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A feasibility analysis of once-a-day feed delivery for Australian feedlots

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Abstract.

The Australian agricultural industry has experienced immense financial pressure and trading conditions in recent times due to drought conditions and up to 30% fluctuations in exchange rates, which have seriously eroded agricultural exports. The feedlot sector has experienced considerable increases in the cost of grain and feeder steers, as well as an increased worldwide fuel price that has significantly increased the costs of production. It is during these times of industry hardship that the optimal and most efficient feedlot practices must be identified and utilised in order to maintain viability. This two part study has investigated how implementing a once-a-day feed delivery regime can both increase fuel and labour use efficiency, and influence animal performance. This was achieved through a large scale machinery trial run concurrently with a feedlot steer trial. The results of this study revealed, on average a 20.4% increase in fuel and labour use efficiency could be achieved through implementing a once-a-day feeding regime. The feedlot steer trial evaluated the associated influence on animal performance by changing from a twice-a-day to a once-a-day feeding regime. Feed intake, average daily weight gain and feed conversion ratio were not significantly different ($P>0.05$) between the feeding frequencies, nor were the economically important carcass composition characteristics ($P>0.05$). The results of this study suggest that it is feasible for feedlots currently operating under a twice-a-day feeding regime to change to a once-a-day regime without altering animal performance. Additionally, benefits could also be achieved through the potential to increase the efficiency of the feed delivery process and decrease the associated costs of production.

Introduction:

The feedlot sector is a very important, value adding component of the Australian Beef Industry, with continual growth stimulated by increasingly stringent requirements in major export and domestic markets for beef products of consistent quality (National Guidelines for Beef Cattle Feedlots in Australia, 2002). Across Australia, the total feedlot cattle capacity is currently 1.13 million head spread over approximately 600 registered feedlots (ALFA/MLA Feedlot Survey, 2008). In September 2008, numbers of cattle on feed were down to 55% of capacity, or 620,000 head, reflecting the difficult period the industry is currently enduring (ALFA/MLA Feedlot Survey, 2008).

The harsh production environment for Australian agriculture, and the regular cycling nature of droughts (Laughlin and Clark, 2000) have in recent years produced all-time high grain prices. When combined with high fuel prices (Rosegrant, 2008) these two factors comprise the largest input costs for feedlot operators. Additionally, the Australian dollar has been increasing against our major export partners (ABARE, 2008), placing substantial pressure on cattle producers on a whole striving to maintain a positive operating margin. As a consequence, the efficiency of feedlot operations has never been more important, thus the need to identify and test changes to operational procedures which could provide input cost savings and positive margins.

The frequency in which cattle are delivered feed, or the number of times the daily ration is split and delivered separately, is an area where possible efficiencies may be gained in terms of cattle performance and feedlot operational efficiency. Decreasing the feeding frequency from twice-a-day to once-a-day has the potential to produce efficiencies in fuel and labor use by reducing the daily feed delivery time. John Doyle (personnel communication, ALFA Field Day 1996 & Proceedings South African Feedlot Association 1998) implemented a once-a-day feed bunk management program in Australian commercial feedlots in 1994 to enhance feed intake during periods of heat stress and reduce labor requirements. This commercial

management program was investigated by Lawrence (1999a) in a large Australian commercial feedlot trial. At present, Lawrence (1999a) is a singular publication cited concerning the efficiencies of multiple, twice-a-day or once-a-day feed delivery in Australian feedlots.

The feasibility of any altered feeding frequency would ultimately be determined by the associated effect on animal performance, as measured by the feed conversion ratio (FCR) and carcass composition. Previous studies have concluded no difference in animal performance as a result of altering the feeding frequency (Lawrence, 1999a, Goonewardene *et al.,* 1995, Renton and Forbest, 1974, Ruiz and Mowat, 1987).

This paper presents an investigation conducted on another Australian commercial feedlot to determine whether a change from twice-a-day feeding to once-a-day feeding produces efficiencies in terms of feeding machinery and labor usage, while not having a negative effect on animal performance.

Materials and Methodology:

Feedlot steer trial:

The trial utilised Angus and British cross-bred cattle. A total of 2,189 steers were randomly allocated into one of eight groups, depending on their breed and arrival date to the feedlot. Cattle were grouped as Angus steers or other Cross-bred British (Hereford, Charolais, Shorthorn) steers, a standard procedure for this feedlot. The steers were approximately eighteen months old with an average initial body weight of 420kg ± 15kg.

A 120 day trial was conducted between November 2007 and February 2008. This is consistent with research conducted by the Beef Cooperative Research Centre (CRC) that

found at least 70 days was required to accurately quantify feed intake (FI), average daily weight gain (ADG) and feed conversion ratio (FCR) (Arthur *et al.,* 2004).

The number of animals in each trial group was determined by pen size, with each animal requiring a minimum of 9m² ground space to meet guidelines related to the national feedlot accreditation scheme regarding animal health and welfare (National Guidelines for Beef Cattle Feedlots in Australia, 2002). The eight trial groups ranged in size from 236 steers to 333 steers. The available resources for this commercial trial were within the feedlot standard operating procedures, limiting the possibility of groups of equal steer numbers.

Feed delivery management.

The eight groups were randomly allocated to one of the two treatment groups; treatment 1 was once-a-day feeding and treatment 2 was twice-a-day feeding (or standard feedlot bunk management practices). For the duration of the trial, the only difference between the management of the two treatments was the frequency with which feed was delivered. For the groups in treatment 1, 100% of the daily feed assigned to each group was delivered at 1000hr each day. The time period after 1000hr is based on the observations of Ray and Roubicek (1971) and Lawrence (1999b), observing cattle were more inclined to feed at sunrise and later in the afternoon. Initiation of feeding at 1000hr is suggested to be a time when the feed delivery process will have a minimal impact on natural feeding behaviour. For treatment 2, 45% of the feed was delivered at 6000hr (sunrise) and the remaining 55% was delivered at 1100hr, a standard practice for this feedlot. The amount of feed delivered to each group was determined by their expected individual feed intake over the past 24 hours as well as the last 5 days. Ration was delivered into the continuous concrete bunks in front of each group.

All groups were initially fed a series of three starter rations for the first 15 to 16 days to train cattle to eat from bunks as well as for a rumen adaptation time period from pasture to a grain

based system (Brown *et al.,* 2006). The roughage to grain ratio was altered with each change in ration during this period to reduce the potential incidence of digestive disease (e.g. bloat and lactic acidosis) (Bevans *et al*., 2005, Schwartzkopf-Genswein *et al.,* 2003). A finisher ration of high energy content containing approximately 12 MJ ME/kgDM was fed for the remaining trial period. For commercial confidentially reasons, the constitution of each ration cannot be published, but was consistent across both treatments.

At the conclusion of the feedlot trial each steer was processed and objective measurements were taken on either a group or individual basis. Group measurements included feed intake (kg/head.day) and feed conversion ratio (kgDM/kgLWTgain) whilst individual measurements included average daily weight gain (kg/head.day), marbling score, meat colour, P8 fat depth (mm), eye muscle area (cm^2), rib fat depth (mm), hot standard carcass weight (kg) and carcass meat yield (%).

Statistical analysis.

Data from individual steer measurements were analysed using the REML procedure of GenStat 10th Edition (Lawes Agricultural Trust, 2007). The random model included the group number (identification code) and the fixed model incorporated the constant and treatment. For measurements only available on a group basis (feed intake and feed conversion ratio), a two-sample t-test from GenStat 10th Edition (Lawes Agricultural Trust, 2007) was used to compare the difference in treatment means.

Machinery trial:

This trial was run for a period of 28 days from December 2007 to January 2008. The trial was conducted by zoning off a section of the feedlot where cattle were fed once-a-day at 1000hrs, which enabled calculation of the time spent feeding this area over the trial period.

The interface scale and software system, Digi-Star (Datakey Electronics, 2008), was used to calculate the total time each of the two feeding trucks spent feeding the trial area each day. This scale software system objectively calculated the quantity of feed loaded and delivered to each group within the trial area each day. Digi-Star is a data-link Windows program which enables communication via radio frequency between the feed mill and feed trucks to complete these tasks. The necessary information is stored on a computer network enabling feed assignment and analysis to take place.

The amount of feed delivered to each pen was calculated by multiplying the estimated individual feed intake by the number of steers in the group for each day, and was adjusted daily to match feed consumption with feed delivery to minimize feed wastage. This is known as a 'clean bunk' management system, where the bunk reader aims to assign enough feed to each group so that all the feed is consumed, and an empty bunk achieved approximately two hours before the next days feed delivery (Pritchard and Bruns, 2003). This calculation is a follows:

Feed delivered to each pen	=	Expected individual feed intake (as fed basis)	X	Number of individuals in each pen

As a comparison to the machinery trial data being collected for once-a-day feeding, historical data was used to provide the same measurements when the entire feedlot was under a twice-a-day feeding frequency. The exact distances travelled by the feed trucks during the machinery trial were not possible to obtain, but the route travelled and location of trial pens were considered an accurate representation of the whole feedlot. This enabled identification and quantification of machinery efficiencies for once-a-day as opposed to a twice-a-day feed delivery.

The data collected included: tonnes of feed delivered per litre fuel (t/l), fuel used per tonne of feed delivered (l/t), fuel cost per tonne of feed delivered ($/t) and tonnes of feed delivered per

hour (t/hour). At the time this study was conducted, the cost of diesel was $1.50/l and was consistent across both treatments. Two different trucks were used to deliver the feed to the trial area of the feedlot; an Oswalt truck with an 8 tonne feeding capacity, and a Roto-Mix truck with an 11 tonne capacity. For analytical purposes, an average across both trucks was used to compare the two treatment groups for each parameter.

The cost of fuel was calculated as fuel use (litres) per tonne of feed delivered. For the trial area, fuel use was determined by calculating the total amount of hours spent feeding, and multiplying this by the previously calculated fuel usage per hour for each of the two feed trucks. This fuel usage per hour was calculated from historical data, and is constant across treatments. The total fuel use was divided by the total feed delivered to calculate the amount of fuel required to deliver each tonne of feed for both treatment groups. When the fuel use per tonne of feed delivered was calculated for the once-a-day frequency, this conversion factor was extrapolated out over the whole feedlot, depending on how much feed was being delivered at a particular time. This calculation gave the theoretical total fuel use and cost of feeding once-a-day over the whole feedlot. This was then compared to the fuel used for feeding twice-a-day for a particular time over the whole feedlot to determine if feeding once-a-day produced cost savings in fuel, and time efficiencies in labour and machinery operation. The calculation for the fuel usage per hour of truck operation is as follows:

Fuel use	=	Total time spent feeding (hours)	X	Pre-determined fuel usage per hour for each feed truck

Results:

Feedlot steer trial:

Feed intake did not differ significantly (P=0.644) between the two treatments, despite the once-a-day fed steers consuming on average 9.52kg/hd.day compared to the twice-a-day steers 9.62kg/hd.day. The once-a-day fed steers maintained the same average daily weight

gain (1.61kg/hd.day) as the twice-a-day fed steers (P=0.990) while their FCR was slightly lower at 5.92kgDM/kgGain compared to 5.98kgDM/kgGain for the twice-a-day fed steers. However, this difference of 0.06kgDM/kgGain was not statistically significant (P=0.728). Individual carcass characteristics were measured during processing at the abattoir for each animal. Table 1 shows that small differences were observed between the treatment groups for all characteristics, but none were deemed statistically significant (P>0.05).

Table 1: Feedlot steer trial results:

	Treatment			
	Twice-a-day	**Once-a-day**	**SEM**	**P-Value**
Feed Intake (kgDM/hd.day)	9.620	9.527	0.190	0.644
ADG (kg/hd.day)	1.610	1.612	0.076	0.990
FCR (kg feed/kg gain)	5.985	5.920	0.178	0.728
Marbling Score (1-9)	1.185	1.138	0.086	0.600
Meat Colour (1-6)	1.895	1.717	0.253	0.506
P8 Fat (mm)	17.35	16.98	0.943	0.706
Eye Muscle Area (cm2)	78.21	77.30	1.498	0.566
Rib Fat (mm)	21.005	21.967	N/A	0.297
HSCW (kg)	355.1	351.7	3.367	0.353
Yield (%)	58.7	58.4	0.351	0.309

Note: A P-Value of <0.05 indicates a significant difference is present between treatments.

Machinery trial:

A comparison of the amount of feed that can be delivered to the two treatments per litre of fuel used by the feed trucks is presented in Table 2. On average, the once-a-day treatment resulted in an increase of 0.57 tonnes (or 570kg) of feed delivered per litre of fuel used, resulting in an efficiency gain of 20.32% when feeding once daily compared to twice daily.

Table 2: Feed delivered (tonnes) per litre fuel

	Treatment	
	Once-a-day	**Twice-a-day**
Oswalt Truck	2.76	2.01
Roto-Mix Truck	2.99	2.60
Average	2.87	2.30
Average Difference	+0.57	-
Efficiency (%)	+19.87	-

The difference between treatments with regards to the amount of fuel used per tonne of feed delivered is presented in Table 3. Across both treatment groups, the Roto-Mix truck required less fuel to deliver each tonne of feed. On average, the once-a-day treatment group required 0.34 litres of fuel to deliver one tonne of feed, compared to 0.44 litres with the twice-a-day treatment group. Overall, this results in an efficiency gain of 20.94% when operating under a once-a-day feeding frequency.

Table 3: Fuel used (litres) per tonne feed delivered

	Treatment	
	Once-a-day	**Twice-a-day**
Oswalt Truck	0.36	0.49
Roto-Mix Truck	0.33	0.38
Average	0.34	0.43
Average Difference	-	+0.09
Efficiency (%)	+20.94	-

The fuel cost per tonne of feed delivered is presented in Table 4. For both treatments, the Roto-Mix truck was more efficient, with a lower fuel cost associated with the feed delivery process. On average, the cost of fuel for the once-a-day treatment group was $0.51 per tonne delivered, compared to $0.65 per tonne delivered for the twice-a-day group, representing a fuel cost saving of $0.14 per tonne of feed delivered. Overall, this represented an increase in fuel cost efficiency of 21.53%.

Table 4: Fuel cost [a] ($) per tonne feed delivered

	Treatment	
	Once-a-day	**Twice-a-day**
Oswalt Truck	0.53	0.73
Roto-Mix Truck	0.49	0.57
Average	0.51	0.65
Average Difference	-	+0.14
Efficiency (%)	+21.53	-

[a] the fuel cost was assumed to be $1.50/L for both treatment groups.

The amount of feed that can be delivered per hour between both feed trucks and across the two treatment groups is presented in Table 5. The higher feed holding capacity of the Roto-Mix truck is reflected by the increased output per hour of operation across both treatments. On average, 5.27 tonnes more feed can be delivered per hour under the once-a-day feeding frequency than the twice-a-day frequency, highlighting an increase in the efficiency of the

feed delivery process of 19.42%. In terms of the time and cost associated with the feed delivery process over the whole feedlot, this represents a very high gain in operational efficiency.

Table 5: Feed delivered (tonnes) per hour

	Treatment	
	Once-a-day	**Twice-a-day**
Oswalt Truck	25.53	18.61
Roto-Mix Truck	28.96	25.14
Average	27.14	21.87
Average Difference	+5.27	-
Efficiency (%)	+19.41	-

Discussion:

This study has investigated the feasibility of changing to a once daily feeding regime for feedlot operators currently feeding twice daily. The results from the machinery trial, feedlot trial and evaluation of carcass data show a substantial increase in feedlot operational efficiency is gained without having detrimental effects on animal performance.

Feedlot operational efficiency:

The feed delivery process operates more efficiently under a once-a-day feeding regime with all four comparative measurements (tonnes of feed delivered per litre fuel; fuel used per tonne of feed delivered; fuel cost per tonne of feed delivered; and tonnes of feed delivered per hour) indicating increases in efficiency in the vicinity of 20% when delivering feed once daily.

Significant increases in the cost of fuel since this trial was conducted in December 2007/Janruary 2008 have placed increased importance on identifying and utilizing the most efficient practices in order to maintain positive operational margins. Three of the four comparative measurements used in this trial related to fuel use in the feed delivery process in order to reflect the importance of this. In terms of machinery operation, a once-a-day feeding regime reduced the feeding time and fuel use, providing a 19.4% gain in labour time

efficiency associated with the feed delivery process and reducing the cost of fuel per tonne of feed delivered by 21.5%.

Labour availability within the agricultural industries has diminished in recent times, with changes in society social and economic structure as a result of the drought and the mining boom producing labour shortages (NFF, 2007). This situation has increase labour costs, demanding labour hours to be used more efficiently. Ultimately, managers must identify the most efficient operational systems for their feedlot in order to achieve this.

This increase in labour use efficiency is clear when considering the same quantity of feed has to be delivered over the whole feedlot each day regardless of the feeding regime (ignoring any influence feeding regime has on cattle feed intake). When feed is delivered under a once-a-day regime the number of visits to each pen is theoretically halved, thus reducing the total time to conduct the feed delivery process across the feedlot. However, the time requirement for the daily feed delivery process is not halved as the time spent driving to and from the feed mill, and the ration ingredient loading and mixing time is also included in the process. Odometer readings on the feed trucks were not possible to obtain, but it is expected that each feed truck would travel a reduced daily distance when operating under a once-a-day regime. With a reduction in the time of the feed delivery process, the surplus labour hours must be best redirected to another area of the feedlot, to enhance other feedlot processes.

Due to time limitations, historical data from feedlot records for the standard twice-a-day feeding practice was compared to the results from the machinery trial for once-a-day feeding. With the time and resources available, this was deemed to be the most accurate methodology available. It is however recognized that completing a trial of similar length for twice-a-day feeding in conjunction with the once-a-day feeding trial may have been more useful if the experiment was to undergo replication at another site.

Animal performance:

There were no significant differences in animal performance between steers fed once and twice daily. The other Australian publication that quantified the effect of feeding frequency upon animal performance also observed no disadvantage in terms of feeding frequency (Lawrence, 1999a). Feeding frequencies of once, twice and four times per day were compared, with no significant differences between feed intake, daily gain, feed conversion, morbidity and carcass assessment between feeding regimes (Lawrence, 1999a). Consequently, the decision of feeding frequency should be reliant on a number of individual feedlot operational factors.

Ruiz and Mowat (1987) provides agreement with these results, concluding feeding frequency achieves small, but non-significant differences in rate of gain, feed intake and feed efficiency. When frequencies of once, twice and three times daily were compared in an unpublished study by Schutz *et al*. (1999) it was found that feed intake and daily weight gain were significantly greater when feeding three times daily, but feeding efficiency was very similar. As feeding efficiency is the ultimate indicator of differences in animal performance, feeding three times daily was not observed to be of benefit. Goonewardene *et al.* (1995) also observed non significant differences in animal performance when comparing the same feeding frequencies.

Along with feeding frequency, the optimal timing of daily feed deliveries has been previously investigated to determine the associated effect on animal performance. The basis for feeding once-a-day at 1000hrs was due to Ray and Roubicek (1971), observing post 1000hrs was optimal to match diurnal feeding behaviour with photoperiod so that animals exhibited natural feeding behaviour. Results from studies conducted in the northern hemisphere suggest the timing of feed delivery does not significantly influence animal performance (Soto-Navarro *et al.,* 2000, Schwartkopt-Genswein *et al.,* 2000). Traditionally in Australia (southern

hemisphere), feed delivery is completed in the morning. The scope of this study was not to investigate the relationship between feed delivery time and animal performance. However, due to the findings of previous work it was expected morning feeding would not influence animal performance or mask the potential influence of feeding frequency.

Schutz *et al.* (1999) highlight that increasing the feeding frequency to take advantage of an increased feed intake and weight gain when steers were fed three times daily may prove uneconomical in terms of labour use and machinery operation. A study conducted by Renton and Forbes (1974) not only confirmed that feeding frequency had no significant influence on animal performance, but also highlighted that the increasing cost of labour had led producers to question the 'traditional' practice of twice daily feeding.

A factor which could determine whether a feedlot can change to a once-a-day feeding frequency relates to the size (volume) of feeding bunks. This relates to whether 100% of a ration will physically fit into the existing bunks. If the bunk size is not adequate the practice of split portion deliveries may be the only option, unless a cost-benefit analysis determines that the cost savings of once-a-day feeding over a certain period are greater than the replacement cost of upgrading to larger bunks.

Carcass performance:

The results from this study suggest feedlot feeding frequency has no significant effect on the carcass characteristics of economic importance. There was no significant difference across both feeding frequencies between the average marbling score, meat colour or eye muscle area, fat deposition, hot standard carcass weight (HSCW) or yield which was to be expected considering the results of the feedlot steer trial.

Carcass performance is commercially important, most notably in determining if the carcass specification parameters of retail cuts are suitable for distribution to high-value markets. If the carcasses produced from feedlot cattle do not meet the stringent specifications for premium

markets, the product will be downgraded and devalued. Feedlot profitability is therefore influenced by carcass weight and specification, the prices paid for each weight and grade, and the length of the feeding period (Hironaka and Sonntag, 1984; Hironaka and Sonntag, 1979).

Of the measured characteristics, HSCW varied the most between treatments, with an increase in weight of 3.4kg/carcass for the twice-a-day fed steers. Although not statistically significant ($P>0.05$), the small increase in weight was consistent with Schutz *et al.* (1999) where no significant difference was observed between once and twice daily feeding. However, steers fed three times per day as opposed to once a day and twice a day produced carcasses of significantly higher weight ($P<0.01$), with an average increase of 9.52kg/carcass. This study did not provide sufficient explanation as to the reasons for this increase in HSCW with feeding three times daily, nor did it indicate if the study had been repeated for confirmation of results. Due to this, further investigation is required into whether this increase in carcass weight was solely due to increased feeding frequency.

Delehant and Hoffman (1996) suggest feeding once daily in the morning (0800hr) improved carcass composition as opposed to once daily feeding in the evening (1600hr) or twice daily feeding at 0800hr and 1600hr. This was supported by higher dressing percentages, larger loin eye areas and less back-fat upon processing. However, when this study was repeated a second time the increase in dressing percentage was not evident, but the carcasses of once-a-day morning fed steers were still leaner.

The results of the current study suggest no advantage in terms of carcass yield or fat cover with either a once-a-day or twice-a-day feeding frequency, as there is no change in carcass composition as a result of altering the feeding frequency. Due to the paucity of information relating to feeding frequency and carcass performance it would be beneficial to conduct further research.

Conclusion:

This study has established that under Australian conditions, feedlot performance can be maintained with a once-a-day feeding regime when using feed intake, average daily weight gain, feed conversion ratio and carcass composition as measures of animal performance. The 20.4% increase in fuel and labour use efficiency associated with once-a-day feeding will translate to a reduction in the costs of production for a feedlot. This will be especially relevant for feedlot managers who aim to maximise feedlot operational efficiency, especially in terms of labour and machinery use, in an effort to reduce the costs of production and achieve positive operating margins.

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