## 3.0 ABSTRACT

The study was established to compare the effects of bunk management strategies on animal health and performance. Six thousand Hereford and Hereford cross two year old steers (average initial weight 430kg) were fed for an average of 162 days in a commercial feedlot during the summer period. Animals were allocated to one of four bunk management treatments with each treatment replicated six times. Treatments were (1) *ad lib* feeding, four feed deliveries per day, delivered throughout the day, with a morning bunk assessment, (2) *ad lib* feeding, one feed delivery per day in the morning with a morning bunk assessment, (3) clean bunk at midday, one delivery per day in afternoon with bunk assessment at midday and (4) clean bunk at midday, two feed deliveries per day, one morning delivery representing a maximum of 30% of total allocation and one afternoon delivery representing a maximum of 70% of total allocation, with bunk assessment at midday. The bunk management strategies were compared on cost of feeding (feed wastage, labour and machinery requirements), live animal performance (feed intake, weight gain, daily gain and feed conversion efficiency), carcass composition (hot carcass weight, dressing percentage, bruising, and number of animals achieving grain fed market specifications), health status (number pulled, treated and non treated, stool assessment and ailments, eg. digestive, respiratory, physical, foot rot/lame), feed intake variation, individual animal carcass composition (individual animal carcass weight, fat depth, fat colour, marbling score and meat colour tested against treatment, breed, origin and age) and feeding activity.

The frequency with which feed bunks required cleaning was significantly greater ($P<0.001$) for the *ad lib* treatments than the clean bunk treatments. Both *ad lib* treatments resulted in significantly higher ($P<0.0001$) feed wastage on a dry matter basis than clean bunk treatments. High feed wastage and cleaning frequency associated with *ad lib* feeding treatments resulted in significantly ($P<0.05$) higher feeding cost than clean bunk treatments. The incidence of digestive disorders for animals in treatment 1 was the only group where health disorders were significantly higher ($P<0.029$) than other bunk management strategies. Significant variation in feed intake occurred ($P<0.05$) on a daily basis, irrespective of treatment, however the clean

bunk management strategies significantly reduced ($P<0.05$) feed intake variation during changes in environmental conditions, eg. heat stress, rain events. Treatment had no effect on feed intake suggesting that the clean bunk strategies were not restricting intake. Feed intake restriction was avoided by the clean bunk management strategy by synchronising the clean bunk with minimal feeding activity and the inherent feed intake indicators, ie. feed remaining in bunk and feeding activity response, provided by the clean bunk at midday management strategy. Live animal performance and carcass composition were not significantly different between bunk management strategies, however in terms of individual carcass composition, fat depth and age were significant for all terms ($P<0.05$) and marbling score was significantly different for treatments ($P<0.04$). Feeding activity pattern was similar for all bunk management strategies. Initiation of feeding corresponded closely with sunrise and sunset and in response to feed delivery. Feeding response was highest for all treatments when feed delivery corresponded with sunrise and sunset. All animals showed a similar feeding activity pattern of high intensity, short feeding duration during morning feeding and low intensity, extended feeding duration during the afternoon feeding, with minimal feeding activity during midday. Animals that fed at midday lacked the intensity of the morning feeding behaviour.

Little work has been undertaken to evaluate the effect of bunk management strategies on animal health, performance and cost of production in a commercial feedlot. A clean bunk management strategy that encourages animals to clean the bunk of feed by midday and provides delivery of feed in proportions which meet animals natural feeding activity pattern has the potential to reduce feeding cost, maintain health status and performance, particularly during the summer period when these aspects can be compromised due to environmental stress. The clean bunk management strategies significantly reduced feeding costs without compromising animal health, performance or carcass composition compared to *ad lib* feeding.

# 4.0 A COMPARATIVE STUDY OF BUNK MANAGEMENT STRATEGIES

## 4.1 INTRODUCTION

Bunk management has an impact on profitability. The time of day feed bunks and animals are assessed, quantity of feed allocated within a day and timing and accuracy of feed delivery has a direct effect on production cost and carcass quality. Traditionally, *ad lib* feeding has been the preferred method of feeding cattle, with animal assessment and feed allocation made in the morning and feed delivered throughout the day. Maintaining satisfactory levels of feed intake is critical to the profitability of feedlotting. However, large fluctuations in feed intake are associated with *ad lib* feeding. Large fluctuations in feed intake predispose animals to digestive disorders and increase feed wastage (Slyter 1976). Maintaining feed *ad libitium* increases machinery and milling requirements (Hicks et al 1990). Bunk management strategies that reduce feed intake variation lower production costs and improve cattle performance.

A clean bunk management strategy is based on animals consuming all feed from bunks at least once per day, with the amount of feed remaining as an indicator of feed required for the following 24 hours. The accuracy of the bunk call is important for controlling animal aggression and feed wastage. This strategy aims to minimise daily intake variation through providing appropriate quantities of feed that are synchronised with the animals natural peaks in feeding activity. Feeding activity is strongly influenced by photoperiod. Peaks in feeding activity are stimulated by sunrise and sunset (Gonyou and Stricklin 1984). In the middle part of the day, most animals rest and ruminate (Vasilatos and Wangsness 1980) with little feeding activity (Ray and Roubicek 1971). Encouraging animals to clean the bunk of feed prior to the middle part of the day provides a greater opportunity to maintain animal performance and health during the summer period. Heat stress in summer can reduce intake and FCR. Feeding strategies which minimise metabolic heat production during the hot part of the day will reduce heat stress.

The study was a test of the hypothesis that a feeding strategy that provides feed in quantities that match natural feeding activity and encourages animals to clean the bunk of feed at midday will be cost effective and give the best animal production results. To test this hypothesis, four feeding strategies were compared under commercial feedlot conditions during the summer months.

Four bunk management strategies were selected and measurements made on animal performance, production costs and health during the summer period. These management strategies included two *ad lib* treatments, one of which involved four deliveries per day and two clean bunk at midday treatments, one of which involved two deliveries per day. The clean bunk treatments were designed to provide appropriate quantities of feed and time of feed delivery to meet natural feeding activity of cattle.

## 4.2 METHODS AND MATERIALS

The study was conducted at Whyalla Feedlot, located 40km north west of Texas in south east Queensland. Animals were held in 30m by 30m shaded pens with access to two watering points and a 30m feed bunk.

The treatments were selected to compare two basic bunk management strategies, *ad lib* feeding (treatments 1 and 2) with clean bunk at midday, (treatments 3 and 4). Also incorporated into the trial was the effect of increasing feeding frequency (treatment 1) and providing appropriate quantities of feed at appropriate times to meet natural feeding activity of cattle (treatment 4). Treatment comparisons were made in terms of feeding cost, animal performance and health.

*Cattle:* A total of 6000 head of mainly *Bos taurus* genotype cattle were selected for the trial. On induction the animals averaged two years of age and 430kg. Animals were composed of mainly Hereford and Hereford cross steers and originated from New South Wales and southern Queensland. At induction all animals were individually weighed and received the hormonal growth promotant Synovex-S, 2ml/hd of vitamin B12, 4 ml/hd of vitamins A,D and E, 4 ml/hd of 5 in 1 vaccine, 10ml/hd of licacide and vaccination for infectious bovine rhinotrachitus and *Pasturella heamolytica.* All animals were moved to clean pens after the second weighing. Feed intake information was taken from the first day trial cattle received feed.

*Feeding:* Animals were fed according to a 150 day feeding programme. Actual days on feed averaged 156 and trial days on feed averaged 137. All animals were fed a barley-based diet throughout the trial. Barley made up the majority of the grain proportion when two grains were utilised. During the trial, three major grain changes occurred. There was a transition from barley to barley/sorghum and then to barley/wheat. Total grain content of diet averaged 74% (as fed basis). Grain was processed by steam flaking. Nutritional analysis of the ration is provided in table 4.1.

**Table 4.1: Nutritional analysis (theoretical values) of the ration fed during trial feeding period**

| Nutrient | Value |
|---|---|
| Dry Matter (%) | 78.1 |
| Crude Protein (%) | 12.9 |
| Metabolisable Energy (MJ/kg DM) | 12.9 |
| Neutral Detergent Fibre (%) | 24.7 |

Feed was allocated to *ad lib* treatments to ensure at least 10cm of feed remained in the bunk throughout the day. For clean bunk treatments feed was allocated to ensure only a scattering of feed remained on the lining of the bunk at time of bunk "call". During the trial, only two allocaters were used for bunk "calling". One allocater for "calling" the *ad lib* treatments and one allocater for "calling" the clean bunk treatments.

All bunks were cleaned as required. The *ad lib* treatment bunks were cleaned at least once every three days and more often when practical. All bunks were cleaned of feed within 24hrs of a rain event. Feed residues were estimated by filling a 50 L bin with feed and recording the number of shovel scoops required to fill it. The bin was filled three times for each bunk cleaned. The bin was weighed on a set of bathroom scales. The weight of feed residue remaining in the bunk was estimated from the number of shovel scoops to clean the bunk. Samples of feed residues were taken for dry matter analysis. All spilt feed was weighed. Records of feed delivered, feed removed and feed dry matter analysis were recorded daily.

Pens that required more than one delivery within the same feeding period, received second delivery within 20 minutes of the first. Feed delivery times were maintained as consistently as possible. General feeding sequence involved feeding in alphabetical order. Of the trial pens, O row was fed first through to W row which was last. However, the afternoon feed delivery times were altered mid December 1996 in preparation for feeding during February, the most environmentally stressful period. During this transition period, afternoon feeding times were moved back by two hours over a three week period. Table 4.2 provides an indicator of average feeding times of replicates during the trial.

**Table 4.2: Average feeding times of replicates from each treatment**

| Treatment | Replicate | Pen | 1st feed | 2nd feed | 3rd feed | 4th feed |
|---|---|---|---|---|---|---|
| 1 | 1 | P04 | 07:10 | 09:00 | 15:00 | 17:45 |
| 1 | 2 | S05 | 08:10 | 09:00 | 16:00 | 17:45 |
| 1 | 3 | W05 | 08:10 | 09:00 | 17:10 | 17:45 |
| 1 | 4 | O03 | 07:45 | 08:45 | 14:00 | 17:15 |
| 1 | 5 | R05 | 07:45 | 09:00 | 15:40 | 17:45 |
| 1 | 6 | Q07 | 08:00 | 09:00 | 15:30 | 17:45 |
| 2 | 1 | P06 | 07:30 | | | |
| 2 | 2 | S07 | 07:45 | | | |
| 2 | 3 | W04 | 08:10 | | | |
| 2 | 4 | O05 | 06:50 | | | |
| 2 | 5 | R03 | 07:45 | | | |
| 2 | 6 | Q05 | 08:00 | | | |
| 3 | 1 | P07 | 15:20 | | | |
| 3 | 2 | S06 | 16:00 | | | |
| 3 | 3 | W02 | 17:00 | | | |
| 3 | 4 | O04 | 14:00 | | | |
| 3 | 5 | R04 | 15:40 | | | |
| 3 | 6 | Q04 | 15:30 | | | |
| 4 | 1 | P05 | 05:20 | 15:35 | | |
| 4 | 2 | S04 | 06:00 | 16:00 | | |
| 4 | 3 | W03 | 06:30 | 17:00 | | |
| 4 | 4 | O06 | 05:15 | 15:15 | | |
| 4 | 5 | R06 | 05:50 | 15:40 | | |
| 4 | 6 | Q07 | 05:50 | 15:30 | | |

*Feeding Behaviour:* During the trial, feeding behaviour observations were made on four separate days. Recording dates were 15th December 1996, 12th January 1997, 19th January 1997 and 9th February 1997. The number of animals standing on the concrete apron in front of the bunk (animals waiting to feed) and the number of animals physically consuming feed were recorded every hour between 3am to 10pm. Chase et al (1976) and Vasilatos and Wangsness (1980) reported the consumption of feed accounted for only 60% of the time cattle remained at the bunk. Animals standing on the concrete apron and therefore waiting were included in the feeding activity observations as not all animals of the pen could stand and feed at the bunk at one time. Other factors recorded included feed remaining in the bunk, times of feed delivery and sunrise and sunset times. Weather station information was also collected every hour during observation period. Data recorded included temperature, humidity and solar radiation. For each recording day, four pens were selected randomly, one pen from each treatment but not from the same replicate.

*Environmental Conditions:* A weather station was used to record daily minimum and maximum temperature (°C), humidity, rainfall events (mm) and solar radiation (nm, nanometer per second). Maximum temperature and humidity records were used to calculate THI (Temperature and Humidity Index) (Hahn 1995b) by the following equation: THI = dry bulb temp °C + 0.36 x dew pt temp °C + 41.2.

*Cattle Management:* Cattle that either died or were removed from treatment pens because of poor health status were recorded by date and diagnosis. Removal of animals from pens, (referred to as "pulls") were categorised into respiratory, physical, digestive or ill thrift groups. Animals were considered to have respiratory problems if they suffered from any two of the following conditions; extended neck, drooling, rapid breathing, flank breathing or coughing. Physical conditions included lameness, foot rot and buller behaviour. Digestive conditions included bloat, coccidiosis, acidosis and Polioencaphalmacia. Ill thrift included any animals that showed a hollow appearance after 20 days on feed. An autopsy was performed on all dead animals. The same group of pen riders were used to assess all trial cattle.

Animals that were removed from treatment pens and not returned, eg. antibiotic treated cattle, bullers and culls, were not included in performance estimations.

A faecal assessment was performed on all treatment pens. Faecals were assessed on the basis of consistency, wetness and colour and given a score as described in table 4.3. Faecal assessments were recorded once weekly from 30 to 60 days on feed and once fortnightly from day 61 to despatch.

**Table 4.3: Faecal assessment**

| Score | Stool Description | Definition |
|---|---|---|
| 1 | firm, dry and tall | digestive tract non challenged |
| 2 | loose, soft and brown | optimum |
| 3 | loose, watery and grey | digestive tract over challenged |
| blood | streaks of blood | ulceration of colon, coccidiosis |

*Cattle Performance Recording:* All treatment cattle were weighed as a group on departure from the feedlot to give the "out" weight. Animals were weighed following a minimum 12 hour curfew, ie. no feed access, only water access. Out weights were used to calculate daily gain, feed conversion efficiency and cost of gain for each pen.

*Carcass Composition Recording:* All carcass information was collected from the abattoir on an individual animal basis. Information collected included hot carcass weight, fat depth, age (dentition assessment) marbling score, meat colour, fat colour, bruising and carcass grade using supplied AUS-MEAT feedback sheets. The assessment of marbling score, meat colour and fat colour were determined by various AUS-MEAT assessors. The cattle in the trial were fed for the Japanese grain-fed market. General carcass specifications are provided in table 4.4.

**Table 4.4: Japanese grain fed carcass specifications (AUS-MEAT 1996)**

| Specifications | Requirement |
|---|---|
| Hot carcass weight (kg) | 299.1 - 470 |
| Fat depth (mm) | less than 30 |
| Age (dentition) | 4 tooth or less (2yrs) |
| Marbling score | 2 and greater |
| Meat colour | less than or equal to 1 |
| Fat colour | less than or equal to 1 |

*Statistical Analysis:* One-way analysis of variance was used to analyse all pen information including, induction weight, trial starting weights, trial out weights, feed intake on an "as fed" basis, dry matter intake, feed wastage, number of times bunks required cleaning, daily live weight gain, feed conversion efficiency, morbidity, dressing weight, payment per kg, dressing percentage, bruising, marketing grade and cost of feeding.

Variation in feed intake was analysed by three methods.

(1) Complete analysis of feed intake variation over the trial period (137days inclusive). Analysis was run by statistical models developed by Sullivan (1997). Variation in feed intake was analysed as actual feed intake as fed, actual feed intake dry matter, delivered feed intake as fed and delivered feed intake dry matter. Actual pen feed intake was calculated as the difference between feed delivered and feed removed, and delivered feed intake was the total quantity of feed delivered to the bunk. The four data sets were analysed using repeated measures and analysis of variance. The repeated measures assumed pens were random variables, so different error terms were used for the between pen analysis and the within pen analysis. The repeated measures for between and within pens were tested using analysis of variance incorporating days as the main factor with 127 levels, each level representing one day. The analysis of variance treated the pens as factors nested within treatments rather than as random variables as in the repeated measures test. Days of intake are modelled as a linear term only.

(2) Feed intake data for actual feed intake dry matter and "as delivered" feed intake dry matter were analysed separately for variation in feed intake over 5 and 10 day periods. Data sets were tested for significance in feed intake variation within these periods using analysis of variance in the form of a two factorial fixed effects design (Montgomery 1997). Analysis was run on Microsoft Excel. The two factors included bunk management treatments at two levels, eg. ad lib and clean bunk and number of feeds at two levels, eg. single feeding and multiple feeding, including interaction between bunk management and number of feeds.

These two methods of analysis were designed to test for differences in feed intake between the treatments only. All replicates were included. Analysis was based on feed intake records collected by days on feed rather than by calendar date, in order to minimise the effect of the environment on the results.

(3) The trial was divided into individual replicates and tested for variation in feed intake between treatments using a two factorial fixed effects design as described in (2) and one-way analysis of variance. Significant differences between means were determined by Duncan's Multiple Range test at 5%. Data tested was in the form of "as fed" and delivered feed intake. Analysis was run on Microsoft Excel. This form was used to signify the possible level of variation in feed intake the allocater would observe. The analysis considered two separate periods in which environmental conditions appeared to have significant influence on feed intake pattern. Periods included 40 days from the 24th October 1996 to the 2nd December 1996 and a 36 day period from the 2nd January 1997 to the 6th February 1997. Feed intake data was converted into Animal Intake Variance (AIVs) as described in Stock et al (1995). AIVs were calculated from 5 day averages within the specified analysis periods.

The objective of the analysis described above was to determine whether prevailing environmental conditions had a significant effect on feed intake variation between treatments and to determine whether any treatments reduced the effect of environmental conditions on feed intake variation. During the two periods of analysis, environmental recordings were made for rain events and average temperature humidity index (THI).

Individual animal data was analysed using a five-factor analysis of variance. These factors were: pen (a factor with 24 levels), treatment (a factor with 4 levels), breed (a factor with 15 levels), origin (a factor with 10 levels), age (continuous measure) and in weight ( continuous measure). Data analysed included carcass weight, fat depth (mm), fat colour, marbling score and meat colour. Analysis was conducted by a statistical model developed by Sullivan (1997).

### 4.2.1 Experimental Design

All animals were grouped into lots of 250hd and randomly allocated to treatments. Each treatment was replicated six times. All 6000 trial cattle were inducted into the feedlot within 22 days. After approximately 30 days on feed all animals received their booster vaccination and were re-weighed. This weight was used as the trial starting weight.

Due to time and space limitations and practical considerations, random allocation of animals to treatments on induction into the feedlot was not possible. Animals were allocated to pens by purchase groups and order of receival. The number of cattle and replicates involved in the trial were included to minimise the effect of non randomisation.

*Treatment:* The trial was composed of four treatments, with each treatment replicated six times. The treatments were:

Treatment 1. Four feed deliveries per day, two in the morning and two in the afternoon, *ad lib* feeding with morning bunk assessment.

Treatment 2. One feed delivery per day in the morning, *ad lib* feeding with morning bunk assessment.

Treatment 3. One feed delivery in the afternoon, clean bunk at midday, bunk assessment at midday

Treatment 4. Two feed deliveries per day, one feed in morning representing a maximum of 30% of total allocation and one feed in afternoon representing a maximum of 70% of allocation, clean bunk at midday, bunk assessment at midday

Summary of treatment descriptions provided in table 4.5.

**Table 4.5: Summary of the various components of each treatment**

| Treatment | Treatment Number | | | |
|---|---|---|---|---|
| Summary | 1 | 2 | 3 | 4 |
| bunk strategy | ad lib | ad lib | clean | clean |
| feeding frequency | 4 | 1 | 1 | 2 |
| feeding time | 2 x am / 2 x pm | 1 x am | 1 x pm | 1 x am / 1 x pm |
| feed proportion | 25:25:25:25 | 100 | 100 | 30:70 |
| bunk assessment | am before first feed | am before first feed | midday | midday |

All treatment pens were located in the same area of the feedlot. Each treatment within each replicate was assigned a pen randomly. All pens not assigned treatments were filled with non trial cattle. Table 4.6 shows pen, treatment and replicate location within the area used for trial.

**Table 4.6: Allocation of treatments to pens, pen and replicate location. Pens containing "0" indicate non trial cattle. Treatments 1, 2, 3 and 4 described as T1, T2, T3 and T4 respectively.**

<table>
<tr><th></th><th colspan="8">Pen number</th><th></th></tr>
<tr><th>Row</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>Replicate</th></tr>
<tr><td>N</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td></td></tr>
<tr><td>O</td><td>0</td><td>0</td><td>T1</td><td>T3</td><td>T2</td><td>T 4</td><td>0</td><td>0</td><td>4</td></tr>
<tr><td>P</td><td>0</td><td>0</td><td>0</td><td>T1</td><td>T4</td><td>T2</td><td>T3</td><td>0</td><td>1</td></tr>
<tr><td>Q</td><td>0</td><td>0</td><td>0</td><td>T3</td><td>T2</td><td>T4</td><td>T1</td><td>0</td><td>6</td></tr>
<tr><td>R</td><td>0</td><td>0</td><td>T2</td><td>T3</td><td>T1</td><td>T4</td><td>0</td><td>0</td><td>5</td></tr>
<tr><td>S</td><td>0</td><td>0</td><td>0</td><td>T4</td><td>T1</td><td>T3</td><td>T2</td><td>0</td><td>2</td></tr>
<tr><td>T</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td></td></tr>
<tr><td>U</td><td colspan="2">0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td></td></tr>
<tr><td>V</td><td colspan="2">0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td></td></tr>
<tr><td>W</td><td colspan="2">0</td><td>T3</td><td>T4</td><td>T2</td><td>T1</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td>X</td><td colspan="2">0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td></td></tr>
</table>

*Strengths and Weaknesses:* The major strength of this trial was that it was conducted under commercial conditions. Therefore, management problems associated with each bunk management strategy could be assessed. It provided the opportunity to obtain realistic figures concerning labour and machinery requirements and production costs. In addition the effects of bunk management treatments on animal performance and health could be determined. A smaller experimental trial could not provide realistic results concerning management problems, animal performance and costs associated with bunk management treatments.

The commercial nature of the trial also introduced inherent experimental weaknesses. Animals could not be randomly allocated to treatments. Animals were allocated to treatments in groups of 250 head, composed of a variety of breeds, origins, frame size and weight. The timing of feed deliveries on a day to day basis was not always consistent. Whenever possible, deliveries were scheduled to minimise feeding disruption to the rest of the feedlot, eg. the morning feed of treatment 2, ie. *ad lib* feeding, one am feed delivery, was delivered at the end of the morning feeds, feed deliveries associated with treatments 3 and 4, ie. clean bunk, one and two deliveries respectively, were scheduled into the general feeding pattern of the feedlot and the first feed for treatment 1, ie. *ad lib* feeding, four deliveries per day, was delivered at the completion of the morning feed delivery, the second and fourth feed were delivered when ever practical, with the third feed scheduled in with the general feedlot operation.

*Feeding Costs*: Feeding costs for each treatment were determined by the costs associated with feed offered on a dry matter basis (including wastage), labour associated with cleaning, delivery and additional milling required to satisfy wastage bunk management requirements of each treatment. These costs were evaluated for each treatment in terms of cost per pen. The explanation of each operational cost associated with the trial is provided in table 4.7.

**Table 4.7. Operation costs including feeding, feed wastage, labour required for cleaning, delivery and milling requirements associated with bunk management and the explanation of how each cost is determined.**

| Operation | Explanation |
|---|---|
| Feeding | cost per tonne of complete feed offered (DM basis) |
| Feed wastage | cost of feed wastage included in feed offered |
| Labour (cleaning) | 400kg cleaned per hour, labour cost per hour $10 |
| Delivery | number of deliveries @ $2.50 per delivery |
| Milling | additional grain production cost associated with feed wastage @ $6.50/MT |

## 4.3 RESULTS

### 4.3.1 Pen Results

#### 4.3.1.1 Bunk management

The frequency with which feed bunks required cleaning was significantly greater ($P<0.001$) for the *ad lib* treatments than the clean bunk treatments. Both *ad lib* treatments resulted in significantly higher ($P<0.0001$) feed wastage on a dry matter basis than clean bunk treatments. Greatest feed wastage occurred with treatment 1. High feed wastage and labour costs associated with *ad lib* treatments resulted in significantly ($P<0.05$) higher feeding cost than clean bunk treatments. Feeding costs (cost/pen/experimental period) associated with treatments are summarised in Table 4.8.

**Table 4.8: Total feed wastage and costs associated with total feed offered, cleaning frequency, labour required for cleaning, delivery and milling required for feed wastage associated with bunk management strategies.**

| | Treatment | | | | |
|---|---|---|---|---|---|
| | 1<br>ad lib<br>4 feeds/d<br>25:25:25:25 | 2<br>ad lib<br>1 feed/d<br>100% am | 3<br>clean bunk<br>1 feed/d<br>100% pm | 4<br>clean bunk<br>2 feeds/d<br>30% am 70% pm | SEM |
| Total dry matter feed delivered (tonnes/pen/exp period) | 375.6$^{a}$ | 385.4$^{a}$ | 376.6$^{a}$ | 363.9$^{a}$ | 7.35 |
| Cost of feed delivered ($/tonne/pen/exp period) | $179.9$^{a}$ | $178.0$^{a}$ | $177.2$^{a}$ | $177.7$^{a}$ | 0.07 |
| Cost of total feed offered ($/pen/exp period) | $66 018$^{a}$ | $67 875$^{a}$ | $66196$^{a}$ | $63 964$^{a}$ | 1257 |
| Total feed wastage (tonnes DM/pen/exp period) | 7.5$^{a}$ | 7.3$^{a}$ | 0.2$^{b}$ | 0.2$^{b}$ | 0.23 |
| Cleaning frequency (no./pen/exp period) | 32$^{a}$ | 31$^{a}$ | 2$^{b}$ | 1$^{b}$ | 3.07 |
| Labour cost ($/pen/exp period) | $189.90$^{a}$ | $183.56$^{a}$ | $4.44$^{b}$ | $5.08$^{b}$ | 12.64 |
| Delivery cost ($/pen/exp period) | $1370.00 | $550.00 | $550.00 | $685.00 | - |
| Milling cost for feed wastage ($/pen/exp period) | $36.54$^{a}$ | $35.31$^{a}$ | $0.85$^{a}$ | $0.98$^{a}$ | 2.43 |

Different superscripts in the same row indicate values that are significantly different, ($P < 0.05$)

Feed wastage was associated with both dry periods and rain events. Feed wastage associated with rain events included feed removed during actual rain days and feed removed on the three days following the rain event. Highest feed wastage was associated with *ad lib* treatments for both dry and rain periods. Feed wastage associated with dry days and rain events are summarised in table 4.9.

**Table 4.9: Treatment feed wastage (tonnes DM/pen/exp period) associated with dry days and rain events (pen averages).**

| | | Treatment | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| Days | rain (mm) | ad lib 4 feeds/d 25:25:25:25 | ad lib 1 feed/d 100% am | clean bunk 1 feed/d 100% pm | clean bunk 2 feeds/d 30% am 70% pm |
| 95 | 0 | 21.4 | 23.3 | 0.5 | 0.04 |
| 4 | 13.8 | - | 0.40 | - | - |
| 1 | 0.8 | 1.74 | 0.00 | 0.00 | 0.00 |
| 3 | 21.2 | 2.89 | 0.80 | 0.20 | 0.02 |
| 1 | 11.2 | 1.43 | 1.91 | 0.23 | 0.25 |
| 3 | 31.4 | 1.82 | 2.05 | 0.45 | 0.12 |
| 2 | 8.4 | 0.69 | 1.68 | 0.00 | 0.51 |
| 2 | 7.0 | 0.48 | 1.30 | 0.11 | 0.00 |
| 8 | 89.8 | 6.35 | 6.51 | 0.30 | 0.00 |
| 2 | 5.2 | 1.41 | 1.32 | 0.00 | 0.00 |
| 1 | 9.8 | 0.71 | 2.01 | 0.00 | 0.00 |
| 7 | 41.6 | 4.53 | 6.79 | 0.23 | 0.28 |
| 6 | 89.6 | 2.49 | 2.96 | 0.00 | 0.00 |
| 1 | 6.2 | 0.00 | 0.48 | 0.00 | 0.00 |
| 1 | 7.4 | 0.08 | 0.04 | 0.00 | 0.00 |
| Total (42 rain days) | 343.4 | 24.62 | 28.25 | 1.52 | 1.18 |

### 4.3.1.2 Cattle performance

Bunk management strategies resulted in no significant difference (see Table 4.10) between treatments, based on pen averages for actual dry matter feed intake, total weight gain, daily gain and feed conversion efficiency. Feed conversion efficiency was calculated using the amount of feed consumed by the pen (ie. excluding feed wastage).

**Table 4.10: Bunk management strategy treatment results for feed intake, weight gain, daily gain and feed conversion efficiency over trial period (pen averages).**

| | Treatment | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | |
| | ad lib<br>4 feeds/d<br>25:25:25:25 | ad lib<br>1 feed/d<br>100% am | clean bunk<br>1 feed/d<br>100% pm | clean bunk<br>2 feeds/d<br>30% am 70% pm | SEM |
| Feed intake (kg DM/hd/d) | 11.6[a] | 11.8[a] | 11.6[a] | 11.4[a] | 0.19 |
| Weight gained (kg) | 212[a] | 207[a] | 205[a] | 200[a] | 3.25 |
| Daily gain (kg/d) | 1.56[a] | 1.51[a] | 1.48[a] | 1.46[a] | 0.28 |
| Feed conversion (as fed) | 9.45[a] | 9.93[a] | 9.92[a] | 9.91[a] | 0.68 |
| Feed conversion (DM) | 7.51[a] | 7.90[a] | 7.88[a] | 7.88[a] | 0.61 |

Different superscripts in the same row indicate values that are significantly different, ($P < 0.05$)

### 4.3.1.3 Carcass traits

Bunk management strategies resulted in no significant difference (see Table 4.11) between treatments (based on pen averages) for hot carcass weight, dressing percentage, bruising incidence and percentage of animals achieving Japanese grain fed carcass specifications.

**Table 4.11: Bunk management strategy treatment results for hot carcass weight, dressing percentage, bruising incidence and percentage of pen achieving Japanese grain fed carcass specifications (pen averages).**

| | Treatment | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | |
| | ad lib<br>4 feeds/d<br>25:25:25:25 | ad lib<br>1 feed/d<br>100% am | clean bunk<br>1 feed/d<br>100% pm | clean bunk<br>2 feeds/d<br>30% am 70% pm | SEM |
| hot carcass weight (kg) | 373.8$^{a}$ | 377.6$^{a}$ | 372.9$^{a}$ | 367.3$^{a}$ | 1.77 |
| dressing % | 55.6$^{a}$ | 55.5$^{a}$ | 55.3$^{a}$ | 55.8$^{a}$ | 0.005 |
| bruising (hd no) | 18$^{a}$ | 21$^{a}$ | 19$^{a}$ | 20$^{a}$ | 1.63 |
| grain fed (%)* | 99.6$^{a}$ | 99.4$^{a}$ | 99.3$^{a}$ | 98.9$^{a}$ | 0.002 |

Different superscripts in the same row indicate values that are significantly different, ($P < 0.05$)
* Animals achieving Japanese grain fed carcass specifications

### 4.3.1.4 Health

Health status of animals (see Table 4.12) in terms of total non treated, treated and returned, non returned, total pulls, bullers and dead animals were not significantly different between treatments.

**Table 4.12: Pen average health status of treatments in terms of total non treated, treated and returned, non returned, total pulls, bullers and deads.**

| | Treatments | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | |
| | ad lib<br>4 feeds/d<br>25:25:25:25 | ad lib<br>1 feed/d<br>100% am | clean bunk<br>1 feed/d<br>100% pm | clean bunk<br>2 feeds/d<br>30% am 70% pm | SEM |
| non treated | 216.7$^{a}$ | 217.5$^{a}$ | 218.8$^{a}$ | 215.3$^{a}$ | 1.49 |
| treated and returned | 19.2$^{a}$ | 13.2$^{a}$ | 14.5$^{a}$ | 18.0$^{a}$ | 1.08 |
| non returned | 8.5$^{a}$ | 10.8$^{a}$ | 6.3$^{a}$ | 8.3$^{a}$ | 0.92 |
| total pulls | 27.7$^{a}$ | 24.0$^{a}$ | 20.8$^{a}$ | 26.3$^{a}$ | 1.37 |
| bullers | 4.0$^{a}$ | 7.5$^{a}$ | 8.2$^{a}$ | 7.3$^{a}$ | 1.06 |
| deads | 1.7$^{a}$ | 1.0$^{a}$ | 2.2$^{a}$ | 1.0$^{a}$ | 0.26 |

Different superscripts in the same row indicate values that are significantly different, ($P < 0.05$)

Faecal assessment was also not significantly different (see Table 4.13) between treatments.

**Table 4.13: Faecal treatment assessment scores for each faecal assessment category during trial feeding period (pen average).**

| | Treatment | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | |
| Faecal assessment category | ad lib 4 feeds/d 25:25:25:25 | ad lib 1 feed/d 100% am | clean bunk 1 feed/d 100% pm | clean bunk 2 feeds/d 30% am 70% pm | SEM |
| 1- firm, dry, tall | 11[a] | 7[a] | 12[a] | 12[a] | 2.01 |
| 2- loose, soft, brown | 401[a] | 439[a] | 433[a] | 378[a] | 2.37 |
| 3- loose, watery, grey | 10[a] | 11[a] | 11[a] | 8[a] | 0.38 |
| blood | 1[a] | 1[a] | 1[a] | 0[a] | 0.04 |

Different superscripts in the same row indicate values that are significantly different, (P < 0.05)

Incidence of digestive disorders was the only health disorder significantly different between treatments (see Table 4.14) on a pen average basis. Treatment 1 was significantly higher than the other three treatments (P<0.029). Treatments 2, 3 and 4 were not significantly different.

**Table 4.14: Number of animals diagnosed with health disorders during the trial period. Diagnosis divided into digestive, respiratory, physical and foot rot/lame disorders (pen average).**

| | Treatment | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | |
| Health Diagnosis (hd/pen) | ad lib 4 feeds/d 25:25:25:25 | ad lib 1 feed/d 100% am | clean bunk 1 feed/d 100% pm | clean bunk 2 feeds/d 30% am 70% pm | SEM |
| digestive | 2.50[a] | 0.83[b] | 0.68[b] | 1.17[b] | 0.25 |
| respiratory | 3.00[a] | 3.67[a] | 4.50[a] | 2.50[a] | 0.37 |
| physical | 4.17[a] | 3.83[a] | 3.67[a] | 5.50[a] | 0.62 |
| foot rot/lame | 1.83[a] | 2.50[a] | 1.67[a] | 2.18[a] | 0.40 |

Different superscripts in the same row indicate values that are significantly different, (P < 0.05)

### 4.3.2 Feed Intake Variation

**Feed intake variation and treatment effect for trial period**

Bunk management strategy and frequency of feeding had no significant effect on feed intake variation over the trial period, ie 137 days. The repeated measures results for both between pen and within pen analysis were not significantly different for the analysed data groups, ie. actual feed intake as fed, actual feed intake dry matter, delivered feed intake as fed and delivered feed intake dry matter.

The analysis of variance which treated pen as factors nested within treatments rather than as random variables also found no significant difference between treatments and feed intake variation. However, significant difference occurred when day was used as a factor in all data groups. Levels of significance for data groups included actual feed intake as fed ($P<0.07$), actual feed intake dry matter ($P<0.05$), delivered feed intake as fed ($P<0.04$) and delivered feed intake dry matter ($P<0.03$), indicating that on a daily basis, irrespective of treatment, significant variation in feed intake occurred. This result is investigated further in the section Feed intake variation and environmental effect.

**Feed intake variation and treatment effect for 5 and 10 day periods**

There was no consistent significant difference in feed intake variation between bunk management treatments and feeding frequency for actual feed intake dry matter and as delivered feed intake dry matter for the 5 and 10 day periods.

**Feed intake variation and environmental effect for 40 day period (24th October 1996 to 2nd December 1996) and 36 day period (2nd January 1997 to 6th February 1997)**

Two periods, one 40 day period from the 24th October 1996 to the 2nd December 1996 and one 36 day period from the 2nd January 1997 to the 6th February 1997, were selected during the trial to highlight the effect of changes in environmental conditions on feed intake and the effect of bunk management strategies on feed intake variation during these selected periods. The analysis of these periods for feed intake variation are presented in tables 4.15 (two way analysis of variance) and 4.16 (one way analysis of variance). The effects of rain events and average THI on feed intake are illustrated in figures provided in the Appendices. These periods were analysed by both two way and one way analysis of variances on an individual replicate basis using animal intake variances. The replicates, representing all treatments and a similar calendar period were selected to determine the effect of environment on feed intake variation and therefore provided more information than the treatment means. For the two way analysis, during the 40 day period, the clean bunk management treatments significantly reduced feed intake variation for replicates 1 ($0.05<P<0.10$), 3 ($0.005<P<0.001$) and 4 ($0.025<P<0.05$). For the two way analysis, during the 36 day period, the clean bunk management treatments significantly reduced feed intake variation for replicates 1 ($P<0.001$), 3 ($0.025<P<0.05$), 4 ($P<0.001$), 5 ($P<0.001$) and 6 ($0.001<P<0.025$) and the single feed significantly reduced feed intake variation for replicates 4 ($0.05<P<0.10$) and 6 ($0.025<P<0.05$).

**Table 4.15: Intake variances for individual replicates during a 40 day (24th October 1996 to 2nd December 1996) and 36 day period (2nd January 1997 to 6th February 1997).**

| | Bunk management | | | Number of feeds | | | |
|---|---|---|---|---|---|---|---|
| Oct - Dec | ad lib | clean bunk | P-value | single | multiple | P-value | SEM |
| Replicate 1 | 1.650[a] | 0.977[b] | <0.10 | 1.345[a] | 1.282[a] | >0.10 | 0.382 |
| Replicate 2 | 1.154[a] | 0.877[a] | >0.10 | 0.961[a] | 1.071[a] | >0.10 | 0.219 |
| Replicate 3 | 1.867[a] | 1.060[b] | <0.001 | 1.317[a] | 1.610[a] | >0.10 | 0.283 |
| Replicate 4 | 1.375[a] | 0.807[b] | <0.05 | 1.125[a] | 1.057[a] | >0.10 | 0.264 |
| Replicate 5 | 1.168[a] | 1.189[a] | >0.10 | 1.130[a] | 1.227[a] | >0.10 | 0.195 |
| Replicate 6 | 1.502[a] | 1.111[a] | >0.10 | 1.248[a] | 1.365[a] | >0.10 | 0.306 |
| Jan - Feb | | | | | | | |
| Replicate 1 | 1.147[a] | 0.476[b] | <0.001 | 0.949[a] | 0.674[a] | >0.10 | 0.171 |
| Replicate 2 | 0.965[a] | 0.861[a] | >0.10 | 0.781[a] | 1.045[a] | >0.10 | 0.279 |
| Replicate 3 | 1.200[a] | 0.591[b] | <0.05 | 0.879[a] | 0.912[a] | >0.10 | 0.261 |
| Replicate 4 | 1.491[a] | 0.490[b] | <0.001 | 0.766[a] | 1.215[b] | <0.10 | 0.261 |
| Replicate 5 | 1.807[a] | 0.501[b] | <0.001 | 0.734[a] | 0.854[a] | >0.10 | 0.140 |
| Replicate 6 | 1.182[a] | 0.643[b] | <0.025 | 0.660[a] | 1.166[b] | <0.05 | 0.220 |

Different superscripts in the same row indicate values that are significantly different, ($P < 0.05$)

**Table 4.16: Intake variances for individual replicates during a 40 day (24th October 1996 to 2nd December 1996) and 36 day period (2nd January 1997 to 6th February 1997).**

| | Treatment | | | | | |
|---|---|---|---|---|---|---|
| Oct - Dec | ad lib<br>4 feeds/d<br>25:25:25:25 | ad lib<br>1 feed/d<br>100% am | clean bunk<br>1 feed/d<br>100% pm | clean bunk<br>2 feeds/d<br>30% am 70% pm | P-value | SEM |
| Replicate 1 | 1.412[a] | 1.887[a] | 0.803[b] | 1.152[a] | <0.05 | 0.429 |
| Replicate 2 | 1.273[a] | 1.036[a] | 0.886[b] | 0.869[b] | <0.05 | 0.267 |
| Replicate 3 | 2.055[a] | 1.679[a] | 0.955[b] | 1.165[b] | <0.05 | 0.283 |
| Replicate 4 | 1.391[a] | 1.359[a] | 0.891[a] | 0.722[b] | <0.05 | 0.264 |
| Replicate 5 | 1.368[a] | 0.967[a] | 1.293[a] | 1.085[a] | <0.05 | 0.195 |
| Replicate 6 | 1.562[a] | 1.054[a] | 1.054[a] | 1.167[a] | >0.05 | 0.307 |
| Jan - Feb | | | | | | |
| Replicate 1 | 1.063[a] | 1.231[b] | 0.668[a] | 0.285[b] | <0.05 | 0.171 |
| Replicate 2 | 1.297[a] | 0.633[b] | 0.929[a] | 0.793[a] | <0.05 | 0.279 |
| Replicate 3 | 1.335[a] | 1.066[a] | 0.692[a] | 0.489[b] | <0.05 | 0.261 |
| Replicate 4 | 1.744[a] | 1.238[a] | 0.295[b] | 0.685[b] | <0.05 | 0.260 |
| Replicate 5 | 1.251[a] | 0.922[a] | 0.545[b] | 0.457[b] | <0.05 | 0.140 |
| Replicate 6 | 1.684[a] | 0.681[a] | 0.638[b] | 0.648[b] | <0.05 | 0.221 |

Different superscripts in the same row indicate values that are significantly different, ($P < 0.05$)

### 4.3.3 Individual Animal Results

Many categories of breed and the origin of the cattle had few data points and after allowing for missing values, (particularly associated with starting weight) the raw data of 5579 points was reduced to 4920. Table 4.17 provides a summary for breed, origin and age data and their distribution.

**Table 4.17: Number of animals and their distribution within the categories of breed, origin and age.**

| Breed Category | | | Origin Category | | | Age Category | |
|---|---|---|---|---|---|---|---|
| Level | Classification | Number of head | Level | Classification | Number of head | Age | Number of head |
| 1 | Angus | 220 | 1 | N NSW Tablelands | 1056 | 1 | 1688 |
| 2 | AxHereford | 242 | 2 | NW NSW | 1693 | 2 | 3133 |
| 3 | Brahman | 3 | 3 | Background | 183 | 3 | 728 |
| 4 | Red Angus | 2 | 4 | Darling Downs | 483 | 4 | 27 |
| 5 | Friesian | 1 | 5 | S NSW Tablelands | 60 | | |
| 6 | Galloway | 1 | 6 | SE Qld | 730 | | |
| 7 | Hereford | 4186 | 7 | S NSW Coast | 18 | | |
| 8 | Santa | 2 | 8 | SW Qld | 628 | | |
| 9 | Limousin | 1 | 9 | SW NSW | 69 | | |
| 10 | MGrey | 209 | | | | | |
| 11 | Braford | 15 | | | | | |
| 12 | Brangus | 18 | | | | | |
| 13 | Short Horn | 13 | | | | | |
| 14 | Simmental | 7 | | | | | |

Due to the number of missing data points, no interaction terms were fitted. The large size of the data set indicated the main areas of significance and that little further advantage would be achieved by analysing interactions. All of the dependent variables including carcass weight, fat depth, fat colour, marbling score and meat colour were treated as numeric variables. The variables which involved scores, eg. fat colour, marbling score and meat colour, were heavily skewed towards one value. Table 4.18 summarises the distribution of these variables.

**Table 4.18: Number of animals and their distribution between scores within the categories of fat colour, marbling and meat colour. Scores for each category represent a scale and are used in the abattoir as part of the carcass assessment.**

| Fat Colour Category | | | Marbling Category | | | Meat Colour Category | | |
|---|---|---|---|---|---|---|---|---|
| Score | Head number | % | Score | Head number | % | Score | Head number | % |
| 0 | 4491 | 91.3 | 1 | 1556 | 31.6 | 1 | 4613 | 93.8 |
| 1 | 357 | 7.3 | 2 | 3044 | 61.9 | 2 | 279 | 5.6 |
| 2 | 67 | 1.4 | 3 | 251 | 5.1 | 3 | 22 | 0.4 |
| 3 | 2 | 0.0 | 4 | 65 | 1.3 | 4 | 3 | 0.0 |
| 4 | 1 | 0.0 | 5 | 3 | 0.0 | 5 | 1 | 0.0 |

Due to the lack of variation, variables were transformed to extend their range. Both untransformed and transformed analysis resulted in the same terms being significant. . Results are summarised in Tables 4.19 and 4.20.

Carcass weight, fat depth, fat colour, marbling score and meat colour were tested against four terms, including treatment, breed, origin and age. Carcass weight was not significant for any term. Fat depth was significant for all terms ($P<0.05$). Age was significantly different ($P<0.05$) for all terms. There was no significant difference between the terms for fat colour. Marbling score was significantly different for treatments ($P<0.04$). Meat colour was significant for age ($P<0.05$).

**Table 4.19: Individual animal analysis of carcass measurements including carcass weight and fat depth in terms of treatment, breed, origin and age (see Table 4.17 for descriptions).**

| Treatment | Carcass weight (kg) | SEM | Fat Depth (mm) | SEM |
|---|---|---|---|---|
| 1 | 373.3[a] | 16.394 | 27.1[a] | 6.616 |
| 2 | 376.2[a] | 16.383 | 27.4[a] | 6.613 |
| 3 | 375.0[a] | 16.358 | 26.5[b] | 6.606 |
| 4 | 367.9[a] | 16.385 | 25.3[c] | 6.613 |
| Breed | | | | |
| 1 | 368.6[a] | 2.016 | 27.7[c] | 0.578 |
| 2 | 374.2[a] | 1.910 | 29.9[e] | 0.548 |
| 3 | 383.0[a] | 13.340 | 26.6[c] | 3.823 |
| 4 | 377.3[a] | 16.336 | 25.7[c] | 4.682 |
| 5 | 393.2[a] | 23.064 | 26.6[c] | 6.610 |
| 6 | 362.0[a] | 23.022 | 31.3[f] | 6.598 |
| 7 | 369.8[a] | 1.276 | 29.1[e] | 0.366 |
| 8 | 373.1[a] | 16.367 | 21.3[a] | 4.690 |
| 9 | 373.6[a] | 23.071 | 22.4[b] | 6.612 |
| 10 | 375.2[a] | 2.033 | 27.4[c] | 0.583 |
| 11 | 371.1[a] | 6.160 | 24.9[c] | 1.765 |
| 12 | 373.5[a] | 5.624 | 27.8[c/d] | 1.612 |
| 13 | 373.3[a] | 6.533 | 27.8[c/d] | 1.872 |
| 14 | 375.7[a] | 8.873 | 24.2[c] | 2.543 |
| Origin | | | | |
| 1 | 372.7[a] | 16.368 | 26.7[c] | 6.613 |
| 2 | 372.3[a] | 16.331 | 26.4[c] | 6.605 |
| 3 | 376.5[a] | 16.852 | 28.8[d] | 6.709 |
| 4 | 368.3[a] | 16.461 | 26.9[c] | 6.620 |
| 5 | 367.4[a] | 16.624 | 28.6[d] | 6.664 |
| 6 | 373.5[a] | 16.375 | 25.5[b] | 6.613 |
| 7 | 385.9[a] | 17.266 | 23.1[a] | 6.789 |
| 8 | 371.4[a] | 16.379 | 26.5[c] | 6.615 |
| 9 | 369.8[a] | 16.673 | 26.7[c] | 6.676 |
| Age | | | | |
| 2 | 371.2[a] | 0.129 | 27[a] | 0.072 |
| 4 | 373.9[a] | 0.095 | 28[b] | 0.047 |
| 6 | 372.9[a] | 0.197 | 29[c] | 0.154 |
| 8 | 371.5[a] | 0.127 | 27[a] | 0.578 |

Different superscripts in the same column indicate values that are significantly different, ($P < 0.05$)

**Table 4.20: Individual animal analysis of scored measurements including marbling score, fat colour and meat colour in terms of treatment, breed, origin and age (see Table 4.17 for descriptions).**

| Treatment | Marbling score | SEM | Fat colour | SEM | Meat colour | SEM |
|---|---|---|---|---|---|---|
| 1 | 1.891[b] | 0.589 | 0.117[a] | 0.091 | 1.049[a] | 0.028 |
| 2 | 1.919[a] | 0.590 | 0.095[a] | 0.091 | 1.072[a] | 0.029 |
| 3 | 1.840[c] | 0.589 | 0.088[a] | 0.092 | 1.061[a] | 0.028 |
| 4 | 1.845[c] | 0.590 | 0.083[a] | 0.090 | 1.080[a] | 0.030 |
| Breed | | | | | | |
| 1 | 2.066[a] | 0.058 | 0.153[a] | 0.031 | 1.066[a] | 0.028 |
| 2 | 2.098[a] | 0.057 | 0.167[a] | 0.031 | 1.068[a] | 0.027 |
| 3 | 2.388[a] | 0.343 | 0.063[a] | 0.197 | 1.346[a] | 0.162 |
| 4 | 1.780[a] | 0.418 | 1.782[a] | 0.241 | 1.022[a] | 0.198 |
| 5 | 1.987[a] | 0.589 | 0.007[a] | 0.339 | 0.977[a] | 0.279 |
| 6 | 1.874[a] | 0.589 | 0.235[a] | 0.339 | 0.971[a] | 0.279 |
| 7 | 1.714[a] | 0.042 | 0.085[a] | 0.022 | 1.074[a] | 0.020 |
| 8 | 2.126[a] | 0.420 | 0.528[a] | 0.240 | 1.031[a] | 0.199 |
| 9 | 2.212[a] | 0.590 | 0.107[a] | 0.339 | 0.986[a] | 0.280 |
| 10 | 2.000[a] | 0.059 | 0.119[a] | 0.031 | 1.107[a] | 0.028 |
| 11 | 1.707[a] | 0.157 | 0.096[a] | 0.090 | 1.048[a] | 0.075 |
| 12 | 1.918[a] | 0.145 | 0.145[a] | 0.082 | 1.017[a] | 0.069 |
| 13 | 1.793[a] | 0.170 | 0.065[a] | 0.096 | 1.080[a] | 0.081 |
| 14 | 1.908[a] | 0.588 | 0.020[a] | 0.130 | 1.046[a] | 0.108 |
| Origin | | | | | | |
| 1 | 1.908[a] | 0.588 | 0.086[a] | 0.089 | 1.053[a] | 0.022 |
| 2 | 1.909[a] | 0.588 | 0.169[a] | 0.089 | 1.051[a] | 0.020 |
| 3 | 1.836[a] | 0.597 | 0.087[a] | 0.113 | 0.930[a] | 0.054 |
| 4 | 1.874[a] | 0.589 | 0.114[a] | 0.091 | 1.066[a] | 0.028 |
| 5 | 1.961[a] | 0.593 | 0.102[a] | 0.100 | 1.085[a] | 0.040 |
| 6 | 1.835[a] | 0.588 | 0.096[a] | 0.090 | 1.068[a] | 0.023 |
| 7 | 1.471[a] | 0.605 | 0.002[a] | 0.112 | 1.058[a] | 0.070 |
| 8 | 1.738[a] | 0.588 | 0.063[a] | 0.090 | 1.081[a] | 0.024 |
| 9 | 1.875[a] | 0.594 | 0.194[a] | 0.101 | 1.092[a] | 0.045 |
| Age | | | | | | |
| 2 | 1.690[a] | 0.018 | 0.074[a] | 0.013 | 1.059[a] | 0.013 |
| 4 | 1.798[a] | 0.015 | 0.105[a] | 0.011 | 1.064[a] | 0.009 |
| 6 | 1.866[a] | 0.029 | 0.134[a] | 0.024 | 1.100[a/b] | 0.021 |
| 8 | 1.833[a] | 0.124 | 0.067[a] | 0.092 | 1.133[a/b] | 0.107 |

Different superscripts in the same column indicate values that are significantly different, ($P < 0.05$)

### 4.3.4 Feeding Activity

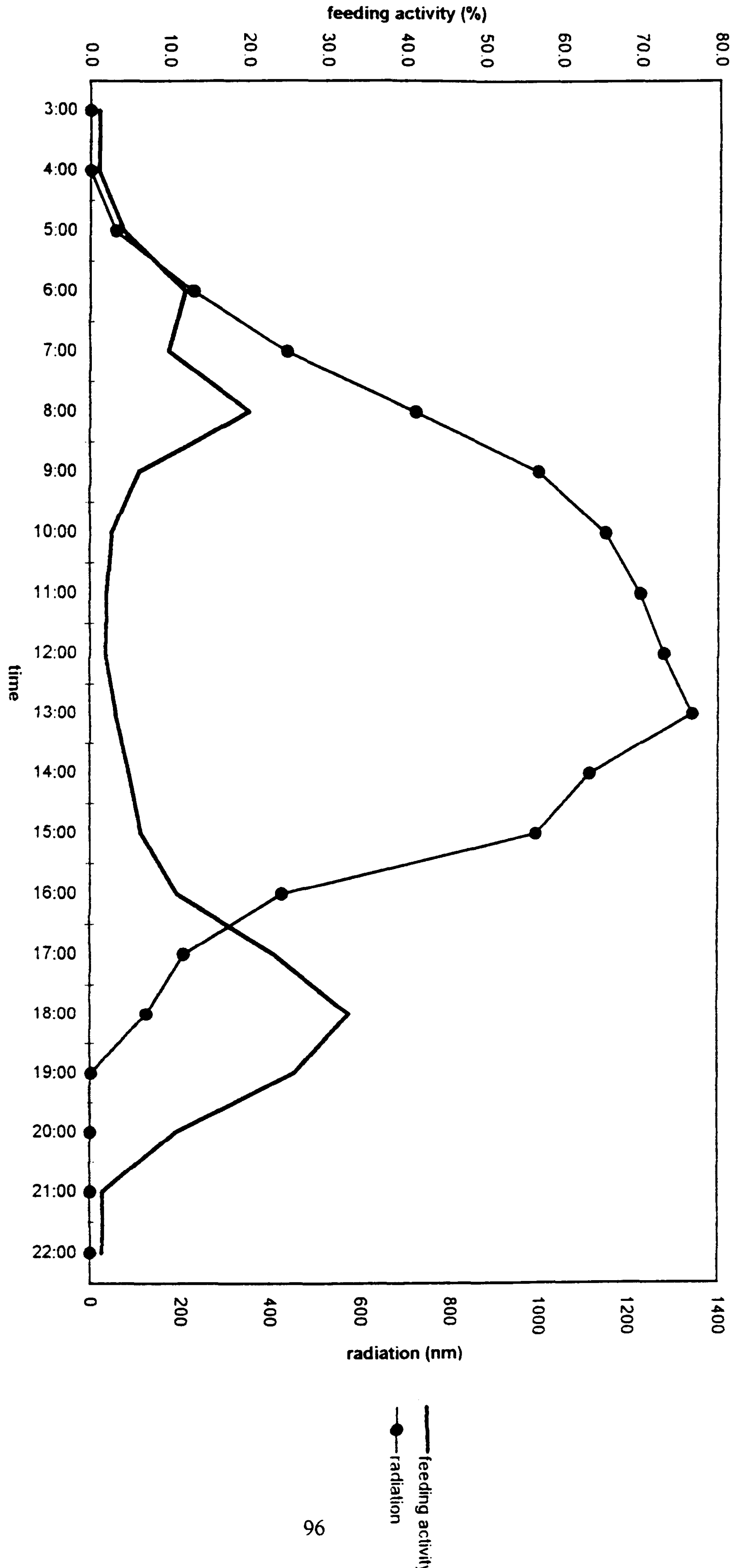
The patterns of feeding activity observed during the four days when feeding activity observations were made, were similar in all cases (note Table 4.21 and Figure 4.1 for average feeding activity across all observation days). Initiation of feeding corresponded closely with sunrise and sunset and in response to feed delivery. Little feeding activity occurred during the middle part of the day. Feeding response was most prominent across all bunk management strategies when feed delivery was within a few hours of sunrise and sunset. However, all strategies showed a similar feeding activity pattern of high intensity, short feeding duration during the morning, ie. 06:00 to 08:00, and low intensity and extended feeding duration during the afternoon, ie. 16:00 to 20:00, with minimal feeding activity between the peak feeding periods, ie. 09:00 to 15:00.

**Table 4.21. Average feeding activity of all treatments for all observation periods. Feeding activity represented by percentage of pen feeding.**

| Time | Treatment feeding activity (%) 1 | 2 | 3 | 4 | Average feeding activity | significance level | SEM | radiation (nm) |
|---|---|---|---|---|---|---|---|---|
| 3:00 | 0.5 | 0.7 | 2.7 | 0.6 | 1.1 | ns | 0.342 | 0 |
| 4:00 | 0.3 | 0.8 | 1.8 | 1.6 | 1.1 | ns | 0.986 | 1 |
| 5:00 | 1.1 | 2.0 | 11.7 | 2.7 | 4.4 | ns | 3.299 | 58 |
| 6:00 | 2.6 | 2.7 | 11.8 | 31.1 | 12.1 | 1%<P<2% | 3.299 | 229 |
| 7:00 | 1.9 | 6.0 | 7.4 | 24.7 | 10.0 | 5%<P<10% | 3.680 | 438 |
| 8:00 | 25.8 | 45.8 | 5.3 | 4.2 | 20.3 | 1%<P<2% | 3.959 | 723 |
| 9:00 | 9.7 | 11.1 | 2.6 | 1.7 | 6.3 | 4%<P<5% | 3.625 | 998 |
| 10:00 | 6.4 | 2.4 | 1.4 | 1.2 | 2.9 | ns | 1.175 | 1150 |
| 11:00 | 3.7 | 2.2 | 1.2 | 1.5 | 2.1 | ns | 0.631 | 1228 |
| 12:00 | 3.1 | 2.0 | 1.6 | 1.2 | 2.0 | ns | 0.385 | 1279 |
| 13:00 | 2.2 | 2.0 | 0.9 | 8.0 | 3.3 | ns | 1.378 | 1342 |
| 14:00 | 3.1 | 5.0 | 8.8 | 3.0 | 5.0 | ns | 1.845 | 1115 |
| 15:00 | 5.7 | 7.0 | 10.9 | 2.5 | 6.5 | ns | 1.833 | 994 |
| 16:00 | 10.7 | 14.1 | 13.2 | 6.4 | 11.1 | 6%<P<10% | 1.712 | 427 |
| 17:00 | 13.8 | 18.5 | 27.1 | 34.2 | 23.4 | 1%<P<2% | 3.454 | 208 |
| 18:00 | 33.7 | 27.5 | 30.2 | 40.1 | 32.9 | 6%<P<10% | 3.734 | 126 |
| 19:00 | 24.3 | 27.0 | 25.7 | 26.9 | 26.0 | 2%<P<4% | 1.970 | 2 |
| 20:00 | 14.4 | 10.4 | 12.1 | 6.9 | 11.0 | P<0.1% | 1.114 | 0 |
| 21:00 | 1.7 | 1.6 | 1.8 | 1.4 | 1.6 | P<0.1% | 0.755 | 0 |
| 22:00 | 2.0 | 1.4 | 1.8 | 1.0 | 1.6 | ns | 0.339 | 0 |

Treatments that did not receive a delivery at sunrise or sunset, eg. treatment 2 received only a morning delivery and treatment 3 received only an afternoon delivery, consistently showed an increase in feeding activity at both sunrise and sunset, however lacked the response of the treatments which received deliveries synchronised with sunrise and sunset. Figures of individual treatment feeding response for each observation period are located in the Appendices. The clean bunk treatments consistently showed definite feeding response peaks when feed delivery occurred. Synchronising delivery of feed to the clean bunk treatments with sunrise and sunset achieved the highest feeding activity response.

**Figure 4.1: Average feeding activity and the relationship with radiation level.**



## 4.4 DISCUSSION

### 4.4.1 Bunk Management and Feeding Costs

#### 4.4.1.1 Feed wastage and labour costs

There were significant differences in feeding and labour costs between the ad lib and clean bunk treatments (see Table 4.8). *Ad libitum* feeding requires feed to be continually available to animals. In this trial, the objective was to have a minimum of 10cm of feed in the *ad lib* treatment bunks throughout the day. After the *ad lib* treatment allocation, bunks were cleaned of residual feed. The removal of residual feed is a normal practise in *ad lib* feeding systems. Therefore, on a daily basis there was always a degree of feed wastage and a labour requirement associated with the *ad lib* treatments. In contrast, the bunk management associated with the clean bunk treatments was designed to encourage animals to clean the bunk of feed prior to the time of allocation. Therefore, on a daily basis, residual feed wastage and labour costs were considerably lower than the *ad lib* treatments.

#### 4.4.1.2 Machinery costs

The major mechanical costs associated with bunk management are machinery and milling requirements. These requirements are significantly increased when feeding *ad lib* and/or feeding frequently (see Table 4.8). Mechanical costs, ie. number of feed deliveries and additional milling operation associated with wasted feed, significantly contributed to the difference in feeding cost between *ad lib* and clean bunk management strategies. Treatment 1 (*ad lib*, four feed deliveries per day) had the highest value in both cases. The demand on machinery increases dramatically as numbers of cattle increase. Feeding large numbers of animals introduces problems associated with increased milling hours, extended feeding times, greater machinery wear and increased risk of machinery breakdown.

### 4.4.1.3. Comparison of *ad lib* and clean bunk costs

The significantly higher feeding costs associated with *ad lib* feeding is derived from a higher level of feed offered and greater feed wastage. On average, the constant availability of feed present in the *ad lib* treatment bunks increased risk of feed spoilage by weather (see Table 4.9). In contrast, clean bunk treatments consistently maintained fresh feed over *ad lib* treatments by encouraging animals to clean the bunk of feed at least once per day. Maintaining fresh feed and minimising feed residue reduced spoilage, feed wastage and labour requirements significantly.

The task of accurately allocating feed is difficult. The use of objective measurements including weather forecasts, days on feed, peak intake, five day average feed intake, ration specifications, ie. dry matter and energy level, morbidity, breed, frame size and weight of cattle aid in indicating potential feed intake level. However, the ability to anticipate changes in feed intake pattern, relies on variables and the allocaters ability to observe and interpret these indicators. The clean bunk treatments further minimised feed wastage because it was easier to estimate animal feed requirements. A clean bunk at midday provides two important indicators. The first is the level of feed remaining in the bunk at allocation, represented by a bunk score (see Table 2.4), the second is feeding activity expressed by animals towards feed delivery, represented by an aggression score (see Table 2.3). The bunk score indicates how much of the previous quantity of feed provided was consumed and the aggression score indicates potential satiety from previous pm feed. The allocater uses these indicators to estimate the quantity of feed that will satisfy animals for the following 24 hours. The aggression level expressed by the cattle for *ad lib* treatments provided an indicator of feed intake pattern (see Appendices A13, 14, 17, 18, 21, 22, 25 and 26), however the bunk score for *ad lib* treatments did not provide an accurate estimate of potential feed intake level as bunks consistently contained varying quantities of feed at allocation. The animal indicators provided by *ad lib* treatments were weak which led to inaccurate bunk calls and the inability to match feed offered with feed required. The consistent availability of feed and the inability to estimate feed requirements accurately for the *ad lib* treatments contributed to the significantly higher level of feed waste and associated labour costs required for cleaning.

Delivery and processing costs are related to feeding frequency and quantity of feed offered. At the same frequency of feeding, *ad lib* costs were significantly higher because more feed was offered. Increasing use of machinery to produce and deliver feed increases the risk of machinery breakdown. In terms of feeding large numbers of cattle, ie. greater than 20 000hd, machinery breakdowns may have less impact on the clean bunk at midday strategy because there is more time to service and repair equipment and avoid delays in feeding. In this experiment, the time period between deliveries for the clean bunk treatments was 4.5h, from 8:30 to 13:00. In contrast, the bunks of the *ad lib* treatments always contained feed and on occasions when bunks were empty another delivery would be made. Therefore, feeding *ad lib* to large numbers of cattle would involve feed deliveries throughout the day, irrespective of feeding frequency. A delay in feeding for the *ad lib* treatments may result in feeding delays to be carried through to the end of feeding for the day. Machinery failure causes delays in feeding, which in turn can increase the risk of digestive disorders (Elam 1976). Delays in feeding increase the opportunity for hungry animals to over consume feed and disrupt rumen environment (Owens et al 1998). A clean bunk at midday management strategy minimises reliance on machinery by only producing and delivering sufficient feed required to satisfy animals level of satiety (Doyle 1996).

### 4.4.2 Bunk Management and Health

The bunk management treatments had no significant effect on the general health status of animals as indicated by Table 4.12. Dividing pulls into specific aliments (see Table 4.14) indicated that only digestive disorders for treatment 1 were significantly higher ($P<0.05$) than the other treatments. However, analysis of faecal assessment (Table 4.13) showed no significant difference in numbers of faecals characteristic of digestive disorders, ie. faecal score 3, loose, watery and grey. This apparent contradiction in results may be explained by the grain content of the trial diet and factors which initiate digestive disorders. Much of the literature concerned with comparisons of bunk management strategies, ie. restricted feeding versus *ad lib* feeding, and their ability to minimise digestive disorders involve diets containing greater than 85% grain on an as fed basis(Lofgreen et al 1987 ; Albin and Durham 1967 ; Murphy and Loerch 1994 ; Galyean 1996). The grain content of the trial diet averaged 74% on an as fed basis and may not have contained sufficient readily fermentable carbohydrate loading to induce a high incidence of digestive disorders. The potential of grain based diets to initiate digestive disorders relates to the high level of readily fermentable carbohydrates (Howie 1997). However, changes in environmental conditions, ie. temperature variation and rain events, are conducive to digestive disorders (Stock and Britton 1993) as feed intake pattern is disrupted (Owens et al 1998).

From the trial results, two periods were selected to highlight the effect of changes in the environment, ie. rain events and THI, on feed intake variation (see Appendices for environmental effect on feed intake pattern). In all cases where significance occurred, the *ad lib* treatments had a higher daily feed intake variation than the clean bunk treatments (see Table 4.15) with treatment 1 consistently achieving higher feed intake variation (see Table 4.16). These results are consistent with those of Hicks et al (1990), Glimp et al (1989) and Aronen (1992) who reported that feeding *ad lib* resulted in greater feed intake variation. Slyter (1976) reported that higher variation in feed intake increases the potential for digestive disorders. However, only treatment 1, receiving four deliveries per day, achieved significantly higher incidence of digestive disorders.

In contrast, increasing feeding frequency has been reported to reduce feed intake fluctuation and maintain rumen fermentation stability (Sniffen and Robinson 1984 ; Robinson and Sniffen 1985 ; Sutton et al 1986 ; Bragg et al 1986 ; Goonewardene et al 1995 : French and Kennelly 1984 ; Clark and Keener 1962), particularly with *ad lib* feeding (Gibson 1981). The stimulation for animals to approach the bunk is derived from the conditioned response as feed is delivered and the availability of fresh palatable feed (Prichard and Knutsen 1995). However, based on the feeding activity observations for treatment 1 (see Appendices for feeding activity), increasing frequency of feeding had no effect on the number of times the animals approached the bunk. Major feeding activity of all treatments was concentrated around sunrise and sunset times, ie. 5:00 to 7:00 and 14:00 to 20:30 with minimal feeding activity during the middle part of the day, eg. 10:00 to 14:00. Increasing feeding frequency throughout day was therefore, unlikely to provide any advantage in stabilising rumen fermentation or feed intake, as animals did not consume feed consistently throughout the day.

The higher incidence of digestive disorders in treatment 1 cannot be explained by differences in feeding activity. Animals respond directly to delivery of feed (Fell and Clarke 1993 ; Vasilatos and Wangsness 1980), particularly when synchronised with the animal's natural times of feeding activity (Driver and Forbes 1981). During the feeding activity observations, deliveries made within the natural feeding activity stimulated the highest feeding activity response. Ray and Roucibek (1971) observed that morning feeding activity is characterised by high intensity, short duration. Owens et al (1998) reported that high feeding activity can lead to digestive disorders as animals are more likely to over consume feed. However, treatments 1 and 4 both received a morning feed delivery and the feeding activity response of treatment 1 was not consistently higher than treatment 4. During the middle part of the day, minimal feeding activity occurred and animals spent their time resting. Ruckebusch and Bueno (1978) reported a strong correlation between resting behaviour and rumination. The similar feeding activity pattern of all treatments suggests that behaviour conducive to rumination and its ability to maintain normal rumen function (Hibbard et al 1995), was also similar and thereby providing no additional benefit to any one treatment.

The significantly higher incidence of digestive disorders relating to treatment 1 may have been due to a combination of factors involving the environment, quantity of feed delivered and timing of delivery. Changes in environmental conditions initiated fluctuations in feed intake pattern in all treatments. Greatest variation occurred in the *ad lib* treatments. The ability to synchronise one or two deliveries with natural feeding activity can be achieved relatively easily. However, increasing feeding frequency, ie. four deliveries per day, increases the likelihood that some deliveries will fall outside the animals natural feeding activity. It is these deliveries, in association with *ad lib* feeding, that have a higher susceptibility to environmental conditions and spoilage. Spoilt feed increases feed refusals and depresses feed intake (Curtis and Houpt 1983 ; Bell 1984). Treatment 1 animals may have also increased quantity of feed consumed when bunks were cleaned and all stale feed removed. These conditions may have affected animal feed consumption patterns, leading to an intermittent pattern of low and high feed consumption and thereby predisposing animals to digestive disorders.

The costs associated with health management were not investigated as total pull rate between the treatments was not significant. However, Edwards (1996) analysis of feedlot records reported that 3 to 7% of total morbidity was due to digestive disorders. In this experiment, pulls for digestive disorders represented 9%, 3.5%, 3.3% and 4.4% for treatments 1, 2, 3 and 4 respectively. Edwards (1996) reported that costs associated with medications, labour and reduced performance during and after illness had a significant economic impact and Nocek (1996) reported subclinical acidosis may cause the highest economic loss to the feedlot operator.

### 4.4.3 Bunk Management and Carcass Composition

The comparison of individual carcass composition for the *ad lib* and clean bunk treatments indicated that treatment had no significant effect on hot carcass weight, fat colour and meat colour (see Tables 4.19 and 4.20). However, fat depth ($P<0.05$) and marbling score ($P<0.04$) were significantly different. Mills et al (1989) reported that rate of fat deposition in bovine tissue is directly related to feed intake above maintenance. Therefore, the slightly lower, but not significant, average dry matter feed intakes for the clean bunk treatments may have resulted in the lower fat depth and marbling score. However, in terms of meeting carcass composition specifications required for the Japanese Grain fed market (see Table 1.2 and Table 4.11), no difference existed between the treatments.

### 4.4.4 Bunk Management and Environment

Changes in environmental conditions directly affect feed intake pattern (Owens et al 1998). The comparison of bunk management strategies indicated that on a daily basis significant variation in feed intake occurred across all treatments. In particular, rain events and average THI greater than 75 had a significant effect on feed intake pattern (see Appendices for environmental effect on feed intake pattern).

Cattle are particularly sensitive to changes in barometric pressure (Elam 1976) and a decrease in air pressure preceding a rain event, stimulates feed intake. During a rain event, depression in feed intake occurs resulting in spoilage and high levels of feed wastage. During the trial, quantities of feed wastage were recorded for both dry periods and rain events. The clean bunk treatments significantly reduced feed wastage in both cases (see Table 4.9). This suggests, that for the ad lib treatment cattle feed intake pattern was more susceptible to changes in environmental conditions than the clean bunk treatments.

Hahn and Mader (1996) reported that THI provides a useful indicator of the relationship between animal response (body temperature and feed intake) and temperature and humidity. Environmental conditions associated with summer have been shown to be directly responsible for depression in feed intake (Hahn 1995b ; Silanikove 1992 ; Hicks et al 1990b). Reduction in feed intake is an important component of acclimation and adaptation process for the animal. The animal needs to balance heat gained from the environment and metabolism with heat loss (Hahn 1995a). Metabolic heat, derived from fermentation contributes to one third of the animals total heat load (Sharma and Kehar 1961 ; Hahn 1995a). Therefore, reducing feed intake reduces heat produced from fermentation and metabolism (Ames and Ray 1983 ; Beede and Collier 1986 ; Silanikove 1992 ; Young 1992 ; Finch 1986) and enables the animal to more efficiently maintain a steady body temperature (Finch 1986). A reduction in feed intake in association with increased animal maintenance requirement (Young 1992 ; Fuquay 1981 ; Beede and Collier 1986 ; Hermel 1996) has shown to be responsible for depression in animal performance during the summer period (Schake 1995 ; Hahn 1995a ; Silanikove 1992 ; Beede and Collier 1986 ; Young 1992 ; Morrison 1983 ; Ray 1991). There was no significant difference in feed intake or performance between the bunk management treatments during the trial period. Periods in which heat stress occurred, ie. periods in which THI reached and exceeded 75, affected all animals, irrespective of treatment. However, the clean bunk management treatments had less feed intake variation compared to the *ad lib* treatments (see Table 4.15) during periods in which THI exceeded 75.

Feed intake variation for the clean bunk treatments may have been less than the *ad lib* treatments because animals were encouraged to clean the bunk by midday. The midday period to early afternoon, ie. 11:00 to 14:00h, represents a period in which the highest environmental recordings of temperature and radiation (see Appendices for environmental record) were recorded and the potential for feed spoilage was greatest, ie. mould. A clean bunk at midday minimises feed spoilage and ensures fresh feed with every delivery. Pritchard and Knutsen (1995), Curtis and Houpt (1983) and Bell (1984) reported that avoiding feed spoilage minimises feed refusals and the delivery of fresh feed stimulates feed intake. The clean bunk treatments also provided flexibility in the scheduling and the proportion of feed delivered in the morning and afternoon feeds. By providing sufficient feed in the morning to satisfy appetite, yet enable the animals to complete feeding activity before the heat of the day provides several advantages for the clean bunk treatments over the *ad lib* bunk treatments. Allowing all cattle to be fed before day time conditions restrict feeding activity and allowing metabolic heat production to decline as ambient temperatures increase reduces total heat load. McLean et al (1983) studied body temperature rhythms of diary cows under constant environmental conditions (10-11$^{o}$C) with animals fed a maintenance diet in two equal amounts. Under these conditions the only detectable change in body temperature was associated with feeding time. In treatment 4, a small feed proportion, ie. 30% of total allocation, in the morning reduced delivery time. The split feeding proportions of treatment 4 can be altered to ensure delivery and feed amounts that best meet environmental conditions. During periods of heat stress, the morning proportion can be reduced, ensuring rapid delivery and completion of feed consumption before the onset of stressful conditions. The *ad lib* treatments provide little flexibility in scheduling feed as feed must be continually available. Therefore, manipulation of feeding times and feed proportions in conjunction with a clean bunk at midday is the strategy most likely to be successful in maintaining feed intake and minimise feed intake variation during environmental stressful periods.

The recording and interpretation of long term environmental records aids in managing feedlot cattle during environmental stressful periods. The use of THI in association with feed intake pattern can highlight environmental conditions in which performance and health are compromised. Hahn and Mader (1996) reported that THI can predict stressful periods for feedlot cattle and bunk management can be altered to maintain performance and reduce death loss under extreme conditions. Management changes available include, reducing carbohydrate content of the diet, including fat in the ration to reduce heat of fermentation, changing feeding order and feeding times, provide adequate access to clean water and only handle and transport cattle in the cooler periods of the day.

### 4.4.5 Bunk Management and Feeding Activity

The natural feeding activity pattern of cattle (Putman et al 1968 ; Chase et al 1976 ; Putman and Davies 1963 ; Vasilatos and Wangsness 1980 ; Ray and Roubicek 1971 ; Gonyou and Stricklin 1984 ; Adams 1985 ; Ruckebusch and Bueno 1978 ; Chase et al 1966 ; Fell and Clarke 1993) corresponded closely with the feeding activity observations made during the bunk management trial (see Figure 4.1 and treatment feeding activity Appendices). The general feeding activity pattern was the same in all cases, irrespective of treatment. Whitt et al (1996) compared feeding times of three feeding treatments and reported that the act of feeding occurred in similar patterns, even though feed was provided at different times and in different proportions. Ray and Roubicek (1971) observed animal feeding activity over two seasons. During the summer feeding activity observations, animals were fed *ad lib* with two deliveries per day, the morning delivery occurred between 07:00 to 08:00h and the afternoon feed delivery between 13:00 to 16:00h. Initiation of feeding corresponded closely with sunrise and sunset and in response to feed delivery with minimal feeding activity during the middle part of the day. The feeding activity observations made during this experiment were very similar to the observations recorded by Ray and Roubicek (1971). These observations highlight the strength of natural feeding activity.

Feeding activity was initiated in response to sunrise, sunset and feed delivery. The highest feeding activity occurred when feed delivery was synchronised with either sunrise or sunset in all treatments. These results are consistent with those of Fell and Clarke (1993) and Vasilatos and Wangsness (1980) who both reported that feed delivery synchronised with natural feeding period initiated highest feeding activity response. Feed deliveries which occurred outside natural feeding activity period initiated a much smaller response compared to deliveries which were synchronised with natural feeding period. Treatment feeding activity Appendices figures A15 and A16 show that feeding activity was initiated with the delivery of feed, however the period of activity was limited and only increased again in response to the animals preferred feeding period. Gonyou and Stricklin (1984) reported that although animals can be conditioned to feed outside their preferred feeding activity period feeding response is limited. Results from this study demonstrate that animals associate feed delivery with feed consumption. This effect is well illustrated in *ad lib* treatments where feeding activity in the morning was initiated by delivery of feed even though feed was available in the bunk prior to feed delivery. Pritchard and Knutsen (1995) reported that the delivery of fresh feed provides a strong stimulus for initiating feed intake. Driver and Forbes (1981) offered feed to sheep regularly at the same time each day and observed animals became conditioned to feeding times and expected to be fed at these times. A conditioned feeding response will only be developed if a consistent feeding time is maintained (Doyle 1995). The ability to maintain consistent feed delivery times is important in reducing the risk of digestive disorders (Owens et al 1998).

Increasing feeding frequency is expected to stimulate feed intake (Kaufmann 1976) and thereby improve performance (Gibson 1981) by stabilising rumen fermentation and improving digestion efficiency (Sniffen and Robinson 1984 ; Robinson and Sniffen 1985 ; Bragg et al 1986). However in this experiment, there was no significant difference in feed intake or performance between the single feed delivery treatments, ie treatments 2 and 3 and the multiple delivery treatments, ie. treatments 1 and 4 (see Tables 4.10). This result is consistent with those of Goonewardene et al (1995), who reported that increasing feeding frequency of an *ad lib* concentrate diet reduced rumen fermentation variation but had no effect on performance. The contributing factors to this result may include the lower grain content of the trial diet, ie 74% (as fed basis) and that the multiple feed deliveries were made outside the preferred feeding times. Pritchard and Knutsen (1995) concluded that a performance response to increased feeding frequency is dependent on providing regular deliveries within the animals natural feeding activity period. Feed deliveries made outside preferred feeding activity period, ie. 5-7:00 and 14-20:30, stimulated little feeding response in the *ad lib* treatment or achieved a feeding response but of limited duration for the clean bunk treatment. The inability to consistently deliver feed within the animals preferred feeding activity period may have contributed to the non significant difference in performance between the single and multiple feed delivery treatments.

In general, the morning feeding activity was characterised by high intensity, ie. 30 to 40% of animals feeding and short duration, ie. 2 to 3h, whereas the afternoon feeding activity was characterised by lower intensity, ie 20 to 30% and extended feeding duration, ie 5 to 7h. This general feeding activity pattern agrees with the observations made by Ray and Roubicek (1971). During environmental stressful periods, feeding intensity appeared to change slightly. Cattle can adjust their feeding behaviour to meet environmental conditions (Arave and Albright 1981 ; Ray and Roubicek 1971 ; Fell and Clarke 1993 ; Gonyou and Stricklin 1984). During the environmental stressful periods, the afternoon feeding intensity increased with feeding duration remaining the same. Ray and Roubicek (1971) observed that hot summer conditions modified feeding behaviour pattern by delaying the afternoon feeding activity peak and increasing the frequency of feeding during the early evening hours.

The clean bunk management treatments encouraged animals to clean the bunk of feed by midday, thereby minimising feed residue during the period of minimal feeding activity. The period in which bunks were void of feed extended for several hours, eg.

5 to 8h. In contrast, even though the *ad lib* treatment animals had continual access to feed, there was only minimal feeding activity during this time. Results from this study indicate that bunks can remain void of feed for several hours during the hot part of the day and not inhibit feed intake provided sufficient feed is available during the preferred feeding periods to satisfy animals level of satiety. Reducing feed availability to 7h of the day did not significantly affect feed intake as feeding periods were concentrated to a relatively small proportion of the day. Fell and Clarke (1993) reported the consumption of feed by feedlot cattle is concentrated to 1.5 to 2 hours per day. The actual time individual animals remain at the bunk can be longer because not all time is spent eating (Chase et al 1976 ; Vasilatos and Wangnsess 1980 ; Friend et al 1977). Prawl et al (1997) reported no significant difference in feed intake between animals restricted to 9h feed access compared to animals with 24h feed access.

The level of feeding response to delivery suggests that the clean bunk treatments encourages all animals of the pen to respond to delivery, thereby intensifying the animals natural feeding activity. Encouraging all animals of the pen to respond to delivery increases competition and social interaction. In this study, not all animals could feed at the bunk at one time. The maximum number of animals observed at the bunk was 87 feeding with 68 waiting. However, this apparent increase in social interaction and competition between animals had no significant effect on animal performance and carcass composition. Corkum et al (1994), Zinn (1989) and Grant and Albright (1997) reported competition for feed had no effect on performance as animals were able to adapt feed intake to competition level (Chase et al 1976 ; Vasilatos and Wangsness 1980). Corkum et al (1994) and Coppock et al (1981) reported that competition appeared to encourage animals to approach the bunk and provide a strong feeding stimulus (Curtis and Houpt 1983 ; Hsia and Wood-Gush 1984 ; Fell and Clarke 1993). The conditioned response to consume feed on delivery is reinforced by the clean bunk at midday treatments. A strong association developed between feed delivery, supply of fresh feed and initiation of feeding.

### 4.4.6 Bunk Management and Performance

The continuous availability of feed associated with *ad lib* feeding was expected to maximise feed intake and thereby performance while a clean bunk implies a restriction of feed availability. However, in this trial there was no significant difference in feed intake or performance (see Table 4.10) between the *ad lib* and clean bunk treatments on a pen average basis. Although bunks remained void of feed for several hours, in this study, this apparent restriction on feed availability had no significant effect on feed intake, performance or carcass composition. The non significant difference in feed intake between the treatments suggests that the clean bunk management strategy does not restrict intake and provides similar advantages to restricted feeding, ie. reduction on feed wastage, labour and machinery requirements (Hick et al 1990a, Glimp et al 1989, Meissner et al 1995 ; Murphy and Loerch 1994).

### 4.4.7 Bunk management strategies

Restricted feeding was developed as an alternative to *ad lib* feeding in an attempt to reduce feeding costs and maintain performance (Eng 1995). The bunk management associated with restricted feeding however, requires precise management, ie. delivery accuracy and consistent feeding times (Glimp et al 1989), and is limited in its ability to deal with feeding interruptions which are an ever present problem when feeding large numbers of cattle. To avoid the possibility of digestive disorders associated with restricted feeding, sufficient bunk space is required to allow all animals of the pen to feed at the bunk at one time and feed delivery must be provided at regular and consistent times. A clean bunk at midday management strategy provides greater feeding flexibility in its ability to manage feeding interruptions, reduce feeding costs and the potential for equivalent level of animal performance compared to *ad lib* feeding.

Increasing feeding frequency has important practical applications, particularly in terms of bunk capacity, encouraging the consumption of fresh wet feed and high pen density. Small bunks require more frequent deliveries to ensure animal appetite is satisfied compared to large capacity bunks. Following wet weather, feed residue that is wet can remain relatively fresh. Animals can be encouraged to consume this feed by providing small quantities of fresh feed over the remaining feed residue and thereby reduce feed wastage. Pens that contain large numbers of animals may have a restriction on bunk space. The National Guidelines for Beef Cattle Feedlots in Australia (1997) recommend a minimum bunk space of 150mm/hd for young cattle and 180mm/hd for steers and bullocks. Insufficient bunk space can possibly be compensated for by providing increased feeding frequency, yet in commercial feedlots this is unfeasible.

## 5.0 CONCLUSION

Encouraging animals to clean the bunk of feed by midday period significantly reduced feeding costs with no significant effect on health, animal performance and carcass composition compared to *ad lib* feeding. The clean bunk at midday corresponded with minimal animal feeding activity and also minimised feed residue and potential for spoilage. The clean bunk at midday significantly contributed to savings in labour, machinery costs and feed wastage. Feed intake restriction was apparently avoided by the clean bunk management strategy by synchronising the clean bunk with minimal feeding activity and the inherent feed intake indicators, ie. feed remaining in bunk and feeding activity response, provided by the clean bunk at midday management strategy.

The clean bunk management strategy is designed to synchronise feed delivery with the animal's natural feeding activity in an attempt to maintain feed intake during environmental stressful conditions. Delivery of feed synchronised with preferred feeding periods achieved high peaks in feeding response, however delivery frequency of the two clean bunk treatments had no significant effect on feed intake. Therefore, a single feed delivery with a clean bunk at midday achieves comparative performance. The ability to successfully increase feeding frequency depends on number of cattle on feed, bunk and mill capacity and availability of labour and machinery. The significant feed cost savings achieved by the clean bunk management strategy is based on encouraging the animal to clean the bunk by midday and synchronising deliveries with preferred periods of feeding activity. This method of bunk management can be utilised successfully for any feeding length and market requirements.