible to immobilise the animals at their relocation sites prior to release and detailed tick estimates could therefore not be made. However, it was possible to conduct close-quarter observation of the animals through the sides and tops of their translocation crates.

Further observations were carried out through the sides of the stockades after the animals were released from the crates. Those ticks which could be reached by hand or be plucked off with a specially adapted pair of forceps were all found to be dead.

The empty translocation crates were searched for detached ticks and large numbers collected. A total of 110 live ticks were collected from the crates but none survived for longer than 24 hours after collection.

All the ticks exposed in vitro to either of the formulations of flumethrin died. The untreated controls were still alive 3 d later at which time they were discarded.

The 1,0% formulation when used at the recommended dosage of 1 mg $kg^{-1}$ spread slowly but in most cases did eventually reach the target areas. The 0,5% formulation used at the dosage volume of 20 mℓ 100 $kg^{-1}$ live mass (1 mg flumethrin per kg) however, spread rapidly and visibly reached the target areas in a much shorter time.

Placement of the dosage for both 1,0% and 0,5% formulations was identical. Solution placed on the hindquarters spread down either side of the tail attachment to the perineum and beyond to the area between the thighs. Spreading also took place forward down the groove formed by the anterior aspect of the hind legs and the posterior aspect of the abdomen. Placement over the forequarters on the shoulders resulted in spreading down behind the front legs, down the girth to the axilla. (Fig. 1).

There was no evidence of sensitivity to flumethrin pour-on in any of the 20 animals with either of the pour-on formulations.

## DISCUSSION

Black rhinoceros appear to suffer no ill effects due to physical damage or tick-borne diseases following tick infestation under the normal extensive wildlife conditions found in the Zambesi Valley. Problems which may result through confining the black rhinoceros to fenced-off areas are to be expected since the confinement of other species of wild animals has, on may occasions, resulted in high tick challenge with its consequent problems[4].

The provisions of the Animal Health Act in Zimbabwe may, at any time, be invoked and applied to translocated wild animals to ensure they are tick free prior to translocation. The rule does apply to domestic livestock (Cattle Cleansing regulations, 1976) and is designed to circumvent the outbreak of serious tick-borne diseases in all classes of domestic livestock and game.

It would appear that before the present exercise, effective de-ticking of black rhinoceros prior to translocation was not carried out. Treatment of rhino after relocation has taken place (P Trembath, 1988 - personal communication). This has been largely due to the unsuitability of conventional means of de-ticking, eg. acaricidal sprays.

Such methods may prove ineffective since the acaricide might not reach some of the inaccessible target areas on black rhinoceros where ticks are likely to be attached. Ticks attached in the deep skin folds of the groin, for example, might not be reached by the acaricide. One of the most important advantages of the "pour-on" method of acaricide application is the fact that it is stress-free. This is an important consideration at a time when the animal is subjected to a considerable amount of stress-producing activity.

The large numbers of dead ticks collected from the empty translocation crates, the relatively tick-free state of the animals when checked at their re-location sites, and the high in vitro efficacy of the acaricide suggest that flumethrin pour-on when applied to tick infested black rhinoceros, will achieve a high degree of efficacy within 24 h.

Regrettably, because immobilisation of the rhinoceros after transportation was not possible, a more critical comparison of the efficacy of the two formulations was not carried out. It is reasonable to assume, however, that the 0,5% formulation was more effective due to its more satisfactory spreading.

The dry, hairless hide of the black rhinoceros implies that it has a low sebaceous gland density, resulting in a much lower level of sebum secretion. Since flumethrin pour-on depends to some extent on naturally secreted sebum to spread across the animal's skin surface, its absence obviously results in slower and less efficient spreading. The spread of the 1,0% flumethrin formulation on the skins of the rhinoceros was slow and in some cases the acaricide may not have reached the target areas in the groin and axilla of treated animals.

A similar situation has been observed in experiments carried out on African Buffalo at Mushandike National Park, west of Masvingo in Zimbabwe (Duncan and Monks, 1986 - unpublished observations).

In addition to the presumed low sebum secretion, the hide of the rhinoceros is characterised by a rich network of wrinkles forming both large and minute channels. When applied to such a surface, instead of spreading rapidly, as it would on the sebum saturated skin surface of most other animals, much of the pour-on formulation is soaked up in the wrinkles. Further spreading only takes place if there is a sufficient volume of pour-on to fill the wrinkles and overflow to unsaturated areas. Since the attachment sites of ticks on black rhinoceros are well defined, the split-dose placement of flumethrin pour-on over the forequarters and hindquarters is advisable.

## ACKNOWLEDGEMENTS

I wish to thank the Director, Department of National Parks and Wildlife Management, Zimbabwe, Mr Justin Muchuwe, as well as Dr Jane B Walker, Dr Mike Kock, and Dr Johann Schröder for their assistance during this project.

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# KLINIESE VERANDERINGE NA INTRAVENEUSE TOEDIENING VAN ENDOTOKSIEN IN DIE PERD

P. STADLER* en S.R. VAN AMSTEL*

**ABSTRACT**

**The results of a study conducted to determine the clinical changes in 4 experimentally-induced cases of endotoxaemia in the horse are reported on. Endotoxaemia was induced by injecting commercially available *E. coli* 055:B5 lipopolysaccharide intravenously at a dose of 1 $\mu$g kg$^{-1}$. The parameters that were monitored include general behaviour, rectal temperature, heart rate, respiratory rate and quality, pulse quality, mucous membrane colour, capillary refill time, appearance of the faeces and the presence of laminitis. Increases in rectal temperature, respiratory and heart rate, capillary refill time, the development of a bounding peripheral pulse, dyspnoea and congestion of mucous membranes, decrease in faecal consistency and behavioural changes were recorded.**

**Key words: Equine, endotoxaemia, clinical changes**

**Stadler P.; Van Amstel S.R. Clinical changes following intravenous administration of endotoxin in the horse.** *Journal of the South African Veterinary Association* **(1989) 60 No. 4, 198-200 (Afrik). Department of Medicine, Faculty of Veterinary Science, University of Pretoria, Private Bag X04, 0110 Onderstepoort, Republic of South Africa**

## INLEIDING

Howel endotoksemie 'n potensieel dodelike toestand in alle spesies kan wees, is die perd baie meer sensitief vir die nadelige effekte van endotoksiene as enige van die ander huisdiere[5]. Entotoksiene speel waarskynlik 'n belangrike rol in die patofisiologiese veranderinge wat voorkom in verskeie toestande van die perd. Die hoofbron van endotoksiene in perde is die flora van die spysverteringskanaal[18]. Aangesien patologiese toestande van die spysverteringskanaal van die mees algemene siektetoestande in perde is[2], is dit duidelik dat endotoksiene dikwels in oormatige hoeveelhede in die perd geabsorbeer kan word.

Die ontstaan van 'n sistemiese endotoksemie veroorsaak verskeie patofisiologiese veranderinge in die liggaam wat lei tot verskeie kliniese en klinies-patologiese veranderinge. Die doel van hierdie studie was om die kliniese veranderinge wat deur die intraveneuse toediening van endotoksien onder plaaslike eksperimentele toestande veroorsaak word, te bepaal.

## MATERIAAL EN METODES

Vier Volbloed X Arabier-kruisings (A, B, C en D) is in hierdie studie gebruik. Volgens hul rekords het hulle nooit aan enige toestand gely wat 'n endotoksemie kon veroorsaak het nie. Ses weke voor die aanvang van die eksperiment is die diere op 'n rantsoen van tefhooi geplaas. Water was vryelik beskikbaar. Die liggaamsmassa van die perde A, B, C en D was onderskeidelik 390, 450, 387 en 545 kg. Elke perd het as sy eie kontrole gedien.

Vyf weke voor die aanvang van die eksperiment is die linker *arteria carotis externa* van elke perd na n subkutane posisie verplaas. Hulle is ook vooraf klinies ondersoek en ontwurm. Die verskillende waarnemings is uitgevoer 24 h voor toediening, 12 h voor toediening, onmiddellik voor toediening en ná endotoksientoediening (Tabel 1).

Lipopolisakkaried (Lipopolysaccharide, Sigma Chemical Company) is teen 'n dosis van 1 $\mu$g kg$^{-1}$ as 'n intraveneuse bolus deur die regter *vena jugularis externa* aan elke perd toegedien.

Die kliniese parameters wat geëvalueer is en die metodes van evaluasie was as volg:

a) Gedrag - Dit is subjektief geëvalueer as normaal, tekens van koliek, matige depressie, uitgesproke depressie, ataksie, lêende houding en enige ander abnormaliteite
b) Rektale temperatuur (°C)
c) Harttempo - Met behulp van 'n kliniese stetoskoop is die aantal hartsiklusse getel
d) Respiratoriese tempo - Die aantal respiratoriese siklusse is getel
e) Polskwaliteit - Dit is subjektief by die linker *incisura vasorum* bepaal en geklassifiseer as normaal, bonsend, swak en onwaarneembaar
f) Kwaliteit van respirasie - Dit is subjektief geëvalueer en geklassifiseer as normaal, verhoogde abdominale komponent, oopgesperde neusgate en dispnee
g) Slymvlieskleur - Die kleur van die oogslymvlies is geëvalueer en geklassifiseer as normaal, matige kongestie, erge kongestie, toksies of modderig en sianoties
h) Kapillêre hervultyd - Dit is bepaal op die slymvlies van die bek bokant die boonste snytande en uitgedruk in sekondes
i) Voorkoms van die ontlasting - Dit is subjektief geëvalueer en geklassifiseer as normaal, sagte balle, konsistensie soos koeimis, vloeistof met vesel en vloeistof sonder vesel
j) Teenwoordigheid van laminitis - Herhaalde verskuiwing van gewig, verhoogde temperatuur van die hoewe, verhoogde digitale pols en pynlike beweging is as tekens van laminitis beskou

Die statistiese verwerking van die data het behels dat, ten opsigte van die betrokke parameter van elke dier, bepaal is of die waardes wat gevind is na die toediening van endotoksien, verskil het van die gemiddelde waarde voor toediening. Vertrouensgrense van 95% is vir elke parameter bereken volgens die metode beskryf deur Stoker et al.[10].

## RESULTATE

'n Opsomming van die waarnemings ten opsigte van die gedrag van die perde verskyn in Tabel 1.

Die vroegste wat enige afwyking gevind is, was na 15 min toe Perd A matige tekens van koliek begin toon het en Perd C begin bewe het. Koliektekens wat waargeneem is, sluit in dat die perd na sy flanke gekyk het, die grond met die voorpote gekap en afwisselend gaan lê het. 'n Addisionele kliniese teken wat deur al 4 perde getoon is, is dat hulle soms die water in hulle bakke met die bek geklap het. Teen 24 h was dit nog net Perd B wat abnormaal voorgekom het. Hy kon uiteindelik nie weer opstaan nie en genadedood is teen 36 h op hom toegepas.

Al 4 perde het 'n styging in rektale temperatuur getoon (Fig. 1).

Die harttempo van al die perde het baie gevarieer gedurende die waarnemingsperiode. Almal het tagikardieë getoon, maar geen bradikardie het voorgekom nie.

Perde A, C en D het statisties-betekenisvolle verhogings ($P<0,05$) van die respiratoriese tempo getoon. Hoewel die tempo van Perd B van tyd tot tyd beide verhogings en verlagings getoon het, was dit nie statisties-betekenisvol nie ($P>0,05$). Teen 24h was die tempo van al die perde weer normaal.

Drie perde het 'n bonsende perifere

*Departement Geneeskunde, Fakulteit Veeartsenykunde, Universiteit van Pretoria, Privaatsak X04, 0110 Onderstepoort, Republiek van Suid-Afrika

Ontvang: Januarie 1989 Aanvaar: Junie 1989

Tabel 1: **Gedrag voor en na endotoksien-toediening by eksperimentele perde**

| Tyd/ Perd | -24h | -12h | 0h | +0h15 | +0h30 | +1h | +2h | +4h | +6h | +8h | +12h | +24h |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | Normaal | Normaal | Normaal | Matige koliek | Gaap Matige koliek Matige depressie | Matige koliek Lêende houding | Matige koliek Ataksie Lêende houding | Normaal | Matige depressie | Matige depressie | Matige depressie | Matige depressie |
| B | Normaal | Normaal | Normaal | Normaal | Matige koliek Matige depressie Lêende houding Gaap | Matige koliek Ataksie Lêende houding | Lêende houding | Matige koliek Ataksie Lêende houding Bewe | Uitgesproke depressie | Matige koliek | Matige koliek Uitgesproke depressie | Uitgesproke depressie Lêende houding |
| C | Normaal | Normaal | Normaal | Bewe Gaap Op- en-af swaai van kop Sit soos hond | Lêende houding Bewe Sweet | Lêende houding | Lêende houding | Matige koliek Matige depressie | Matige koliek | Matige koliek | Normaal | Normaal |
| D | Normaal | Normaal | Normaal | Normaal | Matige koliek Gaap Op- en-af swaai van kop Sit soos hond | Matige koliek | Matige koliek Lêende houding | Matige koliek | Matige koliek Bewe | Matige koliek | Matige koliek | Normaal |

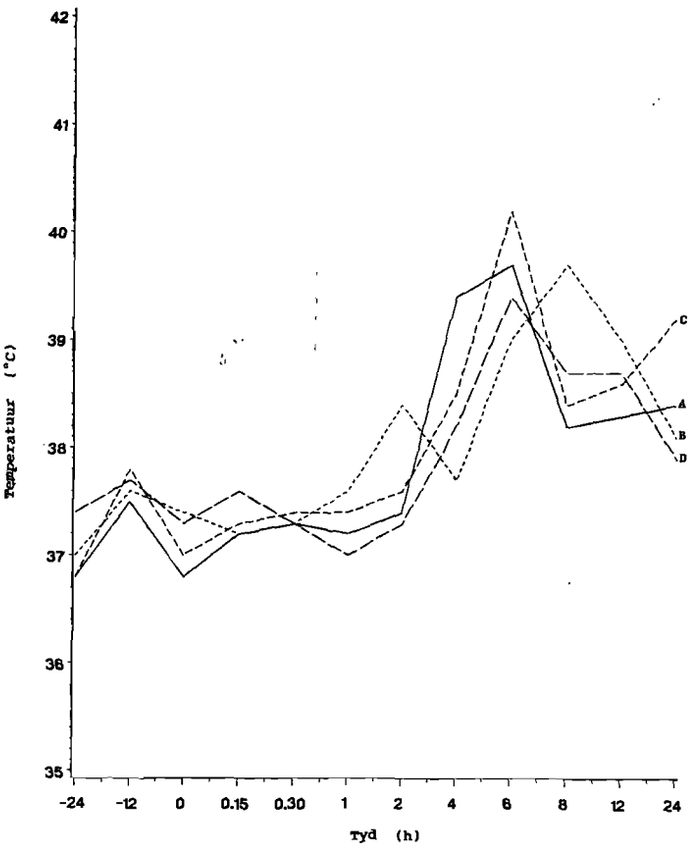


Fig. 1: **Rektale temperatuur in °C voor en na endotoksien-toediening by eksperimentele perde**

polsing ontwikkel. Die polskwaliteit van Perd A het geen afwyking getoon nie.

Hoewel die kwaliteit van respirasie van almal verander het, het slegs Perd B vanaf 12 h dispnee getoon.

Al 4 perde het kongestie van die slymvliese ontwikkel. Dit was egter net in die geval van Perd B uitgesproke en hy was ook die enigste waarvan die slymvlieskleur teen 24 h nog abnormaal was. Die kapillêre hervultye het ook verleng tot 'n maksimum van 3 sek by Perde A en B en 4 sekondes by Perde C en D.

Die voorkoms van die ontlasting van al die perde het tot 'n mindere of meerdere mate verander (Tabel 2).

Geeneen van die gevalle het enige tekens van die teenwoordigheid van laminitis getoon nie.

**BESPREKING**

Voordat daar met hierdie studie begin is, is endotoksien teen 'n dosis van 10 $\mu g$ $kg^{-1}$ intraveneus aan 2 perde onder dieselfde eksperimentele toestande as dié in hierdie studie, toegedien. Beide het egter sulke dramatiese kliniese en kliniespatologiese veranderinge getoon, dat genadedood, weens menslikheidsredes en 'n baie swak prognose vir oorlewing, teen ongeveer 7 h na die toediening toegepas moes word. Vervolgens is besluit om 'n dosis van 1 $\mu g$ $kg^{-1}$ in hierdie studie te gebruik, wat dus aansienlik laer was as die 10 $\mu g$ $kg^{-1}$ wat deur ander navorsers gebruik is[3,6].

Matige koliektekens, 'n lêende houding, anoreksie, 'n ataksiese loopgang, depressie, bewerasie en sweet is veranderinge wat voorheen beskryf is en wat dus te verwagte was[1,6,7]. Verande-

Tabel 2: **Voorkoms van ontlasting voor en na endotoksien-toediening by eksperimentele perde**

| Tyd/ Perd | -24h | -12h | 0h | +0h15 | +0h30 | +1h | +2h | +4h | +6h | +8h | +12h | +24h |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | Normaal | Geen | Normaal | Normaal | Normaal | Geen | Geen | Sagte balle | Geen | Geen | Geen | Normaal |
| B | Normaal | Geen | Normaal | Geen | Normaal Vloeistof sonder vesel | Geen | Konsistensie van koeimis Vloeistof sonder vesel | Geen | Geen | Konsistensie van koeimis | Geen | Geen |
| C | Normaal | Normaal | Geen | Geen | Geen | Normaal | Vloeistof met vesel | Geen | Geen | Normaal | Geen | Geen |
| D | Geen | Geen | Geen | Geen | Geen | Normaal | Konsistensie van koeimis | Vloeistof met vesel | Geen | Geen | Geen | Geen |

ringe wat egter nog nie voorheen in die literatuur beskryf is nie, sluit in die op- en-afswaai van die kop, gaap, die klap van die water met die bek en die inneem van 'n sittende houding soos 'n hond.

Die geskatte minimum pirogeniese dosis van endotoksien is 0,001 $\mu$g kg$^{-1}$ [12]. Volgens Moore[5] is die temperatuurstyging afhanklik van die dosis met 'n monofasiese reaksie by ongeveer die minimum pirogeniese dosis en 'n bifasiese reaksie by subletale dosisse. Hierdie studie het egter getoon dat 'n monofasiese styging selfs nog by subletale dosisse kan voorkom.

Endotoksemie veroorsaak 'n tagikardie[11]. Hoewel al die perde in hierdie studie ook op een of ander stadium 'n tagikardie getoon het, het die hartspoed tydens die duur van die waarnemingsperiode baie gevarieer. Aangesien die hartspoed styg om te kompenseer vir 'n verminderde hartuitset[4], is dit moontlik dat 'n volgehoue tagikardie nie gevind is nie weens die laer dosis van endotoksien wat gebruik is.

Geen verwysing na die polskwaliteit kon in die literatuur gevind word nie. Hierdie studie het egter getoon dat selfs 'n lae dosis van endotoksien 'n verandering in die polskwaliteit van die meerderheid perde veroorsaak.

Kongestie van slymvliese en verlenging van die kapillêre hervultyd kom voor as gevolg van verminderde bloedvloei en die aansameling van bloed in die kapillêre vate[9]. Dit het by al die perde in hierdie studie voorgekom, maar dit blyk dat die graad van hierdie effek dosisafhanklik is, aangesien geeneen van die perde sianose ontwikkel het soos wat voorheen gerapporteer is nie en die verlenging van die kapillêre hervultyd ook kleiner was[3].

Die tagipnee wat by 3 van die gevalle voorgekom het, is in ooreenstemming met vorige bevindinge[3]. Hoewel al die perde veranderinge in die kwaliteit van respirasie getoon het, het slegs een dispnee ontwikkel, waarskynlik weer eens weens die laer dosis wat toegedien is.

Steurnis van die spysverteringskanaal was 'n konstante bevinding. Dit is aangedui deur tekens van koliek en veranderinge in die voorkoms van die ontlasting. Waar die spysverteringskanaal normaalweg vloeistof vir die liggaam absorbeer, verander endotoksien dit spoedig in 'n sekretoriese orgaan, soos aangedui deur die toename in die hoeveelheid vloeistof in die ontlasting.

Hoewel al die perde dieselfde dosis per kg van endotoksien ontvang het en die eksperimentele toestande dieselfde was, het dit uit verskeie van die resultate baie duidelik geblyk dat veral Perd B meer uitgesproke reaksies as die ander getoon het. Teen 24 h na toediening het sy toestand ook versleg en teen 36 h is daar besluit om genadedood op hom toe te pas. Die ander 3 het egter kliniès volkome herstel. Dit is dus duidelik dat die sensitiwiteit vir die toksiese effekte van endotoksien tussen perde varieer.

Hoewel die dosis van endotoksien wat in hierdie studie gebruik is heelwat laer was as wat deur meeste ander navorsers gebruik is, het die kliniese veranderinge wat voorgekom het met enkele uitsonderings baie ooreengestem.

Die verskil in dosis het egter veroorsaak dat die graad van verandering in sommige gevalle verskil het.

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# KLINIES-PATOLOGIESE VERANDERINGE NA INTRAVENEUSE TOEDIENING VAN ENDOTOKSIEN IN DIE PERD

P STADLER* en S R VAN AMSTEL*

**ABSTRACT:**
**The results of a study conducted to determine the clinico-pathological changes in 4 experimentally-induced cases of endotoxaemia in the horse are reported on. Endotoxaemia was induced by injecting commercially available *E. coli* 055 : B5 lipopolysaccharide intravenously at a dose of 1 $\mu g\ kg^{-1}$. The haematocrit, red cell count, total and differential white cell counts, thrombocyte count, prothrombin time, partial thromboplastin time, fibrinogen level, level of fibrin degradation products, arterial acid-base status, serum lactate and blood glucose were determined repeatedly. Changes that occurred, include increases in the haematocrit and red cell count, a leucopaenia followed by a leucocytosis caused mainly by changes in the number of neutrophils, the development of disseminated intravascular coagulation, minor changes in the arterial acid base parameters, hyperglycaemia followed by hypoglycaemia and an increase in serum lactate.**

**Key words: Equine, endotoxaemia, clinico-pathological changes**

*Stadler P.; Van Amstel S.R.* **Clinico-pathological changes following intravenous administration of endotoxin in the horse.** *Journal of the South African Veterinary Association* **(1989) No. 4, 201-205 (Afrik). Department of Medicine, Faculty of Veterinary Science, University of Pretoria, Private Bag X04, 0110 Onderstepoort, Republic of South Africa.**

## INLEIDING

Verskeie hematologiese veranderinge is al gerapporteer tydens endotoksemie in perde[7 8 19]. 'n Verhoging in die hematokrit word veroorsaak deur sametrekking van die milt en 'n vermindering van die plasmavolume weens 'n verskuiwing na die interstisiële weefsel[4]. Hierdie styging mag bifasies wees of dit mag bestaan uit 'n aanvanklike vinnige styging gevolg deur 'n latere geleidelike toename[4]. In sommige gevalle keer die hematokrit geleidelik terug na normaal[19].

Wat die witbloedselle betref, ontstaan 'n aanvanklike uitgesproke leukopenie wat later gevolg word deur 'n leukositose[19]. Die leukopenie is primêr as gevolg van 'n neutropenie[7 8], hoewel daar ook 'n daling is van monosiete, limfosiete en eosinofiele[6]. Die neutropenie ontstaan omdat die neutrofiele in die kapillêre vate van die longe, lewer en milt gesekwestreer word en na die bloedvatwande beweeg[4]. Laasgenoemde word geïnduseer deur endotoksien-geaktiveerde komplement[18]. Die leukositose wat volg, ontstaan feitlik uitsluitlik weens 'n neutrofilie met 'n toename van beide volwasse en onvolwasse neutrofiele wat vrygestel word vanaf die beenmurg weens 'n verhoogde produksie van 'n granulosiet-vrystellingsfaktor[1 6 8]. 'n Trombositopenie kom ook voor[8]. Sommige endotoksien-formulasies veroorsaak 'n bifasiese reaksie, terwyl ander slegs 'n geleidelike daling tot gevolg het[25]. Behalwe vir die verbruik van trombosiete tydens die ontstaan van intravaskulêre stollings, vind daar ook 'n vasklewing van trombosiete aan die vaskulêre endoteel sowel as aan mekaar plaas[12]. Hierdie sameklewende trombosiete word gesekwestreer in die mikrovate van die longe, lewer en milt[9].

Aktivering van die stollingsmeganismes mag lei tot die ontstaan van gedisseminеerde intravaskulêre stolling[6 9]. Hierdie aktivering kan plaasvind as gevolg van direkte stimulasie van die stollingskaskade[9], deur aktivering van komplement[9], deur beskadiging van vaskulêre endoteel[24] en deur stimulering van die sameklewing van trombosiete[9]. Endotoksien mag verder ook die polimorfonukluêre leukosiete en die mononukluêre selle stimuleer om prokoagulantfaktore vry te stel.[23]. Duncan et al.[6] het gevind dat perde wat hiperkoagulasie toon, mag oorgaan tot 'n toestand van hipokoagulasie of tot normaal terugkeer. Abnormaliteite wat gevind is weens die ontstaan van gedisseminеerde intravaskulêre stolling, sluit in 'n trombositopenie[7 8], 'n verlenging van die protrombientyd[7 8], 'n verlenging van die trombientyd[7], 'n verlaging van die antitrombien-III aktiwiteit[22] en 'n verhoogde fibrinogeenvlak[7 22].

Tydens vroeë endotoksemie in die perd ontstaan hiperventilasie wat aanleiding gee tot die ontstaan van 'n respiratoriese alkalose[10 13]. Nieteenstaande hierdie hiperventilasie kom 'n tydelike hipoksemie egter voor[14]. Die aanvanklike respiratoriese alkalose word ook gou vervang deur 'n langdurige metaboliese asidose wat ontstaan weens swak weefselbloedvloei met gevolglike anaerobiese metabolisme op sellulêre vlak[11 13 19]. Die kardiopulmonêre sisteem is nie in staat om volledig te kompenseer vir hierdie metaboliese asidose nie[10 13].

Die genoemde anaerobiese metabolisme gee aanleiding tot 'n verhoogde vlak van serumlaktaat[11]. 'n Tweede bydraende faktor tot hierdie verhoging mag verminderde verbruik van laktaat deur die lewer wees as gevolg van verminderde hepatiese bloedvloei[2]. Aangesien die laktaat begin styg voordat duidelike kliniese tekens van periferele sirkulatoriese wanfunksie voorkom, kan dit as 'n belangrike diagnostiese indikator dien[3]. Die laktaatvlak kan verder ook as 'n prognostiese indikator gebruik word[5].

Endotoksemie word gewoonlik geassosieer met 'n aanvanklike hiperglisemie gevolg deur 'n hipoglisemie[4 8]. Hierdie hiperglisemie mag ontwikkel as gevolg van verhoogde hepatiese glikogenolise[16] aangesien dit gepaard gaan met normale insulienvlakke[8]. Die hipoglisemie wat volg, word geassosieer met 'n verhoogde vlak van insulien in die serum[8] wat waarskynlik voorkom weens 'n verhoogde afskeiding daarvan[26]. 'n Uitgesproke verlaging van glikogeen in die lewer is ook teenwoordig[3]. Die hipoglisemie mag dus ook ontstaan weens uitputting van glikogeen en inhibisie van die induksie van glikogeensintetase en ander ensieme wat nodig is vir glukoneogenese en glikogenese[16].

Dit is dus duidelik dat 'n sistemiese endotoksemie in die perd verskeie kliniespatologiese veranderinge veroorsaak. Die doel van hierdie studie was om die klinies-patologiese veranderinge, wat deur die intraveneuse toediening van endotoksien onder plaaslike eksperimentele toestande veroorsaak word, te bepaal.

## MATERIAAL EN METODES

Die eksperimentele perde, hul voorbereiding, die verwekking van eksperimenteel-geïnduseerde endotoksemie en die waarnemingstye is reeds beskryf[20].

Bloed vir hematologiese bepalings is versamel vanaf die regter *vena jugularis externa* in 5 *m*ℓ vakuumbuisies met EDTA (Venoject tube, Terumo Co. Ltd.). Die hematokrit is bepaal met behulp van 'n mikrohematokritsentrifugeerder (Microhematocrit centrifuge, Hawksley), terwyl die rooiseltelling en die totale witseltelling bepaal is met behulp van 'n Coulterteller model FN (Coulter Electronics Pty. Ltd.).

Differensiële witseltellings is gedoen op

*Departement Geneeskunde, Fakulteit Veeartsenykunde, Universiteit van Pretoria, Privaatsak X04, 0110 Onderstepoort, Republiek van Suid-Afrika

Ontvang: Januarie 1989 Aanvaar: Junie 1989

bloedsmere wat gekleur is met Quick-kleurstof (CAMS Quick stain, C.A. Milsch Pty. Ltd.). Beide die persentasie en getal volwasse en onvolwasse neutrofiele, limfosiete, monosiete, eosinofiele en basofiele is sodoende bepaal. 'n Trombosiettelling is uitgevoer deur gebruik te maak van 'n Sysmex plaatjieteller - PL110 (TOA Medical Electronics Co. Ltd.).

Vir die bepaling van die fibrinogeenvlak is bloed op dieselfde manier versamel in vakuumbuisies sonder 'n stolweermiddel (Venoject tube, Terumo Co. Ltd.). Die persentasie fibrinogeen is daarna bepaal deur gebruik te maak van Boehringer Mannheim se toetsstel.

Bloed vir die bepaling van die protrombientyd, gedeeltelike tromboplastientyd en fibrienafbreekprodukte is op dieselfde manier versamel in vakuumbuisies met natriumsitraat (Venoject tube, Terumo Co. Ltd.). Die protrombientyd is vervolgens bepaal volgens die Hepato Quick-metode deur gebruik te maak van Boehringer Mannheim se toetsstel. Die gedeeltelike tromboplastientyd is ook met behulp van 'n toetsstel van Boehringer Mannheim bepaal, terwyl die fibrienafbreekprodukte bepaal is volgens die Thrombo-Wellco (Rapid Latex) toets HA 13 van Wellcome Laboratories.

Bloed vir suur-basis bepalings is vanaf die verplaasde linker *arteria carotis externa* versamel in geheparineerde 5 ml spuite. Direk na versameling, is die naald omgebuig om die monster anaerobies te hou, waarna dit op ys geplaas en binne 90 min gebruik is vir ontleding. Die pH, $pO_2$, $pCO_2$, $HCO_3^-$, standaard bikarbonaat en standaard bikarbonaat oormaat is bepaal deur gebruik te maak van 'n ABL3 semi-geoutomatiseerde suur-basis-analiseerder (Radiometer, Copenhagen).

Die bepaling van die serumlaktaat- en bloedglukosevlakke is uitgevoer op bloed wat op dieselfde manier versamel is in 5 ml vakuumbuisies met Anderson se stolweermiddel (Venoject tube, Terumo Co. Ltd.). Die serumlaktaat is vervolgens bepaal volgens die ensiematiese UV 365 nm-metode van Boehringer Mannheim, terwyl die bloedglukose bepaal is volgens die heksokinase UV 340 nm endpunt-metode deur gebruik te maak van 'n RA 1000 geoutomatiseerde analiseerder (Technicon Instruments Corporation).

Die data is statisties verwerk soos reeds beskryf[20].

## RESULTATE

Die resultate van die hematokritbepalings en rooiseltellings word weergegee in Tabel 1. Dit toon dat die patroon van verandering wat voorgekom het ten opsigte van hierdie twee parameters, soos verwag kan word, eenders is.

Die totale en differensiële witseltellings wat gevind is, verskyn in Tabel 2.

Hoewel die trombosietgetalle van al die perde dalings getoon het na die toediening van endotoksien, het dit nie dieselfde patroon gevolg nie en was dit net by perde C en D statisties betekenisvol ($P<0,05$).

Al die perde het by een of meer geleenthede duidelike verlenging van protrombientyd getoon, hoewel dit net by perde C en D statisties betekenisvol was ($P<0,05$). Statisties-betekenisvol verlengde gedeeltelike tromboplastientye ($P<0,05$) het ook by almal voorgekom, terwyl slegs perde B en C verhogings in die hoeveelheid firbrienafbreekprodukte getoon het. Wat die persentasie fibrinogeen betref, het verhogings by almal voorgekom, terwyl perde A en B ook verlagings getoon het.

Die resultate van die arteriële suur-basis bepalings verskyn in Tabel 3.

Die serumlaktaat van al die perde het gestyg (Fig. 1). Dit het statistiesbetekenisvol verhoogde vlakke ($P<0,05$) tussen 15 min en 1 h bereik en so gebly totdat die waarnemings teen 24 h gestaak is. Perd B het aansienlik groter verhogings getoon as die ander 3 en hy het, anders as hulle, sy hoogste vlak teen 24 h getoon.

Fig. 2 toon die veranderinge wat voorgekom het ten opsigte van die bloedglukosevlak.

## BESPREKING

Die patroon van 'n aanvanklike tydelike verhoging in die hematokrit en rooiseltelling, gevolg deur 'n tweede, meer langduringe verhoging wat meestal bifasies was, is in ooreenstemming met die bevindinge van navorsers soos Burrows & Cannon[4]. Hulle het egter gevind dat die eerste styging die mees uitgesproke was, terwyl die omgekeerde in hierdie studie gevind is. Sametrekking van die milt is verantwoordelik vir die eerste styging en vermindering van die plasmavolume vir die tweede[4]. Die rede vir die kleiner aanvanklike styging in hierdie studie is dus waarskynlik dat die laer dosis van endotoksien wat gebruik is, in verhouding 'n kleiner effek het op miltsametrekking as ten opsigte van die vermindering van die plasmavolume.

Die aanvanklike uitgesproke leukopenie wat konstant voorgekom het, is hoofsaaklik deur 'n neutropenie veroorsaak, hoewel daar ook dalings was in die getal limfosiete, monosiete en eosinofiele. Dit is by 3 van die gevalle gevolg deur 'n leukositose wat feitlik uitsluitlik veroorsaak is deur 'n toename in volwasse en onvolwasse neutrofiele. Hierdie bevindinge is in ooreenstemming met dié van navorsers soos Duncan et al.[6] en Fessler et al.[8]. Perd B se veranderinge het verskil van dié van die ander 3 deurdat die minimumvlak van die aanvanklike leukopenie gouer bereik is en dit 'n bifasies patroon getoon het. Die leukopenie is ook nie deur 'n leukositose gevolg nie. Dit wil dus voorkom asof die endotoksemie in hierdie perd 'n bifasiese patroon gehad het en/of dat hy meer sensitief was vir die uitwerking van endotoksien.

Die verlaagde trombosietgetalle, verhoogde fibrinogeenvlakke en verlengde protrombientye en gedeeltelike tromboplastientye wat tydens hierdie studie waargeneem is, is in ooreenstemming met die bevindinge van Ewert et al.[7] en Fessler et al.[8]. Dit word aanvaar dat die klinies-patologiese bevindinge wat nodig is om die teenwoordigheid van gedissemineerde intravaskulêre stolling in 'n perd aan te dui, minstens 3 van die volgende moet insluit, naamlik verlengde protrombientyd, verlengde gedeeltelike tromboplastientyd, verlaagde fibrinogeenkonsentrasie, 'n trombositopenie en 'n verhoogde vlak van fibrienafbreekprodukte[17]. Hiervolgens het gedissemineerde intravaskulêre stolling by al die perde in hierdie studie voorgekom, naamlik by perd A teen 8 h soos aangedui deur verlengde protrombientyd, verlengde tromboplastientyd en verlaagde fibrinogeenkonsentrasie; by perd B teen 12 h en 24 h soos aangedui deur die teenwoordigheid van 5 uit 5 van die vereiste veranderinge; by perd C teen 24 h soos aangedui deur die teenwoordigheid van al die vereiste veranderinge, uitgesonderd 'n verlaagde fibrinogeenkonsentrasie en by perd D teen 8 h soos aangedui deur 'n verlengde gedeeltelike protrombientyd, 'n verlaagde getal trombosiete en 'n verhoogde hoeveelheid fibrienafbreekprodukte. Die graad van die gedissemineerde intravaskulêre stolling was volgens die klinies-patologiese bevindinge by perd B meer uitgesproke as by die ander. Die bevinding dat endotoksemie aanleiding tot hierdie patofisiologiese sindroom kan gee, bevestig die bevindinge van Duncan et al.[6] en Moore[12].

Na die toediening van 10 $\mu g\ kg^{-1}$ endotoksien in die perd, ontwikkel 'n respiratoriese alkalose binne 5 min, gevolg deur 'n metaboliese asidose wat mees uitgesproke is tussen 1 tot 2 h en 'n daaropvolgende terugkeer van die pH tot normale vlakke[13]. Die aanvanklike veranderinge wat in hierdie studie gevind is, het oënskynlik dieselfde patroon gevolg, hoewel die veranderinge klein was, waarskynlik weens die laer dosis per kg van endotoksien wat gebruik is. Aangesien die waarnemingstyd in hierdie studie langer was as dié van ander navorsers, kon daar nie 'n verwysing gevind word na moontlike veranderinge in die suur-basis balans tydens die latere stadia van subletale endotoksemie in die perd nie.

'n Uitgesproke hipoksemie ontstaan binne 5 min na endotoksien-toediening, gevolg deur 'n terugkeer in die rigting van normale vlakke teen 15 min[13,14]. Hierdie studie het aangetoon dat hoewel daar in die daaropvolgende periode tot 24 h beide stygings en dalings voorkom, in die arteriële $pO_2$, hulle meestal nie statisties-betekenisvol is nie ($P>0,05$). Die algemene neiging was om weer 'n verlaagde vlak te toon teen 30 min tot 1 h, 'n verhoging teen 4 tot 8 h en weer eens 'n verlaagde vlak teen 24 h. Hierdie veranderinge is veroorsaak deur wisselinge in die effektiwiteit van gaswisseling in die longe. Endotoksiene veroorsaak veranderinge in pulmonale bloedvloei[10] en hierdie veranderde bloedvloei is waarskynlik minstens gedeeltelik verantwoordelik vir die veranderinge in gaswisseling.

Hoewel die dosis van endotoksien wat in hierdie studie gebruik is (1 $\mu g\ kg^{-1}$) aansienlik laer was as die 32-200 $\mu g\ kg^{-1}$ gebruik deur Burrows & Cannon[4] en die 10 $\mu g\ kg^{-1}$ gebruik deur Moore et al.[15] is die bevindinge van eerstens 'n hiperglisemie gevolg deur 'n hipoglisemie, en tweedens 'n verhoogde vlak van serumlaktaat, eenders. Dit, tesame met die feit dat al die gevalle in hierdie studie reeds binne 1 h na endotoksien-toediening veranderinge van beide hierdie parameters getoon het, dui daarop dat dit as sensitiewe indikators van endotoksemie kan dien. Die serumlaktaat blyk 'n beter praktiese indikator te wees, aangesien dit, in teenstelling met die bloedglukose, slegs verhoging sal toon. Dit kan terselfdertyd ook as prognostiese indikator gebruik word soos aangedui deur Donawick et al.[5]. Volgens die bevindinge van laasgenoemde navorsers het 3 van die perde in hierdie studie gely aan subletale endotoksemie, terwyl die vierde



0038-2809 Tydskr. S. Afr. vet. Ver. (1989)60(4):201-205

Tabel 2: **Totale witseltelling en differensiële telling voor en na endotoksien-toediening by eksperimentele perde**

| Bepaling | Perd | Tyd | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | -24h | -12h | 0h | +0h15 | +0h30 | +1h | +2h | +4h | +6h | +8h | +12h | +24h |
| Totale witseltelling x $10^9$ $\ell^{-1}$ | A | 8,8 | 9,2 | 8,9 | 6,7* | 2,9* | 2,2* | 2,3* | 3,4* | 4,5* | 9,0 | 11,4** | 16,8** |
| | B | 7,1 | 8,7 | 8,8 | 5,5* | 1,9* | 2,1* | 2,1* | 2,4* | 1,9* | 2,0* | 3,0* | 7,3 |
| | C | 7,9 | 7,7 | 7,4 | 5,8* | 3,3* | 2,7* | 2,8* | 2,9* | 3,5* | 7,6 | 10,7** | 13,0** |
| | D | 9,2 | 9,3 | 9,2 | 7,4* | 4,9* | 2,4* | 2,1* | 2,9* | 4,7* | 8,9* | 12,6** | 11,6** |
| Getal volwasse neutrofiele x $10^9$ $\ell^{-1}$ | A | 5,192 | 5,980 | 5,340 | 4,422* | 1,189* | 0,484* | 0,138* | 1,054* | 2,475* | 4,950 | 9,006** | 10,080** |
| | B | 2,982 | 5,829 | 5,456 | 3,905 | 0,285* | 0,063* | 0,063* | 0,168* | 0,247* | 0,560* | 1,020 | 4,234 |
| | C | 3,634 | 3,773 | 3,108 | 2,900 | 1,551* | 0,216* | 0,140* | 0,493* | 0,910* | 4,104 | 5,457** | 8,060** |
| | D | 4,416 | 4,650 | 4,324 | 4,514 | 2,009* | 0,216* | 0,063* | 0,337* | 1,692* | 4,895** | 7,560** | 6,380** |
| Getal onvolwasse neutrofiele x $10^9$ $\ell^{-1}$ | A | 0 | 0 | 0,178 | 0 | 0,029 | 0,022 | 0 | 0,068 | 0,450** | 1,530** | 1,710** | 4,200** |
| | B | 0,071 | 0 | 0,088 | 0,055 | 0,019 | 0 | 0 | 0 | 0,019 | 0,060 | 0,060 | 0,949** |
| | C | 0,158 | 0,308 | 0,222 | 0,116 | 0,066 | 0,027* | 0,028* | 0,087 | 0,560** | 1,748** | 2,675** | 2,470** |
| | D | 0,184 | 0,558 | 0,092 | 0,074 | 0 | 0 | 0 | 0,029 | 0,329 | 1,335** | 1,764** | 2,204** |
| Getal limfosiete x $10^9\ell^{-1}$ | A | 3,168 | 3,036 | 2,848 | 2,144* | 1,479* | 1,628* | 2,116* | 2,142* | 1,440* | 1,890* | 0,228* | 1,344* |
| | B | 3,408 | 2,610 | 2,728 | 1,430* | 1,463* | 1,911 | 1,995 | 2,160 | 1,596* | 1,280* | 1,740* | 1,241* |
| | C | 3,792 | 2,695 | 3,404 | 2,668 | 1,452* | 2,322 | 2,576 | 2,262 | 1,925 | 1,520* | 2,354 | 2,080 |
| | D | 4,232 | 3,534 | 4,232 | 2,516* | 2,891* | 2,016* | 1,995* | 2,407* | 2,491* | 2,314* | 2,772* | 2,900 |
| Getal monosiete x $10^9\ell^{-1}$ | A | 0,352 | 0,184 | 0,445 | 0 | 0,087 | 0,044 | 0,023 | 0,136 | 0,135 | 0,630 | 0,456 | 1,176** |
| | B | 0,355 | 0,174 | 0,352 | 0* | 0,019* | 0,063 | 0,021* | 0,048 | 0,019* | 0* | 0,120 | 0,876** |
| | C | 0,158 | 0,847 | 0,444 | 0,058 | 0,132 | 0,081 | 0,028 | 0,029 | 0,070 | 0,152 | 0,214 | 0,390 |
| | D | 0,184 | 0,465 | 0,460 | 0,074 | 0 | 0,048 | 0,042 | 0,029 | 0,141 | 0,356 | 0,504 | 0,116 |
| Getal eosinofiele x $10^9\ell^{-1}$ | A | 0,088 | 0 | 0,089 | 0 | 0,058 | 0,022 | 0,023 | 0 | 0 | 0 | 0 | 0 |
| | B | 0,213 | 0 | 0,176 | 0,055 | 0,114 | 0,063 | 0,021 | 0,024 | 0,019 | 0,100 | 0,060 | 0 |
| | C | 0,079 | 0 | 0,154 | 0,058 | 0,066 | 0,054 | 0,028 | 0,029 | 0 | 0 | 0 | 0,390** |
| | D | 0,092 | 0,093 | 0,092 | 0,222** | 0* | 0,120** | 0* | 0,058* | 0,047* | 0* | 0* | 0* |

* = betekenisvol verlaag by $P<0,05$
** = betekenisvol verhoog by $P<0,05$

geval (perd B) aan potensieel letale endotoksemie gely het. Laasgenoemde is 'n interessante bevinding gesien in die lig van die aanbevelings van Moore[10] dat 'n *intraveneuse dosis van* 10 $\mu$g $kg^{-1}$ endotoksien as 'n model van subletale endotoksemie in die perd gebruik kan word. Die outeurs het ook in 'n ander studie bevind dat 'n intraveneuse dosis van 10 $\mu$g $kg^{-1}$ 'n potensieel letale dosis is[21].

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Tabel 1: **Hematokrit en rooiseltelling voor en na endotoksien-toediening by eksperimentele perde**

| Bepaling | Perd | Tyd | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | -24h | -12h | 0h | +0h15 | +0h30 | +1h | +2h | +4h | +6h | +8h | +12h | +24h |
| Hemato-krit (%) | A | 42 | 39 | 40 | 41 | 40 | 41 | 46* | 47* | 44 | 45* | 45* | 36** |
| | B | 42 | 38 | 40 | 40 | 40 | 47* | 56* | 55* | 50* | 50* | 54* | 57* |
| | C | 40 | 37 | 40 | 42 | 40 | 41 | 44* | 45* | 42 | 45* | 45* | 39 |
| | D | 38 | 36 | 39 | 40 | 38 | 37 | 45* | 48* | 44* | 44* | 42* | 37 |
| Rooisel-telling x $10^{12}$ $\ell^{-1}$ | A | 8,30 | 7,83 | 8,02 | 8,08 | 8,13 | 7,92 | 8,68* | 8,71* | 8,41 | 8,45 | 8,90* | 7,11** |
| | B | 7,81 | 7,61 | 7,75 | 7,71 | 7,81 | 8,45* | 9,64* | 9,41* | 8,81* | 8,91* | 9,65* | 9,88* |
| | C | 8,12 | 7,34 | 8,09 | 8,33 | 7,85 | 8,08 | 8,53 | 8,59 | 8,10 | 9,13* | 8,38 | 7,63 |
| | D | 7,23 | 6,96 | 7,35 | 7,68* | 7,27 | 6,98 | 8,22* | 8,54* | 8,04* | 8,03* | 7,56 | 6,98 |

* = Betekenisvol verhoog by $P<0,05$
** = Beteknisvol verlaag by $P<0,05$

Tabel 3: **Arteriële suur-basis veranderinge voor en na endotoksien-toediening by eksperimentele perde**

| Bepaling | Perd | Tyd | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | -24h | -12h | 0h | +0h15 | +0h30 | +1h | + 2 h | +4h | +6h | +8h | +12h | +24h |
| pH | A | 7,443 | 7,455 | 7,451 | 7,458 | 7,415* | 7,402* | 7,394* | 7,443 | 7,530** | 7,441* | 7,389* | 7,450 |
| | B | 7,453 | 7,433 | 7,441 | 7,439 | 7,430* | 7,407* | 7,357* | 7,448 | 7,480** | 7,424* | 7,375* | 7,372* |
| | C | 7,429 | 7,410 | 7,415 | 7,399 | 7,399 | 7,397 | 7,409 | 7,439 | 7,448** | 7,417 | 7,373* | 7,397 |
| | D | 7,419 | 7,416 | 7,412 | 7,420 | 7,403* | 7,392* | 7,399* | 7,426** | 7,443** | 7,415 | 7,373* | 7,445** |
| $pO_2$ in kPa | A | 12,05 | 12,89 | 11,15 | 11,56 | 10,63 | 10,44 | 10,77 | 15,65 | 13,25 | 12,77 | 12,39 | 12,25 |
| | B | 13,28 | 11,61 | 13,73 | 10,89 | 9,91 | 10,59 | 11,48 | 14,79 | 11,28 | 12,12 | 13,69 | 6,39 |
| | C | 8,86 | 11,50 | 8,96 | 9,15 | 8,53 | 7,84 | 9,31 | 9,39 | 11,97 | 12,15 | 9,23 | 7,84 |
| | D | 11,72 | 8,98 | 14,23 | 7,91 | 8,88 | 9,07 | 10,77 | 9,95 | 11,88 | 13,31 | 11,41 | 12,24 |
| $HCO_3$ in mmol $\ell^{-1}$ | A | 24,2 | 24,2 | 26,0 | 24,4 | 23,5 | 23,1 | 22,3 | 24,4 | 30,4** | 20,8* | 19,4* | 24,9 |
| | B | 27,6 | 25,0 | 24,9 | 24,3 | 23,2 | 22,5 | 15,0* | 23,8 | 23,1 | 19,6* | 16,6* | 19,7* |
| | C | 26,7 | 25,6 | 25,5 | 25,9 | 25,3 | 22,6* | 19,4* | 24,1* | 24,2* | 20,3* | 19,0* | 22,6* |
| | D | 27,0 | 25,2 | 25,4 | 25,6 | 24,0 | 23,3* | 19,8* | 25,5 | 23,7 | 19,9* | 19,9* | 24,0 |
| SBE in mmol $\ell^{-1}$ | A | 0,3 | 0,6 | 1,8 | 0,8 | -0,5 | -1,0 | -1,9* | 1,0 | 7,5** | -2,8* | -4,4* | 1,3 |
| | B | 3,6 | 1,1 | 1,0 | 0,5 | -0,5 | -1,5 | -9,1* | 0,2 | 0,2 | -3,5* | -7,1* | -4,5* |
| | C | 2,4 | 1,3 | 1,2 | 1,3 | 0,8 | -1,5* | -4,4* | 0,5 | 1,1 | -3,2* | -5,0* | -1,5* |
| | D | 2,7 | 1,0 | 1,0 | 1,4 | -0,2 | -1,1* | -4,1* | 1,6 | 0,4 | -3,5* | -4,1* | -0,4 |
| SBC in mmol $\ell^{-1}$ | A | 24,8 | 25,5 | 26,1 | 25,6 | 24,1 | 23,6* | 23,0* | 26,0 | 32,1** | 22,6* | 21,3* | 25,9 |
| | B | 27,6 | 25,5 | 25,6 | 25,1 | 24,1 | 23,4 | 18,3* | 25,3 | 25,8 | 22,6* | 19,8* | 20,8* |
| | C | 26,4 | 25,6 | 25,3 | 25,3 | 24,9 | 23,0* | 21,2* | 25,3 | 26,1 | 22,4* | 20,6* | 23,0* |
| | D | 26,6 | 25,3 | 25,3 | 25,5 | 24,1 | 23,4* | 21,4* | 25,9 | 25,4 | 22,2* | 21,3* | 25,2 |

* = Betekenisvol verlaag by $p<0,05$
** = Betekenisvol verhoog by $p<0,05$



0038-2809 Tydskr. S. Afr. vet. Ver. (1989)60(4):201-205

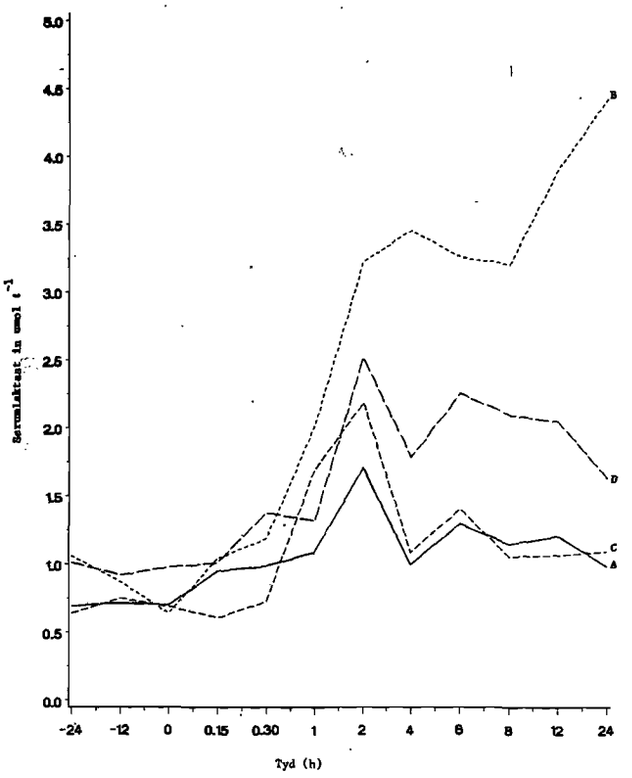


Fig. 1: **Serumlaktaat in $\mu$mol $\ell^{-1}$ voor en na endotoksien-toediening by eksperimentele perde**

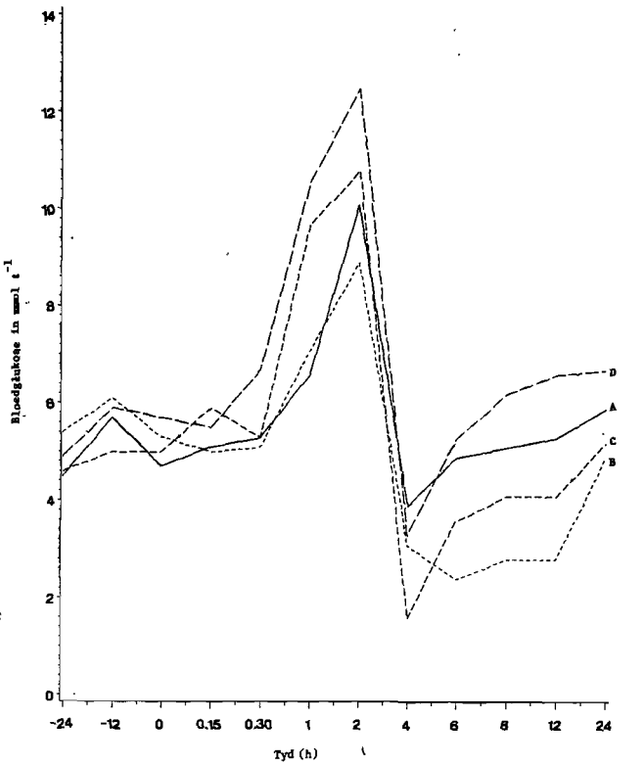


Fig. 2: **Bloedglukose in mmol $\ell^{-1}$ voor en na endotoksien-toediening by eksperimentele perde**


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# THE USE OF LONG-ACTING NEUROLEPTICS IN IMPALA (*AEPYCEROS MELAMPUS*)

G C M GANDINI*, H EBEDES** and R E J BURROUGHS**

**ABSTRACT**

**The long-acting neuroleptics perphenazine enanthate and pipothiazine palmitate were found to be effective for the long-term tranquillisation of newly-captured and captive impala (*Aepyceros melampus*). Perphenazine enanthate (1.5 to 5.7 mg kg$^{-1}$) produced a favourable state of tranquillisation with a maximum effect lasting up to 7 d. Pipothiazine palmitate (4,5 mg kg$^{-1}$) produced tranquillisation lasting 16 d. The animals accepted humans inside their pens, at a distance of 0,5 to 4 m, without showing any excitement. No untoward side-effects were observed.**

**Key words: impala, *Aepyceros melampus*, long-acting neuroleptic, tranquilliser.**

**Gandini G.C.M.; Ebedes H.; Burroughs R.E.J. The use of long-acting neuroleptics in impala (*Aepyceros melampus*). *Journal of the South African Veterinary Association* (1989) 60 No. 4, 206-207 (En.) Instituto di Zootecnica, Facolt à di Medicina Veterinaria, Universita degli Studi di Milano, Via Celoria 10,20133 Milano, Italy.**

## INTRODUCTION

Captured free-ranging impala (*Aepyceros melampus*) show pronounced excitability when confined, especially during the initial period of adaptation to captivity. The psychological stress induced by confinement and the presence of humans may be responsible for overexertion and injuries in attemps to escape. Adult rams are often aggressive and attacks on other animals may be fatal.

Zoo impala similarly show a high degree of excitability when their conditions of captivity are changed, exposing them to new stress factors. At the National Zoological Gardens of South Africa (NZG), Pretoria, surplus young males are routinely removed from impala herds and temporarily housed in small pens before disposal. This change provokes a marked alarm reaction with resultant injuries and mortalities in some cases.

Neuroleptic drugs such as chlorpromazine[7], haloperidol[3], acepromazine maleate and azaperone (unpublished work) have been successfully used for the tranquillisation of impala. The value of these drugs is limited however, because their effect only lasts a few hours. A tranquilliser with a longer duration of action, would be of considerable help in controlling psychomotor excitement during the period of adaptation to captivity.

*Istituto di Zootecnica, Facolta di Medicina Veterinaria, Universita degli Studi di Milano, Via Celoria 10, 20133 Milano, Italy

**National Zoological Gardens of South Africa P.O. Box 754, 0001 Pretoria, Republic of South Africa

Received: January 1987 Accepted: June 1989

A number of long-acting injectable neuroleptics are currently used in human psychiatry. Therapeutic effects are maintained up to 4 weeks after a single injection[5]. The drug formulation consists of a fatty acid ester of a neuroleptic compound dissolved in medicinal oil. Prolonged activity results from the slow release of the ester as it diffuses from the solvent into the tissue fluids[5].

No published information is available on the clinical usage of long-acting neuroleptics in domestic or wild animals. Directions for their use can, however, be derived from clinical experience in humans.

The long-acting neuroleptics perphenazine enanthate (Trilafon enanthate, Sherag) and pipothiazine palmitate (Piportil Depot, Maybaker), are derivatives of phenothiazine used for the treatment of nuerotic and psychotic disorders in man. The dosage varies according to the severity of the condition and the patient's response. A 100 mg intramuscular loading dose of perphenazine enanthate is recommended; this is followed by 50 to 200 mg given intramuscularly every 2-4 weeks to maintain the required degree of tranquillisation (Sherag labelling for Trilafon enanthate). Dosages of up to 300 mg once a week have been used[4]. Pipothiazine palmitate is given intramuscularly once a month at a dosage rate of 25 to 200 mg[2]. As with other neuroleptics, high doses produce side-effects including sedation, drowsiness, ataxia, catalepsy extra-pyramidal signs and anorexia[2].

Perphenazine enanthate produced favourable long-term tranquillisation in red hartebeest (*Alcelaphus buselaphus*), tsessebe (*Damaliscus lunatus*), eland (*Taurotragus oryx*), greater kudu (*Tragelaphus strepsiceros*), Indian blackbuck (*Antilope cervicapra*), sable antelope (*Hippotragus niger*) and hogdeer (*Axis porcius*) at the NZG (unpublished observations). A high incidence of estrapyramidal effects was seen in Barbary sheep (*Ammotragus lervia*).

This note reports on the use of perphenazine enanthate and pipothiazine palmitate, administered alone or in combination with haloperidol (Serenace, Searle), for the long-term tranquillisation of newly-captured and captive impala.

## MATERIALS AND METHODS

The clinical trial was executed in 2 parts. Firstly, 11/40 free-ranging impala were given 1,7-3,3 mg/kg perphenazine enanthate intramuscularly 2 h after they had been caught using the Oelofse helicopter-boma method[6]. These animals were housed in semi-darkness in 5x3 m pens for 5 d before being translocated. The untranquillised groups of animals served as controls.

Secondly, 2 ca 8-month-old impala rams at the NZG which had been immobilised by administration of 1,5 mg etorphine hydrochloride (M-99, R and C Pharmaceuticals) and 40 mg azaperone (Stresnil, Janssen Pharmaceutica) and moved to a 5 x 2,5 m holding pen, were subjected to various treatments using long-acting tranquillisers on their own or in combination with haloperidol (Table 1).

The behaviour of undisturbed impala was observed daily in the pens; the level of tranquillisation was assessed by approaching the impala until they responded to one's presence and moved away. The flight distance was recorded. Body condition was assessed subjectively.

The animals were monitored up to 70 d post capture.

## RESULTS

A state of tranquillisation was seen in all treated impala. When approached in the pens, the impala moved away calmly and could be moved into adjacent pens. The flight distances varied from ca 0,5 to 4 m. Filling the feed and water troughs did not alarm the animals. Feed intake was not noticeably affected and the animals did not lose condition.

The untreated, newly-caught impala reacted voilently to the presence of humans - they ran around their pens bumping into the walls while attempting to escape.

When haloperidol was given in combination with the long-acting neuroleptic drugs, tranquillisation was effective within 5 to 15 min.

When either of the long-acting neuroleptics was administered alone, no signs of tranquillisation were observed during the first day. By Day 2, tranquillisation was evident - maximal effect was achieved on Day 3. In the animals that had received perphenazine enanthate, tranquillisation decreased after a period of 4 to 8 d, after which the effect of the neuro-

Table 1: **The dosage regimen of perphenazine enanthate (P E), pipothiazine palmitate (P P) and haloperidol (Hal) in 2 ca 8-month-old impala rams at the National Zoological Gardens of South Africa**

| Day | Neuroleptic | Dosage rate (mg kg$^{-1}$) | |
|---|---|---|---|
| | | Ram 1 (mass 35 kg) | Ram 2 (mass 33 kg) |
| 0 | P E | 2,8 | 3,0 |
| | Hal | 0,2 | 0,21 |
| 21 | P E | 4,2 | 4,5 |
| 28 | P E | 5,7 | 4,5 |
| 49 | P P | 4,2 | 4,5 |
| | Hal | 0,2 | 0,21 |

leptic was no longer evident. The second injection of perphenazine administered to the two 8-month-old rams, prolonged the period of tranquillisation for a further 7 d.

Pipothiazine palmitate produced a higher level of tranquillisation than perphenazine enanthate, and for a longer period up to 16 d.

## DISCUSSION

Perphenazine enanthate and pipothiazine palmitate controlled psychomotor excitement in newly-captured impala effectively for prolonged periods after a single injection. The interval between administration of the long-acting neuroleptics and the onset of tranquillisation could not be determined accurately. However, with perphenazine enanthate, this interval was estimated to be 8-21 h. The concomitant use of intravenous haloperidol, tranquillised the animals until the long-acting neuroleptics took effect.

The results seem to indicate promising possibilities for the use of these drugs in wild ungulates. Their applications could be summarised as follows:

- control of psychomotor excitement during adaptation to captive conditions. This might include long-term quarantine.
- tranquillisation of nervous and excitable subjects during hospitalisation.
- tranquillisation for transportation over long distances.
- control of intraspecific aggressive behaviour in confined animals.


## ACKNOWLEDGEMENTS

We would like to thank the staff of the National Zoological Gardens, Pretoria, for assistence in this research project and the Director for permission to publish this manuscript. The Directors of the Oasis Ostrich Farm are thanked for providing a number of animals used in this investigation.


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## Book Review/Boekresensie

# ADVANCES IN SMALL ANIMAL PRACTICE

E A CHANDLER (EDITOR)

**Blackwell Scientific Publications, Oxford. 1988 pp 197, 35 colour plates, 31 figures, 16 tables. Price not given. (ISBN 0-632-02134-9)**

**This publication is stated by the editor to be the first in a series aimed at utilising the considerable talent available at British Small Animal Veterinary Association meetings and congresses. It aims to provide the reader with the latest knowledge on specific subjects, disciplines, or organ and system studies.**

**This first edition consists of chapters on the management of ocular diseases in dogs and cats, rigid endoscopy in exotic animals, the laboratory assessment of liver diseases, aspects of reproduction in dogs and cats, principles of and new developments in anaesthesia, feline hyperthyroidism, analgesia and feline chlamydial infection. The text reads easily and subject material is presented in a factual, logical manner with appropriate usage of references.**

**J. van Heerden**

# THE USE OF LONG-ACTING NEUROLEPTICS, PERPHENAZINE ENANTHATE AND PIPOTHIAZINE PALMITATE IN TWO HORSES

CHERYL M E McCRINDLE*, H EBEDES** and G E SWAN***

**ABSTRACT**

**Two Arabian horse stallions with behavioural problems were treated with long-acting neuroleptics in order to facilitate corrective training. Perphenazine enanthate, administered intramuscularly at a dose of 0,5mg $kg^{-1}$ had an effect for 30 d. Pipothiazine palmitate (1 mg $kg^{-1}$) induced tranquilisation of 30 d duration as well as extra-pyramidal clinical signs, ataxia and aphagia. Neither horse showed prolapse of the penis or haemolysis.**

**Key words: Long-acting neuroleptics, perphenazine, pipothiazine, horses, behavioural problems, phenothiazine derivative toxicity.**

**McCrindle Cheryl M.E.; Ebedes H.; Swan G.E. The use of long-acting neuroleptics, perphenazine enanthate and pipothiazine palmitate in two horses.** *Journal of the South African Veterinary Association* **(1989) 60 No. 4, 208-209 (En.) Brooklyn Veterinary Clinic, 770 Duncan Street, 0181 Brooklyn, Republic of South Africa.**

## INTRODUCTION

According to Booth[2], the phenothiazine derivatives were introduced into clinical veterinary medicine in the 1950's and were then referred to as ataractics or tranquillisers. French pharmacologists and chemists, who discovered this group of drugs, have, however, used the term neuroleptics to denote that their most prominent pharmacologic effects are upon certain functions of the central nervous system (CNS). In veterinary medicine phenothiazine derivatives have been valuable in chemical restraint of animals for various diagnostic and clinical procedures and in preparation of patients for neuroleptanalgesia and general anaesthesia[2 11]. Promazine and acetylpromazine are the phenothiazine derivatives most frequently used in horses[5 6 8] for premedication and to produce a state in which the animal is relatively oblivious to its surroundings[6]. However, both of these phenothiazine derivatives have a short duration of effect. At a dosage of 0,3 mg $kg^{-1}$, acetylpromazine was detectable in the plasma of horses for only 8 h after injection[1]. The clinical effect has been observed by the authors to be approximately the same, or of even shorter duration.

In certain cases it would be highly desirable to be able to tranquillise a horse for longer periods: for the long-distance transportation or for the training of semi-wild or wild horses, for repeated treatment, such as that of a deep wound that needs regular bandaging, or for the long term restraint of horses. Two long-acting neuroleptics, perphenazine enanthate (Trilafon L A, Scherag) and Pipothiazine palmitate (Piportil Depot, Maybaker), currently used for the management of psychotic manifestations in man, held out promise that this could be achieved. Both had been used with success in the management of wild animals, inlcuding zebra (Ebedes, unpublished observation, 1987). Perphenazine enanthate, a piperazine phenothiazine, is available in 1 ml ampoules in a sesame oil vehicle with propylparaben as preservative. It is active at all levels of the central nervous system, particularly the hypothalamus, and demonstrates, in man, anxiolytic, antipsychotic and antiemetic properties[9 10]. The prolonged action of this drug is due to the formation of a tissue/oil depot from which the drug is slowly released, as well as the hydrolysis of the ester to form the free base[9 10].

Pipothiazine palmitate is the product of esterification of pipothiazine by palmitic acid. Due to the lipophyllic nature of the molecule, a relatively large amount can be dissolved in sesame seed oil[3]. Animal studies have shown a slow diffusion of drug from the depot site into tissue fluid, where the ester linkage is rapidly split by hydrolytic enzymes. During the past 14 years it has been used with success in man for the suppression of acute and chronic psychoses, and is particularly used for the control of schizophrenia[3].

This report deals with the use of each of these 2 drugs for the retraining of 2 horses with behavioural problems.

**Brooklyn Veterinary Clinic, 770 Duncan Street, 0181 Brooklyn, Pretoria, Republic of South Africa
**National Zoological Gardens, Pretoria
***Department of Pharmacology and Toxicology, Faculty of Veterinary Science, University of Pretoria

*Received: October 1988 Accepted: September 1989*

**CASE REPORT 1:**

A five-year-old, 14,1-hands high Arabian stallion was presented with a history of being entirely intractable. When confined to a stable, he circled faster and faster until he was cantering. The pupils of his eyes were widely dilated and seemed unfocussed. He refused to eat unless haltered and held still by a groom. In his paddock he trotted or cantered up and down one fence, neighing wildly to the other horses and attempting to attack them over the fence as they passed. He was broken in and well-schooled and could be ridden on his own, but if ridden in company, attacked any other horse within 30 m. On clinical examination, the horse was alert and responded well to external stimuli. The heart and respiration rates were within normal limits, but increased markedly in the presence of other horses. According to the owner, the horse had at some stage been attacked by another stallion and this had affected his personality. In order to control the horse, he was continuously shut in a stable. The previous owner had then told a groom to gallop him for an hour every day in an attempt to calm him down.

Although thin, the horse was in good physical condition and selected haematological (haemoglobin concentration, packed cell volume, red cell count, total white cell count) and biochemical (total serum protein, albumin, globulin and blood urea concentration) parameters were within normal limits. As euthanasia was being considered, it was decided to try the effect of long-term tranquilisation with perphenazine enanthate. Accordingly the stallion was injected with 150 mg of this drug intramuscularly in the neck. This corresponded to an approximate dose of 0,5mg $kg^{-1}$. Two days later he showed the first signs of tranquillisation. He was circling less in the stable, and was less aggressive towards passing horses. Seven days after the injection, a second blood sample was taken and analyis showed no significant change in the parameters evaluated previously. On the same day he covered a mare that had come into season (she later foaled from this covering). His libido and erection were normal, and the penis reverted to the sheath without delay following service. The effect of the drug lasted approximately 30 d. During this time the horse relaxed and started to pick up weight. It was possible to ride him in company, at first with geldings, later with another stallion and with a mare in season. It was not pleasant to ride him as he was very lazy and unresponsive except to very emphatic leg aids. Thirty days after administration of the neuroleptic, he could be ridden normally, as the effects had worn off. At this stage the abnormal behaviour previously exhibited by the horse was no longer present to the

same degree. He no longer circled in his stable, ate well, and although still somewhat aggressive towards other horses, his behaviour was not considered to be abnormal for a stallion. Seven months later, he was ridden at a major show. The previous aggressive behaviour was not evident.

**CASE REPORT 2:**

A two-year-old Arab stallion had been brought up without any handling. He was chased out to the paddock during the day and back to a stable at night, where he was fed. It was possible to approach him and put a halter on if 3 grooms worked together in the stable, but if attempts were made to lead him, he would plunge and shake his head or attempt to dash away. The owner and the grooms were afraid of him, and as it was impractical to load him under the circumstances, in order to take him to a trainer, it was decided to try a long-acting neuroleptic. Although satisfactory results had been achieved with the use of long-acting perphenazine in the previous case, a subsequent study of the literature[11] revealed that excitement and convulsions could follow the use of the short-acting form of this drug in horses. It was therefore decided to use pipothiazine palmitate, which had been used successfully in zebra (Ebedes, unpublished observation, 1987). The colt was injected with 250 mg of pipothiazine palmitate.

Blood specimens for selected haematological and blood chemical assays were collected at the time of injection of the drug as well as 14 and 30 d later. Haematological and biochemical parameters remained within normal ranges except for a temporary mild increase in urea concentration (7,9 mmol $\ell^{-1}$).

Three days after the initial injection, the horse could be caught and led with ease. Two days later, the horse was behaving most oddly. On examination, he proved to be showing behaviour which resembled extrapyramidal symptoms in man. He would stand rigidly for a while, then suddenly strike out with both forelegs at once, or begin to "weave", rocking his forelegs from side to side and swaying his head in an ever-increasing arc until his lips touched his flanks on each side. If held, he would rear up and fall over backwards. If talked to soothingly and patted briskly on the neck, he would relax. In the periods between this type of behaviour he would react normally: he was eating both hay and concentrate, and drinking water. The heart rate and respiration were normal, but the heart rate became elevated to 60 beats per minute during these episodes, and the pupils of the eyes became dilated.

Six mg of biperiden (Akineton tablets, Knoll A G) were given orally at 20:00 and the dose was repeated 4 h later. The horse was relatively quiet for the rest of the night. The next day the same clinical signs emerged and 5 mg of biperiden lactate was injected intramuscularly, and the injection repeated within an hour. Several hours later the horse was swaying even more wildly than before; he was sweating and his pupils were fixed, but he relaxed slightly after being injected again with 5 mg biperiden lactate. Eight hours later, the horse was lifting his head back over his neck, then lifting each front leg up alternately as though he were trotting in slow motion. He would then suddenly throw himself violently to one side, and begin rocking, licking first one flank then the other. He was again injected with biperiden and seemed to relax, but it was now becoming questionable whether this drug was having the desired effect or whether the improvement in his condition was merely coincidental to the end of an "attack". As the horse seemed to be in pain, 250 mg pethidine hydrochloride (Pethidine, Centaur) was given intravenously.

For the following 7 d, the horse was injected with 10 mg diazepam every 4 h. Soon after an injection of diazepam, the horse was able to eat, but towards the end of the 4 h period, he seemed to have difficulty swallowing. On Day 20 of treatment, the animal was clinically dehydrated and had lost a lot of condition. The owner was hand-feeding him with concentrate and bran as he seemed unable to eat on his own. He was given 20 mg of diazepam prior to a stomach tube being passed, but as soon as the tube reached his epiglottis, he became frenzied. It seemed as though there was some sort of spasm in this area, as a similar behavioural pattern was shown when swallowing was attempted. Administration of glyceryl guaiacolate ether (G G E, Centaur) intravenously (500 ml of a 5% solution) facilitated the passing and subsequent suturing to the skin of a stomach tube. Water and a breakfast cereal were now administered. The animal by now had several injuries, as a result of falling against the stable walls and door. After 5 d, the stomach tube was removed and the horse was hand-fed with concentrate and finely chopped lucerne hay. Water was given by syringe and by tube to counteract dehydration. As the habitus improved, diazepam was given with less frequency. Tranquillisation was sufficient so that training could proceed at this stage. Thirty days after the administration of the neuroleptic, the horse was returned to his owners. He was now completely halter-trained, obedient on the lunge, and willing to carry a saddle.

**DISCUSSION**

The principal central activity of the neuroleptics, as mentioned above, is the blockade of dopamine, a catecholamine neurotransmitter found mainly in the basal ganglia complex. According to Booth[2] a deficiency of dopamine within the basal ganglia has been shown to be associated with a definite dysfunction of this neuro-anatomical system, ie the Parkinsonian syndrome in man and catalepsy in experimental animals. Extrapyramidal symptoms such as rigidity, tremor, and akinesia are also observed as prominent side-effects, particularly at high doses[2].

These symptoms were shown by the horse injected with long-acting pipothiazine but not by the horse injected with long-acting perphenazine. However, the toxicity of phenothiazine and its derivatives presents a peculiar problem since there is a wide variation in the response of individuals of the same species to similar doses of the drug, and susceptibility to the toxic effects of phenothiazine is generally considered to be greatest in the horse[4].

One of the most important toxic side-effects of phenothiazine and its derivatives in the horse, is haemolysis[1,2,4,6] leading in many cases to anaemia, jaundice and haemoglobinaemia. However, in neither of these horses was this seen.

It is also of interest to note that, although both horses treated were stallions, there was no prolapse of the penis, a complication known to follow the administration of acepromazine in doses as low as 0.4 mg $kg^{-1}$[1].

Considering the difficulties in managing the side-effects encountered when using pipothiazine, it would be a brave soul who attempted to use it under any but experimental conditions in horses. However, the affected colt showed no lasting ill-effects, and the desired aim of making him manageable was achieved. The usefulness of long-acting analeptics in the field of horse-management is undeniable. Based, however, on the findings in the 2 cases discussed here, further research into the optimal dose-levels for long acting pipothiazine and perphenazine for different breeds and types of horses might be advisable.

**ACKNOWLEDGEMENTS**

Sr. Margeurite McGregor is thanked for her able and competent assistance during this project.

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# A FIELD OUTBREAK OF CHRONIC AFLATOXICOSIS IN DAIRY CALVES IN THE WESTERN CAPE PROVINCE

A VAN HALDEREN*, JENNIFER R GREEN*, W F O MARASAS**, P G THIEL** and SONJA STOCKENSTRÖM**

**ABSTRACT**

**An outbreak of mortality in Friesland dairy calves in which 7 out of 25 calves died in the western Cape Province, Republic of South Africa is described. Clinical signs included a loss in body mass, staring hair coat, diarrhoea and rectal prolapse. Histopathological changes in the liver were characterised by severe portal fibrosis with bile duct proliferation and mild portal round cell infiltration. The calves were fed a ration containing locally-produced maize. The implicated maize was infested with *Aspergillus flavus* and contained aflatoxins $B_1$, $B_2$, $G_1$ and $G_2$ with total aflatoxin levels as high as 11 790 ng $g^{-1}$. This is the first report of a field outbreak of bovine aflatoxicosis in South Africa.**

**Key words:** *Aspergillus flavus*, bovine

**Van Halderen A; Green Jennifer R; Marasas W.F.O.; Thiel P.G.; Stockenström S. A field outbreak of chronic aflatoxicosis in dairy calves in the western Cape Province.** *Journal of the South African Veterinary Association.* **(1989) 60 No. 4, 210-211 (En.) Regional Veterinary Laboratory, Private Bag X5020, 7600 Stellenbosch, Republic of South Africa.**

## INTRODUCTION

Aflatoxicosis is a mycotoxicosis caused by aflatoxins, hepatotoxic metabolites of *Aspergillus flavus* Link and *A. parasiticus* Speare produced in a variety of cereals and other foodstuffs, particularly groundnuts (*Arachis hypogaea* L.) and maize (*Zea mays* L.)[1,5,6,10]. A shipment of contaminated Brazilian groundnut meal which caused a massive outbreak of acute aflatoxicosis in turkeys in the United Kingdom in 1960, also affected cattle[2,7]. Only a few well-documented outbreaks of bovine aflatoxicosis have been reported from Australia[8], India[16], Thailand[12], and the United States of America[3,11,14]. In South Africa, outbreaks of aflatoxicosis have been confirmed only in pigs and dogs[5,9]. In this paper we report on a field outbreak of aflatoxicosis in Friesland calves in the western Cape Province following the consumption of rations containing locally-produced, aflatoxin-contaminated maize.

## MATERIALS AND METHODS

### History

The maize involved in this outbreak was produced by Farmer A in the Moorreesburg district, Cape Province, who had a total harvest of ca 58 tons. The maize was harvested at a very high moisture content (estimated by Farmer A at 18 to 19%) in early May 1986 during dry weather and was stored on the floor of a neighbour's shed, where it was said to have been turned daily. One section, where the maize had been piled high, was not turned regularly and was found to be hot, due to fermentation. According to Farmer A this portion was sold last. Farmer B, on whose farm the problem occurred, bought 100 bags (each 75 kg) of maize from Farmer A at the end of May or beginning of June, and a further batch of 60 bags from Farmer A via Farmer C (who fed the maize in small quantities to his own cattle and sheep without apparent problems) at the end of June. Farmer A claims that he fed the maize to his own cattle without ill effects. Maize was sold to 6 different farmers of whom only 2 reported problems:- Farmer B and another unconfirmed case where apparently 15 out of 54 calves died. The maize bought by Farmer B was only fed to his calves. Approximately 25 Friesland calves varying in age from 1.5 to 9 months were kept in pens and supplied with the following ration ad lib: 2 bags milled maize, 2 bags second grade wheat; 1 bag molasses/urea mixture; 1 bag high protein concentrate; 2 bags bran and 4 bags coarsely milled wheat straw.

The first calf died in early August with clinical signs of a loss in body mass, staring hair coat, diarrhoea and rectal prolapse. Two further cases with similar clinical signs occurred and the private veterinarian was summoned for an autopsy. Organ samples were collected from one of these calves (Calf 1) and placed in formalin while a live calf, in extremis, was submitted to the Regional Veterinary Laboratory, Stellenbosch on September 25, 1986 (Calf 2). The farmer immediately stopped feeding the ration, but lost a further 3 calves with similar clinical signs. Many of the surviving calves were stunted and exhibited poor mass gains.

### Materials and methods

Organ samples in 10% formalin of Calf 1 were received for histopathology. A live, 5 month-old bull calf in very poor condition and with obvious diarrhoea was submitted for a post mortem examination (Calf 2). Heparinised blood was collected from the anterior *vena cava* for clinical pathology and the animal was euthanased for autopsy. Organ samples were collected in 10% formalin for histopathology and appropriate samples were collected for bacteriological and parasitological examination.

### Maize samples

Maize samples (1 kg) were collected from each of 4 bags of maize from Farmer B where the outbreak occurred and from 3 bags each from Farmers A and C. Maize samples were examined mycologically by plating kernels directly on *Aspergillus flavus* and *parasiticus* agar (AFPA)[13], and analysed chemically for aflatoxins as follows: extracts of dried and ground maize samples were prepared and purified using the CB procedure described by the Association of Official Analytical Chemists[4]. Quantification of individual aflatoxins was done by reverse-phase HPLC and fluorescence detection incorporating post-column derivitisation with iodine[15].

## RESULTS

### Macroscopic pathology

The carcass of Calf 2 was very cachectic and showed marked hydrothorax, hydropericard and ascites. The kidneys were slightly enlarged and pale. The liver was very shrunken and fibrotic. There were no signs of icterus.

### Microscopic pathology

The changes in the livers of Calves 1 and 2 were characterised by severe fibrosis, bile duct proliferation and mild round cell infiltration in the portal triads. In the kidneys, diffuse mild interstitial fibroplasia (Calf 2) and focal interstitial lymphocyte infiltration (Calf 1) were observed. Demyelinisation in the medulla oblongata and mild neutrophil infiltration of the lamina propria in the intestine (Calf 2) were the only other lesions recorded.

### Clinical pathology

A marked anaemia with moderately increased total bilirubin levels was present in Calf 2, but other serum data were within the normal range: total plasma proteins 62 g $\ell^{-1}$, albumin 22 g $\ell^{-1}$, globulin 40 g $\ell^{-1}$, haemoglobin 5.26 g $\ell^{-1}$, haematocrit 0,18, gammaglutamyl-

*Regional Veterinary Laboratory, Private Bag X5020, 7600 Stellenbosch, Republic of South Africa

**Medical Research Council, Tygerberg

Received February 1989 Accepted June 1989

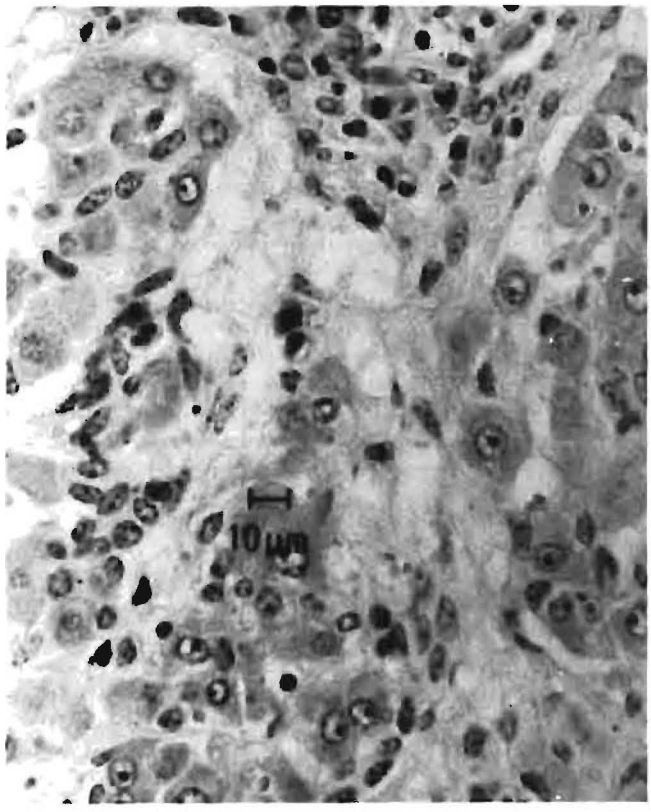


Fig. 1: **Portal fibrosis and bile duct proliferation with mild portal mononuclear cell infiltration. The connective tissue has extended into the parenchyma surrounding small groups of hepatocytes**

Table 1: **Concentrations of aflatoxins in samples of maize implicated in a field outbreak of aflatoxicosis in dairy calves**

| Farm | Sample No | Aflatoxin concentration ng $g^{-1}$ $B_1$ | $B_2$ | $G_1$ | $G_2$ | Total |
|---|---|---|---|---|---|---|
| A. Farm where maize produced | 1 | 12 | 0,5 | 0,5 | 0,1 | 13,1 |
| | 2 | 1,7 | 0,3 | 0,2 | ND | 2,2 |
| | 3 | 14 000 | 730 | 1 090 | 110 | 15 930 |
| B. Farm where outbreak occurred | 1 | 1 880 | 280 | 280 | 42 | 2 482 |
| | 2 | 5 810 | 930 | 960 | 160 | 7 860 |
| | 3 | 830 | 170 | 350 | 37 | 1 387 |
| | 4 | 9 800 | 730 | 1 090 | 170 | 11 790 |
| C. Farm where no cases were recorded | 1 | 580 | 120 | 140 | 12 | 852 |
| | 2 | 1400 | 280 | 260 | 25 | 1 940 |
| | 3 | 900 | 160 | 180 | 14 | 1 254 |

ND Not detected. Detection limit = 0,1 ng $g^{-1}$

transferase 17 U $\ell^{-1}$; aspartate transaminase 44 U $\ell^{-1}$; and total serum bilirubin 9,3 µmol $\ell^{-1}$. Bacteriological isolation yielded *Escherichia coli* from the intestines only and the faeces was negative for helminth eggs.

### Mycotoxicology

*Aspergillus flavus* was isolated from 75 to 100% of the maize kernels (not surface-disinfected) in all samples. All the maize samples also contained aflatoxins (Table 1). Marked variation occurred in the levels of aflatoxins $B_1$, $B_2$, $G_1$ and $G_2$ in the samples obtained from the 10 different bags examined e.g. aflatoxin $B_1$ levels ranged from 1,7 to 14 000 ng $g^{-1}$ and total aflatoxins from 2,2 to 15 930 ng $g^{-1}$.

## DISCUSSION

This is the first reported field outbreak of aflatoxicosis in cattle in South Africa[5]. The clinical signs and pathological changes were consistent with those described for bovine aflatoxicosis[1 3 5 6 8 11], while extremely high levels of the aflatoxins were detected in the mouldy maize (Table 1)

Due to the increases in the purchasing price and transportation cost of maize, more farmers in the western Cape are now planting their own maize for use as animal feed. This maize is usually harvested early in order to prepare the lands for wheat planting. The maize is therefore harvested at a high moisture content during the winter rainfall season in the western Cape. Consequently very favourable conditions for the development of *A. flavus* and the production of aflatoxin can arise during the storage of this maize. This was well illustrated by the present case where samples contained up to 15 930 ng $g^{-1}$ total aflatoxins, whereas the maximum level allowed in feed for lactating cows and calves in South Africa is 20 ng $g^{-1}$ in terms of the Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act[5].

The wide variation in aflatoxin concentration in different bags of maize from the same farm also shows that different amounts of aflatoxin can be produced in "hot spots" in stored maize under these conditions. In view of these conditions, it can be expected that further field outbreaks of aflatoxicosis will occur in the western Cape.


## ACKNOWLEDGEMENTS

We are much obliged to Dr E J Dalton, Mr E W P Heine, Mrs R de Kock, Mr P van der Merwe, Mrs M Schlechter and Mrs P Smith. The Director of Veterinary Services is thanked for permission to publish this article.


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# BRONCHIOLO-ALVEOLAR ADENOCARCINOMA IN A HORSE

VAN RENSBURG I B J*, STADLER P** and SOLEY J***

**ABSTRACT**

**A bronchiolo-alveolar adenocarcinoma was diagnosed in the lungs of a horse which was euthanased after protracted respiratory disease and radiological evidence of pulmonary neoplasia. Multifocal, large, firm neoplasms occurred throughout both lungs. Neoplastic lesions were not found elsewhere. Histologically the bronchiolar and alveolar architecture was retained. The cuboidal cells lining neoplastic alveoli had very vacuolated cytoplasm, while some were ciliated. Electron microscopy identified the cells as Type II pneumocytes. Numerous distended myelinoid bodies in the tumour cells accounted for the vacuolated appearance seen by light microscopy. Special stains for fat, mucin, mucopolysaccharides and glycogen failed to elucidate the nature of the substance in these vacuoles.**

Key words: Bronchiolo-alveolar adenocarcinoma, pulmonary neoplasia, lung tumour, horse, equine

Van Rensburg I.B.J.; Stadler P.; Soley J. **Bronchiolo-alveolar adenocarcinoma in a horse.** *Journal of the South African Veterinary Association* (1989) 60 No. 4, 212-214 (En.) **Department of Pathology, Faculty of Veterinary Science, University of Pretoria, Private Bag X04, 0110 Onderstepoort, Republic of South Africa**

## INTRODUCTION

In general neoplasms, with the exception of sarcoids, have a low incidence in the horse. Cotchin & Baker-Smith[2] found 151 tumours in 1 308 horses examined at an abattoir. Most of these were thyroid and adrenal tumours followed by melanomas and mesenteric lipomas. Only 2 pulmonary tumours namely a bronchiolar adenoma and a granular cell myoblastoma were encountered during this survey. In another survey which spanned 5 years, Sundberg et al.[7] did not encounter any pulmonary tumours during 687 necropsies and 635 biopsies. According to Dungworth[4] granular cell tumours (myoblastomas), which may occur in various organs, constitute the most commonly-reported primary pulmonary tumour in the horse. This tumour was well-described and reviewed by Parker et al.[5]. Uphoff and Lyncoln[9] reported a poorly-differentiated primary adenocarcinoma in the lung of an adult horse. However no reference to an equine bronchiolo-alveolar adenocarcinoma could be traced.

The purpose of this paper is to report what we believe to be the first case of bronchiolo-alveolar adenocarcinoma in a horse.

*Department of Pathology, Faculty of Veterinary Science, University of Pretoria, Private Bag X04, 0110 Onderstepoort, Republic of South Africa

**Department of Medicine, University of Pretoria

***Department of Anatomy, University of Pretoria

Received: April 1989 Accepted: July 1989

## CASE REPORT

A 12-year old Hanoverian stallion was referred to the Faculty of Veterinary Science, University of Pretoria with depression, poor appetite, increased respiratory rate and a chronic non-productive cough of 4 months duration. Shortly before referral, *Pseudomonas aeruginosa* had been isolated from a tracheal wash. Chronic laminitis, which had allegedly developed after a bout of babesiosis, was also present. An exostosis from the mandible, a fibroma from the pectoral groove and an unidentified growth from the penile sheath were previously surgically removed.

Clinical examination confirmed the clinical signs reported in the history. In addition, the horse was in a fairly poor condition and the heart and respiratory rates constantly elevated. The respiration was forced with an increased abdominal component and prolonged expiratory phase. Upon auscultation of the lung fields, almost no sounds were audible on the left while these were louder than normal on the right.

Haematological examination revealed lymphopaenia (0,832 x $10^9/\ell$) and neutrophilia (9,048 x $10^9/\ell$) with a left shift.

Radiographical examination of the thorax revealed multifocal areas of increased density, suspicious of pulmonary neoplasia or chronic abscessation. A lung aspirate revealed a high proportion of mature neutrophils and active macrophages. No micro-organisms or neoplastic cells were noticed.

Due to a poor prognosis the horse was euthanased with intravenous barbiturate and necropsied within 30 min of death.

### Gross pathology

The animal was in a poor condition. The only significant lesions were found in the liver and lungs. There was a multifocal granulomatous parasitic hepatitis, each granuloma being about 1 mm in diameter. Both lungs were extensively infiltrated by numerous discrete tumour nodules (10-100 mm in diameter) distributed throughout all the lobes. These nodules were yellowish-white and extremely firm. By subjective estimation, 70% of lung capacity was taken up by neoplastic tissue (Fig. 1). The lung tissue between tumorous growths did not show significant lesions. The bronchial and mediastinal lymph nodes were moderately enlarged but no evidence of the presence of metastatic tumours was noticed.

No other sites of neoplastic growth were found in the rest of the carcase. Specimens of lung, liver and bronchial lymph nodes were fixed in 10% buffered formalin for routine preparation of paraffin wax and frozen sections for histopathological examination.

Formalin-fixed samples of the lung neoplasm were transferred to glutaraldehyde and processed according to standard techniques for transmission electron microscopy.

### Histopathology

Multifocal neoplastic nodules were present in the lungs and were partially surrounded by a thin fibrous capsule. In the neoplasms the basic bronchiolo-alveolar pattern of lung tissue was retained (Fig. 2) but the neoplastic alveoli and bronchioli were lined by a single layer of large cuboidal, very vacuolar, neoplastic epithelial cells (Fig. 3). In some of the areas where the bronchioli opened into alveolar ducts the neoplastic epithelial cells were distinctly ciliated (Fig. 4). There was a marked increase in interstitial connective tissue. Most tumour cells contained varying numbers of cytoplasmic vacuoles, and in those where they were very numerous, the vacuoles were small and imparted a foamy appearance to the cytoplasm while in those containing fewer vacuoles, they tended to be much larger and were often responsible for compression of the nuclei. These vacuoles did not contain glycogen, mucopolysaccharides or mucin when stained specifically for these substances with Alcian blue, PAS and Mucicarmine, while frozen sections stained by the Sudan - 4 and Nile blue methods failed to demonstrate any acidic or neutral lipids in the tumour cells.

The nuclei were vesicular with distinct chromatin granules when not compressed by cytoplasmic vacuoles. Each nucleus contained a single rather indistinct nucleolus. No mitotic figures were noticed. Most of the lumina formed in the neoplastic nodules were filled with

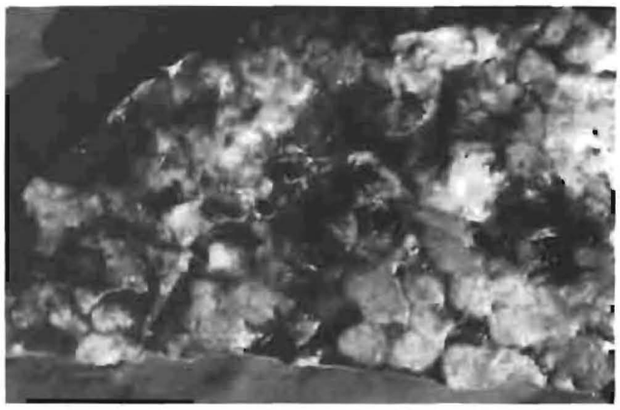

Fig. 1: **Gross picture of a cut-surface of the lung showing extensive neoplastic involvement**

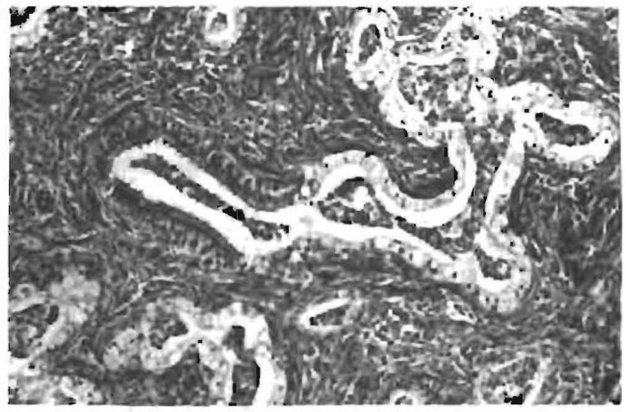

Fig. 2: **Bronchiolo-alveolar architecture with abundant interstitial stroma. HE X200**

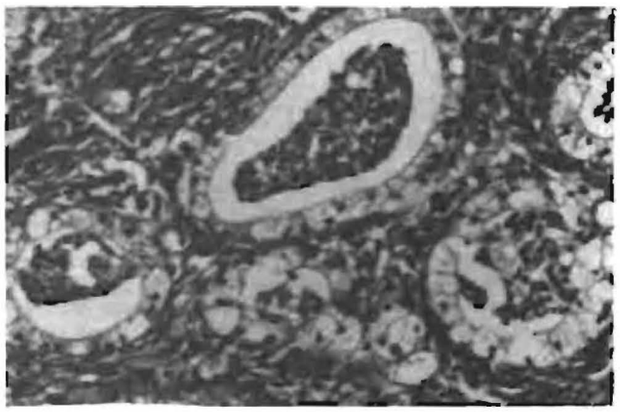

Fig. 3: **Neoplastic alveoli lined by a single layer of very vacuolated cuboidal epithelium. Note debris in alveolar lumina. HE X400**

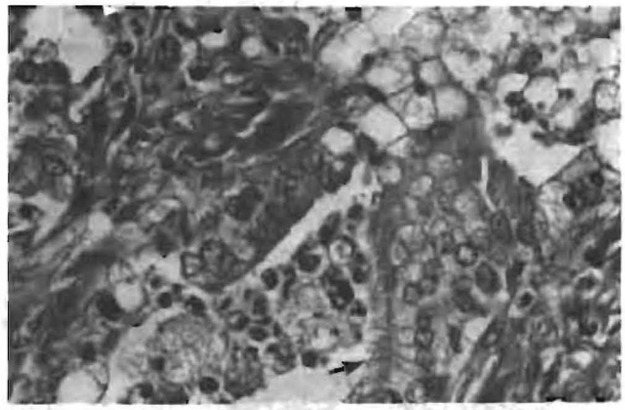

Fig. 4: **Neoplastic bronchiolo-alveolar structure with ciliated epithelial cells (arrow). HE X400**

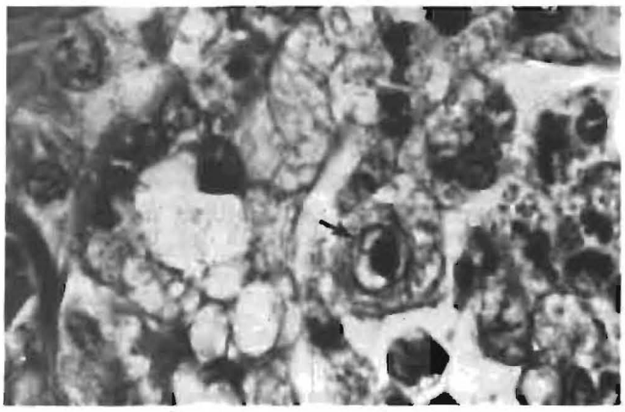

Fig. 5: **Intranuclear inclusions in macrophages present in the debris filling neoplastic alveoli. HE X1000**

cellular debris consisting of dying neutrophils, macrophages and desquamated epithelial cells. Some of the macrophages contained distinct intranuclear inclusions which resembled viral inclusions (Fig. 5). No such inclusions were found in the neoplastic epithelial cells or in the normal parts of the lung.

The connective tissue of the tumour was infiltrated by moderate numbers of lymphocytes and plasma cells and some macrophages. At the periphery of the neoplastic nodules an increase in the number of infiltrating lymphocytes was present.

The non-neoplastic parts of the lung showed a moderate anthracosis and a mild peribronchial infiltration of lymphocytes and fibroblastic proliferation.

The bronchial lymph nodes revealed a reactive hyperplasia of the lymphoid follicles but no signs of tumour emboli or metastatic neoplasms were encountered.

Focal disseminated parasitic granulomata were distributed throughout the liver.

### Electron microscopy

Despite inappropriate fixation, the cytoplasmic and nuclear margins of the alveolar lining cells were sharp and internal organelles distinct. These cells were identified as pneumocyte Type II cells due to the presence of large numbers of multilamellar bodies within the cytoplasm. The cells also had short microvilli on the free surface and were joined to each other by continuous tight junctions and desmosome-like junctions (Fig. 8).

The pronounced light microscopic vacuolar appearance of the cytoplasm of these cells was due to enlargement and distension of the lamellated bodies (Fig. 6 & 7). These bodies resemble secretory granules with electron dense myelinoid whorls (Fig. 9). Lamellated secretory material was present within neoplastic alveoli (Fig. 6) which is a normal characteristic of pulmonary tissue[6].

No intranuclear inclusions in macrophages, which were seen during light microscopy, could be demonstrated during electron microscopy.

## DISCUSSION

The history of skin and sheath tumours removed surgically from this horse on previous occasions, might be indicative that it was predisposed to the development of neoplasia. Careful examination of the carcase during necropsy did not reveal any evidence of neoplastic growths other than those in the lungs.

The histopathological findings of retention of the bronchiolo-alveolar architecture as well as the formation of cilia by some tumour cells are conclusive evidence that this tumour was of primary pulmonary origin. The electron microscopic finding that the tumour cells are of the pneumocyte Type II variety containing lamellated bodies also strongly supports this interpretation.

Morphologically the tumour differs considerably from ovine bronchiolo-alveolar adenocarcinoma (jaagsiekte) as described by Tustin et al.[8] and Verwoerd et al.[10] in that the equine tumour is very scirrhous while the epithelial cells have a very vacuolar cytoplasm. Interestingly

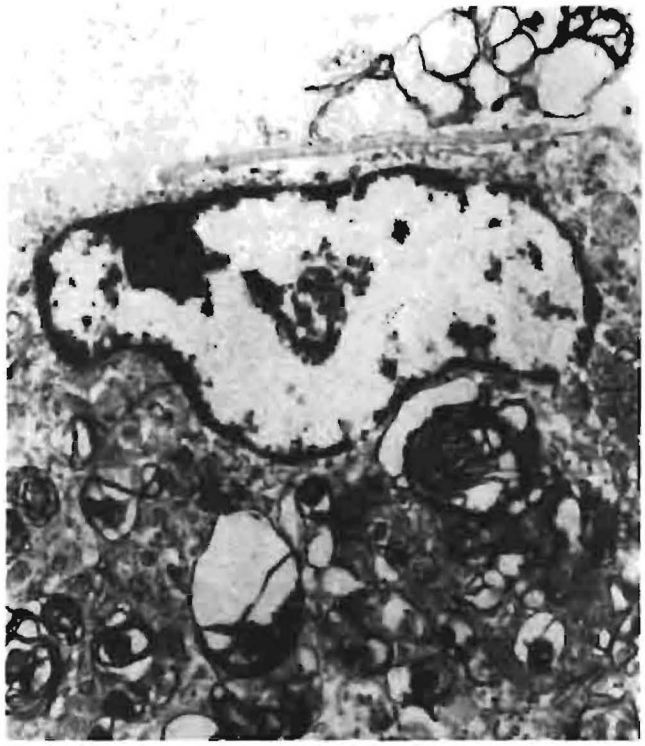

Fig. 6: **Ultrastructure of neoplastic epithelium showing numerous dilated lamellar bodies in the cytoplasm of a Type II pneumocyte and lamellated material in the alveolar lumen. Uranyl acetate and lead citrate X8300**

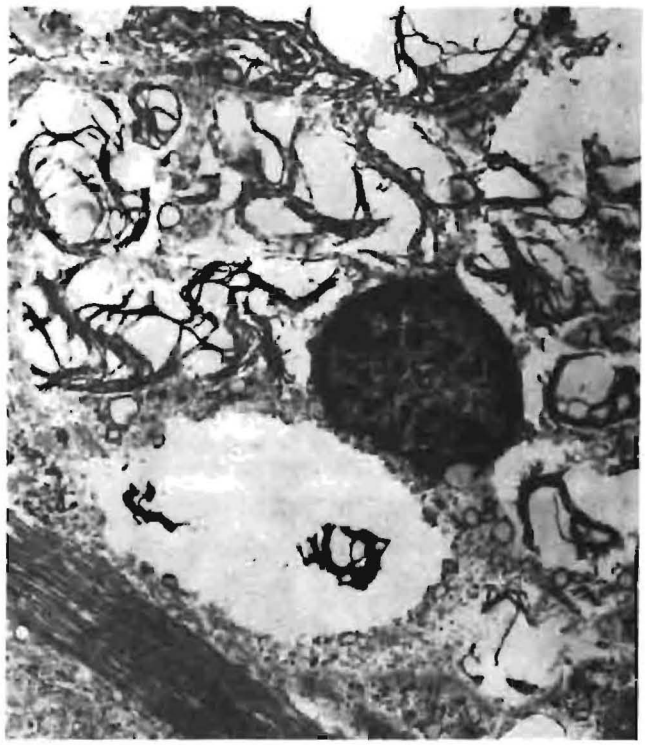

Fig. 7: **Extreme dilatation of lamellar bodies. A bundle of collagen fibres immediately beneath the cell is visible in the lower corner. Uranyl acetate and lead citrate X5950**

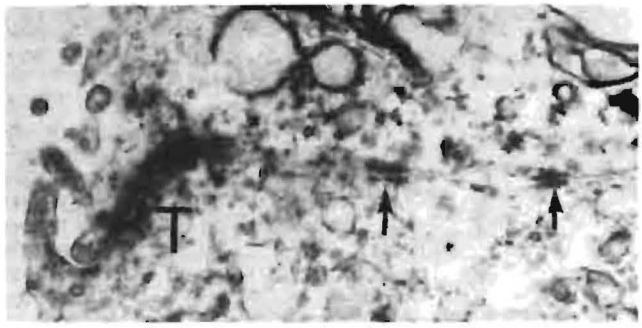

Fig. 8: **Tight junction (T) and desmosonal-like junctions (arrows) between 2 adjacent neoplastic Type II epithelial cells. Uranyl acetate and lead citrate X19700**

Fig. 9: **High power view of lamellated structures in a neoplastic Type II epithelial cell. Uranyl acetate and lead citrate X119000**

however, Dalefield & Alley[3] described an ovine pulmonalry tumour which showed much similarity to the equine tumour described in this paper.

The reason for the distension of the myelinoid bodies which was responsible for the vacuolated appearance of the cytoplasm of the neoplastic epithelial cells in unknown. As the tissue specimens were fixed soon after the death of the horse, it is not considered to be a post mortem change or artefact. Special staining techniques for various lipids, mucin, mucopolysaccharides and glycogen failed to reveal the nature of the content of these vacuoles. It is therefore probable that the vacuolar contents were of a hydropic nature.

A finding of which the significance could not be ascertained was the presence of intranuclear inclusion bodies which resembled viral inclusions within the macrophages present in the lumina of some neoplastic alveoli. Unfortunately these could not be traced in sections examined electron-microscopically and virological isolation was not attempted.

Despite the extent of the space-occupying lesion in the thoracic cavity, there were no signs of hypertrophic pulmonary osteo-arthropathy - a phenomenon which was reported in a horse suffering from a pulmonary granular cell myblastoma[1].


## ACKNOWLEDGEMENTS

The authors wish to thank Prof I W Simson, Prof R C Tustin, Mrs V Käber and the technical staff in the departments of Pathology, Medicine and Photography for their assistance.


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# ANOMALOUS ORIGINS OF THE RIGHT SUBCLAVIAN AND COMMON CAROTID ARTERIES IN THE DOG

A J BEZUIDENHOUT*

**ABSTRACT**

**Anomalous origins of the right subclavian and common carotid arteries in a 6-month old Alsatian bitch are described. The first vessel to branch from the aortic arch was a short bicarotid trunk which divided into left and right common carotid arteries. The right common carotid artery was partially occluded at its origin and its function and area of supply was taken over by the right vertebral artery. The right subclavian artery branched directly from the aortic arch and passed dorsally to the oesophagus, forming an incomplete vascular ring around the oesophagus. Although the oesophagus was constricted between the vessel dorsally and the trachea ventrally, it did not cause obstruction or dysphagia. The right vertebral artery was exceptionally large.**

**Key words: Anomalous vessels, aortic arch, dog**

**Bezuidenhout A.J. Anomalous origins of the right subclavian and common carotid arteries in the dog.** *Journal of the South African Veterinary Association* **(1989) 60 No. 4, 215-218 (En.) Department of Anatomy, Faculty of Veterinary Science, University of Pretoria, Private Bag X04, 0110 Onderstepoort, Republic of South Africa.**

## INTRODUCTION

Anomalous origins of the right subclavian and common carotid arteries have been reported in various domestic and wild animals. They are described by Ellison[4], Smollich[7], and Vitums[8] in the dog, De Garis[1] in rhesus monkeys, Eales[2] and Edmunds[3] in the rabbit and by Paiva[6] in the pig. Ellison[4] gives a detailed account of the types and frequency of the various anomalies, as well as their surgical correction, while Vitums[8] describes the development of anomalous right subclavian arteries in 3 dogs. The normal embryonic development of the vessels must be understood to appreciate the aetiology of anomalous vessels. Embryologically, the principle arteries consist of paired dorsal and ventral aortae, and 6 pairs of aortic arches that connect the 2 sets of vessels. These arches surround the primordial pharynx, which eventually forms the cranial portions of the trachea and oesophagus. The paired dorsal aortae fuse to form the descending aorta. The arches develop and degenerate in sequence, and at no given time are they all present. The ventral aortae between the third and fourth arches elongate to form the left and right common carotid arteries, while the right fourth arch becomes the proximal portion of the right subclavian artery. The left fourth arch enlarges to form the normal adult aortic arch[5].

Abnormal embryonic development of the 6 primordial aortic arches around the embryonic pharynx is a well known cause of post-natal constriction of the thoracic oesophagus[4].

The anomalous right subclavian artery generally arises from the aorta just caudal to the origin of the left subclavian artery. In order to reach the right front limb, the displaced right subclavian artery passes dorsally to the oesophagus, forming an incomplete vascular ring around the oesophagus. Sometimes the vessel may press on the oesophagus, causing obstruction and dysphagia, but in the majority of cases it is asymptomatic. The vessel can also pass between the oesophagus and trachea, or ventrally to the trachea. In the present study, anomalous origins of the right subclavian and common carotid arteries, as well as abnormal patency of the common carotid and vertebral arteries, are described.

## MATERIALS AND METHODS

A 6-month old Alsatian bitch was presented for euthanasia. Following anaesthesia with 6% pentobarbitone, the left common carotid artery was cannulated and the animal allowed to exsanguinate. After exsanguination the dog was fixed by perfusion with 10% formalin and the following day the arterial system was injected with latex. During routine dissection of the thorax, the anomalous vessels were observed. Detailed dissection was then done and the relevant structures photographed and illustrated.

## RESULTS

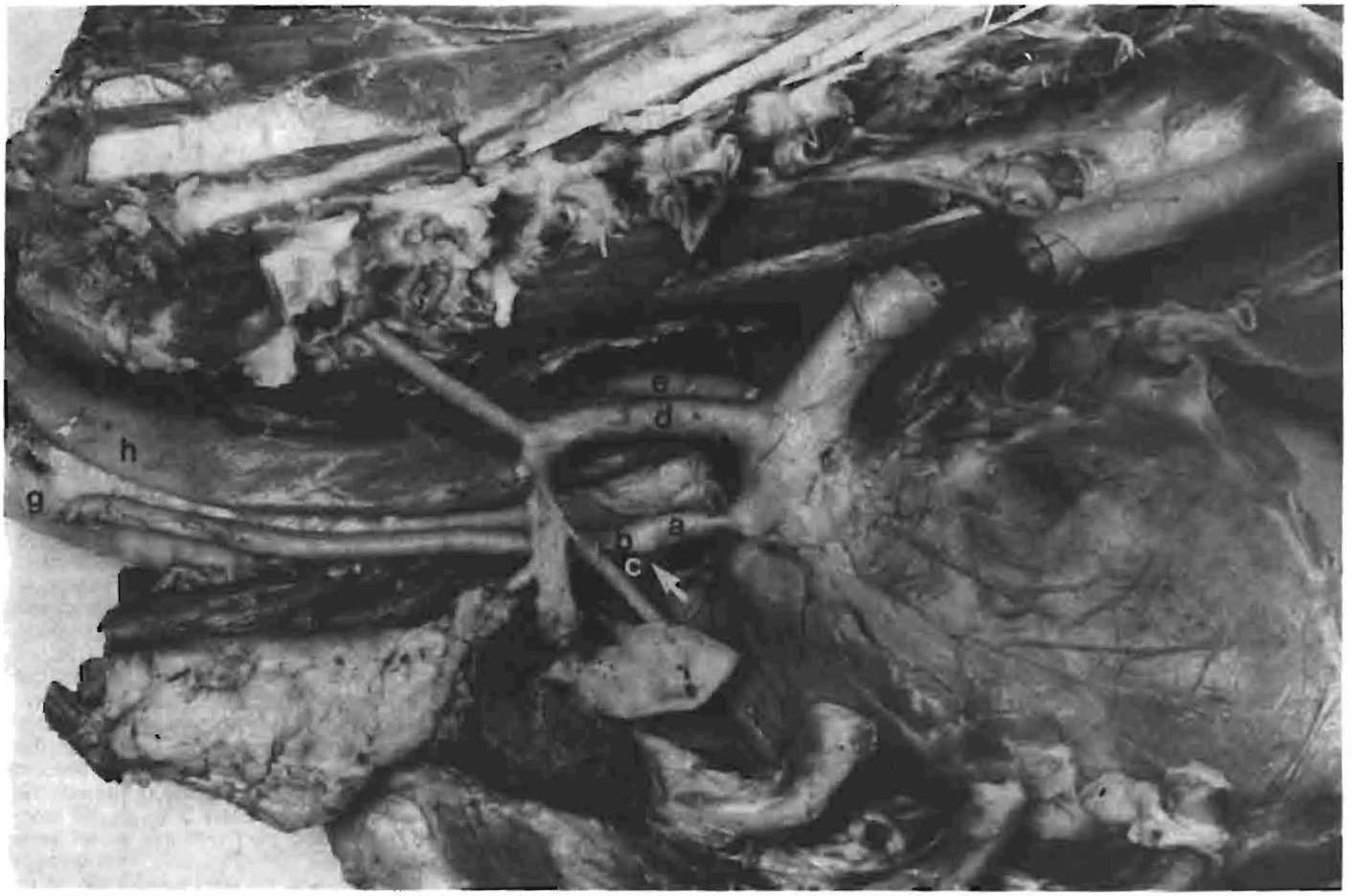
Three cranially-directed vessels were seen to arise directly from the aortic arch. The first vessel to branch from the aorta was the bicarotid trunk (Fig. 1). It passed cranially along the left ventral aspect of the trachea for a short distance and then divided into left and right common carotid arteries. Superficially, both arteries were normal in appearance, but on closer examination, the right common carotid artery was found to be partially occluded at its origin. The rest of the vessel, however, was patent. The second vessel to branch from the aorta was the left subclavian artery (Fig. 1). No anomalies associated with this vessel were observed. The third vessel to branch from the aorta was the right subclavian artery (Fig. 1 & 2). It did not pass from left to right ventrally to the trachea and oesophagus, but coursed across the dorsal aspect of the oesophagus and then cranio-ventrally towards the first rib. In doing so, a deep groove was formed in the muscular wall of the oesophagus. The oesophagus was thus constricted dorsally, but a complete vascular ring was not formed. The right vertebral artery, which branched off the right subclavian artery, was about twice the diameter of the left vertebral artery (Fig. 1 & 2). On further dissection of the neck and head, various connections were found between the right vertebral and common carotid arteries.

## DISCUSSION

Anomalous development of the vessels cranially to the heart are rare, but well-documented. The vessels mainly involved are the common carotid and subclavian arteries. In the cases described by Vitums[8], the bicarotid trunk was 26-31 mm long and 4-5 mm in diameter. In the present study the bicarotid trunk was only 5 mm long, but of normal diameter. Occlusion of a common carotid artery with a concomitant enlargement of the vertebral artery has not been reported in the literature. In the present study, it was found that the vertebral artery took over the function and area of supply of the common carotid artery. Although the latter was patent, it received very little blood from the bicarotid trunk as its origin was partially occluded. Patency of the common carotid artery was probably maintained by the various connections between the vertebral and common carotid arteries. According to Vitums[8] the anomalous right subclavian artery branches from a bisubclavian trunk, while Ellison[4] states that it can arise distally to the left subclavian artery from the aorta,

*A.J. Bezuidenhout, Department of Anatomy, Faculty of Veterinary Science, University of Pretoria, Private Bag X04, 0110, Onderstepoort, Republic of South Africa

Received: May 1989 Accepted July 1989



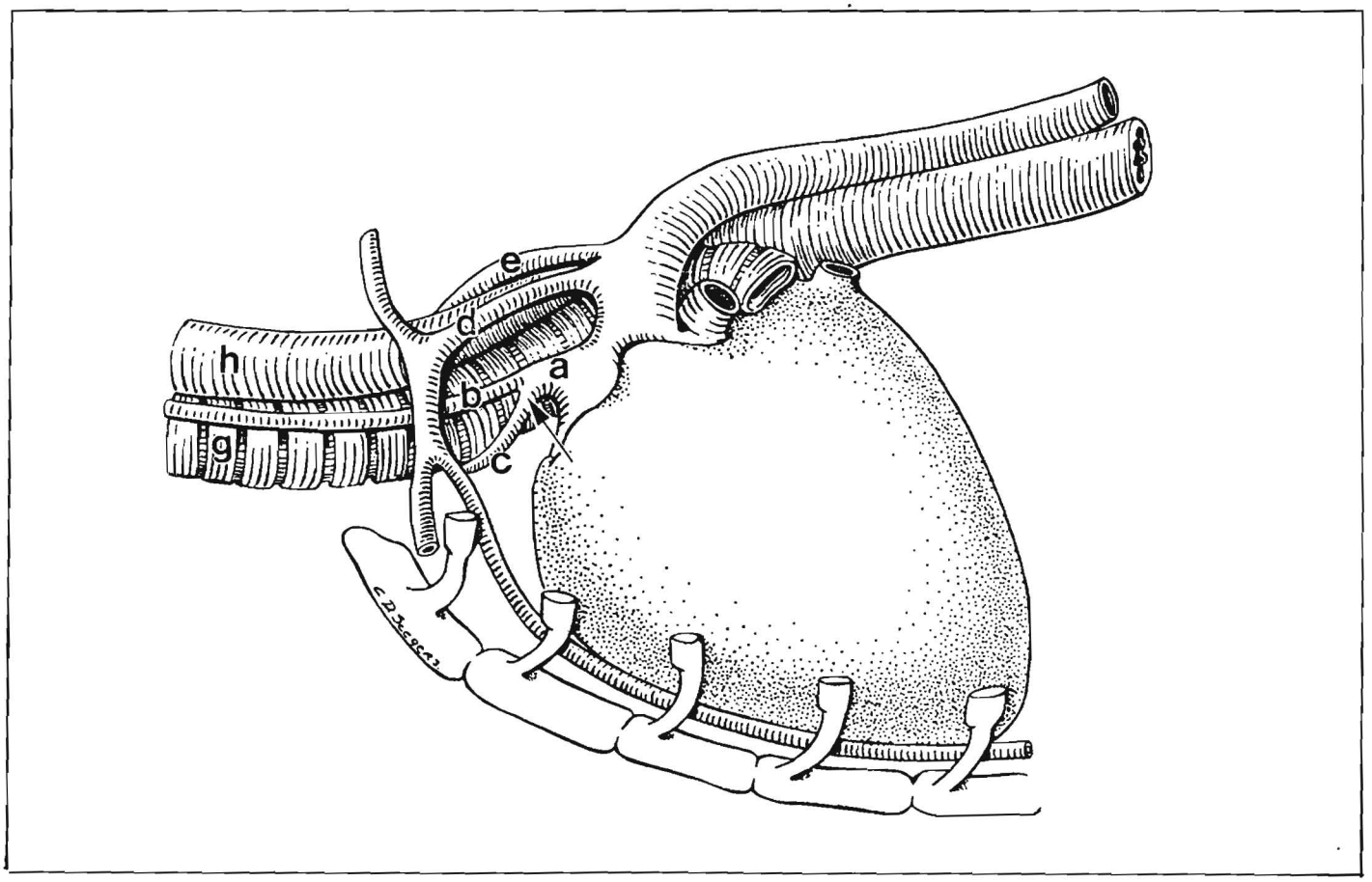




Fig. 1: i)Left view of the thorax. The arrow indicates the position of partial occlusion of the right common carotid artery. ii)Schematic view of the left view of thorax. a)=bicarotid trunk b)=left common carotid artery c)=right common carotid artery d)=left subclavian artery e)=right subclavian artery g)=trachea h)=oesophagus

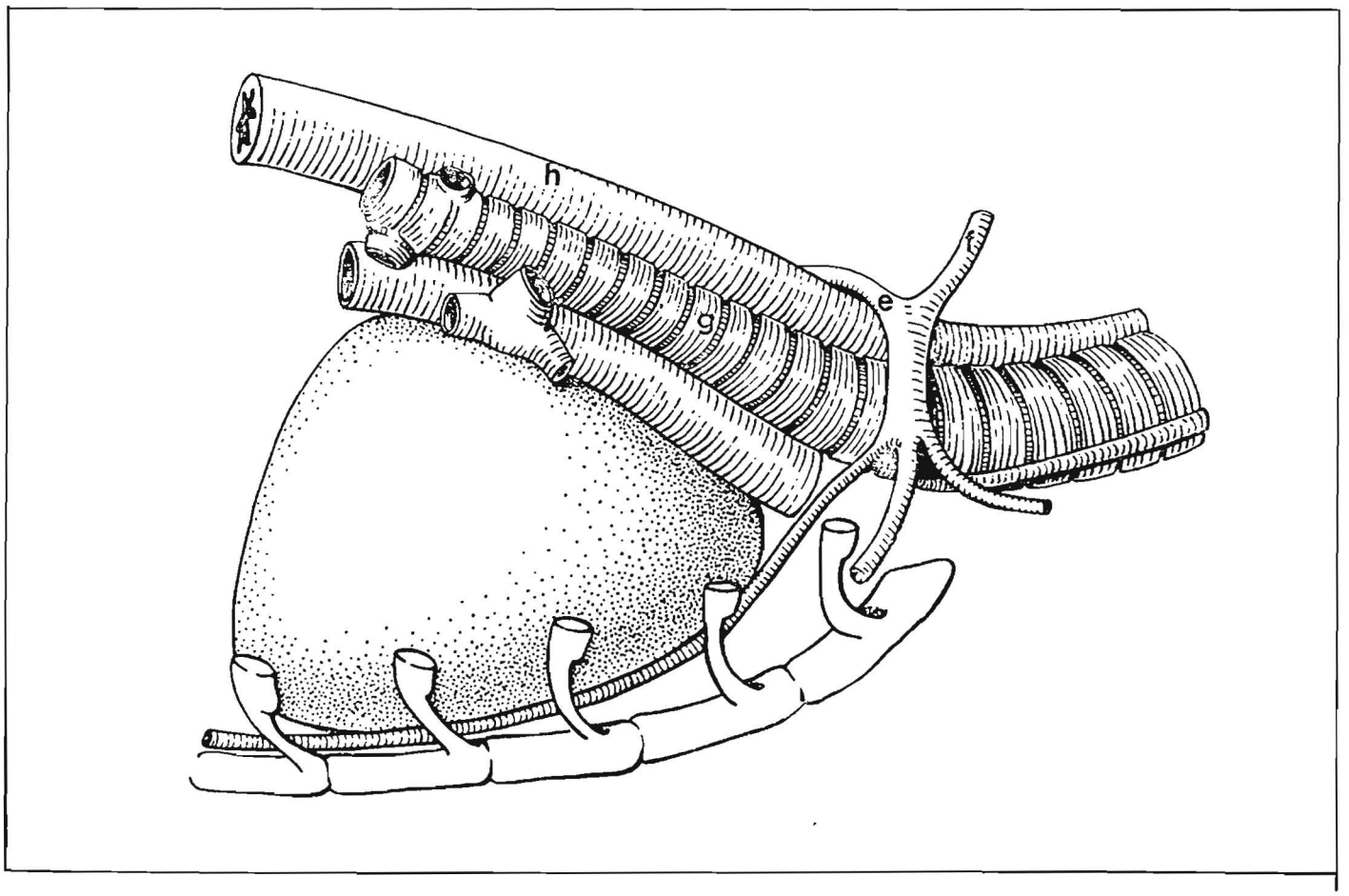




Fig. 2 i)Right view of the thorax and ii)schematic presentation thereof. e)=right subclavian artery f)=right vertebral artery g)=trachea h)=oesophagus

or from a bisubclavian trunk. In the present study, a bisubclavian trunk was absent and the right subclavian artery branched directly from the aorta, distally to the left subclavian artery. The anomalous vessel can pass between the trachea and oesophagus, or dorsally to the oesophagus, as reported by Ellison[4] and Vitums[8]. In the present study, it passed dorsally to the oesophagus forming an incomplete vascular ring, the so-called *arteria lusoria*, around the oesophagus.

Although the oesophagus is constricted between the vessel dorsally and the trachea ventrally, it rarely causes oesophageal obstruction in the dog[8]. In the present study there was no history of obstruction or dysphagia. The presence of an anomalous right subclavian artery should be borne in mind when evaluating radiographic oesophageal abnormalities.

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# BLOOD CONSTITUENT RESPONSES OF CATTLE TO HERDING

J HATTINGH, MARIA GANHAO* and G KAY**

**ABSTRACT**

**Blood was obtained over a period of 20 minutes by remote controlled procedures from cattle while they were herded. Samples were analysed for catecholamines, cortisol, haematocrit, total lipid, glucose and lactate. The results show that the response to a given stressor is specific and suggest that multiple stressors may not necessarily result in additive effects.**

**key words: Cattle, stress, blood**

**Hattingh J.; Gahao M.; Kay G. Blood constituent responses of cattle to herding.** *Journal of the South African Veterinary Association* **(1989) 60 No. 4, 219-220 (En.) Department of General Physiology, University of the Witwatersrand, 2050 Johannesburg, Republic of South Africa.**

## INTRODUCTION

The effects of blood sampling on the blood composition of cattle in a crush, during transport and after slaughter have recently been investigated. It was found that significant changes occur as a consequence of blood sampling in a crush in animals unaccustomed to handling, after transport and after slaughter[3]. By comparing the results obtained for the different groups, it was concluded that the physiological response to stressors occurs in 2 phases: a hypothalamic-adrenal cortex phase which is associated with perceived environmental stress, and a sympathetic adrenal-medulla phase which is associated with neurogenic "stress"[5]. In all cases the cattle were exposed to multiple stressors (noise, handling, transport, slaughter, etc.) and it was suggested that combinations of such stressors produce mixed responses[5].

In the above studies, all cattle were subjected to some degree of exercise to which they were unaccustomed. The animals in question normally went about their routine without, for instance, having to run a certain distance or frequently having to resist handling. As a first step in dissecting the mixed responses to multiple stressors, the reaction of cattle to chasing was studied by remote blood sampling procedures. Although probably not a single stressor, chasing alone eliminates many of the other influences imposed when cattle are handled, transported or slaughtered.

## MATERIALS AND METHODS

Four adult and healthy Nguni oxen, unaccustomed to handling, were studied individually at the Animal and Dairy Science Research Institute at Irene. They were kept in a large enclosure (ca 100 x 150 m) where they could move around and graze freely. Water was available ad lib. Blood samples were obtained from the jugular vein by a remote controlled sampler placed around the animal's neck[4]. The equipment was left on the animal for at least 36 h with samples taken every 4 h before the present experiment was done. On the day of the experiment (between 10:00 and 14:00), a blood specimen was taken at time zero (To). The animal was then chased and samples taken as closely as possible to every ensuing 5 min for a 20 min period. The animal was then left to rest for 5 min and a further sample taken.

The samples were analysed immediately for haematocrit. Plasma for glucose, lactate, total lipids, (cholesterol, free fatty acids) cortisol and total catecholamines was stored at -20°C and analysed within 7 d as described previously[1,2]. The results were lumped and mean and standard deviation calculated for $T_0$, $T_5$, $T_{10}$, $T_{15}$, $T_{20}$ and $T_{25}$.

## RESULTS

The results are shown in Table 1. Over time, the values of all variables increased, and were significantly different to the $T_0$ value in some cases. The small sample size was possibly responsible for masking others. After a rest period of 5 min, mean cortisol values continued to show an increase and mean total lipid and haematocrit values tended to decrease. During the period of exercise, total catecholamine values remained constant for the first 10 min and then increased markedly whereas cortisol values showed a progressive increase from $T_0$.

Table 1: **Effects of chasing over time on variables in cattle blood. (Mean ± s.d.) (P<0,05)**

| Variable | $T_0$ | $T_5$ | $T_{10}$ | $T_{15}$ | $T_{20}$ | $T_{25}$ |
|---|---|---|---|---|---|---|
| Total catecholamines ng ml$^{-1}$ | 5,0 ± 3,3 | 5,2 ± 2,9 | 6,4 ± 3,1 | 10,0 ± 3,8 | 14,2 ± 7,6 | 15,8 ± 11,0 |
| Cortisol nmol $\ell^{-1}$ | 21 ± 15 | 51 ± 49 | 67 ± 53 | *91 ± 46 | *120 ± 45 | *142 ± 18 |
| Total lipids g $\ell^{-1}$ | 4,9 ± 2,2 | 5,1 ± 2,7 | 5,7 ± 2,4 | 6,1 ± 2,8 | 6,4 ± 3,1 | 5,3 ± 2,2 |
| Lactate mmol $\ell^{-1}$ | 1,3 ± 0,7 | 4,8 ± 2,5 | 7,7 ± 3,3 | *9,1 ± 3,4 | *10,4 ± 2,7 | *10,7 ± 1,4 |
| Glucose mmol $\ell^{-1}$ | 3,5 ± 1,0 | 3,7 ± 0,5 | 4,1 ± 0,3 | 4,7 ± 0,6 | 5,1 ± 0,4 | 5,1 ± 0,7 |
| Haematocrit | 0,32 ± 0,01 | 0,38 ± 0,06 | *0,42 ± 0,05 | *0,44 ± 0,05 | *0,46 ± 0,07 | *0,41 ± 0,04 |

*indicates significantly different from $T_0$ (P<0,05)

*Department of General Physiology, University of the Witwatersrand, 2050 Johannesburg, Republic of South Africa
**Dairy Science Research Institute, Irene
Received: April 1989 Accepted: June 1989

## DISCUSSION

The $T_0$ values recorded in this study are not significantly different from control values obtained by sampling cattle accustomed to handling[2], although some of the mean values are higher. This indicates that the sampling procedures used here did not result in significant changes in the blood variables measured after the animals had become accustomed to the equipment. This agrees with previous observations[4].

The animals in the present study were not fit as they were unaccustomed to running. Although not chased to exhaustion, running for 20 min was probably stressful. The physiological response to this stressor included increases in the values of all variables measured, although not to the same degree. Catecholamines, for instance, only increased 3 fold compared to cortisol which increased about 6 fold. Apart from providing data showing how cattle respond to chasing, the results also show that this stressor gives rise to increases in **both** catecholamines and cortisol comparable to those found separately in handling (cortisol) and slaughter (catecholamines)[5]. This strengthens the view that the response to a given stressor is specific and suggests that multiple stressors do not necessarily result in additive effects.


## ACKNOWLEDGEMENTS

The financial assistance of the University of the Witwatersrand and the FRD is gratefully acknowledged.


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# SWOLLEN HEAD SYNDROME IN CHICKENS: A PRELIMINARY REPORT ON THE ISOLATION OF A POSSIBLE AETIOLOGICAL AGENT

S B BUYS*, J H DU PREEZ* and H J ELS**

**ABSTRACT**

**An extremely pleomorphic virus was isolated from broilers with swollen head syndrome. This virus seems to be related to the virus causing turkey rhinotracheitis.**

**Key words: swollen head syndrome, virus isolation.**

**Buys S.B.; du Preez J.H.; Els H.J. Swollen head syndrome in chickens: A preliminary report on the isolation of a possible aetiological agent.** *Journal of the South African Veterinary Association* **(1989) 60 No. 4, 221-222 (En.) Festive Farms, P.O. Box 237, 1665 Olifantsfontein, Republic of South Africa.**

Swollen head syndrome (SHS) was first observed in South Arica in broilers during 1971[6]. Subsequent to the identification of the causal organism of turkey rhinotracheitis (TRT) in South Africa in 1979, the possibility of this organism being the cause of SHS in chickens was investigated with negative results[2]. When TRT appeared in the United Kingdom[1], SHS in chickens was simultaneously observed by different workers for the first time[7 9]. Positive seroconversion to TRT occurred after SHS was observed in broiler breeder flocks in both England[9] and France[8]. However various investigators[3 4 5 8] were unable to induce clinical signs of SHS in chickens with TRT viruses isolated from turkeys.

Picault, et al.,[8] did however isolate a TRT virus from chickens by blind passages in chicken embryo tracheal ring organ cultures (CTROC). Since they were able to induce clinical signs in susceptible turkeys with the same inoculum as used for the CTROC, it was concluded that TRT virus is a common infectious agent affecting the upper respiratory tract of turkeys, chickens and guinea fowl. In addition, Morley & Thomson[6] isolated a coronavirus from SHS cases which they thought could be the cause of the disease.

In August 1988, SHS was clinically diagnosed in 18-day old broilers in broiler test houses which are well isolated from commercial farms. This followed a feed transfer from a commercial broiler farm. The first clinical signs observed were sneezing, followed by a nasal discharge in more than 50% of the birds. Swelling of the infraorbital sinuses occurred in a lower percentage of the birds with fewer than 1% developing classical swollen heads. Experience with SHS in the broiler industry is that up to 50% of the birds could develop nasal discharge with a varying degree of swelling of the infraorbital sinus, but that only a limited number will develop a conspicuous swelling involving the skin over the dorsal and lateral parts of the head which gave origin to the name SHS.

Sinus exudate from affected broilers was inoculated via the infraorbital sinus into unvaccinated 8-week old commercial layer chicks that had been reared in isolation from one day old. On Day 4 after inoculation, the birds developed a nasal discharge followed by swelling of the infraorbital sinuses which started clearing 4-5 d later, and 10 d after inoculation no evidence of any disease was apparent. Material collected from the sinuses of affected broilers was filtered through a 0,22$\mu$m filter and inoculated into embryonated eggs (via both the allantoic sac and yolk sac routes), CTROC's. Vero cells and examined bacteriologically.

After 14 serial passages via the allantoic sac, neither embryo mortality nor macroscopic pathology could be observed. No cilia stasis have as yet been observed in CTROC's after 4 blind passages. Bacteriologically, apart from *E.coli*, no pathogenic bacteria could be isolated. During the 3rd passage via the yolk sac, embryo mortality was observed from Day 7, the embryos being red, but without macroscopic liver pathology. In the third and fourth passage in Vero cell cultures, numberous loose cells were observed floating around after 4 d without other observable specific cytopathic changes in the cell layer.

Electron microscopy of allantoic fluid from the fourth allantoic sac passage as well as supernatant fluid from the third Vero passage, revealed numerous highly pleomorphic virus particles with a fringe, but no definite internal structure has as yet been observed.

Commercial layer type chickens (Amber Link) originating from *M.gallisepticum* and *M.synoviae* negative parents, were reared with 4 turkeys from one day old in a filtered air positive pressure room (FAPP).

Table 1: **The clinical results of 6-week-old layer type chickens and poults challenged with 2381/88**

| Type of bird | No. | Inoculum | Number of birds with sinusitis post-challenge Days | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Layer type | 8 | 2381/88AS//8 | 0 | 0 | 1 | 4 | 5 | 4 | 0 | 0 |
| Turkey poults | 4 | 2381/88AS//8 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 0 |

Table 2: **The clinical results of broiler type chickens exposed to 91/78 at 10 d of age and challenged with 2381/88 (AS$\frac{1}{1}$3 YS$\frac{1}{1}$3) 14d later**

| Treatment | No/Group | Number of birds with sinusitis post-challenge Days | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Exposed to 91/78 | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Susceptible | 25 | 0 | 0 | 0 | 4 | 18 | 9 | 2 | 0 |

*Festive Farms, P.O. Box 237, 1665 Olifantsfontein, Republic of South Africa
**Electron Microscope Unit, Medical University of Southern Africa.

*Received: May 1989 Accepted: September 1989*

At 6 weeks of age, the chicks and the 4 turkeys were challenged via the infraorbital sinus route with isolate 2381/88, in its eigth allantoic sac egg passage.

Isolate 2381/88 induced in the layer type chickens respiratory symptoms from Day 3 onward. Two of the 4 turkeys also developed a nasal discharge from Day 5 which was similar to that induced by TRT virus (Table 1.)

Since a reliable serum neutralisation test has not yet been developed, it was decided to cross-challenge birds in order to assess the relationship between chicken isolate 2381/88 and the TRT isolate 91/78. To do this, 30 ten-day-old broilers, raised in isolation, were infected with isolate 91/78 propagated in the yolk sac. The yolk material was diluted $10^{-2}$ and 0,03 ml administered as an eyedrop in one eye of each chick. No clinical signs developed in any of the chicks. After 14 d, the infected chicks together with 25 uninfected controls were exposed to the chicken isolate 2381/88 propagated in the yolk sac via the infraorbital sinus. The results are tabulated in Table 2. Of the controls, 72% developed sinusitis with a nasal discharge, whereas the birds previously infected with 91/78 remained clinically negative.

Isolate 2381/88 morphologically resembles the turkey isolate 91/78 and does not haemagglutinate chicken red blood cells[3]. It therefore seems to belong to the family *Paramyxoviridae* and since it does not haemagglutinate red blood cells, could be a pneumovirus. A highly significant difference between the chicken isolate (2381/88) and the turkey isolate (91/78), is that the latter cannot induce respiratory signs in either layer type chickens or broiler type chickens[3], while isolate 2381/88 could repeatedly produce respiratory signs in both layer and broiler type chickens as well as in turkeys. There are however also points of resemblance between the 2 isolates, namely the extreme pleomorphism of both isolates, the inability of both isolates to haemagglutinate chicken red blood cells and the ability of the turkey isolate (91/78) to protect chickens against a challenge with the chicken isolate (2381/88).

On a further 2 farms where chickens were suffering from SHS, a virus, morphologically similar to isolate 2381/88, has been isolated. It is therefore tentatively concluded, pending further experiments in progress, that this isolate (2381/88) is most likely the causative agent of SHS in chickens. Since there are indictions that a relationship exists between isolate 2381/88 and the virus causing TRT in turkeys, the possibility that isolate 2381/88 might represent a subpopulation of the TRT virus that has adapted to chickens, will have to be considered.

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**Book Review/Boekresensie**

## HOW TO KEEP YOUR HORSE HEALTHY

COLIN VOGEL

BSP Professional Books, Oxford. 1989. pp 156 with figures and tables. Price not mentioned. (ISBN 0-632-02588-3).

Colin Vogel, a practising veterinarian, who has worked with horses for many years, is to be congratulated on a well-written, easy-to-read, easy-to-understand text for the horse owner. In line with the approach of present-day veterinarians to production animals, this book provides basic knowledge and excellent guidelines on how to keep the horse healthy.

The text, which includes chapters on vaccination, immunity, prevention of respiratory disease, nutrition, parasites, fitness, lameness and mental health, is concluded with an example of an "overall plan" for the care of the horse.

Although the book has been written primarily for those who care for horses on a daily basis, I have no hesitation in recommending it to undergraduate veterinary students, veterinary technologists and veterinary nurses. The recommendation of this book by veterinarians to clients, will certainly allow for more efficient communication between veterinarian and client.

J van Heerden

# A REVIEW OF ENERGY METABOLISM IN PRODUCING RUMINANTS

## Part 1: Metabolism of energy substrates

J G VAN DER WALT* and MARGARET J LININGTON**

**ABSTRACT**

**The efficiency of metabolisable energy utilisation, for growth and fattening, is dependent upon the relative VFA proportions produced in the rumen. Sufficient propionate is required to meet glucose demand for producing NADPH, glycerol and nucleic acid synthesis. Since diet has the greatest effect on the pattern of VFA fermentation, it will play a major role in controlling the supply of VFA to the animal. Magnitude of the acetate supply determines the proportion of acetate supplied to oxidation or to fatty acid synthesis, which is also dependent upon the extracellular supply of glucose, NADPH and ATP. Since the optimal levels of acetate and glucose for lipogenesis appear to vary with glucose concentration, a diet that decreases the supply of glucogenic precursors, but increases the acetate supply, may suppress fatty acid synthesis. An increased supply of propionate may suppress glucose synthesis from other sources. The isoenergetic replacement of roughage by concentrate, appears to increase the glucose entry rate, due to both an increase in propionate, and glucose absorbed from the small intestine. Dietary nitrogen source also affects the rate of gluconeogenesis. An optimum dietary energy-protein ratio exists for maximum efficiency of utilisation of both dietary energy and protein. In dairy cows, for example, the energy is most effectively metabolised when protein content of the diet is 15-25% of net energy.**

**Key words: Ruminant, metabolism, partitioning, pathway**

**Van der Walt, J.G.; Linington, M.J. A review of energy metabolism in producing ruminants. Part 1: Metabolism of energy substrates.** *Journal of the South African Veterinary Association* **(1989) 60 No. 4, 223-227. Department of Physiology, Faculty of Veterinary Science, University of Pretoria, 0110 Onderstepoort, Republic of South Africa.**

### INTRODUCTION

The life cycle of an animal should be seen as a continuum stretching from birth to death, during which time nutrient requirements will differ considerably. It is the process of growth, during which the mass of the animal increases due to an increase in nutrient intake, which forms the subject matter of this review.

The metabolism of the animal is always in a state of dynamic equilibrium in which the influx of nutrients is balanced by the production of energy (catabolism) and tissue growth (anabolism). Partitioning of key metabolites between these biochemical processes and the control of this partitioning determines the overall direction of the integrated metabolism of the animal[68 94]. These processes may be controlled in the short-term, i.e. homeostatically, and will function continuously throughout the life of the animal to preserve vital functions[33].

*Department of Physiology, Faculty of Veterinary Science, University of Pretoria, 0110 Onderstepoort, Republic of South Africa
**Animal Nutrition, Animal and Dairy Science Research Institute, Irene.

Despite this, the animal must be capable of responding metabolically to changes in physiological and nutritional state. Controls that allow for chronic redirection of nutrient partitioning in support of these long-term changes, are classified as homeorhetic mechanisms and may operate by modifying the sensitivity of homeostatic controls[17 18]. By increasing the intake of concentrate in the diet, these controls may be extended beyond their design limits, thereby leading to the pathological syndromes associated with intensive production.

The fate of the major precursors of protein and energy metabolism that are absorbed from the digestive tract, will be reviewed in this article, while the hormones, both homeostatic and homeorhetic, that control the partitioning of these metabolites will be reviewed in the following article.

### SOURCE OF EXOGENOUS PRECURSORS

About 75% of volatile fatty acids (VFA) produced in the rumen are absorbed by free diffusion from the rumen, 20% from the omasum and abomasum and the rest from the small intestine[102]. The order of absorption is butyric > propionic > acetic and is depressed by raising the pH of the rumen[41]. However, at the same pH, the absorption of VFA is considerably enhanced by feeding a high concentrate diet instead of roughage[29]. Butyrate is extensively metabolised in the ruminal epithelium, and, about half of the amount taken up appears in portal blood as 3-hydroxybutyrate, thereby sparing the liver from a considerable toxic load[7]. Although some propionate is metabolised during transport through the epithelium, only about 5% of that absorbed, appears as lactate in the portal blood[98]. Ammonia equilibrates rapidly across the ruminal epithelium above pH 6.5 (rate of transfer proportional to concentration gradient), while the net uptake is depressed by a low pH[29] (negligible transfer below pH 5). Lactic acid may also be absorbed from the rumen[50], as may certain amino acis[62 65 66] (e.g. leucine, isoleucine, and lysine).

Hydrochloric acid added to the digesta in the abomasum by the epithelium results in a low pH (pH = 2.3), which is responsible for the death of most of the bacteria and protozoa, and for the initiation of peptic digestion of proteins in this region[71]. Digesta then passes, at a rate determined by fibre content, frequency and level of feeding[85], through the pyloric sphincter into the proximal duodenum, where bile plus pancreatic secretions are added[45]. In contrast to monogastric mammals, the pH of the digesta in the small intestine changes gradually, rising to about pH 4 at the level of the common bile duct (due to a very low concentration of bicarbonate in ruminant pancreatic secretion) and reaching neutrality only in the lower jejunum[44]. These conditions favour the continued action of pepsin, but would retard the action of the pancreatic proteolytic enzymes. Pancreatic amylase and lipase have near neutral pH optima, and thus would operate most efficiently in the lower jejunum[44]. The amount of pancreatic amylase secreted is proportional to the amount of grain in the feed[88], although a high concentration of glucose in the blood suppresses this secretion[43].

While little carbohydrate may bypass the rumen in roughage-fed ruminants, considerable amounts may pass into the duodenum of animals fed diets containing a high proportion of grain[93 103]. Enzymes that hydrolyse disaccharides are present in the epithelium of the small intestine[56], and are most active in the proximal jejunum[97]. Up to 100 g $d^{-1}$ of alpha-linked polysaccharides may pass into the duodenum of sheep fed a ground maize-based diet, and up to 90% of that carbohydrate may be absorbed. While no data are available for cattle, this amount of glucose may represent up to 60% of the whole-body flux of glucose in the

sheep[78]. Cattle fed a feedlot-type diet, which contains a large amount of readily-fermentable carbohydrate, may, therefore, have such large quantities of starch reaching the small intestine, that the process of digestion becomes saturated[91 92]. The excess undigested carbohydrate may then pass on to the large intestine, where it is subjected to microbial fermentation, is not available to the animal as such, and may, in excess, create conditions suitable for the development of diarrhoea[36]. Glucose which is absorbed, is taken up along the entire length of the small intestine, with maximum activity at the proximal end[56 97]. About 20% of glucose may be metabolised by the gut wall during transport, while the remainder appears in mesenteric blood.

Aside from the first few days of life, when globulins are absorbed intact from the small intestine[89], proteins are hydrolysed to peptides and amino acids before being transported across the wall of the entire small intestine[75 76]. Isoleucine, arginine, valine and methionine appear to be more rapidly absorbed than other amino acids[2]. Recent evidence suggests that short peptides are more rapidly absorbed than individual amino acids, and that final hydrolysis occurs during transport through the gut wall[19 54]. Nothing is known about the metabolic fate of amino acids en route across the gut wall, other than that enzymes which hydrolyse dipeptides are present in the epithelium of the small intestine[74]. The activity of these dipeptidases rises progressively from the duodenum to the mid-ileum, and are all affected by stage of growth of the ruminant and diet composition[74].

Lipids comprise only 6-8% of the dry matter of leaf tissue[47]. Therefore a dairy cow ingesting 15 kg forage will take in about 1 kg lipid. Lipids are hydrolysed in the rumen to free fatty acids[39], largely by means of plant lipase activity[73]. Unsaturated fatty acids are then biohydrogenated[46 107], and adsorbed onto the surface of small particles (80%), or taken up by bacteria and protozoa[28]. Fatty acids are also synthesised de novo from acetate and, to a lesser extent, glucose by both bacteria[77] and protozoa[67]. Despite wide compositional changes in diet and the resultant ruminal lipid composition, the distribution of the major lipid classes in the digesta from the duodenum remains constant, comprising largely free fatty acids and some phospholipids[79]. However, the amount of lipid is proportional to the amount of concentrate in the diet[79] (at high levels of concentrate intake, up to 100% more lipid may flow out of the reticulorumen than entered with the feed).

Pancreatic lipase in ruminants has a lower acitivity than corresponding lipases in monogastric mammals[60]. Following hydrolysis of triglycerides in the small intestine, the fatty acids are absorbed largely in the middle region of the jejunum and appear in the lymphatic system as chylomicrons and very low density lipoproteins (VLDL)[67]. Lipid concentration in the lymph reaches a maximum about 6 h after feeding[40].

## BLOOD FLOW THROUGH THE SPLANCHNIC BED

Eating stimulates blood flow to the splanchnic bed, which may contain up to 50% of the total amount of blood in the animal's body[37], via increases in the concentration of luminal butyric acid and carbon dioxide. The increased rate of fermentation associated with concentrate feeding would, therefore, lead to large increases in splanchnic blood flow[23 52]. The liver is, as a consequence, perfused by a large blood flow[42 87] (about 20-25% of cardiac output), of which the portal system contributes the most[15 20] (85-95%). Maximum increase in portal blood flow (about 20%) occurs approximately 2 h after feeding[14]. Of the various components of portal flow, only the flows from the reticulorumen, omasum, abomasum and duodenum contribute, in decreasing order, to this increase[14] (mostly in the vessels of the epithelial and subepithelial layers). The increased blood flow to the reticulorumen during the period of maximal fermentation in the rumen will assist in the uptake and transport of the VFA and ammonia to the liver.

## METABOLITE PARTITIONING

Since this review concerns chiefly the metabolism of energy-producing substrates, only those aspects of protein metabolism will be discussed.

**Glucose:** When expressed in terms of metabolic body weight, the entry rate of glucose[37 48] in ruminants (1,1-2,3 mmol $h^{-1}$ per $kg^{0.75}$) is not different to that of other mammals[69] (from 1,8-2,2 mmol $h^{-1}$ per $kg^{0.75}$). Glucose entry rate is proportional to the digestible energy intake of the ruminant[108], and may also be estimated from the arterial plasma concentration[55] (within a particular physiological state).

Glucose makes a small contribution to carbon dioxide production[4] (4% or 11% in fed or fasted adult ruminants respectively). Only a third of glucose produced is totally oxidised, other metabolites such as FFA providing the major contribution to energy metabolism[4]. Only the brain, central nervous system and testes have an absolute requirement for glucose[64]. While erythrocytes have adapted to a low glucose metabolism[100] (3% of glucose supply), the digestive tract uses large amounts of glucose[83] (20% of the whole-body entry rate), much of which may be recycled as lactate[11]. The glucose requirement of the gut does not appear to be affected by nutrient limitation, suggesting that these tissues have a specific glucose requirement[22].

Very little glucose is normally taken up by the ruminant liver, due to low concentrations of glucokinase[13]. On the other hand, glycogen from the liver may be mobilised to supply glucose on a short-term basis[32], thereby providing an important reserve of glucose during fasting, exercise or stress[31 55] (enough glucose for 1 day).

Glycogen stores in the muscle are quantitatively more important than those in the liver, and provide a direct supply of glucose for metabolism by muscle tissue.

About 85% of gluconeogenesis takes place in the liver, the rest in the kidneys[24]. The total amount of all glucose precursors available to the normally-fed animal is far greater than that needed for glucose production. However, all contribute partially to gluconeogenesis while the individual contribution of the different precursors depends upon such factors as availability and physiological state[99] (Table 1). The major precursors of glucose are propionate[21], certain amino acids[104 105], lactate[23] and glycerol[26], all of which are extracted by the liver in net amounts[3].

**Propionate:** This is quantitatively the most important precursor of glucose in the ruminant, and is converted to glucose via oxaloacetate[27] (see Fig. 1). The amount of glucose derived from propionate varies considerably[25] (27-59%). Sufficient propionate may reach the liver normally to meet the total glucose requirement of the ruminant. However, only about 50% (increased slightly during pregnancy) is converted to glucose, while the rest is utilised in oxidative or synthetic reactions[27].

**Amino acids:** Amino acids are the primary nitrogen products absorbed from the small intestine, which appear in the portal blood in significant amounts, and are then transported to the liver[106]. Although considerable research has been done on the digestion and disappearance of amino acids from the small intestine, little is known about the actual amounts entering the portal blood. While few data are available for cattle, the pattern should be similar to that found in fed sheep, where these amino acids appear to be absorbed in net amounts into the blood from the gut[51 106], with the exception of glutamine and glutamate which are used by the gut as energy sources[49]. Most of the amino acids appearing in the portal circulation, especially the glucogenic precursors, are removed by the liver[106], where they enter the gluconeogenic pathway either via the tricarboxylic acid (TCA) cycle, oxaloacetate or pyruvate[1] (Fig. 1). Approximately 15-25% of glucose[63] may be derived in this way from amino acids such as glycine, alanine and glutamine[90].

It seems that the quantity of amino

Table 1: **In vivo estimates of contribution to total hepatic gluconeogenesis of different substrates in cows and ewes under various physiological states, as well as the total rate of gluconeogenesis**

| Animals and their Condition | Total | Hepatic glucose production (mmol/h) From: P* | A* | G* | L* |
|---|---|---|---|---|---|
| Cow 400-500 kg non-lactating, fed | 276 | 120 | 84 | - | 72 |
| lactating 10kg.$d^{-1}$, fed | 264 | 96 | 66 | - | 102 |
| lactating 15kg.$d^{-1}$, fed | 462 | 300 | 54 | - | 108 |
| lactating, fasted 6d | 96 | 0 | 30 | 9 | 54 |

*P = propionate, A = amino-acids, G = glycerol, L = lactate



0038-2809 Tydskr. S. Afr. vet. Ver. (1989)60(4):223-227

acids being converted to glucose may remain relatively constant, thereby linking the percentage contribution to the rate of glucose synthesis[38].

Although certain tissues may have a high requirement for amino acids (inter alia, the gut epithelium, liver, muscle, kidneys, mammary gland and developing foetus), most of these are not capable of disposing of ammonia[86]. While the carbon skeletons of these amino acids may be directly metabolised by the tissues, the amine group is transferred to other amino acids and is carrier systems[24 49] (glutamate/glutamine, aspartate/asparagine or alanine) where the reverse reaction takes place, entering the amine group into the urea cycle[49]. This sequence of reactions thus plays an important role in balancing the nitrogen metabolism of the tissues.

Kidneys are important sites of amino acid metabolism, taking up amino acids, using the nitrogen for acid neutralisation and the carbon skeletons for gluconeogenesis. Thus glucose production by the kidneys is chiefly a by-product of pH control[31].

Ammonia may either be absorbed from the rumen into the portal blood and then be transported to the liver, or may be formed within the liver from the deamination of amino acids[29]. Ammonia is converted into urea via the Krebs-Henseleit cycle[35] (ureagenesis). The activity of enzymes involved in ureagenesis, may vary with physiological state and protein intake, but not necessarily with free ammonia concentrations in the rumen[34]. Thus, when a critical level of ammonia concentration in the rumen is exceeded, and the amount of ammonia reaching the liver, saturates the urea cycle enzymes, ammonia poisoning may occur.

**Lactate:** This acid is derived from glucose breakdown[5] (endogenous or recycled), from ruminal fermentation and from propionate that is converted to lactate in the rumen wall[98]. Nearly all the lactate in portal blood is taken up by the liver, of which 85% is converted to glucose via pyruvate[101] (Fig 1). In the fed non-pregnant, non-lactating ruminant, only about 8% of the whole body lactate turnover is derived from exogenous sources, while the remainder comes from the anaerobic metabolism of glucose in the peripheral tissues[63]. During starvation, approximately 15% of glucose may be derived from lactate[83] (this includes endogenous lactate), while this may increase further to 45% during lactation[10].

**Glycerol:** Glycerol may enter the gluconeogenic pathway via triose phosphate (Fig 1). The contribution of glycerol to glucose depends upon the fat mobilisation rate, and is about 5% in fed sheep, rising to 23% in starved sheep[26]. Most of the body pool of glycerol is endogenous, being derived from the conversion of glucose to glycerol-3-phosphate (for FFA esterification). For these reasons, glycerol will probably not play an important role in the metabolism of cattle receiving an adequate energy intake[26].

**Acetate:** Acetate in portal blood is not significantly taken up by the liver[27 61 82] (20% of the whole-body entry rate), and is excluded from hepatic lipogenesis due to the high activity of hydrolase enzymes[58]. However, the liver produces net amounts of acetate, mainly from FFA oxidation[27 82]. As a result, the endogenous fraction of circulating acetate (about 25%) may increase with fasting[6 80]. Acetate derived from ruminal fermentation may provide up to 75% of the total entry rate, which remains constant (6,3-9,1 mmol.h$^{-1}$ per kg$^{0.75}$) over a large range of energy intakes[81] (7-14 MJ/day). The combined uptake of acetate by muscle, gut and liver appears to account for about 96% of the entry rate[81]. Oxidation of acetate accounts for about 30% of total carbon dioxide production in ruminants[4 82].

**Fatty Acids:** Fatty acids that are taken up by the liver may be involved in a number of reactions, inter alia incorporation into triglycerides and lipoproteins, as well as oxidation and ketone body formation[59]. The liver has a low capacity for FFA storage as triglycerides, rather exporting the FFA in the form of VLDL[60]. About half of the FFA entering the metabolic pool may be oxidised directly to carbon dioxide, contributing 34-58% of the respiratory carbon dioxide in fed and fasted ruminants respectively[12 57].

In adipose tissue, however, glucose and acetate are the major precursors of the de novo synthesis of glycerol-3-phosphate and FFA respectively[95]. FFA are continually recycled intracellularly via a futile cycle in which triglycerides are formed and lysed[96]. Only about 30 to 40% of the fatty acids incorporated into triglycerides result from de novo synthesis[30]. Although such a cycle costs energy, it ensures an immediate and sensitive response to any sudden energy demand. The contribution of glucose to fatty acid synthesis is minimal in ruminants, due to a lack of citrate lyase[16]. The synthesis of fatty acids from acetate, however, still requires large amounts of NADPH which are derived from the oxidation of glucose, i.e. pentose phosphate pathway[16]. FFA synthesis also requires considerable quantities of ATP (23 mol per mol palmitate), which, in ruminants, may result from the metabolism of both glucose and acetate. In steers, acetate oxidation supplies four fifths of the ATP required for FFA synthesis[16].

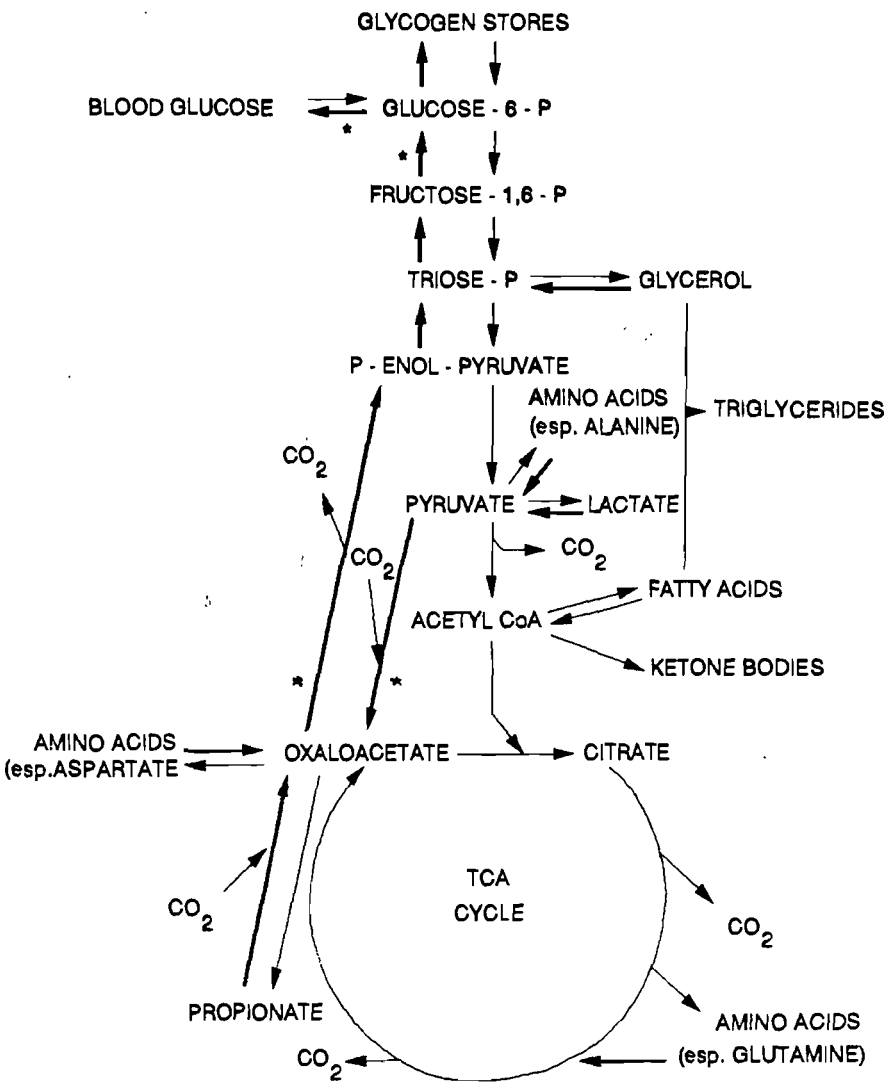


Fig. 1: **Major metabolic pathways in the ruminant liver (and kidney cortex). Pathways for gluconeogenesis are indicated with heavy arrows, while the asterisks denote the 4 irreversible reactions of gluconeogenesis**

**Ketone Bodies:** These are produced in the liver from FFA[70], butyrate[9] and acetate[80], and comprise chiefly 3-hydroxybutyrate and acetoacetate in a 10:1 ratio[4 8 57]. Considerable amounts of 3-hydroxybutyrate may also be produced in the ruminal epithelium from butyrate[72], the major precursor, accounting for 80% of total ketogenesis in fed ruminants[11]. A net uptake of acetoacetate by, and a net production of 3-hydroxybutyrate from the liver occurs in fed ruminants, resulting in an overall net production of total ketone bodies[84] (about 60 $\mu$mol Carbon.h$^{-1}$ per g liver). This rate may be increased about 3-fold during peak lactation or by fasting the animal[11]. Ketone bodies are readily used as a source of energy by muscle, their uptake more than doubling after 6 d fasting (from 16 to 36 $\mu$mol/min per leg), during which time they may account for more than 40% of the carbon dioxide output[53].

The control of these processes will be described in a following article.

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# SILVER MEDAL OF THE SAVA : 1989
# SILWER MEDALJE VAN DIE SAVV : 1989

THEUNIS WILLEM NAUDE

The Silver Medal of the South African Veterinary Association is awarded annually upon nomination to any veterinarian registered with the South African Veterinary Council in acknowledgement of outstanding service to and advancement of the veterinary profession or calling in South Africa. The 1989-medal is awarded to Professor Theuns Naude for his dedicated service to the profession over many years in the fields of pharmacology and toxicology. He gave his services unconditionally and unselfishly, as a human being, as a friend and colleague and as a scientist. In particular, his contribution lies not only in his untiring service to, as well as through, the Association, but also in his activities as lecturer and as a member of the Medicines Control Council and the Veterinary Committee of the Council. Above all, Professor Naude is renowned for his unstinting efforts at public relations and the promotion of the veterinary profession through continued contact and improved liaison with many other institutions and related professions.

Theunis Willem Naude was born in Pretoria on 28 October 1932 where he matriculated from the Afrikaanse Hoër Seunskool in 1949. After enrolling at the University of Pretoria, he obtained the BVSc-degree in 1954 and, after seconded full-time study at the same University, a MSc (Agric) in Biochemistry *cum laude* in 1966.

Upon qualifying in 1954, Theuns Naude joined the then Division of Veterinary Services and served as state veterinarian in Vryheid, Pretoria and Louis Trichardt from 1955 to 1961. He was transferred, at his own request, to the Section of Toxicology of the Veterinary Research Institute at Onderstepoort in 1961 where he remained until 1976.

During this time he was seconded for full-time study to the University of Pretoria and was promoted to the post of Assistant Director in 1968. During 1976 he was promoted to Deputy Director of the Veterinary Research Institute in which capacity he served until his resignation from the Institute in 1984 to join the University of Pretoria in the Faculty of Veterinary Science.

His interest in tertiary education emerged in the early stages of his career. During 1969 and 1970 he was a visiting Associate Professor in Toxicology at the Veterinary School of Illinois where he was instrumental in the establishment of a diagnostic toxicology laboratory. In addition, he also served as part-time lecturer in Pharmacology and Toxicology in the Veterinary Faculty at the University of Pretoria from 1966 to 1969 and again from 1978 to 1980. It was therefore, no surprise to see Theuns Naude take up the Coopers Animal Health chair in Pharmacology and Toxicology at the Faculty of Veterinary Science, University of Pretoria in 1984 nor that he became Professor and Head of the Department in 1986, a post he still holds today.

As teacher and lecturer, Professor Naude is liked by both his students and his colleagues. His knowledge of toxicology, interest in and dedication to the subject, has earned him the respect of the entire profession. His willingness to share knowledge and experience with the public, students and colleagues alike, his attitude of encouraging young colleagues at every opportunity and his willingness to listen and to treat everyone equally and with friendship, remain a living tribute to a truly great friend and colleague.

During his professional career, Theuns Naude joined several scientific associations, notably the SA Biological Society of which he was a council member from 1975 to 1980 and President in 1977, the International Association of Forensic Toxicologists and the American College of Veterinary and Comparative Toxicology. He is well-known for his contributions to our knowledge of cardiotoxic conditions in livestock and is responsible for the isolation and characterisation of the active principle of *Homeria pallida (H. glauca)*, one of the tulip species. He is the author and co-author of 38 scientific publications and is co-author of the internationally acclaimed handbook on Plant Poisonings and Mycotoxicoses of Livestock in southern Africa.

Throughout his professional career, Theuns Naude contributed selflessly to the service and furtherance of the veterinary profession. He joined the SAVA in 1955 and has been a council member since 1978. During this time he served on the Advisory Committee, Medicines Committee, Awards Committee of which he was chairman from 1982 to 1986 and the Constitutional Committee. From 1984 to 1986 he served as Vice-President and from 1986 to 1988 as President of the SAVA.

During his term of office, Theuns Naude led the SAVA onto the road of negotiation and liaison. He strongly supported and furthered the multidisciplinary approach and promoted the contact and good liaison currently existing between the veterinary profession and the animal scientists, Pharmaceutical Society, Medical and Dental Association and animal welfare organisations. In addition, he has retained excellent contact with the branches and groups of the Association either as a member or as a participant in their activities. He is also responsible for instating the presentation of citations to senior colleagues.

Notwithstanding the above, Professor Naude also played a major role in the establishment of internationally recognised standards for the registration of veterinary medicines in South Africa. He was the first coordinating technical advisor appointed for the registration of stock remedies under Act 36 of 1947 and served in this capacity from 1972 to 1978. In 1974 he became a member of the Scheduling Committee of the Medicines Control Council (MCC) under Act 101 of 1965 and has been a member of the MCC since 1976. With the establishment of a Veterinary Committee of the MCC in 1983, he was a natural choice for appointment as chairman of this committee.

Last but not least, Theuns Naude has also contributed to the veterinary aspects of aquaculture in South Africa. During 1976 he undertook a study tour of Great Britain, Switzerland, West Germany, Belgium and the USA in connection with veterinary medicines and fish diseases and attended a symposium on aquaculture in 1982 in Israel. During his term of office as Deputy Director at the VRI he was, as a result of these professional interests, instrumental in establishing research in this fast-growing discipline.

Many of the major contributions of Theunis Willem Naude to the Profession he dearly loves, have gone unnoticed due to his integrity, dedication and humility. It is therefore an honour and a privilege to award the 1989 Silver Medal to Professor TW Naude as a small token of our esteem and appreciation.



0038-2809 Tydskr. S. Afr. vet. Ver. (1989)60(4):228-229

# CLINICAL AWARD OF THE SAVA : 1989
# KLINIESE TOEKENNING VAN DIE SAVV : 1989

JAN MARNEWICK

The Clinical Award of the Association is granted annually upon nomination to any veterinarian who is a member of the SAVA and is registered with the SA Veterinary Council and who has excelled in applied veterinary practice. The 1989-award is made to Jan Marnewick for the way in which he has achieved excellence in applied large animal practice. He has been involved in general practice for many years, having made contributions to the dairy industry and more recently to the feedlot industry. He is well-known for his untiring efforts in promoting feedlotting and as a practising consultant has excelled in the feedlot industry, but also in the veterinary profession through continuing and informal education.

Jan Marnewick was born in Bethal on 13 July 1938. He matriculated from the Hoogenhout Hoërskool in Bethal in 1955 and qualified from the University of Pretoria as a veterinarian in 1961. During this time his clinical aptitude had already become evident and he was awarded the Clinical Medal of the Wits branch as well as the Milborrow Prize in Pharmacology and Genesiology.

The first 3 years of his professional career were spent with the Germiston City Council during which time he was involved in milk hygiene. He then joined a private practice in Germiston, continuing to provide part-time services to the City Council. Jan became progressively more involved in dairy farming and spent the next 10 years as a private practitioner in and consultant to approximately 50 dairy herds.

With the advent of the feedlot industry in the early seventies in South Africa, Jan Marnewick gradually channelled his interests in that direction. He undertook no less than 4 study tours to the USA to increase his knowledge in this field and is currently a member of the American Cattle Practitioners Group as well as the American Academy of Consultants. He has also indulged in local studies and obtained a Dip Med Vet (Med) in 1969 and MMed Vet (Med) in 1983, both from the University of Pretoria. Jan is currently registered for a DVSc-degree at the Medical University of Southern Africa, his field of study being aimed at the pathophysiology of intensive feeding in ruminants.

As a practising consultant, Jan Marnewick is today responsible for the overall planning of optimal production in approximately 25 feedlots with a turnover of close on 750 000-800 000 animals per annum. He is involved in the strategic planning of nutrition, handling, disease control and marketing of these feedlots but makes extensive use of local veterinarians to render daily routine veterinary services.

A noteworthy aspect of the excellence achieved in this practice, lies in the willingness of Jan Marnewick to share his knowledge and experience with his clients, colleagues and the industry he serves. He is involved in educational courses for feedlot personnel; he has been requested by the pharmaceutical industry to train their personnel; he assists Vleissentraal with the training of their personnel. He is also involved in formal education as an external examiner to the Faculty of Veterinary Science of the University of Pretoria and is the author of 7 publications.

Jan Marnewick has excelled as a private practitioner and as a consultant. He has promoted the role and image of the veterinarian in large animal practice and in cost-effective livestock production. He has opened the way for the veterinary profession in the future and it is therefore our honour and privilege to bestow on him the 1989 - Clinical Award of the SAVA.

# EQUINE LAMENESS

GERAINT WYN-JONES

1st Edn. Blackwell Scientific Publications, Oxford, London, Edinburgh, Boston, Palo Alto, Melbourne, 1988, pp 302, illustrations 135, Price not stated (ISBN 0-630-01543-8)

The author says in the preface to this book that it is not intended for the experienced orthopaedic specialist, but rather caters for the undergraduate student and those who require a broad base of general knowledge on the subject. Techniques which are the province of the specialist clinician are attended to, though they are not fully described. However, enough information and detail have been provided in the text to enable the clinician to explain and discuss these cases with owners and to present them with those facts necessary to make decisions on the animals' future.

The first chapter deals with the diagnosis of the causes of lameness in 21 pages and is very well illustrated, comprehensive and methodical. It includes a discussion of the case history or anamnesis, the physical examination, detection of lameness, ancillary aids to the detection of lameness and the diagnostic nerve blocks. The second chapter on radiography, is very brief owing to the fact that techniques for examination of individual areas are mentioned in association with the specific disease conditions. Good quality prints of radiographs are provided to illustrate these conditions. Conditions of the hoof, horn and sole are discussed in Chapter 3 while Chapter 4 describes problems associated with the other structures of the foot up to and including the third metacarpal and metatarsal bones. Chapters 5 and 6 deal with conditions of the upper forelimb and upper hindlimb respectively, while deformities of the appendicular skeleton and tendon injuries are discussed in the following 2 chapters. In a separate chapter on fracture fixation techniques, both internal fixation and external coaptation with all their practical implications are described for the more specific fracture types and fracture sites in the horse. In the tenth and final chapter the author discusses the problem of degenerative joint disease and septic arthritis and osteomyelitis in foals. Relevant anatomy, aetiopathogenesis, clinical aspects, diagnosis, radiography, treatment and prognosis of individual conditions are all dealt with systematically. References, are not numbered but "suggested further reading" lists are incorporated in the text after each individual section. Although it is the authors' intention that this book be a compilation of the latest thinking on the various aspects of limb lameness in horses, more specific discussion of the role of the axial skeleton and associated soft tissues, in the differential diagnosis of gait abnormalities could have been included in the text especially for the under-graduate student.

In spite of printing errors e.g. as in Fig. 1.1, the book has a durable and good general appearance with regard to paper quality, type, size and clarity of illustrations.

This book can confidently be recommended to under-graduate veterinary students as well as to veterinary practitioners, as it should enable a non-specialist to cope with equine limb lamenesses competently, informing them what can and cannot be done to treat the condition.

M.J. Potgieter

# NUCLEAR TECHNIQUES IN THE STUDY AND CONTROL OF PARASITIC DISEASES OF LIVESTOCK

Proceedings of the final research co-ordination meeting Vienna, 11-14 May 1987, organised by the joint FAO/IAEA Division of Isotope and Radiation Applications of Atomic Energy for Food and Agricultural Development.
International Atomic Energy Agency, Vienna, 1988 pp 208, some illustrations. (ISBN 92-0-111288-2)

The title is a little misleading, as it creates the expectation of a textbook which could be used as a reference work by someone wanting to study in this field. Only when one reads the subtitle, does it become evident that this could be a collection of papers read at a scientific meeting, which it is. These 15 papers present the results of 5 years of research done under the auspices of the Joint FAO/IAEA Division of Isotope and Radiation Applications of Atomic Energy for Food and Agricultural Development.

The papers describe experiments on:

a) the use of ionising radiation in the development of vaccines against *Fasciola gigantica, Schistosoma bovis, Echinococcus granulosus,* trichostrongylid sheep nematodes, *Dictyocaulus filaria, Babesia bovis, Babesia bigemina,* and *Anaplasma marginale,*
b) radioactive antibody tests for *Echinococcus granulosus, Obeliscoides cuniculi, Babesia bovis,* and *Babesia bigemina,* and
c) helminth pathophysiology, using radiolabelling.

Heartwater (strictly speaking not a parasitic disease, but in some parts of Africa as important, if not more so, than anaplasmosis) and coccidiosis did not receive attention in this research programme.

Several experiments not using, related to or referring to nuclear technology, such as intestinal helminth surveys, helminth pathophysiology, trypanosomiasis and East Coast Fever immunisation, and effect of nutrition on immunity to helminths, are also described.

In a book under this title, one would have expected the nuclear techniques to have been classified by type and purpose, for instance irradiation (eg. for attenuation of pathogens), radio-isotape labelling (for immunodiagnostics or illucidation of life-history or pathophysiology), etc. Then, each technique could have been evaulated in terms of its accuracy, reliability, ease of use, etc., compared to conventional methods, and some justification given as to its desirability.

The IAEA would have done better, had they published this work as a series of articles in a journal in the field of veterinary parasitology.

J. Schröder

# DISEASES OF DOMESTIC RABBITS

LIEVE OKERMAN

Translated by Richard Sundahl. Published by Blackwell Scientific Publications Ltd, London. Pages 120. Colour plates 28. Price not given.

The interest in rabbits in this country has a history of ups and downs. Some years ago there was great enthusiasm for rabbit meat production. Now the emphasis is on Angora wool production. For the veterinarian confronted with rabbit disease this publication can be of great value. The author has many years' experience in this field and she originally wrote this publication in Dutch.

The information given in the first part deals with anatomical peculiarities, brief remarks on physiology, animal behaviour, feeding, housing and breeding. This is relevant information especially where the rabbit as a production animal is not included in veterinary courses.

Part 2 very briefly describes the clinical examination of a rabbit. The description of the post-mortem examination gives interesting facts on normal findings e.g. calcification of large veins occasionally seen in old rabbits. Diseases of the different organ systems are then discussed starting with diseases of the skin. As diseases of the respiratory system are so important in rabbit farming, the chapter on respiratory diseases is of importance. The description of pasteurellosis is very informative. Symptoms and lesions are demonstrated with 28 excellent colour plates.

The chapter on breeding problems deals with common conditions, resulting losses among neonates, artificial feeding and fertility problems.

The section describing administration of medicine and the different antibiotics that may or may not be used is important. Many rabbits are killed by antibiotic treatment because veterinarians do not realise the dangers of penicillins and certain macrolide antibiotics to rabbits. Failure in treatment is often due to a too low dose e.g. potentiated sulphonamides must be given at twice the dose used for larger domestic species. These aspects are fully covered in the chapter dealing with medication.

From time to time the need for anaesthesia and hypnosis arises. The chapter dealing with these aspects describes clearly the many problems experienced with anaesthesia in rabbits.

A short appendix on the inside of the back cover lists the most frequent problems experienced with different types of rabbit e.g. pet rabbits, show rabbits and rabbits bred for industry.

This book can be recommended to practitioners confronted with sick rabbits as well as those colleagues who work with laboratory rabbits.

A IMMELMAN



0038-2809 Tydskr. S. Afr. vet. Ver. (1989)60(4):230-23

# JOURNAL OF THE SOUTH AFRICAN VETERINARY ASSOCIATION

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