EXPORT OF LIVE SHEEP : NUTRITIONAL STUDIES AND THE FAILURE TO EAT SYNDROME

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SUMMARY

The nutritive value of pelleted feed for export sheep (as defined by voluntary intake of digestible dry matter and change in liveweight) could not be predicted from measurements of dry matter digestibility alone; knowledge of the percent starch in the ration was also required. Nutritive value was also influenced by environment; sheep penned outdoors at a stocking density of 1.5 m^2/hd consumed more feed and utilized feed more efficiently ($P<0.01$) than those penned indoors at 0.33 m^2/hd.

The phenomenon of failure to eat of some export sheep was not related to variation in level of feeding (restricted v ad libitum), trough space (5 cm/hd v 38 cm/hd) or stocking density (0.33 m^2/hd v 1.5 m^2/hd). However the incidence of failure to eat was influenced by the physical form in which the ration was presented. Chaffing, grinding or pelleting lucerne hay increased failure to eat of the sheep offered hay from 0.8 percent to 1.7, 2.9 and 1.7 percent respectively ($P<0.001$).

INTRODUCTION

The nutritional status of sheep for export is potentially influenced by a number of management practices employed in the industry. For example, sheep for export must first recognize and then adapt to pelleted rations (which can vary widely in content of cereal grain and quality of roughage) within a period of six to 10 days. In addition there are potential stressors associated with ship transport such as high stocking densities which may impact on the intake and utilization of feed. All these factors may be associated with the phenomenon observed on board ship of complete failure to eat (FTE) by some sheep. This is now known to be the highest single cause of serious weight loss and deaths on board ship (Beers and Kelly, 1988, Beers et al. 1989 and Richards et al. 1989).

This paper presents a preliminary report on the influence of composition of the ration, the environment and stocking density on the intake and liveweight change of adult Merino sheep and discusses the relationship between various husbandry practices and physical form of the ration on the incidence of FTE.

MATERIALS AND METHODS

(i) <u>Composition of the ration</u> Six hundred and forty eight mature Merino wethers were fasted overnight and next morning transported by road (7 hours) to the Victorian Institute of Animal Science (VIAS). On arrival the sheep were ear tagged, weighed (mean fasted liveweight and standard error 49.9 ± 0.8 kg) and offered 1 kg grass hay/head.

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The next day the animals were allotted on liveweight to one of 18 treatments and to one of six replicates each of six animals. The treatments consisted of six levels of wheat (20, 30, 40, 50, 60 and 70 percent) and three types of roughage (lucerne chaff, grass hay or cereal straw). Urea, calcium and phosphorus were added to ensure that the nitrogen, calcium and phosphorus content did not fall below 1.6, 0.8 and 0.3 percent respectively; a trace element and vitamin premix (0.1 percent) was also added to each ration. The rations were pelleted and progressively replaced the hay over a seven day period and then offered ad libitum for 21 days. The straw diet containing 20 percent wheat was contaminated with lucerne during pelleting.

The residues of the feed offered were recorded every third or fourth day and the fasted liveweights of all sheep recorded on day 29. The digestibility of each diet was determined with four sheep per diet at the end of the experiment.

The pH of samples of ruminal fluid obtained from two sheep from each pen (six per diet) by stomach tube approximately two to three hours after feeding was determined on days 12, 13, 26 and 27.

(ii) Environment, availability of feed and trough space One thousand and eight mature Merino sheep from each of three different sources were yarded overnight and transported by road (two to eight hours) to the VIAS. On arrival the sheep were ear tagged, weighed and offered 1 kg grass hay/hd. The hay was progressively replaced with commercial pellets (in vitro digestibility = 56 per cent) over a six day period. On day seven the sheep were allotted to either outside feedlot pens (1.5 m^2/hd) or to indoor pens (0.33 m^2/hd) in which conditions simulated the increase in temperature experienced during transport to the Middle East. Each pen contained 18 sheep with seven replicates of each treatment.

The sheep were offered the pellets ad libitum or restricted to 1.1 kg/hd/d in troughs providing either five cm or 38 cm of trough space/hd) for a period of 20 days. Feed residues were recorded every third or fourth day and fasted liveweights determined on day 28. Within each pen the two sheep with the greatest liveweight loss were killed and examined for evidence of failure to eat. Failure to eat was defined as greatly reduced rumen solids content (less than 1.5 percent of bodyweight), atrophy of rumen papillae and a variable degree of fatty degeneration of the liver (Beers and Kelly 1988).

(iii) Environment and Stocking density Nine hundred mature Merino wethers from three sources were initially treated as described in (b) and then allotted to outside feedlot pens or indoor ship simulation pens at stocking densities for each environment of 0.33 or 1.5 m^2/hd. Each pen contained 18 sheep with 15 replications of each treatment except for the sheep stocked at 1.5 m^2/hd in the indoor pens which could be replicated only five times.

The sheep were offered commercial shipping pellets (in vitro digestibility = 54%) at the rate of 1.1 kg/hd/d and trough space was restricted to five cm/hd, i.e. the feeding rate and trough space experienced by sheep transported by ship to the Middle East.

Fasted liveweights of all sheep were recorded on day 29 and the three sheep from each pen with the largest weight loss were killed and examined for evidence of failure to eat (Beers and Kelly, 1988).

(iv) Physical form of the ration Six thousand mature Merino wethers from each of 3 sources were fasted overnight and transported by road to the VIAS. On arrival the animals were ear tagged, weighed and allotted to one of six rations. Four of the rations consisted of different physical forms of lucerne hay (in vitro digestibility = 65 percent) - baled hay, chaffed hay, tub-ground hay and pelleted hay; one was a mixture of pelleted hay (80 percent) and chaffed hay (20 percent) and the other consisted of commercial shipboard pellets (in vitro digestibility = 56 percent) typical of those used in the industry.

The sheep were placed in outdoor, bare earth pens (400 m^2) in a three replicate randomised block design with each pen containing 333 sheep, i.e. a total of 999 sheep per treatment. Feed was offered at rates ranging from 1.0 kg/hd/d (minimum) to 1.5 kg/hd/d (maximum) for a period of 14 days. These rates ensured that feed was available for at least eight hours/day.

The pelleted hay, chaffed hay, tub-ground hay and the mixture of pelleted hay and chaffed hay were offered in 18 metre long troughs constructed from plastic shade cloth suspended from two wires. The baled hay was offered in conventional wire mesh hay feeders which provided the same feeding space (5 cm/hd) as the shade cloth feeders.

Fasted liveweight of all animals was recorded on arrival and again 14 days later. The 15 sheep in each pen with the greatest liveweight loss were slaughtered and examined for failure to eat.

RESULTS

Composition of the ration

(i) Digestibility The percentage dry matter digestibility (DMD) of the diets varied from 52.6 percent for the straw diet containing 30 percent wheat to 83.2 percent for the lucerne pellets containing 70 percent wheat. Within each roughage type there was a linear increase in DMD with increased wheat content.

(ii) Voluntary intake and liveweight change Both the type of roughage and the percentage of wheat in the diet influenced voluntary intake of digestible dry matter (DDMI) and fasted liveweight change (FLWC) - Figs 1 and 2. The relationship between FLWC and DDMI (FLWC = -9.3 + 12.5 DDMI, r^2 = 93.1, RSD = 0.5 1) indicated that 0.75 kg DDM/hd/d was required to maintain liveweight.

The highest DDMI intakes were achieved by the sheep offered pellets containing lucerne and 20 or 30 percent wheat; further increases in percent wheat progressively reduced DDMI. There was also a linear decline in the DDMI of the sheep given pellets containing grass hay or straw as the content of wheat increased.

The difference observed in DDMI was reflected in the mean FLWC of the sheep (Figure 2). Thus the highest liveweight gains were obtained with sheep given diets containing lucerne hay and 20, 30 or 40 percent wheat but a mean loss in liveweight was experienced by sheep fed diets containing lucerne and 70 percent wheat. Diets containing grass hay and 20 or 30 percent wheat promoted liveweight gains, those with 40 or 50 percent wheat maintained liveweight, but losses in liveweight occurred if the diets contained 60 or 70 percent wheat. With the straw based diets there was a mean loss in liveweight for all diets except the one containing only 20 percent wheat and contaminated with lucerne (0.2 kg/hd/4 weeks).

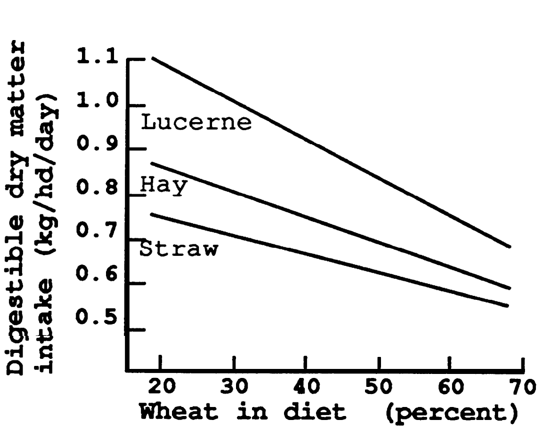

Fig. 1. Intake in response to percent wheat and type of roughage in the diet

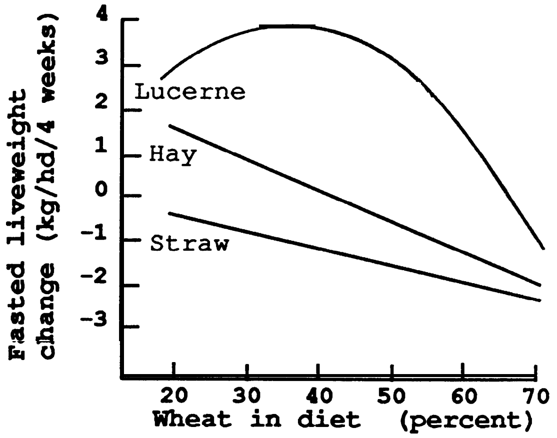

Fig. 2. Liveweight change in response to percent wheat and type of roughage

The regression equations relating type of roughage and percent wheat to DDMI and FLWC are set out below.

Lucerne:

DDMI = 1.25 - 0.008W; r^2 = 0.90, RSD = 0.05

FLWC = -0.53 + 0.244W - 0.0037W^2; r^2 = 0.92, RSD = 0.61

Hay:

DDMI = 0.95 - 0.005W; r^2 = 0.93, RSD = 0.03

FLWC = 3.01 - 0.07W; r^2 = 0.96, RSD = 0.24

Straw:

DDMI = 0.79 - 0.003W; r^2 = 0.62, RSD = 0.12

FLWC = 0.03 - 0.03W; r^2 = 0.46, RSD = 0.42

Where DDMI = digestible dry matter intake (kg/hd/d), FLWC = fasted liveweight change (kg/hd/4 weeks) and W = percent wheat in the ration.

(iii) pH of ruminal fluid The variation in pH of ruminal fluid was large and the values for the lucerne, hay and straw diets were combined. There was a marked decline in pH with diets containing more than 40 percent wheat on days 12/13 (5.9-5.0) and a lesser decline on days 26/27 (6.2-5.8). The regression equations were significant (P0<0.01) and are set out below:

Day 12/13 pH = 5.75 + 0.0244W - 0.0005W^2; r^2 = 0.21, RSD = 0.52

Day 26/27 pH = 5.94 + 0.019W - 0.0003W^2; r^2 = 0.20, RSD = 0.38

(iv) Prediction of fasted liveweight change The direct relationship between FLWC and DMD and after adjustment for percent starch in the rations is depicted in Figures 3 and 4.

There was no direct effect of DMD on FLWC but after adjustment for percent starch the relationship accounted for 64 percent of the variation (Fig 2). Liveweight change could be predicted from the regression equation: FLWC = -13.6 + 0.273 DMD - 0.00432 $(S)^2$, r^2 = 0.74, RSD = 1.004,where FLWC = fasted liveweight change (kg/hd/4 weeks), DMD = dry matter digestibility and S = percent starch.

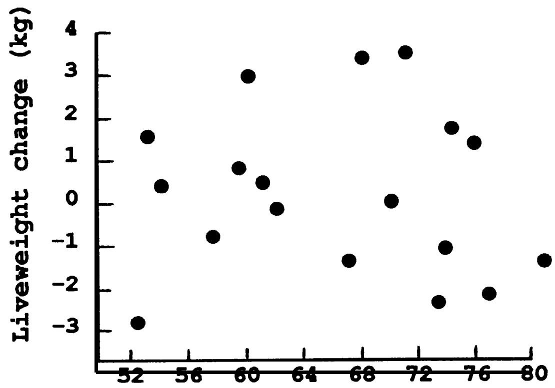

Fig. 3. Liveweight change and dry matter digestibility

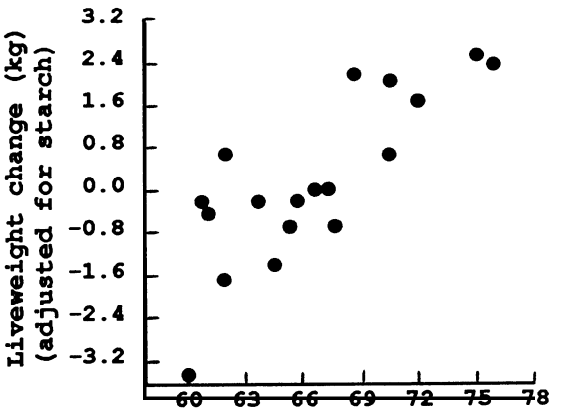

Fig. 4. Liveweight change and dry matter digestibility after adjustment for percent starch

Intake and liveweight change

The intake and FLWC of sheep fed ad libitum or restricted to 1.1 kg/hd/d in either outdoor or indoor pens under simulated ship transport is set out in Table 1. Trough length had no effect on intake or FLWC and the results have been included with the pen data.

Table 1. Voluntary intake and liveweight change of sheep in outdoor pens or simulated ship pens.

	Environment*	
	Outdoor pens	Simulated ship pens
Intake of pellets as fed# (kg/hd/d)	2.04 (1.1)	1.36 (1.1)
Liveweight change’ (kg/hd/4 weeks)	4.9 (-0.9)*	-0.9 (-2.1)

SED = 0.024, P<0.001; + SED = 0.41, P<0.001; * figures in parentheses = intake or FLWC of animals restricted to 1.1 kg/hd/d; δ sheep in outdoor pens stocked at $1.5m^2$/hd, sheep in simulated ship pens at $0.33m^2$/hd

Sheep fed ad libitum in the outdoor pens consumed 50 percent more feed than those indoors and gained weight over the four weeks compared to a loss in weight of the sheep penned indoors. All sheep consumed the restricted ration of 1.1 kg/hd/d but those fed outdoors lost significantly less weight than those indoors.

The FLWC of sheep restricted to 1.1 kg/hd/d (in the next experiment) in relation to environment and stocking density is shown in Table 2.

Table 2. Liveweight change (kg/hd/4 weeks) of sheep related to environment and stocking density

Stocking density	Environment: Outdoor pen	Environment: Simulated ship pens
1.5 m^2/hd	-1.7	-1.0
0.33 m^2/hd	-2.7	-2.9

SED = 0.423, $P < 0.001$

The environment had no significant effect on liveweight change but those animals stocked at 0.33 m^2/hd lost significantly more weight than those stocked at 1.5 m^2/hd.

Failure to eat

The incidence of failure to eat of the sheep in relation to husbandry practices and physical form of the diet is set out in Table 3.

Table 3. Incidence of failure to eat (percent) related to level of feeding, trough length, environment, stocking density and physical form of the diet.

Level of feeding and trough space+			
ad libitum		Restricted (1.1 kg/hd/d)	
Short trough	Long trough	Short trough	Long trough
3.2	1.6	0	3.2

Environment and stocking density#			
Outside		Simulated ship	
Low density	High density	Low density	High density
2.2	1.1	3.3	2.2

Physical forms$^{\delta}$					
Hay	Chaff	Mash	Pellet	Pellet/chaff	Commercial pellet
0.8	1.7	2.9	1.7	1.2	1.9

+ Short = 5 cm/hd, long = 38 cm/hd; in simulated ship pens, n=126, P>0.1; # Low density = 1.5 m^2/hd, high density = 0.33 m^2/hd, n=90, P>0.1; $^{\delta}$ in outdoor pens, n = 999, SED = 0.37, P<0.01

The incidence of FTE was not significantly related to the level of feeding (ad libitum v restricted 1.1kg/hd/d), trough length (5 cm v 38 cm/hd) or whether the sheep were placed in outside pens or in indoor pens under conditions simulating ship transport (using non parametric rank test - Table 3). However, the incidence of FTE of sheep offered lucerne hay or ground lucerne hay was significantly less or significantly more ($P<0.01$) respectively than those fed chaffed lucerne hay, pelleted lucerne hay, a mixture of pelleted lucerne hay and chaff (80:20) or commercial ship board pellets (Table 3).

DISCUSSION

The first experiment in this study established that the mean potential intake over 3 weeks of adult Merino wethers (subjected to fasting, road transport and sudden adaptation to pelleted rations) was about one kg DDM/hd/d. This intake was well in excess of that apparently required for maintenance of liveweight (0.75 kg DDM/hd/d) but was reduced to below maintenance as percent wheat (starch) was increased and quality of roughage declined (Fig.1). The decline in voluntary intake was probably associated with less stable fermentation patterns within the rumen as indicated by the decline in pH of ruminal fluid. Certainly the prediction of nutritive value of the rations expressed in terms of FLWC required DMD to be adjusted for level of starch (Figs 3 and 4).

However, these results were attained with sheep in outside feedlots at relatively low stocking densities (4.7 m^2/hd). When the animals were subjected to simulated ship transport (high stocking densities and high ambient temperatures) voluntary intake was reduced to only 66 percent of that consumed by sheep in outdoor feedlot pens (Table 1) and below the calculated maintenance requirements. It is likely that the reduction in intake was associated with stocking density rather than environment per se because the rate of consumption of sheep penned outdoors or indoors at 0.33 m^2/hd and offered restricted feed was similar (1.1. kg/7.5 hours) and considerably slower than those penned in both environments at 1.5 m^2/hd (1.1 kg/2.5 hours). Certainly high stocking densities reduced the efficiency of utilization of feed (for maintenance of liveweight) when fed at the restricted levels offered on board ship (Table 2). This suggests that the maintenance requirements of the sheep were increased at the higher stocking densities similar to that observed by Round (1989) and which may be due to stress (Graham 1967).

Our simulated studies suggest that sheep transported to the Middle East are likely to suffer a mean loss in liveweight of about two to three kg. Kelly (per.comm.) has in fact observed a median loss in liveweight of 2.0 and 2.7 kg in two out of three voyages to the Middle East. However a loss in weight of this magnitude of adult Merino wethers over four weeks is clearly not a major welfare issue although it may influence meat quality.

Most importantly our studies revealed that a mean of 3.4 percent of sheep under simulated ship transport lost over 20 percent of their initial weight during the three week ‘voyage’. This level of loss has been confirmed on board ship (Beers et al. 1989) and does pose a major welfare problem. Animals suffering this sort of weight loss are exhibiting the classic failure to eat syndrome and may die on board ship (Beers and Kelly, 1988, Richards et al, 1989) or in assembly feedlots in the Middle East (Brightling, per.comm.)

The results show that FTE is not associated with level of feeding, nutritive value of the ration, trough space, environment or stocking density. However, Hodge et al (1990) concluded that the FTE syndrome was associated in large part with a lack of ability to recognize or accept pellets as feed. This was confirmed to some extent in the current study where the incidence of FTE in animals offered lucerne hay was significantly less than those offered the same hay processed in various ways (Table 3). However almost one percent of animals exhibited FTE even when offered lucerne hay and there was no evidence that alternative rations that could perhaps be used on board ship (pellet/chaff mixtures) would reduce the incidence of FTE.

Our results suggest that changes in management practices such as reducing stocking density and providing feed ad libitum should ensure maintenance or gain in liveweight of sheep transported by ship to the Middle East. However changes of this magnitude are unlikely to be commercially viable and, in any event, they will not solve the major problem of exporting live sheep - the FTE syndrome. This is likely to be achieved only by developing techniques which enable the hard core FTE sheep to be identified and culled before boarding the ship.

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