Controlling variation in feed intake through bunk management[1]

R. H. Pritchard and K. W. Bruns

South Dakota State University, Brookings 57007

ABSTRACT: The desire to control variation in daily feed intake by feedlot cattle stems from the obvious concern that a significant aberration in grain intake can lead to clinical acidosis or death. Although less dramatic, aberrations also occur when cattle have unrestricted access to feed. A cyclic pattern of higher and lower daily DMI can cause gain efficiency to be less than that predicted from the mean DMI because responses in ADG to changes in DMI are not linear. If bunk management is a means of ameliorating either of these events, it is presumed that management ascribed to the pen is affecting variability in daily DMI by individuals within the pen. Two likely mechanisms by which bunk management may affect intake patterns are limiting availability of feed to prevent overconsumption events or affecting animal behavior so that daily intake is more consistent. Bunk management approaches that have been evaluated for their effect on production rates, and in some instances on day-to-day variability in DMI, include: 1) limiting the quantity of feed available or the amount of time feed is available each day; 2) the timing and frequency of feed deliveries; 3) linear bunk space allocation; and 4) mixed diet or segregated ingredient feeding. When bunk management approaches alter responses, it may be that the approach has a direct biological and/or behavioral effect on the animal or that the approach itself involves less variation, which is consequently favorable to the animal (or the data). The causes of variable results in bunk management research can be ambiguous. Management and feeding systems are difficult to standardize, which can cause the definitions of controls, the characterizations of treatments, and the context of responses to be inconsistent. A rudimentary limitation is that in systems where individual daily DMI is known, competition for access to feed is usually not comparable to typical pen feeding. There is evidence of favorable responses to some bunk management approaches that could be used commercially. Effects on production efficiency in these studies are of significant biological and economic importance, and underlying mechanisms must be more fully characterized to allow broad application.

Key Words: Cattle, Feed Intake, Feedlots, Management

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Introduction

Bunk management is generally thought of as the approach to feed deliveries for confined cattle. It should probably be considered a more encompassing process that includes feed batching and delivery in contexts of quality, quantity, and time. Bunk management has to be dynamic in response to type of diet, class of cattle, changes in climatic conditions, and bunk space allocations. Research on many aspects of bunk management is extremely difficult, if not impossible, to conduct without experiencing confounding or bias. These limitations bring to the forefront Wolfe's (1991) Third Law of Thermodynamics, which states "the emotion generated in scientific discussion increases proportionally with the softness of the data".

The simplistic title of this manuscript is fraught with ambiguities. Intake variation can be an issue on a pen basis or on an individual basis. It is unclear to what extent, and in what ways the two are related. The link in a cause and effect relationship to inefficiency, morbidity, or mortality exists only in extreme instances. Finally, in a feedlot setting, we are inclined to refer to feed delivered as feed intake without providing evidence that all feed offered was consumed on that day.

The overwhelming consideration of bunk management is control of clinical and subclinical metabolic disorders. In spite of our improved capabilities to weigh and mix properly proportioned diets, grain overloads do occur. Digestive disorders are a leading cause of death in feedlot cattle (USDA, 2000). Subclinical and clinical acidosis reduce gain efficiency, cause liver abscesses, and ruminitis (Owens et al., 1996). The question at hand is whether bunk management can reduce variability in feed intake and ameliorate these mala-

[1]Correspondence: Box 2170 SDSU (phone: 605-688-5165; fax: 605-688-6170; E-mail: robbi_pritchard@sdstate.edu).

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dies. To evaluate this, we will break down bunk management into component parts and examine their influence on cattle performance.

Overview

Interest in bunk management is not new. Henry and Morrison (1928) included a chapter (Counsel in the Feedlot) that represented three enduring points regarding bunk management. The first point is “Many an experienced stockman can carry steers through the fattening period without once getting them ‘off feed,’ but yet cannot well describe to others just why he/she is so successful.” This is not necessarily a lack of communication skills. We typically describe things by contrast: more, bigger, shorter, longer. Consistent feeding is essentially unremarkable and consequently difficult to describe.

The second and third points in this chapter were in turn quoted from Mumford’s Beef Production (1907). “As soon as the fattening process begins, the cattle should be fed at certain hours and in the same way. This cannot be varied 15 minutes without some detriment to the cattle. The extent of injury will depend upon the frequency and extent of irregularity. . ..” We interpret this to mean that beef cattle, like dairy cows, are creatures of habit. If behavior can be modified favorably by cultivating and respecting good habits, the potential exists to improve performance. Hungate (1966) likened the rumen to a continuous culture fermentor and discussed in detail how diet, eating, rumination, and digestive tract function coordinate to achieve this steady-state condition. The consistent management steps advocated by Mumford may complement this expectation.

The final point, again attributed to Mumford (1907), is that “Scouring, the bane of the stockfeeder, should be carefully avoided since a single day’s laxness may cut off a week’s gain. The trouble is generally brought on by overfeeding, by unwholesome feed, or by a faulty ration. Overfeeding comes from a desire of the attendant to push cattle to better gains or from carelessness or irregularity in measuring out the feed supply. The ideal stockman has a quick discernment. . . which guides the hand in dealing out feed ample for the wants of all but not a pound in excess.” Here Mumford has described weaknesses in human nature that persist as a critical element of bunk management today. It also seems that Mumford advocated a clean bunk feeding strategy, where no feed should be carried over from one feeding to the next.

Feeding vs. Eating

A dichotomy exists between the motivation behind the cattle feeder’s bunk management decisions and motivation of cattle to eat. Feedlot management has to be concerned with the capability to manufacture and deliver sufficient quantities of feed in a timely fashion. Bunk volume allocation per animal may be limited. Combined, these constraints may force management to plan two to four feed deliveries per pen, per day. Inherent in multiple feedings are the advantages that feed delivery errors or weather interruptions are reduced to some degree for each multiple of feed deliveries per day.

Cattle eating behavior is driven by a loss of the satiety signals that suppress hunger. Cattle consume most feed near sunrise and especially around sunset (Stricklin and Kautz-Scanavy, 1984). Short winter days in northern latitudes promote more nighttime eating, and high effective ambient temperatures can reduce mid-day and daily DMI (Hahn, 1999). When observing eating behavior by adapted cattle in a commercial feedlot, Hicks et al. (1989) reported that 7.5 to 20% of cattle might not be observed eating in a 24-h period. It is unclear whether this was caused by digestive disorder or is an inherent eating behavior trait. Cattle not observed to be eating were not identified as morbid.

Hickman et al. (2002) noted fluctuations in day-to-day DMI with a new system for monitoring feed intake by individuals in a group-fed environment. The feed intake pattern variability was not compressed in faster-growing or more efficient steers. They did not report any episodes of inappetence in that research. Day-to-day fluctuations in DMI are not surprising when considering that the short term feed intake regulation mechanism in cattle was evolved to support relatively high roughage diets. This research does cloud the issue of how/when aberrations in DMI can lead to clinical or subclinical acidosis.

Cattle eating behavior is also driven by nonbiological signals. Like Pavlov’s dogs, cattle may learn to come to the feed truck. They acquire aversions to feeds (Provenza, 1996), and they respond to changes in the weather. These intuitive and learned responses may interact with signals provided by bunk management in favorable or unfavorable ways. Ample feed, available on a consistent schedule may indeed reduce aggression at feeding time, and that may improve production. Unfortunately, data are limited on this subject.

Feed Delivery Management Approaches

Limit-fed high-concentrate diets involve a substantial restriction of feed allocation relative to expected DMI. Cattle performance can be predictable. When bias occurs, it is likely that cattle are more efficient than modeled predictions (Loerch and Fluharty, 1998). When cattle are fed at 75 to 80% of expected DMI, prehension is rapid, and cattle do not sort through feed. Amounts fed are constant from day to day, and this system would accommodate a consistent feed delivery schedule.

Programmed or restricted feeding systems involve lesser restrictions of feed deliveries, perhaps at 5 to 10% less than expected DMI. As in limit feeding, cattle can be expected to remove all feed from bunks relatively quickly, leaving bunks empty much of the day. Growth rate is predictable and gain efficiency is sometimes improved over full-fed cattle (Plegge, 1986). Feeding at this level likely meets the criteria of ample feed for all, but with no excess. This method eliminates the human factor of the inclination to overfeed the cattle. When improved gain efficiency is observed, it is not possible to discern whether it is brought about by affecting digestibility of the diet, ruminal methane production, or reduced variability in feed deliveries (Zinn, 1995).

Clean-bunk management systems attempt to allow cattle to achieve long-term average DMI that will meet or exceed that of cattle fed ad libitum. The caveat that distinguishes clean bunk from ad libitum management is that in clean-bunk systems, it is expected that the bunks will contain no carryover feed at a specified time each day. This approach, with its many possible variations, has become a common practice in the major cattle feeding regions of the United States. This system, however, is susceptible to errors of judgment regarding feeding quantities. It may be more susceptible to time variations. By virtue of the high intake level, the effects of errors in quality or quantity of feed delivered may be more acute.

True ad libitum feeding can be achieved using feed bunks or self-feeders. The intent is to allow unrestricted access to feed at all times. Self-feeders cannot accommodate high-moisture feeds and usually can accommodate only low levels of small-particle-size roughages. Feeding schedules and variable feed deliveries presumably are not components of these systems. The animal has absolute control of daily feed consumption. It has not been proven that ad libitum access to high-grain diets results in higher DMI than that which occurs with clean-bunk management systems.

We can evaluate the bunk management systems for their application with the constraints set forth earlier. Limit feeding and restricted/programmed feeding allow management to be consistent in quantities of feed delivered and to not overfeed cattle. The cyclic feed delivery patterns described by Fulton et al. (1979) are avoided. Finite feed deliveries and competition for this feed among contemporaries dictates the upper limits of daily DMI by individuals. There is a compressed window of feed availability. Sorting is not likely under these conditions. Excess feed is not available to allow binge eating, if indeed this is the root of acidosis problems in feedlot cattle. Variability in DMI must occur at less than a critical level since growth rates are predictable and gain is efficient (Sip and Pritchard, 1991; Loerch and Fluharty, 1998). Furthermore, the literature does not make reference to an inordinate frequency of digestive disorders associated with these prescriptive feeding programs. By definition, restricted feeding has a bias that may not allow cattle to demonstrate maximal growth rates. Restricted feeding may cause reductions in carcass quality (Pritchard, 1995). By virtue of their systematic approach, these programs may cultivate favorable learned eating responses in cattle.

Ad libitum feeding provides feeds in excess. As a consequence, binge feeding cannot be curbed. In dairy systems that allow continuous access to feed, feed tossing is a common problem (Albright, 1993). This behavior is also observed in feedlots and strongly suggests that sorting is a concern since feed tossing causes diet separation. Atwood et al. (2001) showed that cattle vary in their feed preferences and that an individual's preferences may change over time. Selective eating could alter diets of individuals doing the sorting/selection, as well as those left with access to their refusals. The potential for sorted diets to affect gain efficiency is obvious when considering the large disparity of nutrients and energy density of individual ingredients included in a diet.

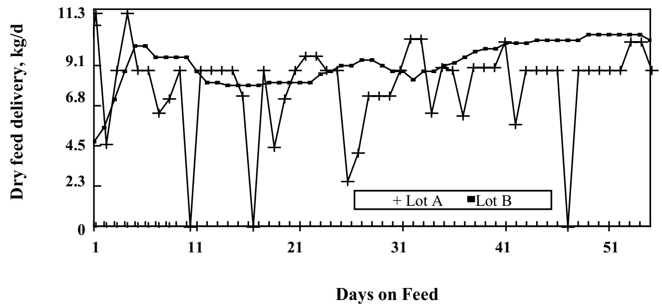

Figure 1. Feed deliveries expressed as dry matter per animal daily for representative pens. Lot A was offered ad libitum access to feed; Lot B was fed using a clean-bunk management system.

The short-term intake regulation mechanisms employed by cattle are not conducive to concentrate feeding (Preston, 1995a). The mechanism by which cattle learn to regulate grain intake on low/no roughage diets provided in self-feeders is unclear. A better understanding of this situation may aid other types of feed-delivery management. These self-fed cattle may indeed learn to reduce intake or meal sizes to avoid the discomfort of indigestion. Alternatively, they may develop an aversion to the diet. In spite of this aversion, hunger is a force strong enough to cause them to eat. Having no substitute feeds available, intake may reflect the balance of hunger and aversion. Perhaps it is a combination of these concepts that allows cattle to avoid a lethal meal size.

Fluctuating Feed Deliveries

We had occasion to feed a common set of steers either ad libitum or in a clean bunk system. Feed deliveries for a 56 d period for two representative pens are depicted in Figure 1. These two feeding programs ran concurrently, but were managed by different individuals in separate facilities. In such a comparison, the gambit of factors contributing to bunk management occur (timing, batching, etc.) and there could be facility influences on performance. For the pooled replicates of pens (n = 5), there was no effect on DMI (9.18 vs. 8.95 kg; $P > 0.10$), but ADG was reduced (0.94 vs. 1.71 kg; $P < 0.05$) and feed:gain ratio was increased (9.58 vs. 5.35; $P < 0.05$) by ad libitum feeding. It should be noted that DMI in this study was DM delivered to the pens. Feed wastage becomes a part of the problem of lost efficiency in these data, just as it occurs in commercial feeding operations.

More controlled influences on feed delivery have been tested. Galyean et al. (1992) used programmed feeding to assure steady delivery of feed to control steers. They then introduced feed delivery fluctuations of 10% from controls either daily or weekly. Weekly fluctuations did not affect cattle performance. Daily fluctuations caused a 6.5% reduction in ADG ($P < 0.10$) and a 7% increase in feed:gain ($P < 0.10$). Most of the performance difference occurred in the initial 56 d of the 84-d study. These were heavy feeder cattle with previous bunk experience and may have been challenged to adjust to the fluctuating feed deliveries implemented at the onset of the trial.

In a similarly designed experiment, Zinn (1994) found no difference in cattle performance attributable to fluctuating deliveries. Holstein steers were on feed for 138 d and controls were program-fed to gain 1.1 kg/d. The lack of an effect of daily 20% feed fluctuations may have been because the extended time on feed could dilute out early effects (interim data were not reported). Also, the control cattle were fed to achieve a relatively low growth rate. Applying fluctuations at this level of production may not have constituted a metabolic challenge to the rumen or to the steers.

Cooper et al. (1998) applied feed delivery fluctuations of ±0.91 kg daily from control steers. Unlike the two previous examples of restricted feed deliveries, control steers in these two experiments were provided feed to appetite. During the initial 140-d trial, fluctuating deliveries caused a 1.7% increase in DMI ($P < 0.05$), with no influence on other production variables. In the second similar experiment lasting 147 d, performance was not influenced by feed deliveries.

The feed-delivery patterns depicted in graphs included by Cooper et al. (1998) bring to light how we look at variation. In those trials, the feed deliveries for the control cattle appeared to deviate as much as 20% above and below the overall mean daily DMI. The patterns for the controls may be typical, but we have yet to establish whether those deviations constitute variability that affects performance. If the typical fluctuations for controls represent sufficient variability to affect performance, the deviations imposed from the control may not cause further compromises of production efficiencies. This may be especially true in that the imposed deviations are consistent and symmetrical, unlike a cyclic intake pattern.

Bierman and Pritchard (1996) attempted to answer part of that question by allowing control treatment feed deliveries to fluctuate as we fed cattle to appetite. The managed treatment was intended to allow cattle to achieve expected maximal feed intake, but to not allow periods of higher than expected DMI. Variation in feed deliveries to control pens (Figure 2) was quite similar to that depicted in the first trial of Cooper et al. (1998). Feed delivery highs and lows were eliminated in the managed bunk treatment (Figure 2), but it appears that

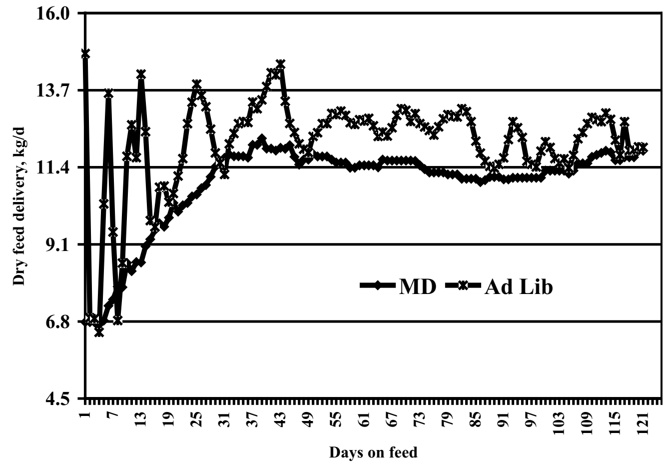

Figure 2. Feed deliveries (kg·steer^{-1}·d^{-1}) over time for ad libitum (Ad Lib) and managed delivery (MD) treatments.

restricted feeding may have been imposed. Intake was reduced 12% ($P < 0.01$) by the managed bunk approach (Table 1) even though there was carryover feed present in the bunks at 0700 on 40% of the pen days. Feed carryover occurred in 69% of the pen days for cattle fed to appetite. Growth rate was not affected by bunk management. However, ADG became more variable before d 30 ($P < 0.05$) and after d 85 ($P < 0.10$) when steers were fed to appetite. Feed efficiency and marbling scores tended ($P < 0.10$) to be improved by the more restrictive bunk management. Gain efficiency was numerically higher early and late in the feeding period (Figure 3), which corresponds with periods of heterogeneity of ADG between treatments. The variable ADG was caused by a disproportionate increase in steers with very low ADG (<0.5 kg) when fed to appetite. This

Table 1. Influence of feed delivery management on steer performance and carcass traits[a]

	Treatment		
Item	Ad libitum	Managed	SEM
Initial BW, kg	392	392	3.0
Final BW, kg	604	602	5.4
ADG, kg	1.75	1.74	0.049
DMI, kg[b]	11.97	10.69	0.262
Gain:feed, g/kgc	145	162	3.6
Clean bunks, %[d]	40	69	—
Carcass weight, kg	373	373	3.5
Dressing, %	61.8	61.9	0.16
Fat thickness, cm	1.10	1.05	0.038
Marbling[ce]	5.31	5.67	0.103

[a]Production variables are reported on a pen basis (n = 5); carcass variables are reported on individual basis (n = 38); 121 d on feed.
[b]Means differ ($P < 0.10$).
[c]Means differ ($P < 0.05$).
[d]Percentage of pen days when no feed was present in bunks at 0700.
[e]5.0 = small^0; 6.0 = modest^0.

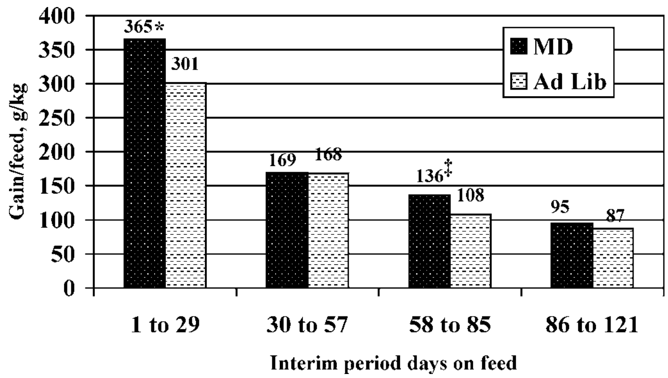

Figure 3. Interim gain:feed (g/kg) for ad libitum (Ad Lib) and managed feed deliveries (MD). *Treatment effects within interim period ($P < 0.05$). ‡Treatment effects within interim period ($P < 0.10$).

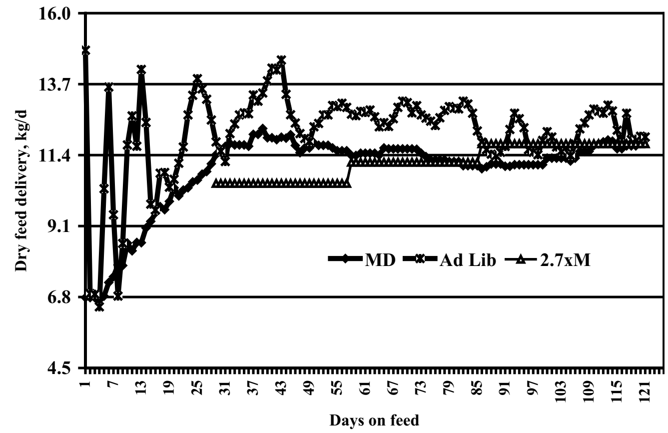

Figure 4. Feed deliveries (kg·steer^{-1}·d^{-1}) over time for ad libitum (Ad Lib), managed delivery (MD), and 2.7× maintenance DMI treatments (2.7× M).

may reflect individuals experiencing acidosis and would be consistent with responses observed for gain:feed and marbling.

It seems probable that DMI restrictions can be imposed by tightly managed feed deliveries. Production per unit of input was improved in this study. Rossi et al. (2001) demonstrated that programming growth early in the feeding period allows comparable growth rates and carcass traits to ad libitum-fed steers, but less feed is required per unit of production.

If the advantages of restricted or programmed feeding are that they prevent unacceptably high feed intakes, there may be a simpler approach. Preston (1995b) described the use of maximal intake limits on cattle during step-up and finishing phases. The principle would accommodate most classes of cattle and diets in that limits are set as multiples of maintenance energy intake. Feed deliveries are allowed to deviate as needed for the circumstances at hand, but overfeeding is avoided by the limits. The limits proposed were 2.1, 2.3, and 2.5 times maintenance DMI for step-up and 2.7 times maintenance DMI for finishing. We have calculated the 2.7 times maintenance value for the latter periods of the experiment reported by Bierman and Pritchard (1996) and imposed those levels on the daily feed delivery graph (Figure 4). Managed deliveries were coincidentally similar to the 2.7 times maintenance threshold. In contrast, when cattle were fed to appetite, feed deliveries frequently spiked well above the maximal intake limit, but did not increase ADG.

Feeding Schedules-Frequency

When limit-feeding Holsteins once daily in the summer, Reinhart and Brandt (1994) reported an 18% increase ($P < 0.05$) in ADG by feeding in evenings rather than in mornings. In a clean-bunk finishing program, Pritchard and Knutsen (1995) reported similar DMI, but higher ($P < 0.05$) ADG and lower ($P < 0.05$) feed:gain during the summer–fall seasons when cattle fed once daily received the delivery at 1630 rather than 0730. The mode(s) of action for this response has not been elucidated. Thermodynamics may be involved. How evening feeding influences variation in eating behavior has not been studied. Pritchard and Knutsen (1995) indicated that based on within-day changes in BW, diurnal fill patterns were altered by the time of feeding. Mitloehner et al. (1999) reported that evening feeding has influences on behaviors that may indirectly relate to variability in feed intake by individuals.

Hanke et al. (1981) saw no advantage to multiple daily feed deliveries. We (Pritchard and Knutsen, 1995) have observed that in some, but not all, instances, feeding twice daily results in better gain efficiency than feeding once daily in the morning. The reason behind the inconsistent response is unclear. As mentioned previously, multiple feedings may reduce the magnitude of feeding errors, and the opportunity for binge feeding may be reduced as well.

It may be that multiple feeding may better accommodate the inherent variability in an individual steer's access to feed or the accuracy of its short-term intake regulation. Soto-Navarro et al. (2000) studied the influence of once vs. twice daily feeding, with or without imposed fluctuations in feed delivery on ruminal conditions. Interactions occurred where feeding twice daily caused numerical increases in the amount of time ruminal pH was below 6.2 ($P < 0.10$) and in the rate of acetate production ($P < 0.05$). Both responses would be considered liabilities in growing-finishing cattle. However, when feed deliveries were fluctuated, ruminal conditions became more favorable for steers fed twice daily than those fed once daily. In group-feeding situations, variability in feed availability to an individual is inevitable. Consequently, multiple feed deliveries may be beneficial to the ruminal environment although that has not been specifically tested.

Implications

Feed delivery management research is fraught with ambiguities. Feed delivery management can affect production efficiency of cattle fed high-grain diets. Although variability in feed delivery, as we assess it in feeding programs, may not be documenting variability in intake by individuals within a pen, systems that achieve more consistent feed deliveries seem beneficial. Bunk management programs that prevent cyclic intake patterns and/or overconsumption for pens of steers may be most beneficial. Both the reference point from which the magnitude of feed delivery deviations is measured and the types of deviations that occur are relevant when assessing variability. To minimize variation, management must anticipate physiological and behavioral responses by cattle to their environment. More research is needed to develop management programs that minimize digestive disorders and are adaptable to different diets, cattle, climates, and feeding situations.

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