The effect of shearing on sheep feeding and behaviour

Teresa Collins
Lourdes-Angelica Aguilar, Sarah Wickham, Anne Barnes, David Miller, Trish Fleming and Teresa Collins

School of Veterinary and Life Sciences,
Murdoch University, Murdoch, WA, 6150, Australia

Abstract
Sheep destined for live export may be shorn in the immediate period before shipping, to limit wool cover and so improve heat loss. Shearing can contribute to increased stress, and there are concerns this may lead to inappetance. In this study, 600 sheep were fitted with Radio Frequency Identification tags, to determine time and frequency of feed and water trough attendance. The sheep were shorn on day 1, 2, 3, 4 or 5, and compared to an unshorn group. Ethograms were generated through analysis of video footage of the sheep taken one hour after shearing. There was no difference in time spent at feed or water troughs between any treatment groups on any day, and minimal behavioural changes. This suggests that shearing may occur on any day during the pre-embarkation feedlot period, and that current management practices do not disrupt time spent feeding.

Introduction
Live export of sheep plays an important role in Australia's economy. Australia exported 20,020,941 head of live sheep in 2013-2014; 97% were exported to the Middle East. Sheep shipped to the Middle East may undergo exposure to contrasting environments, from an Australian winter to a summer in the Middle East. Large heat loads on sheep can cause an increase in respiratory rate, body temperature and water consumption, and decreased feed intake. In order to limit excessive heat loads of the sheep, regulations require that sheep sourced for live export have been shorn recently prior to loading onto the live export vessel. That is, sheep exported to the Middle East must have wool not longer than 25mm in length, be 10 days or more since shearing, or if they are to be shorn during the 10 day period before shipping, this must occur while the animals are accommodated in sheds on registered premises.

Shearing primarily involves the act of wool removal; however, other aspects of the procedure contribute to sheep stress, including being yarded, moved along a race, penned, caught, upended and then dragged to the shearing station to be shorn as well as the noise and vibration of the shearing hand-piece and risk of skin injury. However, the effect of day of the shearing procedure on feeding behaviour has not been previously studied. Feeding behaviour is extremely important in the live export process as the main causes for shipboard death of sheep have been identified as inanition and salmonellosis[1], accounting for approximately 75% of mortality in live sheep export industry[2]. . There was a high risk of death on the ship when sheep did not eat pellets late in the pre-embarkation feedlot period, which indicated that mortality on board the ship was linked to sheep inappetance late in the feedlot period[3]. Sheep entering the live export chain will have experienced increased handling, road transportation, vaccinations, drafting, shearing, altered diets, novel forms of feed, novel environments before the journey on the export ship itself; all occurring over a period of around one month. These factors can also cause stress in sheep that can result in decreased feed intake and inanition leading to mortality[1]. Therefore, this study aims to determine whether the day

of shearing while in the pre-embarkation feedlot influences the time sheep spend at the feed and water troughs.

In addition, this study aims to determine if day of shearing will affect sheep behaviour, specifically posture, locomotion activity and rumination. Changes in locomotion activity of the sheep can be interpreted in several ways, with studies by Molony & Kent (1993)[4] finding that an increase in locomotion in terms of pacing and restlessness, due to castration and tail-docking, could be used as an indicator of pain and discomfort. Increased locomotion could also reflect fear or nervous agitation, which can be an indicator of stress.

Understanding any association between the day of shearing, feeding patterns and behavioural responses may indicate where sheep incur stress, and where the welfare risks are highest, and could assist in promoting management practices that reduce the incidence of abnormal feeding. The null hypotheses being tested in this study are that there will be no difference in time spent at the feed and water trough, and no difference in observed behaviour, between sheep shorn on different days.

Materials and Methods

Location and Housing

Sheep were housed in a pre-embarkation feedlot, approximately 30 km south of Perth, Western Australia for 13 days. The feedlot has elevated sheds, with the sheds operating using a 24-hour, fully automated feed and water system providing *ad libitum* feed and water. Each feed and water trough was fitted with tracking antennae, which pulse at millisecond intervals to detect the presence of the Radio Frequency Identification Tags (RFID) on the ears of sheep when they approach the trough within 350mm. The RFID tags are able to transfer information including the individual identification number and recognize when their heads are in such a position that they are likely to be eating or drinking. The data points recorded are used to generate reports containing information on the number of visits at the feed and water troughs and the total amount of time at the troughs per day that the sheep were at the troughs. For the purposes of analysis, each day ran from 13:00-12:59.

Animals

A total of 600 Merino weaners (born in 2014) were sourced from a property in Cranbrook, Western Australia. The lambs had last been shorn in January of 2015. On arrival to the feedlot, the sheep had a RFID ear tag inserted into its right ear. After insertion of the RFID ear tag, an ALEIS Reader Model 8030 One-Piece portable wand recorded the ear tag number, which was uploaded onto an electronic tracking program to be used for identification of sheep at the water and feed troughs.

The 600 merino sheep were randomly separated into two pen groups and within these two groups they were further separated into six treatment groups. A coloured ear tag was inserted on the opposing side of the RFID ear tag. The colour of this ear tag served as identification of which sheep were shorn on which allocated day. Body condition score (BCS) was recorded on entry and exit to the feedlot

Shearing

Five hundred sheep were shorn over the five days of this experiment, with the colour of the ear tag corresponding to the day of shearing. The red-tagged sheep remained unshorn and assigned controls. Sheep were drafted at midday each day, and sheep that were to be shorn the following day moved to the shearing shed, where feed and water was withdrawn overnight. Sheep were shorn in the morning and returned to the mob at

13:00 the same day. Sheep were shorn daily until day 5, as no sheep were being shorn the following day. Two shearers were present to shear 100 sheep at a rate of approximately 2.4 minutes per sheep, and the same shearers shore all sheep in this study.

Filming

Eight digital camcorders were mounted on portable tripods attached to the corner of each pen, with four cameras per pen. These cameras faced towards the middle of the pen. The same researcher turned on all cameras and left so the sheep were recorded undisturbed for an hour in the afternoon after the sheep had returned to their respective pens approximately one hour after shearing. The sheep were filmed on day 0, through to day 6 and again on day 13. No sheep were shorn on day 6 and day 13. However, to simulate handling conditions on day of shearing, on day 6 and day 13, all sheep were still taken out of the feedlot shed to be run through the race once and held in the yards for approximately one hour before being moved back into the feedlot shed to be filmed.

The footage was edited into clips of 60 seconds using iMovie (10.0.5). The 60-second clips were selected from the 20-30 minutes after cameras were turned on. This time frame was selected to be analyzed as 60-seconds was the maximum time that the sheep generally stayed in focus in the camera frame, before either walking out of frame and being obscured by another sheep. The clips were taken from 20 minutes to allow time for the sheep to perform normal behaviours rather than detecting behaviour resulting from handling or from the researcher turning on the cameras, and a 10-minute range to ensure at least 10 sheep was analyzed.

Behavioural Ethograms

A behavioural ethogram was modified from Lauber *et al.* (2012)[5] and McClelland (1991)[6]. The ethogram contained 3 states and 21 events to describe the behaviour the sheep demonstrated (Table 1). The 3 states were walking, standing and lying, describing the activity of the animal. The duration of the states was presented as a proportion (%) of time for the 60-second clip as they are mutually exclusive, with it being impossible for two states to occur at the same time. The events were quick actions that occurred for less than 5 seconds and were counted every time one occurred. At least 10 focal sheep from each treatment group per pen were selected from one camera in each pen. However, if visibility of ear tags was poor or if less than ten sheep could be identified, sheep from another camera within same pen and time were used to identify ten sheep. The sheep clips were analyzed on day 0,3,4,5,6, & 13.

Table 1. Behavioural categories for quantifying animal behaviour.

States	
Walking	Moving around in pen, not standing stationary
Standing	Standing stationary on four legs
Lying	Lying on floor
Events	
Being Pushed 1	Being pushed by another sheep's head
Being Pushed 2	Being pushed by another sheep's body
Being pawed by another sheep	Being pawed by another sheep
Body shake	Whole body shake
Breathing fast	Breathing rapidly with short, quick breaths
Chew Pen fixtures	Chewing pen fixtures (floor slats, wire, palings, feeder)

Head-butting	Aggressor hits another sheep with head without first backing up
Head Down	Head lowered below shoulders
Head Up	Head above shoulders
Move mouth parts	Curling of the upper lip (Flehmen response)
Nosing Pen fixtures	Nosing or rubbing muzzle of pen fixtures
Pawing another sheep	Striking another sheep with forelegs
Pawing Ground	Striking ground with forelegs
Pushing 1	Pushing another sheep using its head
Pushing 2	Pushing another sheep using its body
Ruminating	Chewing cud
Smelling	Inhale odour of the environment through nose
Smelling another sheep	Inhale odour of another sheep through nose
Sneezing	Expulsion of air from the nose/mouth
Tongue Movements	Licking himself (front legs, shoulders, hind legs, rump, underside)
Vocalization	Producing sounds with mouth

Statistical Analysis

A Mixed Model ANOVA was used to analyse any significant difference between treatment groups and pens for the proportion of time sheep performed walking, standing or lying. The time spent at the feed and water trough for each sheep was also analysed using a Mixed Model ANOVA to cater for the missing data from the days of shearing. To correlate body condition score and mean total time at feed and water trough, correlation matrices were performed on body condition entry, body condition exit, body condition differences, total time at feed and water trough, total attendance at time at feed and water trough and the mean of total time and total attendance at the feed and water trough. As the data for time at feed and water trough did not meet the requirement of normality, the data was transformed using a log function, and tested using Shapiro-Wilk and Kolmogorov-Smirnov tests. Wet-bulb temperature was determined through an equation between relative humidity and temperature previously described by Stull (2011)7.

Results

Although the feed and water trough antennae worked throughout the duration of the experiment; 6 sheep were removed from the experiment due to faulty RFID ear tags or due to health concerns. Altogether, 594 sheep were used for analysis.

Time Spent at the Feed Troughs

There was no pen effect and therefore the pens were combined analysis of each treatment group. As seen in Figure 1, there is no statistical difference in mean daily feed time between treatment groups ($P>0.05$). However, on day 5 there was a significant time x day interaction, with an increase in mean total time spent at the feed trough for all treatment groups ($p<0.001$). There was an increase in amount of time all treatment groups spent at the feed trough from day 0 to day 13 ($P<0.001$). There was also a significant interaction between wet-bulb temperature and day where there was an increase in amount of time all treatment groups spent at feed as wet-bulb temperature increased from day 0 to day 13 ($P<0.001$).

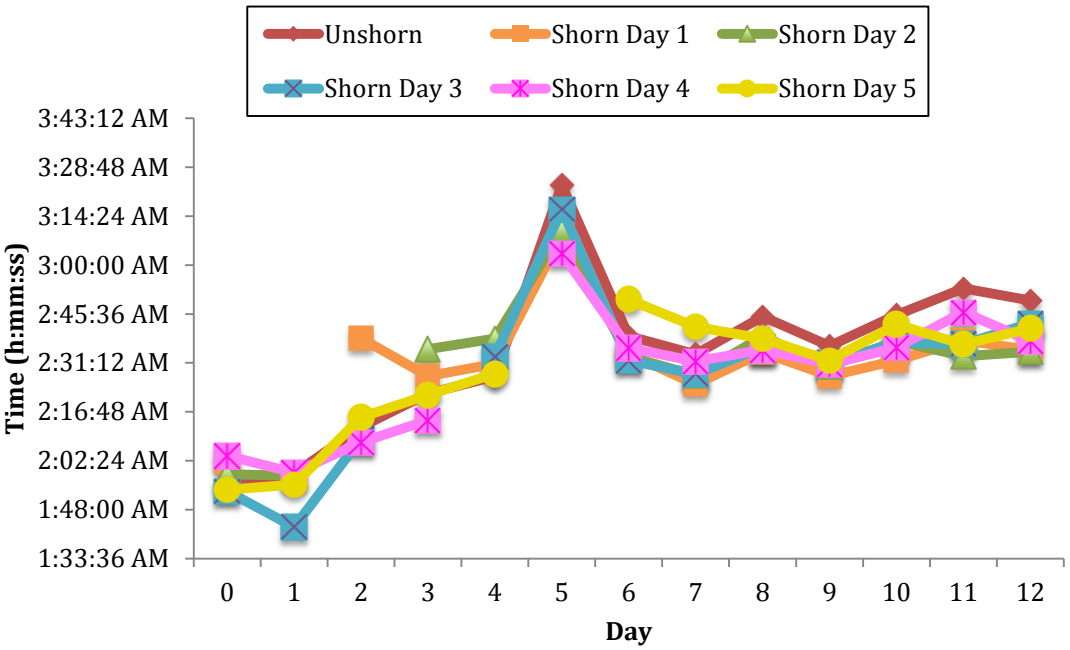


Figure 1. Mean total time sheep spent at the feed trough (pens combined).

Using the recorded data to add up the total time per day at the feed trough, those sheep that attended the feed trough for less than 30 minutes per day were identified. More sheep spent less than 30 minutes at the feed trough on day 1, and by day 4 most sheep were attending the feed troughs for more than 30 minutes.

Time Spent at the Water Troughs

There was no pen effect and therefore the pens were combined for each treatment group. There was no difference in time spent at the water trough per day between the shorn treatment groups (Figure 2). Only the control (unshorn) sheep had a time x day interaction ($p<0.001$) where they spent significantly more time at the water trough than other groups on day 4 to day 12 ($P<0.05$). There was also a significant difference between shorn and unshorn sheep ($P<0.05$), with unshorn sheep spending more time at the water trough. There was also a significant interaction between wet-bulb temperature and day where there was an increase in amount of time all treatment groups spent at the water trough as wet-bulb temperature increased from day 0 to day 13 ($P<0.001$)

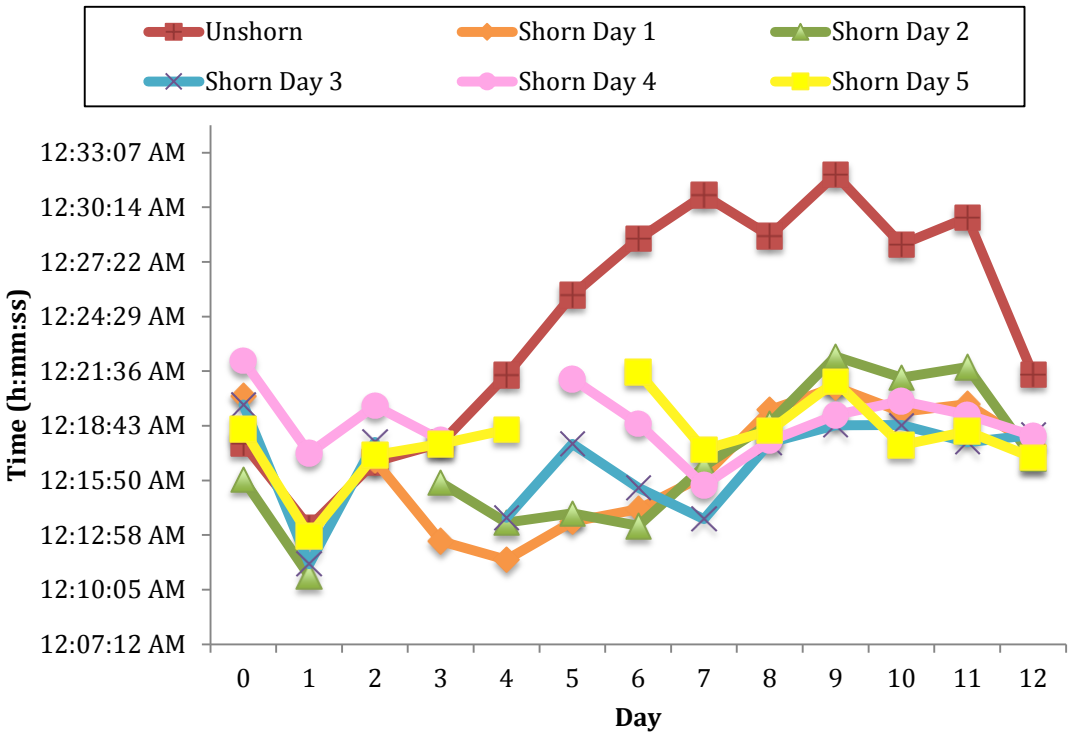


Figure 2. The mean total time sheep spent at water trough (pens combined).

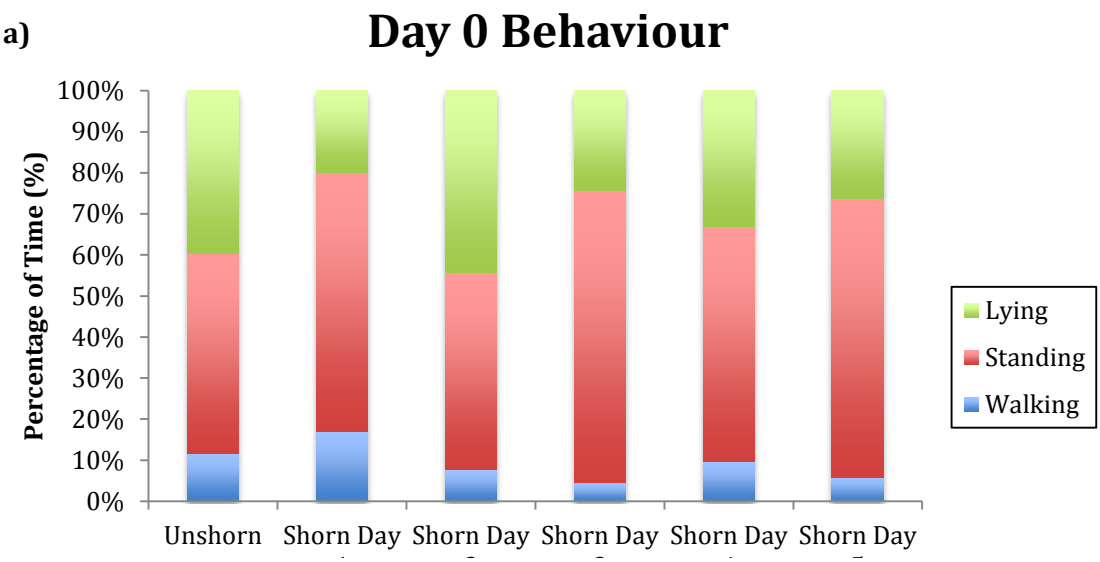
Body Condition Score

There was no statistical difference of BCS on entry to feedlot, BCS on exit from feedlot and BCS differences from entry and exit between any treatment groups ($p>0.05$). There was also no correlation in the time spent at feed troughs and the body condition score of sheep at entry, at exit and BCS differences ($p>0.05$).

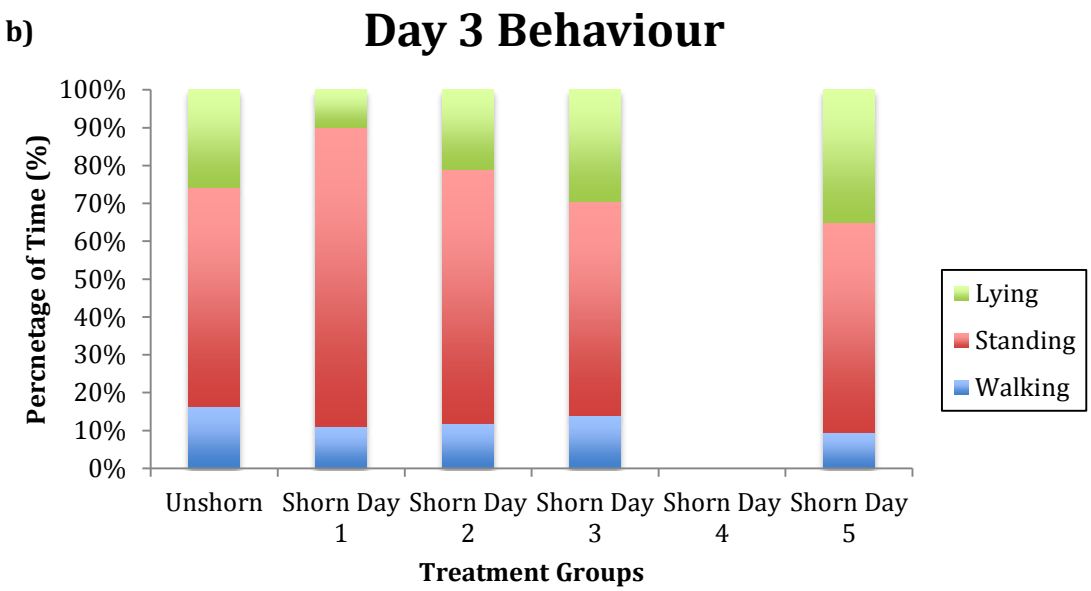
Behavioural Ethograms

The results of the behavioural ethograms for standing, lying and walking are shown in Figure 3. There was no pen effect and therefore the pens were combined for each treatment group. There was a treatment x day interaction for standing ($p<0.05$) and lying ($p<0.05$), where all treatment groups spent more time standing and less time lying from day 0 to day 13. However, it can be seen that the control (unshorn) group spent more time lying and stood less on day 6 ($p<0.05$).

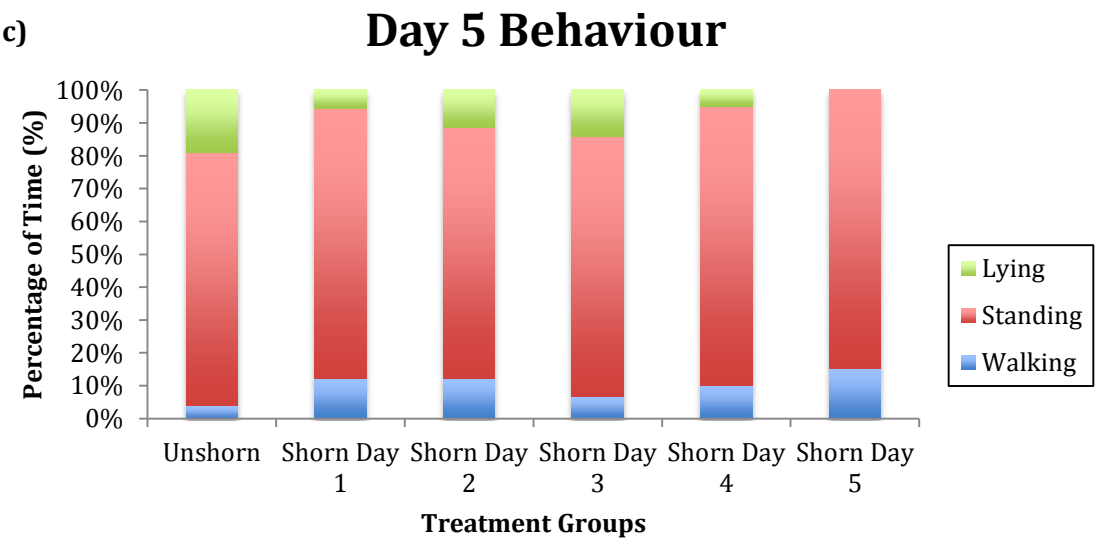
a)


Day 0 Behaviour
Percentage of Time (%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Unshorn
Shorn Day
Shorn Day
Shorn Day
Shorn Day
Shorn Day
Lying
Standing
Walking

b)


Day 3 Behaviour
Percnetage of Time (%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Unshorn
Shorn Day 1
Shorn Day 2
Shorn Day 3
Shorn Day 4
Shorn Day 5
Treatment Groups
Lying
Standing
Walking

c)


Day 5 Behaviour
Percentage of Time (%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Unshorn
Shorn Day 1
Shorn Day 2
Shorn Day 3
Shorn Day 4
Shorn Day 5
Treatment Groups
Lying
Standing
Walking

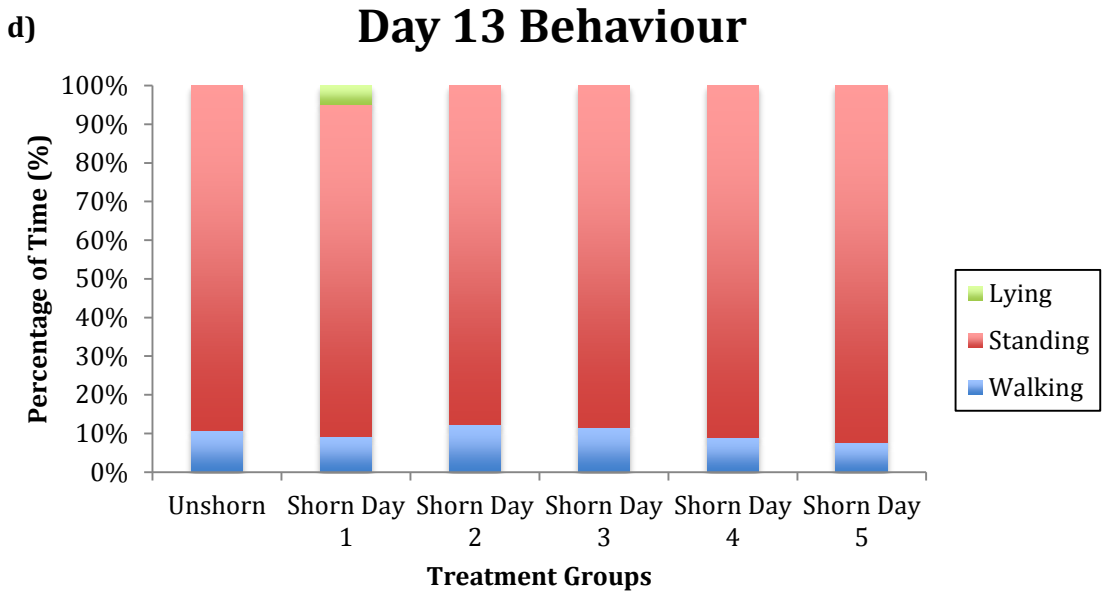


Figure 3. Percentage of time the sheep spent lying, standing and walking on day 0 (a), day 3 (b), day 5 (c), and day 13 (d)

.

Discussion

We found that there was no significant effect of day of shearing in terms of the time sheep spent at the feed trough, the water trough and in behaviour.

Several other behavioural events were recorded, including head butting, breathing fast, foot stamping, head down, rumination and vocalization (Table 1). There was no treatment effect for any event except breathing fast ($p<0.05$) by the control (unshorn) group. There was also a significant time by day interaction for breathing fast ($p<0.001$), where the control (unshorn) group performed this behaviour significantly more on day 5 and day 13 compared to the other treatment groups.

Time Spent at the Feed Troughs

There was no significant difference in total feeding time between treatment groups on any day. Therefore, our null hypothesis was retained. This indicates that day of shearing had no significant effect on the time sheep spent at the feed trough.

Whilst the effect of the shearing procedure on sheep and feedlot feed intake has been studied, these two factors have not been studied together and their correlation is unknown. Beatty *et al.* (2008)[8] found no differences in feed intake between fleeced and shorn sheep where shorn and fleeced sheep were kept in climate control rooms under thermoneutral conditions compared to hot and humid environmental conditions. The environmentally hot and humid conditions found in the Beatty *et al.* (2008)[8] study contrasted to the cooler conditions present in our study; however, neither study found a difference in feeding behaviour between shorn and unshorn sheep in terms of feed intake or time spent at the feed trough, which supports the idea that shearing does not affect

feeding behaviour. It has been found that there is a high risk of death on the live export ship when the sheep did not eat pellets late in the pre-embarkation feedlot period, indicating that mortality on board the ship was linked to sheep inappetance late in the feedlot period (Norris *et al.,* 1989c)[3]. Our experiment indicates that shearing did not appear to be a contributing factor to sheep inappetance, under our conditions, during the pre-embarkation phase of live export, and therefore shearing may occur on any day in the feedlot.

This experiment also determined how many sheep attended the feed trough for less than 30 minutes, as 30 minutes was the minimum total time previously determined to indicate adequate feed trough attendance with sheep spending less than 30 minutes being at a high risk of mortality (Barnes *et al.,* 2013)[9]. Our results corresponded with those of Barnes *et al.* (2013)[9], with some sheep spending 30 minutes or less at the feed trough on day 1 and day 2, but by day 4, most sheep were attending the feed troughs for more than 30 minutes, with no effect of shearing.

It can be seen that there was no treatment effect in the time spent at the feed trough; however, there was a time x day interaction where, on day 5, all groups significantly increased their total mean time at the feed trough. The reason for the increase in total feed time on day 5 is unknown, with the feed troughs being checked daily to ensure that the sheep were not without feed overnight as well as there being no major environmental events such as sudden changes in the temperature that could cause this increased time at the feed trough for all treatment groups. It can be speculated that perhaps the silos had been refilled on day 5 and therefore the sheep consumed more pellets compared to the day before, due to increased amount of fresh pellets available. It could also be possible that a disturbance during the night may have caused the sheep to become more active with less sleep and thus had a higher need for feeding the next day. This is possible as the sheep shed was adjacent to the sheep receival area for the feedlot and therefore a possible disturbance during the night could be the receival or loading of other sheep from a transport vehicle. Whilst this increase of time at feed trough is statistically significant, it can be postulated that this is biologically not significant.

Time Spent at the Water Troughs

There was only one treatment effect with the control (unshorn) sheep spending more time at the water trough. However, there was no significant difference in total drinking time between the shorn sheep indicating that the day of shearing had no significant effect on the sheep's time at the water trough. The control (unshorn) sheep had a time x day interaction where they spent more time at the water trough from day 4 onwards ($p<0.001$) compared to the other treatment groups. This is most likely due to the fact that the control sheep retained their fleece for the duration of this experiment. Water intake comparison between shorn and fleeced sheep has been studied before by Beatty *et al.* (2008)[8] who found that fleeced sheep had higher respiratory rates and water intakes, possibly reflecting the use of respiratory water loss via panting for evaporative cooling. The results from this experiment supports the idea that shearing is able to generate a difference in feeding behaviour between shorn and unshorn sheep, with unshorn sheep having higher requirements for water intake compared to the shorn sheep.

Body Condition Score

In this study, there was no correlation between time spent at feed trough and BCS. There was also no statistical difference between BCS on entry to feedlot and exit from feedlot, and BCS differences between any treatment groups ($p>0.05$). These results indicate that shearing on any day whilst the sheep are in the feedlot will not cause the body condition score of sheep to differ.

Behavioural Ethograms

This study determined that there was no significant difference between day of shearing groups in behaviour the sheep exhibited. Therefore, our null hypothesis that there would be no difference in behaviour was retained. However, there was a treatment x day interaction for standing ($p<0.05$) and lying ($p<0.05$), where all treatment groups spent more time standing than lying by day 13 compared to day 0. Sheep that are considered to be 'calm' generally lie down ventrally with their legs tucked under. Rather than thinking that the sheep were less calm throughout the experiment, another possible reason for why the sheep lay more on day 0 could be that the sheep were tired after standing in the transport vehicle from farm of origin to the feedlot.

Transport involves introducing animals to novel, noisy environments with food and water restriction, transport motion, mixing of animals, periods of confinement, crowding, vibration, loading and unloading, and has the potential to be a stressor for livestock. The behavioural response to transport has been investigated, with Cockram *et al.* (1996)[10] finding that in a 12-hour journey, sheep would lie down if given sufficient space, and Bradshaw *et al.* (1996)[11] finding that sheep would continue to stand regardless of available space. Therefore when arriving at the feedlot the sheep might choose to lie more on day 0 in order to rest, and then would stand more once they had recovered, as the length of stay increased.

Another reason for sheep standing more throughout the duration of the study could be due to confinements of the pen. During this study, sheep were in pens of 10 x 25 m with two hundred other sheep, and with six feed troughs and three water troughs readily available. Therefore, the sheep did not have to walk to find feed and water and, once they had recovered from the road transportation, perhaps they had a greater tendency for standing due to lack of space or options for them to perform another state to a higher degree.

On day 6, the control (unshorn) group lay more and stood less ($p<0.05$) compared to the other treatment groups. It can be postulated the control sheep and having not undergone the feed/water curfew and shearing, may have been 'calm' compared to all other groups that had been drafted, penned and isolated, feed/water deprived, shorn with risk of skin injury, and then returned to the pen the following day, all which has been seen to cause stress in the sheep.

There was only one treatment effect for the events stated in Table 1, with the control (unshorn) group being observed to be breathing faster compared to the other groups. The control (unshorn) group had a time by day interaction where they breathed faster more on day 5 and day 13 compared to the other treatment groups. Heat stress is generally associated with a reduction in feed take; however, contrary to this, all treatment groups spent more time at the feed trough on day 5 and could be breathing faster more on this day due to the additional metabolic heat generated. The heat of fermentation generated by microbial activity in the rumen may increase the heat load a sheep undergoes, with Beatty *et al.* (2008)[5] finding that the presence of fleece corresponded with high core body temperature and rumen temperatures in sheep. In addition, on day 5 and day 13, all other sheep were shorn or in the shearing shed to be shorn, so the addition of fleece could cause the increased respiratory rate.

Limitations

In retrospect, the observed behaviour of this study only focused on twenty individuals from treatment groups of one hundred, and therefore this small sample size has the

potential to skew the results compared to if these states and events where studied with a greater sample size. This study only focused on a ten-minute window of time after shearing, and therefore it could be expected if this study was filmed over the course of a day for the thirteen days, possible differences in behaviour may have been found. Also, the sheep clips were primarily taken only from one corner of the pen, with sheep constantly walking out of frame before 60 seconds, which made it difficult to ensure that the sheep that walked back into frame was the same sheep that had already been counted. Future studies may consider the use of digital pedometers to recognise whether individual sheep are at rest or are walking per day for a more accurate result.

It must also be taken into account that one line of sheep, from the same farm, was used in this study. Social mixing has been seen to disrupt social structures and influence behavioural responses in sheep and therefore our results may be skewed due to the performance of this one group of sheep. Future studies may endeavour to use different lines of sheep from different farms to allow for social mixing and individuality. A third repeat of this experiment may also be considered for confidence that all results found are significant.

Conclusion

This study demonstrated the effect of day of shearing on the time spent at the feed and water trough as well as the effect on observed behaviour. Sheep where randomly allocated days 1-5 to be shorn, with RFID tags being used to record the total time spent at the feed and water trough. Our results found there was no difference in time spent at the feed and water trough for sheep shorn on any day. Our results also found that there was no difference in observed behaviour between day of shearing treatment groups.

The main causes of shipboard death of sheep are inanition and salmonellosis, accounting for approximately 75% of mortality in the live sheep export industry. Our study shows that shearing did not appear to be a contributing factor to sheep inappetance under these conditions. However, future studies should endeavour to overcome the limitations of our experiment to verify our findings. It can be concluded, that for this group of sheep, shearing may occur on any day that the sheep are at the pre-embarkation feedlot and that current management practices will not disrupt feeding behaviour, that is the amount of time the sheep will spend at the feed and water trough, and observed behaviour.

References:

1. Norris RT, Richards RB, Dunlop RH. Pre-embarkation risk factors for sheep deaths during export by sea from Western Australia. *Australian Veterinary Journal* 1989*; 66*:309-314.
2. Makin K, House J, Perkins NR, Curran G. (2010). Investigating mortality in sheep and lambs exported through Adelaide and Portland. B.LIVE.0123, *Meat and Livestock Australia* 2010.
3. Norris RT, Richards RB. Deaths in sheep exported by sea from Western Australia - analysis of ship Master's reports. *Australian Veterinary Journal* 1989; 66:97-102.
4. Molony V, Kent JE. Assessment of acute of pain in farm animals using behavioural and physiological measurements. *Journal of Animal Science* 1997;75:266-272.
5. Lauber M, Nash JA, Gatt A, Hemsworth PH. Prevalence and incidence of abnormal behaviours in individually housed sheep. *Animals* 2012;2:27-37.

6. McClelland, B.E. (1991). Courtship and agonistic behaviour in Mouflon sheep. *Applied Animal Behaviour Science* 1991;29:67-85.
7. Stull R. Wet-bulb temperature from relative humidity and air temperature. *Journal of Applied Meteorology and Climatology* 2011;50:2267-2269.
8. Beatty DT, Barnes A, Fleming PA, Taylor E, Maloney SK. The effect on core and rumen temperature in sheep. *Journal of Thermal Biology* 2008;33:437-443.
9. Barnes A, Wickham S, Miller D, Fleming P, Collins T, Stockman C. Inanition tracking in pre-embarkation feedlots. In *Proceedings of the Australian Sheep Veterinarians Annual Conference*, Australian Veterinary Association, September 2013.
10. Cockram MS, Kent JE, Goddard PJ, Waran NK, McGilp IM, Jackson RE, Muwanga GM, Prytherch S. Effect of space allowance during transport on the behavioural and physiological responses of lambs during and after transport. *Animal Science* 1996;62:461-477.
11. Bradshaw RH, Hall SJG, Broom DM. Behavioural and cortisol response of pigs and sheep during transport. *Veterinary Record* 1996;138:233-234.