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SOME NUTRITIONAL ASPECTS OF HAEMONCHOSIS IN EXPERIMENTALLY INFESTED LAMBS

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OPSOMMING: ENKELE VOEDINGSASPEKTE VAN HEMONCHOSE IN EKSPERIMENTEEL BESMETTE LAMMERS

Proewe is uitgevoer om die invloed van eksperimentele hemonchose op die droë materiaalinname, massatoename, droë materiaalverteerbaarheid en stikstofretensie by skape te bestudeer. Ses en 9 maand oud lammers is met 'n suiwer stam van besmetlike larwes van *Haemochus contortus* (3de stadium) onder gekontroleerde toestande besmet. Besmette skape het 'n betekenisvolle afname in stikstofretensie en droë materiaalverteerbaarheid getoon ($P < 0,01$). Hierdie veranderings was hoofsaaklik tot die 2de week en die latere gedeeltes van die 6-week proefperiode beperk. Verminderde liggaamsmassatoename by besmette lammers was minder opvallend; moontlik verberg deur oortollige vloeistofretensie. Droë materiaalinname was nie merkbaar beïnvloed nie. Hierdie nadelige gevolge van hemonchose staan direk in verband met die graad van besmetting.

SUMMARY

Trials were conducted to study the effect of experimental haemonchosis on dry matter intake, live mass gain, dry matter digestibility and nitrogen retention in sheep. Six and 9 month old lambs were infested with a pure strain of infective larvae of *Haemonchus contortus* (3rd stage) under controlled conditions. Infestation resulted in significant decreases in nitrogen retention and dry matter digestibility ($P < 0,01$). These changes were mainly confined to the 2nd week and the latter stages of the 6 week experimental period. Decreased body mass gains by the infested lambs were less prominent; possibly being obscured by excessive fluid retention. Dry matter intake was not markedly influenced. These deleterious effects of haemonchosis are directly related to the severity of infestation.

Internal parasites are responsible for considerable economic losses to the sheep industry in South Africa and elsewhere. Apart from the mortality resulting directly from infestation, even greater losses probably stem from a lowered productivity due to reduced feed utilization. This latter aspect has been demonstrated with intestinal parasites both as pure (Horak & Clark, 1964) and as mixed infestations (Shumard, Bolin & Eveleth, 1957). In general, however, this feature of verminosis appears to have received little attention. In the case of haemonchosis, the principal nutritional aberration has been described as anorexia in both pure (Evans, Blunt & Southcott, 1963) and mixed infestations where *Haemonchus contortus* was prominent (Clark, Ortlepp, Bosman, Laurence, Groenewald & Quin, 1951; Shumard *et al.* 1957). Further observations on nutritional aspects of a pure infestation of *H. contortus* in lambs form the basis of this report.

Two separate trials were conducted using South African Mutton Merino lambs reared and housed under worm-free conditions.

Procedure

Trial 1

Four 9 months old lambs were each infested with 50 000 third stage larvae of *H. contortus* (Owen, 1968), while 4 uninfested lambs acted as controls. All sheep were housed individually and fed milled lucerne hay. The housing was so arranged that the feeding of each infested animal could be paired with that of a control. Each morning an infested animal received more feed than it would consume that day. The next morning the amount eaten (air dry) was offered to the respective control animal. Feed samples, feed refusals and faeces were collected for each alternate week following infestation. Weekly live masses were recorded for the duration of the 6 week trial period, and all sheep were finally autopsied for total worm counts as described by Reinecke, Horak & Snijders (1963).

Trial 2

In this instance 6 four months old lambs were used. Three were infested with larvae of *H. contortus* as before and three were left uninfested as controls. All the sheep were housed in metabolism cages and fed milled lucerne hay (16% crude protein) *ad libitum*. Dry matter intake and live mass gains were recorded on a weekly basis. The daily feed ration was weighed out for each sheep prior to commencement of the experiment. At this time random feed samples were taken for subsequent analysis and computation of nitrogen intake. Feed refusals, faeces and urine samples were collected and pooled for each week. These were subsequently analysed for nitrogen content. Dry matter digestibilities and nitrogen balances were calculated for each week of the experiment in the standard way. The nitrogen content of the samples was determined by the Kjeldhal method. At the end of the experiment, total

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worm counts were performed as before.

Results

Trial 1

Two lambs developed mild infestations, while the remaining 2 were more severely affected. The worm burdens established at the end of the trial period together with the effect of mild and severe infestation on mean dry matter intake and live mass gain per week are presented in Table 1.

All sheep showed some variation in apparent dry matter digestibility during the course of the experiment. Hence, the experimental error was determined on the control sheep after removing "between sheep" and "between week" variation. The decrease in apparent dry matter digestibility of hay by an infested sheep was then compared with the mean decrease for the controls during the same period by t-test. Sheep 1 showed a significant decrease during the second and third week after infestation.

The mean increase in dry matter consumption per week did not differ significantly between infested and

Table 1

Severity of infestation and effect on dry matter intake and live mass gain (Trial 1)

Experimental group	Adult *H. contortus* at autopsy (mean)	Parameter* (mean)	Number of weeks after infestation					
			1	2	3	4	5	6
Control	Nil	DM	as for respective pair mate**					
		L.M.G.	1,5	0,5	1,0	1,3	2,0	1,0
Mild	635	DM	9,28	9,38	10,02	10,09	10,95	–
		L.M.G.	1,5	1,0	1,4	1,3	0,9	1,6
Severe	7 208	DM	11,98	12,24	12,83	13,04	12,46	12,71
		L.M.G.	1,7	–1,0	1,2	1,5	2,6	–0,3

*DM : denotes dry matter consumption (Kg/week).
L.M.G. : denotes live mass gain (Kg/week).
**Feeding paired in this experiment.

The results show that the severely infested sheep lost mass during the 2nd and 6th weeks of the experiment while the mildly infested sheep continued to gain mass throughout. The mean mass gain per week was significantly greater ($P < 0,05$) for the mildly infested animals. The mildly infested and control sheep did not differ in this regard. In both infested and control groups the dry matter intake increased progressively each week and did not differ significantly.

Facilities only permitted comparison of the mildly infested lambs and their respecitve controls with regard to apparent dry matter digestibilities. These were found to remain virtually constant at 60% and 58% for the infested and control sheep respectively. This difference was not statistically significant.

Table 2

Degree of infestation and apparant dry matter digestibilities of lucerne hay by experimental sheep

Sheep No.	Apparent dry matter digestibilities (%) No. of weeks after infestation						Adult *H. contortus* recovered at autopsy
	1	2	3	4	5	6	
Infested							
1	64	40***	49**	59	57	56	9 470
2	63	61	68	60	61	54	7 410
3	60	48	57	61	62	58	2 750
Control							
4	64	55	61	60	55	58	Nil
5	62	53	61	60	53	58	Nil
6	58	53	54	59	57	56	Nil

($P < 0,001$ ***; $P < 0,01$ **)

Trial 2

The severity of infestation again varied between individual animals. Two of the infested lambs developed severe haemonchosis, while the third was only mildly affected. The degree of infestation of the individual animals and the calculated apparent dry matter digestibilities are given in Table 2.

control sheep. However, the infested sheep did show a transient loss of appetite during the second week after infestation. The results obtained from nitrogen balance calculations are shown in Table 3.

Both groups of sheep showed a mean positive nitrogen retention over the experimental period (Infested:

Table 3

Nitrogen balances of experimental sheep (gN/week)

Sheep No.	Number of weeks after infestation					
	1	2	3	4	5	6
Infested						
1	56,5	−23,6***	37,8	8,6*	24,1	− 1,3**
2	75,9	38,1*	70,7	39,6	19,0**	23,8*
3	37,0	18,5	41,8	18,7	23,3	41,1
Control						
4	72,2	45,9	53,4	12,3	29,2	29,8
5	73,8	38,3	61,2	44,3	35,1	42,7
6	44,1	40,0	25,1	36,4	21,4	18,4

(P< 0,001***; P <0,01**: P <0,05*)

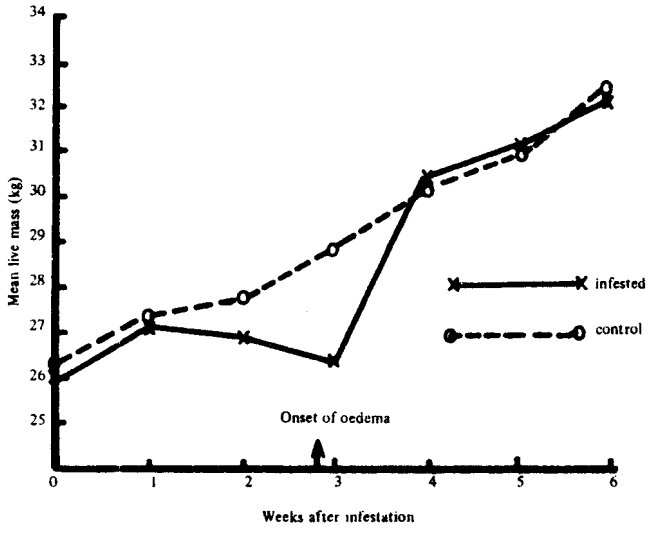

Fig. 1. *Live mass gains by infested and control sheep*

32,3 ± 18 gN/week; control: 40,2 ± 13 gN/week). Analysis of the results (see apparent dry matter digestibility) showed a significant decrease in nitrogen retention for both the severely infested sheep during the second week and again towards the end of the experiment. The most severely infested lamb (1) actually went into negative nitrogen balance during the second and sixth weeks.

The mean live mass gains of infested and control groups did not differ over the experimental period. However, the infested sheep lost live mass during the second week while the uninfested animals continued to gain in mass. Hereafter, during the third and fourth weeks, the infested sheep gained markedly in body mass. This trend is illustrated in Fig. 1.

The increase in live mass coincided with significantly increased plasma volumes in the 2 more severely infested sheep from the 20th day onwards. Sheep 2 developed a marked submandibular oedema at this time and passed abnormally large amounts of urine. These aspects of the pathogenesis of haemonchosis have been fully dealt with in previous publications (Owen, 1968; Owen, 1971).

Discussion

The significant features of these trials are decreased nitrogen retention and live mass loss. This is especially prominent during the second week after infestation. A further decrease in nitrogen retention occurs at about the sixth week of parasitism. These periods correspond to the fourth larval moult and the adult stage of the parasite's life cycle respectively (Veglia, 1915).

The apparent absence of a decrease in live mass in some severely affected sheep (Trial 2) may be ascribed to excessive fluid retention after about the third week when clinical oedema may appear. The parasitized animal appears to increase its extracellular fluid volume in compensation for the reduction in red cell volume as the anaemia progresses (Owen, 1968).

The initial decrease in nitrogen retention may be due to the onset of mucosal damage caused by the larvae (Charleston, 1965) resulting in impaired protein digestion. This period coincides with a systemic reaction as evidenced by the distinct eosinophilia (Owen, 1968). Little information is available on the effect of the parasite on abomasal function. Charleston (1965) failed to show any pH changes in the abomasum during the first 20 days of parasitism, while Chistrie, Brambell & Mapes (1967) demonstrated a marked increase in pH 72 to 76 hours after infestation. *H. contortus* infestation did not appear to affect Vitamin B_{12} absorption suggesting an unimpaired intrinsic factor mechanism (Owen, Neethling & Terblance 1971). Protein loss by exudation from the damaged mucosal lining has also been suggested (Charleston, 1965).

The decreased nitrogen retention during the latter stages of the experiments may reflect the extent of blood loss due to the adult parasite. Calculations based upon the estimated daily blood loss (Andrews, 1942; Clark, Kiesel & Goby, 1962) caused by the adult parasite show that a lamb

may lose as much as 20 g of protein per day. This would contribute considerably to a decreased nitrogen retention quite apart from any direct effect which the parasite may have on the digestive process.

The isolated decrease in dry matter digestibility cannot be explained by these experiments.

The anorexia described by Evans *et al.* (1963) for sheep infested with *H. contortus* was not a prominent result of these experiments. A transient decrease in feed intake was nevertheless observed about 2 weeks after infestation corresponding to the early decrease in both nitrogen retention and body mass.

These preliminary results require further investigation, especially with regard to the effect the parasite may have on protein digestion. One problem with such experiments is the difficulty in obtaining uniform levels of infestation for comparative purposes.

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