The Impact of Feed Intake and Feeding Behaviour of Cattle on Feedlot and Feedbunk Management

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■ Introduction

Prediction formula compiled by the NRC (1984) confirm intuition that suggests performance improves at an increasing rate as intakes increase and feed required for maintenance is diluted. After critical evaluation however, it is recognized that the impact of intake and feeding patterns on feedlot and bunk management is not as clear cut as is frequently assumed. Excellent symposia have been held on this topic at Oklahoma State University. As well, much research has been conducted on intake patterns and on their relationship to acidosis at the University of Nebraska. Both sources deserve recognition for the valuable information they provide and their extensive citations in compiling this information. Research on feeding behaviour of feedlot cattle conducted at the Lethbridge Research Centre using a unique radio frequency identification system will also be presented. The impact of feed intake and its regulation on performance is an expansive topic. This paper, however, will focus on the information believed to be most relevant at the production level.

■ Measuring Intake

When discussing feed intake by beef cattle, it is important to understand and differentiate between the different types of intake measurement. Intakes measured for pen-fed cattle are always average intakes, but it is not always a safe assumption that average intake for a pen is indicative of intake by the individual animals in that pen. For example, apparent variation in daily intake by individually fed cattle was reduced 10-fold when individual intakes were averaged across animals in the pen (Stock et al., 1995a). Mean intakes for a feeding period can mask further the changes in intake that occur through the period. A full understanding of intake patterns and their impact on performance requires that intake by individuals is monitored. Such measurements usually require individually penned animals, or devices that restrict access to a feeding station to individual animals (e.g., Calan™ gates, pinpointers). However, the effects of social behaviour among penmates on their feeding behavior is often lost or altered under such feeding conditions. New radio frequency technology utilized at the Lethbridge Research Centre enables eating behaviors of individual animals in a pen to be monitored with minimal disruption in their social behaviors. For the most part, however, when assessing intake information, it is important to recognize the differences between individual intake and average intake for a pen.

■ The Economics of Intake

The positive correlation between intake and performance, and the negative relationship of intake to cost of gain can be clearly demonstrated using the equations established by the National Research Council (NRC, 1984). For a typical 900-lb feedlot steer consuming 19.5 lbs/day of dry matter of a typical barley based finishing ration, a 10% increase in dry matter intake (DMI) results in a 17.8% improvement in gain, a 4.4% improvement in feed efficiency and a 4.6% reduction in cost of gain. Thus, the incentive to maximize intake is obvious.

Small improvements in feed efficiency can reduce the cost of gain considerably. For example, using current costs of production, a 5% improvement in feed efficiency has about four times the economic impact as a 5% improvement in daily gain (this scenario assumes that faster gaining cattle will be sold sooner, rather than at a heavier weight; the potential additional advantage of feeding more cattle each year has not been factored in to the calculation).

The economic impact of improving feed efficiency is a reflection of its large contribution (usually near 70%) to calculating the total cost of gain. Many producers also believe that consistency of intake affects performance and has financial implications.

■ Variations in Intake

Twenty years ago a pair of papers published by the University of Nebraska (Fulton et al., 1979a; 1979b) demonstrated that low (<5.6) ruminal pH inhibits intake and that subacute acidosis manifests as low and/or fluctuating intakes. Variations in average intake (calculated for groups of 4) were documented as cattle were stepped up from 35% to 95% concentrate diets of wheat or corn. The lowest ruminal pH (< 5.2) occurred on the first day of introduction to the 55, 75, and 95% wheat diets, which correspond to the days of lowest intake. The larger variations in intake observed on wheat diets as compared to corn were attributed to the greater acid production from the more rapidly fermented grain. Reduced pH fluctuations and higher feed intake following ruminal infusions of sodium and potassium hydroxides also demonstrated the close correlation between ruminal pH and intake level.
As a result of this research, erratic intake patterns are assumed to be an obvious symptom of a very subtle malady and the simplicity of using intake patterns as a gauge of subacute acidosis has led to wide embrace. Despite the previously discussed inadequacies of average intake as indicators of intake by individuals, intake “crashes” similar to those observed by Fulton et al. (1979b) are commonly seen at the feedlot level. Typically, a crash occurs after cattle have settled into the feedlot and their intake is climbing rapidly. Under such a condition, abrupt changes in pen intake indicate that a large percentage of the cattle in the pen are affected and the average intake in this case likely does reflect individual intake by most of the cattle in the pen.

It is commonly assumed that fluctuations in intake can also cause acidosis. This belief, held by most feedlot producers, stems in large part from research conducted by Galyean et al. (1992) and subsequently disseminated by industry personnel. Delivery of a 90% concentrate diet to limit fed 380-kg calves was either kept constant from day to day, or was varied by 10% on a daily or weekly basis in a manner that allowed intakes by all groups to be equal. The cattle whose feeding level fluctuated daily had 6% poorer gains and 7% poorer feed efficiencies than those fed at a constant level. The common conclusion drawn from this research is that the impaired performance was a result of the acidosis arising from intake variation, even though ruminal pH was not measured. This theory, generated from a single trial, remains prevalent despite a mounting body of research that suggests otherwise (Zinn, 1994; Stock et al. 1995b; Soto-Navarro et al., 1997; Cooper et al., 1998a). Cooper et al. (1998a; 1998b) monitored ruminal pH in a metabolism trial, and animal performance in a finishing trial which included deliberate fluctuations in intake. Ruminal pH was lower for limit-fed cattle when day-to-day intakes were varied by 1.4 kg, but there were no differences in pH when the cattle were fed to meet ad libitum intake. During the study, an equipment malfunction delayed feeding for 4 h. At that point it was observed that delayed feeding (such as could arise in a commercial lot, with equipment breakdown or inconsistent timing of delivery) can have a greater effect on ruminal pH than fluctuating quantities of feed. In the finishing trial (Cooper et al. 1998a), varying the amount fed by 1.8 kg per day numerically increased intake but did not affect performance.

It is feasible that cattle become adapted to consistent variations in the quantity of feed delivered, thereby decreasing the negative effects of feed intake fluctuation. Observations of the comfort and eating behaviours of milk-fed dairy calves indicate that predictable inconsistencies are tolerated better than are random inconsistencies (Johannesson, 1998).

Stabilizing intake levels is not a primary objective of every feedlot manager, but most do recognize the positive relationship between intake level and growth performance. Most bunk management programs aim to achieve stable intake levels as a means by which maximum intake can be achieved.

■ Bunk management

Most of the principles of bunk management are based primarily on personal opinion derived from simple correlations and extrapolations from a few experiments. The lack of references in this section is a reflection of the lack of science, but an attempt will be made to summarize some of the logic of bunk management principles, and the means by which attempts are made to stabilize and maximize intake in the feedlot.

In the following discussion, a “self feeder” is a cattle feeder committed to ensuring that their cattle always have access to feed. This term is coined in reference to the self-feeding devices that are available to provide a continuous supply of feed, and is intended to raise questions on the advantage of fence-line feeding if bunks are merely used as self-feeders. “Regulated feed delivery” is a euphemism for “slick bunk management” (the term “slick bunk” scares a lot of feedlot managers) and refers to a style or logic of bunk management. The regulated feed delivery strategy seeks to improve performance by regulating intake (i.e., average pen intake) to reduce digestive problems resulting from overconsumption of feed. With regulated feed deliver, slick bunks are not the objective, merely a frequent result of this type of management.

Historically, cattle feeders have pursued maximum intake by ensuring continual availability of feed. Bunk management strategies in this scenario focus primarily on maintaining bunk hygiene by reducing orts to a small percentage of what was delivered. Attempts to target intake to a level at which orts are reduced to crumbs often amplifies fluctuations in delivery as feed callers overcompensate in their attempts to achieve the balance between too much and too little. Slick-bunk managers generally acknowledge that intake could be temporarily increased by 0.5 or 1 kg per head if more feed was delivered. However, the extra feed is typically thought to cause mild acidosis, which would result in a subsequent decline of 1 or 2 kg of intake/day. These managers believe that higher mean intakes can be maintained by avoiding intake crashes than by achieving the peaks. Whereas the self feeder attempts to maximize intake on a daily basis, the slick-bunk manager strives to maximize mean intake over the course of the feeding period.

Because there are frequently no orts in a regulated feeding strategy, bunk managers must rely heavily on interpreting cattle interest and feeding aggression when making feed calls. Orts in appreciable amounts are uncommon; bunk condition is typically categorized as clean (no feed present), crumbs (literally a few scattered kernels), or dirty (somewhat more orts, but still typically < 5% of what was fed). Subtle changes in cattle interest are considered along with bunk condition, when making the feed call.

Surprisingly, in the one reported study in which ruminal pH was actually measured in steers fed either to meet ad libitum intake (self-feeding) or using a regulated feed delivery strategy, the cattle fed with a slick bunk protocol exhibited lower and more variable ruminal pH, as a consequence of changes in their eating patterns (Fanning et al., 1999). Larger meals and a faster rate of eating resulted in a greater pH decline in the regulated cattle. Those findings are consistent with our own observations that individual cattle at the Lethbridge Research Centre exhibited increased day-to-day variation in time spent at the bunk when they were limit-fed (to 95% of ad libitum intake) than when they were on full feed (Gibb et al., 1998a). This increased variation occurred even though the timing and amount of feed delivered was held constant from day to day.

The assumption that animal responses to bunk management (if present) are a direct result of reduced acidosis is drawn from pure speculation and simple correlation. The observations reported by Fanning et al. (1999) contradict these assumptions, but this does not necessarily discredit the practice of slick bunk management to improve performance. Increased eating rates and less frequent meals are commonly observed among cattle with limited access to feed (Gibb et al., 1998a; Prawl et al., 1998a; Fanning et al., 1999). Increased eating rates have been associated with improved performance in sheep (Church et al., 1980) and with increased intake and performance by cattle (Frisch and Vercoe, 1969; Prawl et al., 1997). From unpublished data collected by Whitley and McCollum, Streeter et al. (1999) identified an apparent negative correlation between time spent at the feed bunk and average daily gain. Unless the faster gaining cattle were eating less feed, they were eating feed faster. The mechanism(s) by which increased eating rates might influence performance are unknown. Possibly, the increased rate of absorption that would result from enhanced protonization of VFA with reduced pH (Masson and Phillipson, 1950) could enhance energetic efficiency. Similar observations have been observed with chickens (Nitsan et al., 1984), however, which suggests another (non-ruminal) mechanism. Perhaps enhanced appetite impinges on the hypothalamus through the limbic system, thereby affecting satiety control and physiological regulation of growth.

If the popularity of slick or regulated bunk management, or the enthusiasm with which it is practiced, are any indication of its value, no supporting science is needed. Galyean (1996) reported that although recommendations for roughage level, implant programs and protein levels varied among feedlot nutritionists serving over 3.5 million cattle, all consultants felt regulated bunk management is a critical factor in influencing feed intake and growth performance. Personal experience indicates that converted bunk managers become enthusiastic disciples even without the confirmation of improved performance.

■ Limit Feeding

Contrary to the opinions of slick bunk skeptics, limit feeding is not the same as regulated feed delivery. The objective of the two strategies are actually quite different. Whereas the goal of regulated feed delivery is to maximize intake (and performance) over the course of the feeding period, limit feeding involves intentionally reducing intake. In some regions, it is often more economical to background cattle at a specific rate of gain (programmed feeding) calculated from dietary energy density, by limit feeding a high energy ration. Such a program also reduces manure production and simplifies transition onto the finishing diet. Limiting intake of finishing cattle is sometimes practiced to capitalize on improved feed efficiency, hopefully with only minimal effects on gain. Unlike bunk management practices, for which the logic and rationale are more anecdotal, there is at least some documentation and scientific explanation behind the mechanisms and advantages of limit feeding.

Meissner (1995) found a modest correlation between intake and daily gain (Fig. 1) but no correlation (R^2 = 0.008) between intake and feed efficiency. Similar results were obtained when intake and gain data from 300 commercial pens in the midwestern U.S. were compared (Gill, 1986). When intakes and gains from over 1000 pen summaries from southern Alberta feedlots were compared, the correlations (R^2) of intake to gain and intake to feed efficiency were 0.57 and 0.09 respectively (Gibb, unpublished information). These data illustrate the potential for cost savings if intakes and feed costs can be reduced while exerting essentially no effect on feed conversion and only a modest (if any) effect on gain.

Owens et al. (1995) made similar comparisons while summarizing 556 feeding trials conducted between 1984 and 1994. Efficiency of feed utilization was negatively correlated to intake. Gain was found to increase with intake, but at a decreasing rate. Generally, cattle gain better than expected on low intake, and more poorly than expected on high intake.

The weak, or even negative correlations demonstrated between feed intake and feed efficiency run counter to intuition for those of us indoctrinated by NRC formulae, but the phenomenon is not totally unexplainable. Most of the discrepancies between NRC-predicted responses and observed responses can be explained by differences in diet digestibility, carcass composition, and/or maintenance requirements, which are factors not accounted for in NRC equations.

Diet Digestibility

According to NRC (1989), digestibility of organic matter is reduced by 4% for each incremental increase in feed intake, relative to maintenance requirements (i.e., consumption of 3X maintenance *vs* 2X maintenance). Reduced digestibility with increasing intake is typically attributed to a faster rate of passage, resulting in reduced ruminal retention time. Feedlot cattle are typically fed 2X to 2.5X their requirements for maintenance, so a 10% restriction in intake should improve organic matter digestibility by about only 1% (Sainz, 1995). Zinn (1995) suggested that the effect of intake on digestibility is greatest at intakes between 1X and 2X maintenance, and that any improvements in digestibility associated with reduced intake are negated by a higher percentage of digestible energy lost as methane. Microbial efficiency and metabolizable protein supply are also reduced with lower feed intake (Owens and Zinn, 1988). Thus, improvements in diet digestibility associated with slight restrictions in intake are modest, and are likely offset by other factors.

Carcass Composition

One of the most consistent responses to limit feeding is a reduction in carcass fat. Increased fat content of empty body gain is one of the most notable physiological changes observed as animals' energy intake is increased (Rohr and Daenicke, 1984). Carcass fat increases with increasing rate of gain, which indicates that there may be a daily biological limit on the physiological potential to deposit protein (Byers, 1982). A shift, arising from increased intake, toward increased fat storage at the expense of protein accretion results in a reduced rate of gain, because the density of fat is lower than the density of lean (Rohr and Daenicke, 1984). The corollary of this suggests that decreasing energy intake would affect fat deposition more than protein accretion. Because fat is less dense than lean, fat deposition can be reduced with only a moderate effect on rate of gain. Hence, limit feeding can effectively increase the lean:fat ratio and improve feed efficiency with only minimal effects on gain.

Maintenance Requirements

Maintenance energy requirements of beef cattle are assumed to be 77 kcal of Net energy (NEm) for each kg of metabolic body weight (NRC, 1984). Although this value is likely a good average to use for general calculations, it is not consistent across all intake levels. Visceral organs represent a greater proportion of body metabolism than of body mass, and organ weights are affected by feed intake (Pekas, 1995). The increased energy use by larger visceral organs as a result of higher intake would increase energy required for maintenance and reduce the amount of energy available for gain (Ferrell and and Jenkins, 1995; Fig. 2). Heat production during fasting was shown to decrease by 5.8% and 8.7%, as intake levels were restricted by 15 and 30%, respectively (Old and Garret, 1987). The improved energetic efficiency realized by reducing energy requirements for maintenance also helps explain the improvement in feed efficiency observed with limit feeding.

■ Competition

The interest, intrigue and possible benefits of regulated and restricted feeding are not enough to offset the concerns of many feedlot managers over the increased competition among penmates and possible inequitable access to feed that may result if feed is not provided to meet ad libitum consumption. This concern is understandable, but is unsubstantiated, in fact the benefits of increased competition may outweigh its unproven risks.

A novel research approach demonstrated the possible advantages of increased competition and appetite, and put to rest the notion that slick bunks are an absolute indication of reduced intake. Rather than restricting the amount of feed offered, Prawl et al. (1997) limited the amount of time cattle had access to an 87% whole corn diet, to 1.5, 3, 6, 9, or 24 h each day. Due to low intake and poor performance, the 1.5-h treatment was eliminated halfway through the trial. By the end of the 120-d trial, cattle limited to feeding 9 hours per day had higher ($P < 0.05$) average daily gains, feed efficiency and dressing percentages, and numerically increased intake, carcass weight, and ribeye area than those with unrestricted access to feed (Table 1). Subsequent trials by the same researchers (Prawl et al., 1998a; 1998b) confirmed that intake can be maintained or even increased by regulating access to feed, either by blocking access or making appropriate feed calls.
It is feasible that increased competition and/or interrupted feed availability stimulates appetite, which would help explain why cattle typically eat more when group-fed than when fed individually (Kidwell et al., 1954; Coppock et al., 1972; Warnick et al., 1977; Phipps et al., 1983;).

Zinn (1986) increased competition of limit-fed cattle by restricting bunk space to to provide linear allowances of 60, 45, 30 or 15 cm per head. With heavy calves (227 kg), weight gain and feed efficiency increased linearly as bunk space was reduced. With light calves (200 kg), however, this trend was reversed. Whether or not the different responses can be accounted for by differences in aggression levels between the two weights of calves is not known. Reducing the available bunk space did not increase variability in weight gain among the calves, which indicates that increased competition likely had little effect on equality of intake among penmates. In a feedlot setting, performance of calves limit-fed a corn-based diet did not differ when bunk space was either 20 or 26.4 cm per animal (Lake, 1986).

With continual availability to feed, surprisingly little bunk space is required to ensure all animals have adequate access to feed. Growth performance was similar between groups of 15 bulls fed either from a single stall, or from a bunk with adequate bunk space for all bulls (Stricklin, 1986). Eating rates of the stall-fed bulls increased in response to the increased pressure to occupy the feeding stall. Obviously, feeding frequency may need to be adjusted based on bunk volume to accomodate total feed requirements.

Increased competition and pressure at the feed bunk can actually decrease aggressive behaviors between animals. Range cows allowed excess bunk space when supplemented on pasture spent more time defending than eating feed (Wagnon, 1966). When bunk space was reduced, the animals engaged in fewer aggressive interactions, possibly because of the risk of losing their feeding position while fighting. Wagnon (1996) found that cattle labeled as dominant, on the basis of their non-eating interactions with the other cows, frequently gave up their position to subordinate animals, and that subordinate animals did not always give up their position to dominant individuals.

Although dominant cattle frequently occupy limited bunk space more than submissive cattle (Friend and Polan, 1974; Friend et al., 1977; Wierenga, 1990), it is not always confirmed that this results in intake differences. Cattle considered submissive on the basis of their non-eating interactions frequently displace dominant cattle at the trough (Stricklin and Gonyou, 1981). As well, eating rates are typically altered to accomodate competition and pressure at the bunk (Kenwright and Forbes, 1993; Gibb et al., 1998a; Prawl et al., 1998a). Subordinate dairy cows also spend more time at the bunk during times of low attendance (Kenwright and Forbes, 1993). Daily bunk attendance among yearling steers varied 10-fold in a study conducted at the Lethbridge Research Centre (Gibb et al., 1998a) but there was no correlation between daily gain and time spent at the bunk (unpublished data), indicating that time spent at the bunk is likely a poor indicator of intake. The lack of correlation between bunk attendance and feed intake has been observed by others (Metz, 1974; Friend and Polan, 1974).

It is important to recognize that dominance and aggression are not synonymous. Appetite is dictated by physiological hunger and determines how aggressively an animal is willing to compete for food (Metz, 1983). Aggressive cattle that dominate the bunk on the first feeding are likely displaced by hungrier cattle on subsequent feedings. It is also feasible that increased competition helps prevent cattle near satiety from gaining access to feed that would result in digestive problems.

■ Effect of Ionophores on Feeding Behaviour

It is generally assumed that most of the beneficial response to feeding ionophores is a result of improved energetic efficiency resulting from increased propionate:acetate ratios and reduced methane losses. However, some of the beneficial effects of ionophores may also be attributable to their modifying effect on feeding behaviour.

Monensin is the most extensively studied ionophore, with regard to its effect on feeding behaviour. Feed intake decreased linearly with increasing monensin dosage; at 27.5 ppm, monensin reduced intake by approximately 7% (Goodrich et al., 1984). More recent estimates suggest that the reduction in feed intake is only 1%, due to higher energy finishing rations now utilized (Stock et al., 1995a). The intake-suppressing effect of monensin also manifests through changes in eating patterns. Cattle fed monensin typically eat smaller, more frequent meals (Chirase et al., 1992; Laudert, 1995; Fanning et al., 1999), which helps explain the increased ruminal pH observed when monensin is administered (Nagaraja et al., 1982). This moderating effect is noticed most when eating rates are naturally increased through regulated, or restricted feeding (Fanning et al., 1999; Gibb et al., 1998b; Table 2).

Monensin reduces day-to-day variability in intake by individually fed cattle (Burrin et al., 1986; Stock et al., 1995a). This effect has been attributed to the moderating influence of this ionophore on acid (particularly lactate) production (Nagaraja et al., 1982). Although this explanation fits comfortably with the acidosis paradigm, reduced eating rates in conjunction with decreased acid production is inconsistent with previous research and commonly proposed mechanisms. Fulton et al. (1979b) attributed the slower eating rate of wheat-fed *vs* corn-fed cattle to the lower ruminal pH of the cattle receiving wheat. This contradiction, along with fact that the effect diminishes as days on feed increase (Stock et al., 1995b) indicates that the effect of ionophores on intake is not entirely pH-related. Whatever the mechanism, the ability of monensin to reduce eating rate and variability in intake may be particularly appealing in situations where appetite is increased through a bunk management protocol.

■ Intake Patterns Through the Feeding Period

Intake patterns documented by Hicks et al. (1990) from over 1500 pen summaries from commercial feedlots illustrate general intake patterns of feedlot cattle throughout the feeding period (Fig 3). Yearling cattle exhibited an intake plateau between 28 and 56 days on feed, whereas calves did not exhibit a plateau until after approximately 80 days on feed. Others have found that intake by calves continue to increase throughout the feeding period (DeHaan et al., 1995; Jim et al., 1998). Despite minor differences in weights and ages of cattle, the primary trend of a rapid initial increase in intake followed by a more gradual increase or even a plateau is consistent for all feedlot cattle. The primary segments of this trend deserve mention.

Starting Cattle

Feed intake by newly weaned calves entering the feedlot can be very low. The low average pen intakes recorded during this period, as calves become adapted to their novel surroundings and diet, arise not only from low individual intakes but from no intake at all by some individuals in the pen. During the first 10 days in the feedlot, 24 full animal-days of no bunk attendance were attributable to 10 of the 60 calves in a recent study at Lethbridge (Gibb et al., 1999). One calf did not come to the bunk until its eleventh day in the feedlot. Similar intake patterns by recently weaned calves were observed by Hutcheson and Cole (1986). Increased health problems of newly weaned feedlot cattle are often complicated by low intakes (Fluharty et al., 1994). This challenge in turn is compounded by the timid eating patterns of morbid cattle (Sowell et al., 1998). Presumably, digestive disturbances such as acidosis would have a similar effect on eating aggression, and increased competition would help reduce consumption by these animals, thereby fostering their recovery.

Climbing Intakes and Ration Changes

Even with modest levels of grain in the ration, rapid increases in intake can result in acidosis and then a subsequent abrupt drop in intake. When grain content of the diets was increased from 35% to 95% in 20% increments, low ruminal pH values were measured on the first day that each of the transition rations were fed (Fulton et al.,1979b). Lactate levels were up to 10 times higher on the 35% concentrate diets than on the 95% concentrate diets. The most elevated lactate levels occurring in association with the lowest grain content diet likely reflects increased production of lactate, as well as the lag time for proliferation of lactate-utilizing microbes. Lactate is a stronger acid than the other VFAs and has also been implicated as suppressor of feed intake (Baile and Forbes, 1974). Abrupt drops in intake early in the feeding period when intakes are climbing rapidly is likely attributable to the high lactate levels in conjunction with low pH. Regulating feed delivery to reduce over-consumption may be especially beneficial during this period. Spreading competition out over more feed deliveries during this phase will help ensure hungrier cattle have more opportunities to out-compete cattle that may have dominated the bunk at previous feedings.

The limited maximum intake program implemented by Xiong et al. (1991) provides an example of how intake can be regulated through climbing intake and ration changes. With this system, average energy intake (based on DMI and energy density) is limited, and incremental increases are allowed until cattle reach the desired level of energy intake. This system accounts for the changing energy density of rations while assuring a smooth, regulated increase in energy intake. Although this system has been used successfully with cattle fed corn based diets (Preston, 1995), there were no improvements in performance with this system for feedlot cattle fed barley-based diets (Jim et al., 1997).

Plateau

Once intakes have stabilized following adaptation and ration transition, most bunk management challenges result directly or indirectly from changes in the weather or problems with feed delivery schedules. When this occurs, dietary forage levels are often increased to help buffer potentially aggressive appetites when normal eating patterns are disrupted by these factors. As well, increasing frequency of feed delivery may help improve intake equality in a pen when intakes are regulated.

Late in the feeding period, intake may begin to decrease, particularly with British yearling cattle (Fox and Black, 1984). Reduced intake at this time may be explained by increasing body fat stores which may exert feedback control to reduce feed intake (Hyer et al., 1986). Intakes begin to decline when carcass fat levels reach 22 to 28% (Fox and Black, 1984; NRC 1987). Producers often use this signal as an indication of when cattle are “finished”. Even if declining intake is an imperfect indicator of carcass fat, it typically does signal reduced performance and increased costs of gain.

■ Conclusion

Performance and cost of production may be improved by manipulating level and patterns of feed intake. Although responses to limit feeding can be explained scientifically, the responses and logic behind bunk management protocols are poorly documented and require more scientific validation. Potential benefits of specific bunk management protocols must be investigated under pen feeding conditions representative of commercial feedlot production in order that the dynamics of social interaction and competition are considered. New approaches including radio frequency technologies will facilitate such research.

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Table 1. Effects of limiting access to feed[z] on performance of feedlot cattle

	3 h	6 h	9 h	24 h
Dry matter intake (kg/d)	8.72[a]	9.29[a]	9.76[a]	9.57[a]
Average daily gain (kg/d)	1.31[b]	1.23[b]	1.54[a]	1.38[b]
Feed/gain	6.69[a]	7.58[a]	6.35[b]	6.93[a]

[z]Access to feed bunk was time-limited (hours per day).
[a,b]Values in the same row lacking common superscripts differ ($P < 0.05$).
From Prawl et al. 1997.

Table 2. Effect of ionophores and feeding level on feedbunk attendance

	Feeding to ad libitum intake		Feeding to 95% of ad libitum intake	
	Monensin[z]	Salinomycin[y]	Monensin	Salinomycin
No. of bunk visits (visits/d)	7.9[a]	7.2[b]	6.9[a]	6.3[b]
Total daily attendance (min)	35.4[c]	31.8[d]	32.8[a]	25.9[b]
Variation in TDA[x] (%)	30.7[f]	31.2[e]	31.0[b]	35.8[a]

[z]Monensin was included in feed at 25 ppm; [y]Salinomycin was included in feed at 13 ppm.
[x]Total daily attendance
Within a feeding level, values within a row lacking common superscripts differ:
[a,b] = ($P < 0.001$); [c,d] = ($P < 0.01$); [e,f] = ($P < 0.05$).
From Gibb et al., 1998b

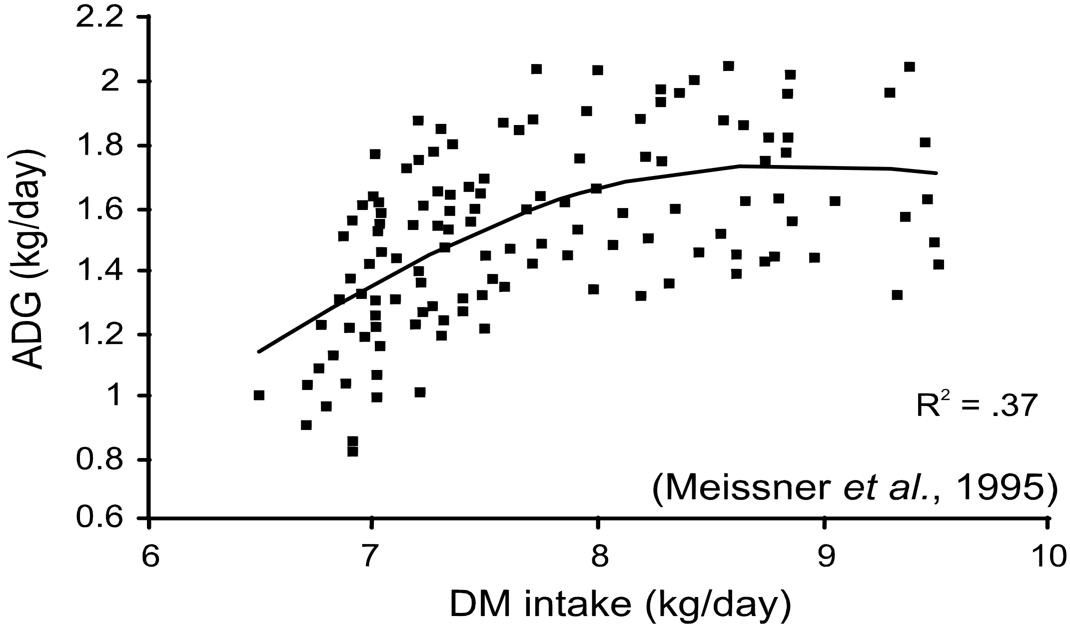


Figure 1. The relationship between dry matter intake and average daily gain. From Meissner et al., 1995.

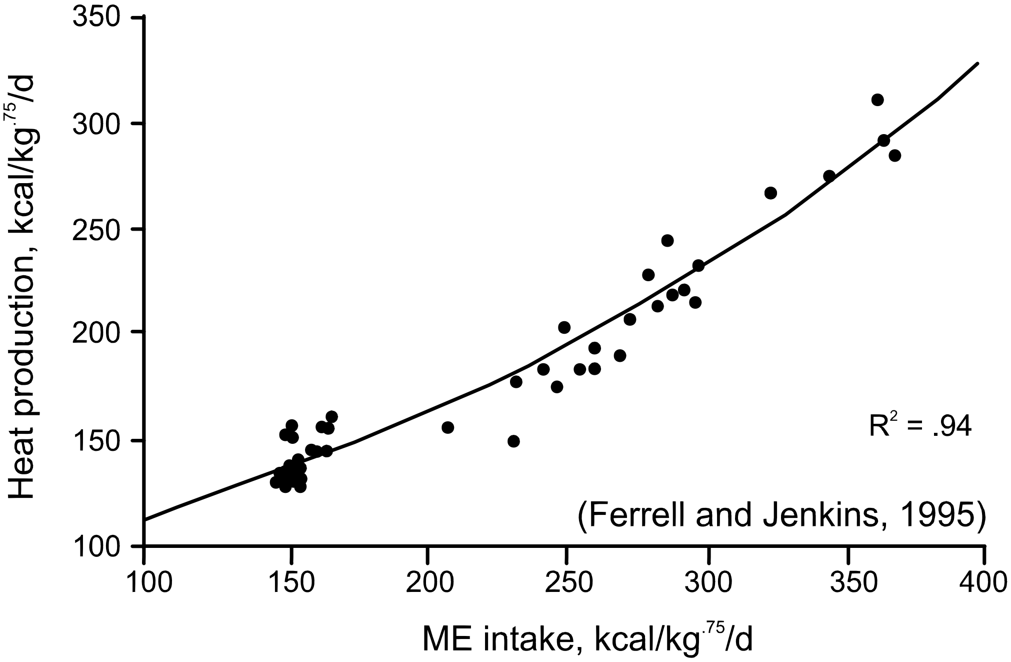


Figure 2. The relationship between energy intake (Mcal ME/kg.^{75}) and heat production. From Ferrell and Jenkins, 1995.

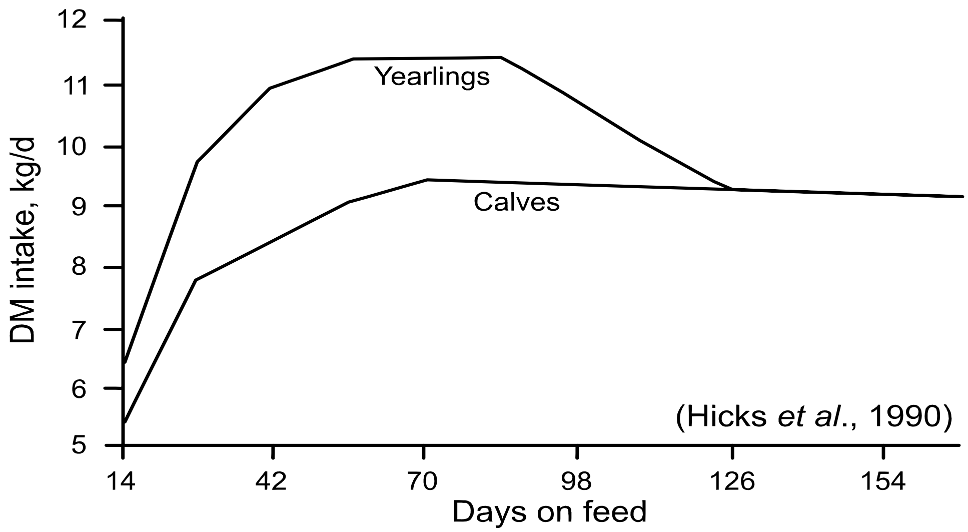
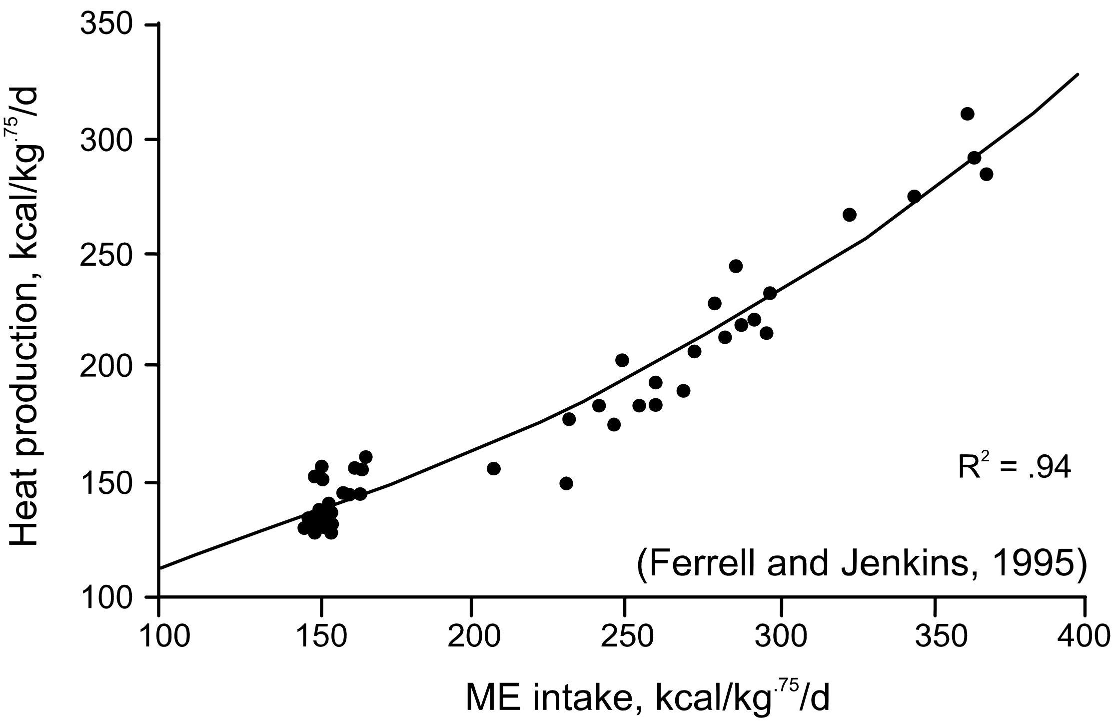


Figure 3. Intake patterns of calves and yearlings through the feeding period. From Hicks et al., 1990.



Heat production, kcal/kg$^{.75}$/d
ME intake, kcal/kg$^{.75}$/d
350
300
250
200
150
100
100
150
200
250
300
350
400
R^2 = .94
(Ferrell and Jenkins, 1995)