EFFECTS OF SEASON, HEALTH, AND MANAGEMENT ON FEED INTAKE BY BEEF CATTLE

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INTRODUCTION

In his review of factors controlling feed intake at the 1st Oklahoma State University conference on Feed Intake by Beef Cattle in 1986, W. L. Grovum stated, "The productivity of a given animal fed a given diet is largely dependent upon the quantity of food consumed and the efficiencies of digestion and metabolism." Our ability to predict efficiencies of digestion and metabolism (e.g., net energy values) for common feeds is high relative to our ability to predict feed intake by beef cattle. Hence, for practical purposes, feed intake is the single most important driving force affecting production by feedlot cattle, and its prediction is the single greatest enigma facing researchers and cattle producers. By empirical means, we can at best account for approximately 70% of the variation in feed intake by growing and finishing beef cattle (Galyean et al., 1993). Despite years of proposed models and theories of intake regulation, and seemingly endless discussion, a definitive mechanistic model of intake control in ruminants remains a lofty but elusive goal.

Because we have been unable to fully elucidate feed intake control mechanisms, it is not surprising that we also have failed to adequately delineate factors that are not central, from the standpoint of physiological mechanisms, to intake control, but nonetheless can have significant impacts on feed intake. Among these "less-central" factors, we will focus our discussion of the effects health, season, and management. Our presentation will rely on published information, but we also will attempt to synthesize information from data obtained at commercial beef feedlots and from hypothetical models.

Health Effects on Feed Intake

Stresses associated with weaning, marketing, and transport of beef cattle have marked effects on health, but effects on feed intake also are important. Fluharty et al. (1994) subjected newly weaned, ruminally cannulated calves to 8.5 h of transport, 15.5 h of housing in a sale barn, and a 24-h period of feed and water deprivation period. After arrival in the feedlot, the steers were offered a 60% corn silage receiving diet. Dry matter intake on the day of arrival in the feedlot was 62% of the DMI 7 d after arrival, but the ability of the ruminal microbial population to digest substrate was not decreased by weaning, transport, and fasting stress (Fluharty et al., 1994). Similarly, Hutcheson and Cole (1986) noted that fewer morbid than healthy calves consumed feed during the 1st 7 d after arrival in the feedlot. Dry matter intake ranged from .5 to 1.5% of BW during d 1 to 7, 1.5 to 2.5% of BW during d 8 to 14, and 2.5 to 3.5% of BW during d 15 to 28 after arrival. As suggested by the data of Fluharty et al. (1994), ruminal effects may not account for the decrease in DMI that occurs with fasting stress. Exchanging ruminal contents between fed and fasted lambs did not offset decreased intake by fasted lambs (Cole, 1991). Cole and Hallford (1994), using fasted lambs as a model, concluded that considerable metabolic alterations (e.g., insulin, growth hormone, glucose, and free fatty acid concentrations in serum) occur with fasting, and that these measurements returned to normal within 5 d of refeeding. Hence, effects on feed intake associated only with fasting (and presumably transport) stress seem to be relatively short term in nature.

In calves that succumb to respiratory disease, decreases in feed intake may be even more severe than those resulting from fasting and transport stress. Several reports suggest that calves that do not succumb to respiratory disease gain more rapidly than morbid calves (Bateman et al., 1990; Morck et al., 1993; McCoy et al., 1994; Wittum et al., 1994), presumably as a result of greater DMI by healthy calves. Hutcheson and Cole (1986) compared the performance of 305 healthy and 385 morbid calves from arrival to d 56 in the feedlot. Feed intake averaged 1.55% of BW for healthy calves during d 1 to 7 after arrival compared with .9% of BW for morbid calves. Averaged for d 1 to 28 after arrival, intake was 2.71 and 1.84% of BW for healthy and morbid calves,
respectively. Intake from d 28 to 56 was greater for the previously morbid calves (3.52 vs 3.33% of BW), indicating that after d 28, previously morbid calves had begun to compensate. But because intake had been depressed earlier, mean intake, when averaged over the full 56 d, still remained lower for morbid than for healthy calves (2.68% vs 3.03% of BW). Hence, when the stress of infection with bovine respiratory disease is coupled with fasting/transport stress, effects on DMI seem to last at least 28 d and residual effects may continue even longer. Most experiments dealing with feed intake by healthy and morbid cattle have been conducted with newly weaned/received cattle of fairly low BW (e.g., 140 to 200 kg). Data relative to yearling cattle are limited, but it seems logical to assume that yearling cattle subjected to the same stress(es) as calves would respond similarly in terms of feed intake.

Given the potentially long-term effects of morbidity from respiratory disease on feed intake by beef cattle, the logical question that arises is what type of management actions are appropriate for previously morbid cattle. If the background and health history of cattle is known, it might be desirable to sort cattle into previously healthy and previously morbid groups. For previously morbid cattle, special efforts could be made to alter the diet for greater intake and(or) performance (e.g., an increased roughage or protein level). Such a sorting procedure also would allow development of a data base to determine the relationship between previous health and subsequent health, particularly subsequent metabolic disorders like bloat and acidosis. Evaluating DMI and feedlot performance by cattle that previously were morbid with respiratory disease seems to be a fruitful area for research.

Effects of Season and(or) Photoperiod on Feed Intake

Seasonal effects on feed intake by beef cattle are poorly understood fully and difficult to define. Climatic, photoperiod, animal, and, most likely, management differences contribute to seasonal patterns, and separate effects are difficult to delineate. Considerable research has been conducted with regard to the effects of thermal stress on feed intake (see reviews by Minton, 1987 and Young, 1987), and photoperiod has been suggested as a potentially important factor influencing feed intake by beef cattle (NRC, 1987). Effects of photoperiod on intake and metabolism are particularly notable in wild and recently domesticated ruminants (Barry et al., 1991). Voluntary intake by red deer was considerably greater during the summer than the winter, whereas sheep showed little effect of season on voluntary DMI, goats showed an intermediate response to season (Domínguez et al., 1991). The seasonal changes in feed intake noted in red deer and other wild ruminants seem to be controlled by changes in daylength, such changes being entrained to photoperiod by changes in the hormone melatonin (Barry et al., 1991). Barry et al. (1991) suggested that the annual rhythms in food intake most likely are a result of an increase in metabolic demand associated with photoperiod-entrained changes in hormones. In sheep fed at near-maintenance levels, Blaxter and Boyne (1982) noted cycles in the rate of metabolic heat production that coincided with natural seasonal changes. Tucker et al. (1984) reviewed effects of photoperiod on growth, intake, and hormonal secretion by domesticated ruminants. They noted that increased daily exposure to light increased feed intake by sheep and cattle given ad libitum access to feed, but effects on feed intake likely were secondary to effects on growth. However, growth responses with longer photoperiod have not been consistent, presumably because sexual maturity and other hormonal mechanisms can affect response to photoperiod (Tucker et al., 1984). Ingvarsen et al. (1992) evaluated effects of daylength on voluntary DMI capacity of Danish Black and White bulls, steers, and heifers. Voluntary DMI increased .32% per hour increase in daylength; the range in the literature reviewed by the authors was a change of minus .6 to positive 1.5%. Based on the deviation from the voluntary intake at 12 h of daylight, voluntary intake would be expected to be 1.5 to 2% greater in long-day months (July in the northern hemisphere) and 1.5 to 2% less in short-day months (January; Ingvarsen et al. 1992).

Hicks et al. (1990) grouped intake data collected at a commercial feedlot by season received in the yard and thereby accounted for much of the seasonal pattern in feed intake by yearling beef steers. Average intake for the feeding period was 9.35 kg/d for steers started on feed from July 31 to October 29, 9.23 kg/d for steers started on feed from January 29 to April 30 and from May 1 to July 30, and 9.15 kg/d for steers started on feed from October 30 to January 28. Pattern of intake over time during the feeding period (average of 138 d) was fairly similar among seasons. Correlations of weather data with DMI generally were low, but DMI by steers of heavier BW tended to be negatively correlated with measures of heat stress, whereas DMI by steers of lighter BW tended to be correlated negatively with measures of cold stress.
To further investigate seasonal effects on feed intake by cattle in commercial feedlots, we analyzed two data sets from different geographical locations. The Arizona data set consisted of 1,881 pen records of average DMI for the feeding period (data set average = 6.07 ± .34 kg) collected over a 13-yr period from one feedlot in Arizona. The Kansas data set, collected over a 4-yr period from one feedlot in Kansas, included 733 pen records of average DMI for the feeding period (data set average = 9.54 ± .82 kg). The two data sets differed considerably in the type of cattle and the length of the feeding period. The Arizona data set represented primarily cattle with some degree of Brahman breeding (average initial BW = 168.4 ± 29.4 kg) that were fed for extended periods (average days on feed = 281.3 ± 31.1). The Kansas data set represented cattle of British or British x Continental breeding (average initial BW = 345.2 ± 38.6 kg) that were fed in a more yearling grazing system (average days on feed = 125.1 ± 17.5). These two data sets were analyzed separately using stepwise regression procedures (SAS, 1987) to determine the influence on season and year on the relationship between DMI and initial BW on feed. We used this approach because our previous work (Galyean and Hubbert, 1993) indicated that initial BW has considerable value for predicting DMI, accounting for approximately 50% of the variation in DMI. Months of the year in which cattle were started on feed were grouped by season (see footnote to Table 1) and dummy variables for the four seasons, along with dummy variables for the years were included with initial BW in a stepwise regression procedure. In addition, the interactions of seasons with initial BW (slope adjustments for seasons) were included for selection in the model. All variables that were selected by the stepwise approach were significant at P < .05. To simplify presentation, we did not attempt to account for the interaction of year with initial BW, season x year, or season x year x initial BW interactions. Such interactions likely exist, but would be expected to increase the R² of the model to a very limited degree.

Results of our analysis are shown in Table 1. Effects of season varied between the two data sets. In the Arizona data set, the intercept was adjusted downward for cattle started on feed during the spring and summer months compared with cattle started on feed during the winter and fall months. The slope of the regression of DMI on initial BW was greater for cattle started on feed during the winter and spring months than during summer and fall months (Table 1). For the Kansas data set, intercepts differed among the four seasons, with the greatest value for cattle started on feed in the spring months, followed by summer and fall, with the lowest intercept for cattle started on feed during the winter months. The slope differed only for cattle started on feed during the spring, with a lower value than for cattle started on feed during other seasons. It also should be noted that year effects were sizable and variable, particularly in the Arizona data set (see footnote to Table 1).

Several interpretations of the biology of seasonal effects on feed intake are possible from these two data sets. If seasonal effects are primarily a function of climatic events (temperature, precipitation, and so on), one might expect cattle started on feed during the winter and spring months in Arizona to have greater intakes than those started on feed during the presumably hotter and wetter summer and fall months. Similarly, cattle started on feed during the winter in Kansas might have lower overall DMI because of severe winter weather. Conversely, if seasonal effects are primarily a function of changes in photoperiod, cattle started on feed during the winter and spring months in Arizona would spend most of their 9- to 10-month feeding period during a period of long daylength. Similarly, cattle started on feed during the spring and summer months in Kansas would spend most of their 4- to 5-month feeding period during a period of long daylength. Most likely, changes with season that we noted in Table 1 were caused by a combination of factors, including climate, photoperiod, and management. From a practical standpoint, seasonal effects probably should be considered when predicting feed intake by beef cattle. However, the year-to-year variation, the potential for season to interact with year, and management effects make development of generalized prediction equations difficult.

**Management Effects on Feed Intake**

**Effects of Intake Pattern.** Hicks et al. (1990) noted that the average DMI for a feeding period was correlated positively (r = approximately .5 to .85, depending on season) with the DMI during the period from d 8 to 28 after arrival in the yard. They suggested that many nutritionists and feedlot managers believed cattle that start the feeding period with "above average" intakes will tend to be "above average" for the entire feeding period. By the same token, cattle that are "below average" initially will remain "below average." To determine the potential effects of "above" and "below" average intake on feedlot performance by beef cattle and production
economics, we modeled daily gain by cattle with three different intake patterns. Based on the data of Hicks et al. (1990), “above average” cattle were projected to consume .5 kg/d more, and “below average” .5 kg/d of DM less than “average” cattle. Also based on intake patterns reported by Hicks et al. (1990), at 16 wk on feed, the intake of “above average” and “average” cattle was decreased so that by 19 wk on feed, the DMI for each of the three groups was equal (Figure 1). All cattle were assumed to have an initial BW of 320 kg, and the net energy equations of NRC (1984) were used to project daily gain based on the three different intake patterns.

Results of these projections are shown in Table 2. As would be expected from net energy calculations, greater intake resulted in greater daily gain. Because gain increased in proportion to DMI, feed:gain ratios did not differ among the groups and averaged approximately 5.4. If one assumes that the cattle were purchased for $1.74/kg with a 4% shrink from pay weight, feed costs were $.12/kg of DM, and the price at final sale was $1.52/kg, the “above average” cattle would yield a profit above feed costs that was $18.78 greater than “below average” cattle. Similarly, “average” cattle would yield $9.66 greater profit above feed costs than the “below average” cattle. Another alternative would be to sell the “above” and “below average” cattle at the same final BW as the “average” cattle. In this scenario, “above average” cattle would be on feed fewer days, and “below average” cattle on feed more days, than “average” cattle, resulting in differences in feed inputs and subsequent production economics.

Results of our projections may indicate differences of a smaller magnitude than would be observed in practice. Based on the data of Hicks et al. (1990), cattle that have greater peak intakes often seem to have a faster rate of increase in intake to the peak. In addition, with large-framed cattle that mature at heavy BW, intake may not decrease as projected in Figure 1 at the end of the feeding period. Both these factors would tend to increase the area under the DMI x time-on-feed curve, resulting in greater energy consumption and presumably greater gain. Unfortunately, little is known about the characteristics of cattle, diets, and management that lead to “above average” intake. Research is needed to determine contributing factors and thereby allow management decisions that favor “above average” intake and performance.

Effects of Implanting. Estrogenic implants typically have a long-term positive effect (Runsey et al., 1992) on feed intake; however, short-term effects can be negative. In commercial feedlot settings, feed intake typically is decreased for a few days after implanting or reimplanting cattle. Whether such decreases are a result of the implant or merely associated with movement of the cattle and disruption of eating behavior is generally unknown because comparisons with cattle worked in a similar manner but not implanted are generally unavailable. Nonetheless, to compensate for the decreased intake that can occur with reimplanting, commercial feedlots often “step back” one diet and gradually bring reimplanted cattle back to ad libitum consumption on the final finishing diet. The extent to which short-term disruptions in feed intake patterns alter performance by feedlot cattle is largely unknown; however, it may be possible to mitigate the effects of reimplanting on feed intake by altering management procedures.

Figure 2 shows the feed intake patterns (as-fed basis) by four pens of cattle in a commercial feedlot in the Texas Panhandle during the period that often is affected by reimplanting. All four pens of cattle received a terminal Revalor implant on June 19. Two of the pens (broken lines) were implanted at approximately 0600, whereas the other two were implanted at 1500. The two pens implanted in the morning displayed the expected pattern of a short-term decrease in feed intake after implantation, with a return to pre-implant feed intake levels in 10 to 14 d. The two pens that were implanted in the afternoon showed no decrease in feed intake after implanting. Clearly, the data presented in Figure 2 were not derived from a designed experiment, and one should be concerned about the possible effects of differences in pre-implant feed intake between the morning- and afternoon-implanted cattle; however, considerable practical experience with afternoon implanting of cattle has yielded results consistent with those shown in Figure 2 (M. E. Hubbert, unpublished observations). If simply working cattle in the afternoon can offset negative effects of reimplanting on feed intake, the obvious question is what factors are responsible for this effect? In the example presented in Figure 2, cattle reimplanted in the morning had not yet received their first feeding of the day; in contrast, cattle reimplanted in the afternoon had received the last major feeding of the day at approximately 1300, or 2 h before being reimplanted. Perhaps reimplanting cattle in the afternoon, given the feeding times used, caused less disruption in feeding behavior than reimplanting in the morning. Alternatively, cattle that are reimplanted in the afternoon would be exposed to
fewer hours of daylight than those reimplanted in the morning, perhaps suggesting an interaction of estrogentic implants with hormones related to photoperiod. Further research related to the time of day when cattle are reimplanted seems warranted.

Effects of Vaccination. As with reimplanting, routine vaccinations that are used in the feedlot industry may have short-term negative effects on feed intake. This is most obvious with clostridial vaccines (e.g., seven-way vaccine) that often are given late in the feeding period to boost titers and prevent clostridial infections. Figure 3 shows the feed intake patterns of four pens of cattle in the same commercial feedlot in the Texas Panhandle described in Figure 2. In this case, cattle in all four pens were reimplanted (Revalor) in the afternoon of June 19, but the two pens depicted by the broken lines also received a booster of seven-way vaccine; the two pens shown by the solid lines did not receive a booster. Intake decreased substantially for the two pens that were given a seven-way booster and returning to pre-vaccination levels only after approximately 2 wk. As noted in the discussion of reimplanting, these data were not derived from a designed experiment, but are consistent with practical observations at commercial feedlots in other locations (M. E. Hubbert, unpublished observations). The reason for the negative effect of a seven-way booster on feed intake no doubt relates to the pyrogenic properties of the particular vaccine used, and effects might not be the same with other seven-way vaccines. Data for other vaccines given routinely to feedlot cattle are limited, but these observations point out the need for feedlot managers to carefully evaluate the effects of such routine management programs on feed intake.

CONCLUSIONS

Factors that control feed intake by ruminants continue to be less than completely understood. As we strive to understand basic mechanisms, we also should recognize that such factors as health, natural seasonal changes in climate and photoperiod, and routine management practices can alter feed intake. Based primarily on data from highly stressed, lightweight cattle, the animals that succumb to respiratory disease typically have lower feed intakes and daily gains than healthy counterparts. These effects of morbidity seem to be fairly long term. Intake patterns and the quantity of feed consumed vary with season, but delineation of the individual effects of temperature, precipitation, humidity, and photoperiod remains to be accomplished. Eating patterns of cattle, particularly those of cattle with superior intake and performance, deserve additional study because of the potential impact that "above average" consumption can have on production economics. Finally, routine management practices used by the feedlot industry need further study with respect to their effects on feed intake and performance.

LITERATURE CITED


QUESTIONS & ANSWERS

Preston: Were control cattle worked when test cattle were implanted and vaccinated?
A: Yes, all cattle went through the chute in AM or PM to be implanted and only half got the vaccine.

Owens: Were the shots given in an area where the injection site might contact the feed bunk?
A: They were given in the neck region.

Gill: What was the pyrogenic endotoxin level in the vaccine?
A: Good question. I don't know. Most 7-way vaccines are similar and fairly pyrogenic.

Peters: Were cattle worked at different times deprived of feed for an equal time period?
A: Cattle worked at 6 AM were worked before they were fed. Working time was equal. Those worked at 3 PM had been fed their final meal before being worked.

Q: How soon were they re-fed?
A: Cattle had access to feed immediately when they were returned to the pen. Maybe they experienced an aversion response.
Table 1. Effect of season in which cattle were started on feed on the regression of dry matter intake on initial body weight using data from two commercial feedlots.

<table>
<thead>
<tr>
<th>Feedlot</th>
<th>Season</th>
<th>Intercept</th>
<th>Slope</th>
<th>$R^2$</th>
<th>$S_{YX}$</th>
</tr>
</thead>
</table>
| Arizona | Winter  | 4.5375    | .0095 | .7021
d | .1872
| Spring  | 4.2361  | .0116     |       |       |          |
| Summer  | 4.4754  | .0082     |       |       |          |
| Fall    | 4.5375  | .0082     |       |       |          |
| Kansas  | Winter  | 4.1120    | .0150 | .4965 | .5814    |
| Spring  | 5.7389  | .0108     |       |       |          |
| Summer  | 4.5762  | .0150     |       |       |          |
| Fall    | 4.4176  | .0150     |       |       |          |

\(^a\)Winter = December, January, February; Spring = March, April, May; Summer = June, July, August; Fall = September, October, November.

\(^b\)Intercept adjustments for year in the Arizona feedlot were as follows: 1979 = +.1233; 1982 = +.0448; 1983 = +.0558; 1984 = +.2306; 1985 = +.2858; 1986 = -.0502; 1988 = +.0989; 1989 = +.1135; 1991 = -.1269. For the Kansas feedlot, the only intercept adjustment was for 1990 (+.1593).

\(^c\)The $R^2$ and $S_{YX}$ value apply to the overall series of equations that describe the effects of season and year adjustments.

Table 2. Effects of feed intake pattern on projected performance by finishing beef steers.

<table>
<thead>
<tr>
<th>Item</th>
<th>Intake pattern(^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Above</td>
</tr>
<tr>
<td>Initial BW, kg</td>
<td>320</td>
</tr>
<tr>
<td>Final BW, kg</td>
<td>588.9</td>
</tr>
<tr>
<td>Days on feed</td>
<td>140</td>
</tr>
<tr>
<td>Daily DMI, kg</td>
<td>10.36</td>
</tr>
<tr>
<td>Daily gain, kg</td>
<td>1.92</td>
</tr>
<tr>
<td>Feed:gain</td>
<td>5.39</td>
</tr>
</tbody>
</table>

\(^a\)Above cattle were projected to eat .5 kg/d more feed, and Below cattle to eat .5 kg/d less feed, than Average cattle through the first 16 wk of the feeding period.
Figure 1. Projected DMI by cattle with “average”, “above average”, and “below average” intake patterns. Adapted from Hicks et al. (1990).

Figure 2. Effects of time of day when steers were implanted on feed intake pattern. The data represent two pens of cattle for each group (morning and afternoon implant) and were obtained from a commercial feedlot in the Texas Panhandle.
Figure 3. Effects of a booster injection of a seven-way clostridial vaccine on feed intake pattern by beef cattle. The data represent two pens of cattle for each group (implant or implant plus booster) and were obtained from a commercial feedlot in the Texas Panhandle. All pens of cattle were processed in the afternoon.