RESEARCH INTO BEHAVIOUR, NUTRITION AND HEALTH OF SHEEP DURING LIVE EXPORT

INTRODUCTION

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The export of live sheep from Australia to the Middle East has developed into a major industry over the past 10 to 15 years (Liqhtfoot and McDonald 1982), seven million sheep being exported in 1984 (Australian Meat and Livestock Corporation pers. comm.). Several reports on this industry have highlighted an urgent need for research into husbandry at sales and during road transport, assembly and shipping (Truscott and Wroth 1976; Australian Bureau of Animal Health 1981; Grandin 1983; Brennan 1984).

It is normal practice to use a feedlot to hold sheep while the consignment is being purchased and assembled prior to shipment. A major objective durinq assembly is to introduce the sheep to the pelleted rations used on board ship. Australian Bureau of Animal Health standards are a minimum period of four to five days for this purpose (ABAH 1982), but it has been suggested that in excess of one week would be more appropriate because there is a belief that sheep which eat consistently during assembly tend to perform better aboard ship (Grandin 1983). Problems of irregular feedinq include weight loss, digestive upsets and susceptibility to disease.

Feeding behaviour of sheep during assembly for live export may be influenced by a host of conditions associated with the immediate and past experiences of the animals on farms and the sale, truckinq, desiqn and management of animals in assembly feedlots. Industry reports by Grandin (1983) and by Brennan (1984) highlight the wide variability in conditions, facilities and procedures used and show that there is little evidence from which to make recommendations to the live sheep shipping industry.

Australian wethers are worth between $A60 and $A80 in the Middle East (R.J. Lightfoot pers. comm.). Therefore, as well as improvinq animal welfare, research to minimise wastage by way of weight loss, disease and mortality during assembly and shipping has the potential to bring larqe economic benefits.

Research conducted independently by three State Departments of Agriculture (W.A., S.A., and Vic.) is outlined in this contract. Papers cover factors affecting feedinq behaviour of sheep during live export (W.A.) causes of ill-health and mortality (W.A.), ration formulation in regard to nutritive value and durability of pellets (S.A.), growth performance and ruminal changes in sheep fed wheat based rations containing rice hulls, rice pollard and citrus pulp (Vic.) and control of acidosis by chemical means (W.A.).

FEEDING BEHAVIOUR OF MERINO WETHER SHEEP UNDER CONDITIONS SIMILAR TO THOSE USED IN ASSEMBLY FOR LIVE EXPORT

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This paper reviews seven experiments which investiqated the behaviour of groups of Merino wethers under conditions similar to those used in the assembly for live export. In these experiments the feeding behaviour of each wether was monitored by securing paint-soaked marker bars (T.P. Pollard pers. comm.) at the edge of feed troughs containinq shipping pellets so that animals were

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required to either reach over the bar and mark their chins and lower necks, or to reach under the bar and mark the top of their heads or upper necks. The availability of six colours, combined with the two options for the position of the bar, allowed twelve periods for measurements of when individuals fed.

The effect of source of sheep In two sinqle factor experiments and two multi factorial experiments with mixed groups of Merino wethers (400, 400, 392 and 576 sheep, respectively) the feeding behaviour observed in the six to 12 day assembly phases was hiqhly variable (C.L. McDonald, R.T. Norris, H. Ridinqs and J. Speijers, unpublished data). A larqe part of this variation was associated with "source" of sheep, which was examined throuqh the purchase of a number of different lines from different localities. The proportion of sheep classified as "satisfactory adapters" (sheep which were marked by the paint on at least three days of the third, fourth, fifth and sixth days of assembly) varied from three to 96% (mean 59%) amonqst the 11 sources of sheep from the four experiments. In addition to this 23% of the sheep (range 1 to 78%) failed to be marked on any of the days of assembly. Current research is aimed at establishing factors which miqht be associated with these differences between sources of sheep and emphasis is being placed on previous experience with supplementary feeds.

Effect of fasting before assembly It is normal for sheep to be without feed and water during mustering, sale and trucking to assembly depots. Periods of fasting up to 96 hours before assembly produced significant effects on feedinq behaviour over a six day assembly phase with a diet of hay and pellets (C.L. McDonald, R.T. Norris, H. Ridinqs and J. Speijers, unpublished data). Groups fasted for 12 and 24 hours had similar percentages of satisfactory adapters (62 and 79%). In comparison more (98%, $P < 0.01$) of the wethers fasted for 48 hours were classified as satisfactory adapters, which was possibly associated with compensation for the extra period of fasting. However, the qroups fasted for 96 hours had only 71% of satisfactory adapters ($P < 0.001$ compared with 48 hr fast). Consequently, adverse effects on feeding behaviour of fastinq for as lonq as four days in addition to weight loss and possible increased susceptibility to disease (Grau et al. 1969) are indicated.

Effect of diet type Pelleted diets made principally of cereal grain and roughaqe are normally fed durinq shipping. Hay is often fed in association with the pellets durinq assembly to sustain sheep which are slow to adapt to pellets, to encourage sheep to eat pellets and to provide extra rouqhaqe to reduce the risk of acidosis.

In one seven day assembly experiment, daily proportions of sheep visitinq a trouqh containing hay/pellet mix varied from 40 to 75% while those visiting troughs containinq only pellets varied from 5 to 30% (C.L. McDonald, R.T. Norris, H. Ridinqs, J. Speijers unpublished data). Most Australian sheep are not likely to have eaten pelleted diets prior to assembly, and probably require extra time to learn to recognise and accept pellets durinq assembly.

To test the effect of attractants to encourage sheep to eat pellets, an experiment was conducted to compare the use of oaten and lucerne hay versus molasses, butyric acid and aniseed added to pellets (C.L. McDonald, J.B. Rowe, S.P. Gittins and J.A.W. Smith, unpublished data). The daily intake over 10 days of pooled treatments of pellets without hay rose from 25 q/head on day one to 770 g/head on day four and then dropped to about 650 q/head on day five ($P < 0.05$), increasing thereafter to more than 1140 g/head by days nine and 10 (the mean intake for 10 days was 735 g/head). Addition of oaten or lucerne hay did not significantly affect this mean intake fiqure, however it appeared to alter the pattern by preventing the drop in intake on days five and six observed for the groups offered pellets only. Possibly, this was related to a lower lactic acid build-up in the rumens of sheep fed hay together with pellets. The mean daily intake of pellets plus butyrate was not significantly different to the control daily intake of 840 g/head but mean daily intakes of pellets treated with aniseed or molasses were reduced to 624 and 725 q/head respectively ($P < 0.01$ and $P < 0.05$).

Effect of stocking rate, trough length and trough placement Assembly feedlot design involves balancing construction costs against sheep performance and ease of management. Denser stocking rates and shorter lengths of trouqhinq mean lower overhead costs per sheep; location of trouqhs along laneway fences makes feeding out easier. However, when yard space and trough length per animal are limited and when troughs are not centrally located, there is evidence that performance of sheep is adversely affected. Sheep stocked in yards at 0.27, 0.62, 1.42, 3.38 and 7.56 m^2/h were classified as reqular feeders if they were marked on every day of a 12 day assembly (C.L. McDonald, S.P. Gittins, J.A.W. Smith and J.B. Rowe, unpublished data). There was a significant association of regularity of feeding with stockinq rate ($P < 0.001$) with 38, 59, 73, 75 and 75% "regular feeders" at each of the above stockinq rates.

In the same experiment the association of trouqh lenqth with per cent reqular feeders ($P < 0.001$) was such that trouqh lenqths of 0.5, 1.0, 2.0, 4.0 and 8.0 cm/h resulted in 37, 47, 74, 79 and 81% reqular feeders respectively. A second experiment by the same workers using feed rationed to 1000 q/h/d also showed an association of per cent reqular feeders with trough lenqth ($P < 0.001$), trough lenqths of 2, 4, 8, 16 and 32 cm/h resulting in 58, 77, 91, 81 and 95% regular feeders.

In an experiment where trouqhs were incorporated into boundary fences compared with beinq located in the centre of yards, 67 versus 79% satisfactory adapters were observed respectively over a seven day assembly ($p < 0.001$, C.L. McDonald, R.T. Norris, H. Ridings and J. Speijers, unpublished data).

Carryover affects from assembly to shipping In two experiments time lapse photography was used to successfully monitor the performance of the sheep after assembly when placed in pens of similar size and shape to those aboard ship (C.L. McDonald, R.T. Norris, H. Ridinqs and J. Speijers, unpublished data). Sheep present at the feed troughs at every fifth minute in the films were identified for nine selected 24 hour periods and were allotted a filming score. Results for one experiment showed that the hiqher the animal's assembly marking scores, the higher their shippinq filming scores ($P < 0.001$). The results for the other experiment showed no significant relationship between these two scores with very low markinq scores during assembly and a marked improvement in performance in the shippinq phase.

The effects of source of sheep were shown to carry-over from assembly to shipping. In both experiments it appeared that the hiqher the per cent satisfactory adapters for particular sources durinq assembly, the hiqher the shippinq filming score, the qreater the qain in liveweight and condition score.

ACKNOWLEDGEMENTS

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REASONS FOR ILL-HEALTH AND MORTALITY DURING LIVE SHEEP EXPORTS

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The initial phase of the project was to identify the diseases contributing to ill-health and mortality during assembly at local feedlots. Several secondary objectives were involved' including the establishment of minimum diagnostic criteria for the diseases encountered, development of ante- and post-mortem protocols for future land-based and shipboard disease investigations, identification of minor diseases and assessment of the degree of stress in animals with disease.

Examination of 206 terminally ill or recently dead sheep from commercial feedlots revealed multiple causes of ill-health in the majority of sheep which succumbed. The causes were divided into five categories: salmonellosis, adaptational diseases, metabolic diseases, trauma and intercurrent diseases. A large percentage of sheep examined had more than one disease at the time of necropsy.

The combined weight of both adrenal glands in each sheep was used to indicate the degree of stress experienced prior to death. The mean adrenal weight of feedlot sheep (6.1 ± 0.1 g) was significantly higher ($P < 0.001$) than 34 healthy pen-housed sheep (3.1 ± 0.7 g) on a similar diet.

Septicaemic and enteric salmonellosis were encountered as the primary cause of death in 38% of cases and Salmonella typhi-murium was the organism mainly responsible. The large number of animals with salmonellosis indicated that sheep suddenly placed under intensive husbandry conditions were faced with a substantial challenge from the heavily contaminated environment.

The next largest group (23%) were the intercurrent diseases, most of which were probably present prior to transport from the farm to the feedlot. They included urolithiasis, lupinosis, caseous lymphadenitis, foot abscess and a number of others. The relative proportions of most of these diseases are likely to fluctuate markedly between seasons as many, for example lupinosis and foot abscess have a strict seasonal incidence in Western Australia.

Adaptational conditions (12%) included lactic acidosis, enterotoxaemia and starvation and were related to feed intake. The metabolic diseases (5%) could be included in this group but the predisposing factors are probably multiple and not related solely to feed intake.

Traumatic injury (12%) was caused durinq loading, transport, unloading and drafting procedures for the most part althouqh occasional chronic injuries were seen.

The remaining 10% of cases included acute septicaemic and toxic diseases and those for which a final diagnosis could not be made.

Although adaptational, metabolic and infectious diseases were clearly a significant cause of mortality in this study, the role of nutritional, host and environmental factors in the development of these diseases must be defined in future investigations.

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Reduction of the proportion of intercurrent diseases is possible with more effective on-farm selection of sheep for export and traumatic injuries are largely a reflection of the care taken during sheep handling procedures.

The information derived from studies of feedlot diseases will complement future shipboard mortality investigations.

INFLUENCE OF PELLET COMPOSITION ON THE PERFORMANCE OF EXPORT WETHERS

M.H. ROUND*

Loss in live weight of export wethers may frequently equal or exceed losses due to mortality which are currently around two per cent. Low feed intake is undoubtedly a major cause of live weight loss during sea transport. Low intakes of pellets, the predominant feed type used in the industry, have been attributed to inadequate preparation of sheep, physical environment and the pelleted diets themselves. Feed dust, in particular, is a readily observed and major problem (Grandin 1983).

A research program at Northfield Research Centre is examining the influences of pellet composition and feeding manaqement on the performance of wethers held under yard and pen conditions simulating export. In the program, sheep in groups of 14-18 are typically fed for five days in small outdoor yards (4 m^2/head) followed by 16-21 days of intensive feeding (0.33 m^2/head) in indoor pens. In the initial experiments, sheep were restricted to a maximum daily level of 900 g/head pellets. In more recent experiments, daily allowances of up to 1200-1400 g/head pellets have been made. This has generally exceeded the appetite limits of the sheep. If export wethers are to maintain live weight, they would generally need to eat more than 1000 g/head daily of pellets in the middle and later stages of the voyage to make up for low feed intakes that seem to commonly occur during the first week on board ship. While the group sizes he used were small by comparison with commercial practice, Arnold (1976) has shown that stocking density and not group size is an important stress factor in sheep and may significantly raise the maintenance requirements of sheep above generally accepted levels.

Main areas examined in the project are suitable formulations for high grain pellets, the types of grain and roughage used as well as alternative feeds to pellets as shipboard diets. Current research is concerned with quantifying the effects of feed dust on export wethers.

Pellet formulation Severe handling, often by pneumatic blowers during loadinq and feeding, is generally blamed for the feed dust problem. However, many pellets may have an inherently low durability because of their highly fibrous nature. This may lead to dustiness.

The following data, recently obtained from the Australian Bureau of Animal Health (ABAH, personal communication), show the neutral deterqent fibre (NDF), metabolizable energy (ME) and crude protein (CP) values of 50 pelleted diets supplied to the export industry. These were (mean $\pm$ st. dev., range and number (n) of samples): NDF (% DM) 49.4 $\pm$ 7.3, 31.3 - 61.4, n = 50; ME (MJ/kg DM) 8.1 $\pm$ 1.0, 4.7 - 9.9, n = 43; CP (% DM) 8.7 $\pm$ 2.0, 6.0 - 14.2, n = 50. If a 50 kg wether has a minimum maintenance requirement of 7.5 MJ of ME/d and is fed 1000 g/d pellets as recommended in current industry standards (ABAH 1982), then about half of the pellets contain less ME than

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required. Daily feed intakes around 600-700 g/head on some voyages have been reported and obviously fall well short of providing maintenance requirements.

The main considerations in pellet formulation are roughage to concentrate ratio, choice of the types of grain and roughage to be used and costs. The major constraints to pellet formulation are the risk of acidosis from high grain pellets and lowered durability of pellets consisting of low quality roughages. Because of the nature of the industry, these constraints are probably greater under export conditions than under normal farm practice, particularly in relation to the risks of acidosis and feed dust on high and low energy pellets respectively.

Costs are a factor contributing to the inclusion of grains in pellets. The cost of grains and roughages must be compared on the basis of their energy contents as well as the reduced operating and transportation costs associated with higher energy pellets. For this reason higher grain pellets may be a cheaper alternative than finer grinding of roughages and the changeover to smaller pellet mill die sizes, a practice adopted by some operators in an attempt to increase pellet durability. Inclusion of cereal grains in pellets, particularly if they are gelatinized at high operating temperatures during pelleting, is one of the main ways of increasing the durability of pellets. Oats are commonly used in pellets but barley and wheat could also be used if adequately buffered (Round 1984, M.H. Round unpublished data).

One of the major advantages of low grain diets is the reduced risk of acidosis and diqestive upset. Mortality rates of 1.2% and 0.7% respectively have occurred in sheep fed high (60% wheat) and low (30% oats) qrain pellets in the Northfield program. The problem of feed dust often associated with low grain pellets must then be overcome. The main reason for pelleting is to make the ground feed more palatable and in this way feed intake may be increased by up to 40%, the extent probably depending on the dustiness of the ground feed. Given this, the potential deleterious effect of dusty feed on the appetite of sheep during sea shipment is easy to appreciate.

Milling offals such as oat hulls and rice hulls, hay and straw are the most commonly used rouqhages in pellets. Work has shown no difference in the voluntary consumption or liveweight change of sheep fed pellets containing either 45% oat hulls or 45% grass hay or a 50/50 mixture of these roughages (M.H. Round, unpublished data). This was despite the fact that under free choice feeding, sheep ate pellets containing higher levels of hay to the virtual exclusion of pellets containing lower levels.

<u>An industry standard for pellet quality</u> The question arises whether government guidelines or regulations should cover the formulation of pellets supplied to the live export industry. Standards could for example, cover both the chemical composition and the physical durability of pellets. A combined standard would have the advantage of directly attacking a major problem in the industry while ensuring the nutritional adequacy of pellets supplied to the industry. It remains to be demonstrated, for example, if feed dust is a factor contributing to the level of mortality and morbidity during sea transport. Such a demonstration may be needed to determine whether any standards are introduced as a regulation or a recommendation only. It seems likely, however, that only by taking such measures can society's increasing commitment to animal welfare, as well as the future viability of the industry, be secured.

THE INCORPORATION OF RICE HULLS, RICE POLLARD AND CITRUS PULP IN RATIONS FOR THE LIVE SHEEP TRADE

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Rations containing a high proportion of wheat require a longer adaptation period than is currently available to the live sheep trade (six-seven days). Rice hulls would obviously act as a diluent and depending on particle size, as a source of roughage influencing rumination time, saliva flow and pH of the rumen. Other by-products which may influence these parameters are rice Pollard and citrus pulp.

MATERIALS AND METHODS

One hundred and forty four four year old Merino wethers were transported by road from Portland to the Animal Research Institute (322 km). The animals were weighed and allotted on the basis of liveweight (mean 51.2 kg) to one of six diets and to one of four replicates. Each replicate of six animals was transferred to yards (56 m^2) and offered hay and pellets at the rate of 1000 and 200 q/head respectively (day one). The amount of hay or pellets fed was progressively reduced or increased respectively so that by day seven no hay was fed and the pellets were available ad lib. for the next 20 days. The composition and organic matter digestibility of the pelleted rations is set out in Table 1. The wheat, citrus pulp and rice hulls were ground through a 4.0 mm screen before pelleting through a 9.5 mm die.

Table 1 Composition and apparent digestibility of the six rations

Ingredient	Ration and per cent inclusion of ingredients 1	2	3	4	5	6
Wheat	74	64	54	34	24	14
Rice hulls	20	30	40	20	30	40
Rice pollard				20	20	20
Citrus pulp	-	-	-	20	20	20
Minerals	6	6	6	6	6	6
Nitrogen (x 6.25)(% d.m.)	14.1	13.3	11.9	12.3	12.0	11.3
Acid detergent fibre (% d.m.)	15.7	21.8	27.4	21.8	26.8	33.1
Organic matter digestibility (%)	77.7	68.7	62.2	73.5	67.2	58.1

RESULTS AND DISCUSSION

Intake The digestible organic matter intake of the rations is given in Table 2. Increasing the percentage of rice hulls from 20 to 40% significantly depressed intake only in the final week and then only when the ration also contained rice pollard and citrus pulp. At all other times the animals were able to compensate for the lower digestibility by eating more of the pellets. The intake of the sheep given rations containing rice pollard and citrus pulp was significantly higher in the second week than the sheep offered rations containing only wheat, rice hulls and minerals. The mean difference in daily

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intake of pellets (205 g/head) was substantial and was probably associated with the more stable rumen fermentation of these rations (see following paper).

Table 2 Mean daily digestible organic matter intake (g/head) of the pelleted rations

Ration	Ingredient %		Week			
	Wheat	Rice hulls	1	2**	3	4*
1.	74	20	+157a	244a	510a	594a
2.	64	30	56a	257a	530a	800bc
3.	54	40	74a	278a	549a	756ac
4.	34	20	112a	525b	692a	863bd
5.	24	30	96a	420b	679a	835bd
6.	14	40	94a	451b	605a	640ac

\+ Different superscripts within columns denote significance
* (P < 0.05), ** (P < 0.01)

The quicker adaptation of the sheep to the diets containing rice pollard and citrus pulp had no apparent influence on the overall performance of the sheep under the conditions of this experiment but may be important under the high stocking rates and intense competition that exists on board ship.

Liveweight gain or loss The percentage of animals that gained or lost fasted live weight over the 28 d period is given in Table 3.

Increasing the percentage of rice hulls from 20% to 30% or 40% in rations one to three significantly decreased the percentage of animals that lost more than 5 kg of live weight. Although these animals did not die it is perhaps reasonable to assume that their survival would have been at risk under the considerably more stressful conditions on board ship. The opposite trend was evident with rations four, five and six: increasing the percentage of rice hulls tended to increase the percentage of animals that lost weight.

Table 3 Percentage of animals that gained or lost live weight

	Ingredient %		Per cent gain or loss			
Ration	Wheat	Rice hulls	Gain	Loss		Final liveweight
				1-5 kg	6-12 kg	(kg)
1.	74	20	33.3a(2.1)#	45.8a(2.7)	20.9a(8.4)	48.6a
2.	64	30	62.5a(2.1)	33.3a(1.5)	4.2b(9.0)	51.4a
3.	54	40	75.0a(2.2)	25.0a(1.1)	0b	52.5a
4.	34	20	66.7a(3.2)	33.3a(2.8)	0b	51.5a
5.	24	30	45.8a(3.3)	54.2a(1.6)	0b	51.5a
6.	14	40	33.3a(1.9)	58.4a(2.1)	8.2b(6.8)	49.7a

* Different superscripts within columns denote significance (P < 0.05)
\# Figures in parentheses equal mean liveweight gain or loss (kg)

These studies demonstrate that significant quantities of rice hulls, rice pollard and citrus pulp can be included in rations for the live sheep trade.

ACKNOWLEDGMENT

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RUMEN ADAPTATION BY SHEEP TO PELLETED RATIONS CONTAINING WHEAT, RICE HULLS, RICE POLLARD AND CITRUS PULP

M.J. WATSON*, C.H. BURGE*, C. KAT* and R.W. HODGE*

MATERIALS AND METHODS

(i) Phase 1 Fifteen Merino wethers with rumen fistulae and previously grazing were allocated to three rations (1, 2 and 3, see paper above) and placed in individual metabolism stalls. Following an 18 hour fast the sheep were introduced to the experimental rations with pellets replacing hay over a six day period when sheep received daily 500 g/head of pellets alone. When sheep consumed daily 500 g/head of pellets, feed offered was increased daily by 50 g/head until daily intake of pellets was 700 g/head. Feed offered daily remained at 700 g/head pellets until day 18 when intake was rapidly increased to ad lib.

(ii) Phase 2 Eighteen comparable wethers were allocated to three other rations (4, 5 and 6, see paper above and a similar schedule followed.

Rumen fluid samples were collected on days one, 15 and 30 from all sheep at 0800 h prior to feeding at 0830 h and thereafter at 1130 h, 1430 h, 1730 h, 2030 h and at 0830 h the followinq day. The pH of rumen fluid was determined immediately after collection.

RESULTS

The changes in pH of rumen fluid during the feeding cycles are shown in Fig. 1. Initially the changes in pH on the high wheat rations were erratic (see Fig. la) but by day 15 a diurnal pattern emerged with a marked fall in pH after feedinq and a gradual increase to the pre-feeding value (Fig. lc). At the highest level of feeding on day 30 (Fig. le) there was a lack of diurnal variation and a uniformly low pH. In contrast, the changes in pH on the rations containing citrus pulp and rice pollard were less variable (see Figs. lb, d and f).

Mean pH was lower ($P < 0.05$) on day one and 30 with the high wheat rations compared with the rations containing citrus pulp/rice pollard. The pH range was greater ($P < 0.05$) on the high wheat rations on days one and 15 but less ($P < 0.05$) on day 30 when compared to the citrus pulp/rice pollard rations. On day one, pH was lower ($P < 0.05$) on the wheat 74%, rice hulls 20% ration than all others and on day 15 the pH was less ($P < 0.05$) on the 20% rice hull rations, while pH differences on day one and 15 were greater compared to rations containing more rice hulls.

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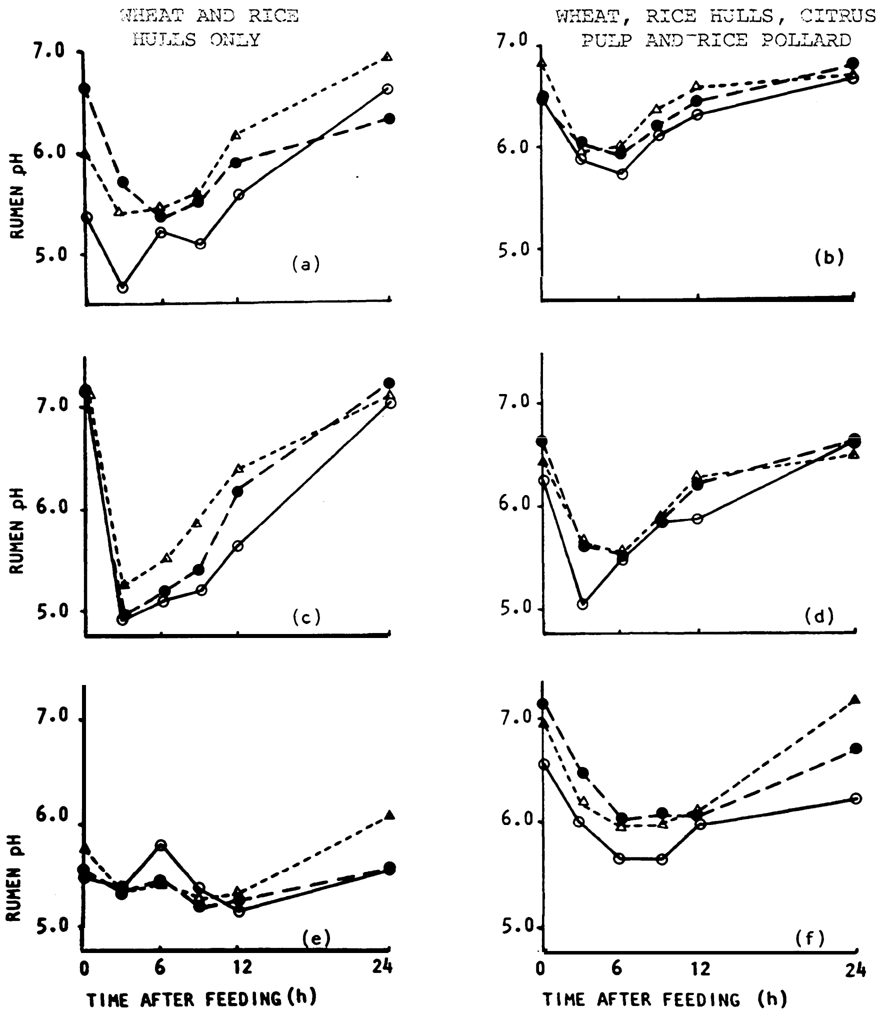

Fig. 1. Mean rumen pH during the feeding cycle for pelleted rations containing 20% rice hulls o o; 30% rice hulls ● ●; 40% rice hulls Δ Δ; with wheat replacing 20% rice **pollard,** 20% citrus pulp on LHS compared with RHS and when offered 500 g/head on day one (a and b); 700 g/head on day 15 **(c** and **d);** and between 1120 and 1680 q/head on day 30 (e and f).

DISCUSSION

The restricted intakes on the high wheat rations (see paper above) were presumably related to the lower and more erratic pH values as a high intake of wheat is known to result in an unstable fermentation and depressed appetite (Lee et al. 1982). Initially on these rations, the diluting effect of rice hulls increased the stability of ruminal fermentation, and up to a moderate daily feeding level (700 g/head) the inclusion of rice hulls at greater than 20% decreased the diurnal variation and increased mean **rumen pH.** There was less duirnal variation on the rations containing citrus pulp and rice pollard, except at the highest level of feeding when the very low rumen pH throughout the feeding cycle on the high wheat rations indicated potentially unstable rumen fermentation.

Rations containing citrus pulp and rice pollard have a lower molar proportion of rumen propionate (M.J. Watson, unpublished data). Ration components such as these, which increase hemicellulose and pectin probably reduce the amylolytic rumen microbes (Baldwin and Allison 1983) and stabilize the rumen environment in sheep fed pelleted rations containing readily fermentable substrates.

CONTROL OF LACTIC ACIDOSIS DURING LIVE SHEEP EXPORTS BY USE OF CHEMICAL ADDITIVES

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As has been discussed in previous papers in this contract the sheep-shipping industry prefers the use of hiqh density pellets with sufficient physical strenqth to withstand the handling involved in loadinq the ship and feeding out. To satisfy these requirements relatively high levels of cereal grain are often included in the diet and this gives rise to the danger of lactic acidosis. Althouqh acidosis is not a problem in sheep adequately prepared for the shipboard diets in assembly feedlots, all shippinq companies are aware of the significant losses which can occur through errors in feed formulation or feeding management. The safety of high-starch feeds for sheep accustomed to roughaqe diets can be significantly improved by the use of chemical additives. In this short review the biological action of the major groups of additives will be discussed toqether with the presentation of data from our laboratories.

Lactic acid is an important intermediate of carbohydrate fermentation of grain-fed animals and is normally rapidly converted to acetic, propionic and butyric acids. Rapid fermentation of starch results in a reduced pH and also in increased lactate production. Some of the bacteria which ferment lactate are inhibited by low pH (e.g. Veillonella alcalescens) and for others tolerant to low pH (e.g. Megasphera elsdenii) the build up of sufficient numbers requires time (see Schwartz and Gilchrist 1975). The build up of lactic acid may be controlled either by reducing its production or increasing the rate at which it is fermented in the rumen.

<u>Reducing lactic acid production through (a) gram-positive antibiotics</u>. The main lactate producing Streptococcus bovis and Lactobacillus are gram positive. A range of feed additives used in cattle feedlots in America and Europe (e.g. monensin, lasalocid and avoparcin) have selective activity against these gram positive oragnisms and can significantly reduce the build up lactic acid. Nagaraja et al. (1981) have reported work on monensin and lasalocid and preliminary work in our laboratories (see Table 1) has indicated that avoparcin could significantly reduce lactic acid concentrations. There was also considerable between-animal variation in the concentration of lactic acid in response to intra-ruminal administration of wheat. Nagaraja et al. (1981) in showing lower levels of lactic acid in response to the ionophores (monensin and lasalocid) also found substantial variation between animals.

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Table 1 Effect of including avoparcin with a slurry of cracked wheat introduced directly into the rumen of sheep, on lactic acid concentration in rumen fluid (m mol/litre). The dose of cracked wheat was 14 g/kg live weight (C.L. McDonald, E.M. Aitchison, and J.B. Rowe, unpublished-data)

Avoparcin mg/kg wheat	No. of sheep per treatment	Time after dosing (h) 0	4	8	12	24
0	11	0.04	0.70	29.6	13.8	29.5
30	3	0.01	1.63	20.7	51.3	53.6
60	3	0.21	0.25	9.3	30.4	20.9
90	3	0.04	1.42	3.2	11.4	12.2
SED		0.11	0.86	19.4	20.2	15.5

It appears that while the ionophore compounds (monensin and lasalocid) need to be fed for at least three days before affording protection against the production of lactic acid the effect of avoparcin may be immediate.

(b) Bentonite clays have been successfully used to decrease stock losses and improve liveweight gain of animals introduced rapidly to high starch diets. It appears that this may be through their ability to decrease lactic acid production through changing the pattern of rumen fermentation towards acetate production (J.B. Rowe and E.M. Aitchison, unpublished data).

Increasing lactic acid utilization through use of buffers. Buffers such as sodium bicarbonate can be effective in maintaining a stable rumen pH even when high levels of starch are fed (Rogers and Davis 1982). This higher pH reduces the rapid proliferation of lactic acid forming bacteria, while at the same time preventing the inhibition of lactate utilising bacteria. The accumulation of lactic acid in rumen fluid can therefore be reduced when buffers are included in high concentrate diets (Prigge et al.1975).

Before the use of these chemicals becomes widespread in the industry more information is required on how quickly they become effective and at what level they need to be included in the feed.

SUMMARY AND CONCLUSIONS

C.L. McDONALD*

The live sheep export industry returns more than $150 million annually in export income but has been threatened by industrial action from meat workers and objections from Animal Welfare groups and communities surrounding assembly areas and ports (Lightfoot and McDonald, 1982). Recent research, which was set against a background of scant knowledge, therefore has the potential to assist the development of a more secure industry where animals are well cared for and wastage by way of weight loss, ill health and mortality are minimized.

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The work presented in this contract shows that feeding behaviour of the sheep entering assembly depots can be improved by several factors which are under the direct control of feedlot managers. Additionally there is some support for the opinion that sheep which adapt well during assembly perform well aboard ship. Recent veterinary studies have shown that 12% of feedlot diseases were closely related to feed intake (adaptive conditions). However, problems with feeding behaviour are also likely to be associated with another 38% (samonellosis) and 5% (metabolic disorders) of cases studied.

The scope for improvement of animal performance via ration formulation has been highlighted in this contract. Problems with insufficient metabolisable energy contents and dustiness of current rations have been discussed, optimum levels of inclusion of rice hulls, rice pollard and citrus pulp in wheat-based pellets have been defined and methods of controlling acidosis by use of chemical additives have shown considerable potential.

Future research programmes are aimed at determining the effects of previous experiences of sheep and feeding behaviour during assembly on liveweight wastage, disease and mortality during export. Protocols involve large scale investigations using commercial shipments with sheep histories traced back to farms of origin together with experiments on research stations involving applied nutritional treatments and intensive observations and measurements.

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