DIURNAL BEHAVIOR PATTERNS OF FEEDLOT BULLS DURING WINTER AND SPRING IN NORTHERN LATITUDES

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Summary

The diurnal behavior patterns of feedlot bulls were investigated at 52°N during winter and spring. Two trials were conducted during periods when the daylight portion of the day increased by over 7 h. In trial 1, 324 bulls were observed hourly for 24 h on nine occasions at 2-wk intervals. The average proportions of bulls eating, drinking, standing and lying were 9.8, 1.9, 27.4 and 60.0%, respectively. Major periods of eating, drinking and standing were associated with the times of sunrise and sunset and shifted with seasonal changes. Initiation and termination of the afternoon period of eating was greatly affected by changing times of sunset and not by the daily addition of feed, which always occurred at approximately 1600 h. A significant period of eating, involving up to 15% of the bulls at one time, occurred near midnight during the longer winter night but decreased in duration and intensity as day-length increased. In trial 2, continuous observations for 24 h were made at 2-wk intervals on two groups of nine bulls. When the spread in time between morning and evening activity increased due to longer daylength, bulls were active at midday. This became more pronounced on days when the photoperiod exceeded 10 h. Minor periods of activity were evident at night. Mounting and agonistic encounters increased dramatically in frequency near sunset and in general were associated with the major periods of eating and standing. Grooming occurred throughout the daylight portion of the day, and from winter to spring, scratching tended to decrease and cross-
grooming to increase. Standing and agonistic activity increased on days when precipitation was recorded. During both trials, there was a period before sunrise that was notable because of the lack of activity.

(Key Words: Feedlot, Behavior, Diurnal, Season, Bulls, Photoperiod.)

Introduction

An essential step in the ethological study of a species is the development of an ethogram (Banks, 1982). This catalog of behavior should also include temporal components (Lehner, 1979). When animals such as cattle are managed in greatly diverse environments, considerable variation in their time budgets and diurnal activity patterns may be expected. To quantify these patterns, observations on the temporal aspects of behavior may be made at intervals or continuously. Interval observations may involve many animals and are appropriate for behaviors such as feeding or resting. Continuous observations involve fewer animals but are essential to study events or short duration behaviors (Lehner, 1979; Mullen et al., 1980).

Although eating patterns of feedlot cattle are known to be associated with daylength (Ray and Roubicek, 1971; Hoffman and Self, 1973), reports on the occurrence of a midnight eating period during the extended winter nights in northern latitudes are conflicting (Christopherson, 1973; Wilson and Flynn, 1979). Concerns for total eating time because of the extremes in daylength in northern areas have been expressed by Wilson and Flynn (1975), and daylength is likely to affect other behaviors as well. Because cattle have been selected for production in a wide variety of conditions, it is hypothesized that behavioral adaptations to extremes of daylength should be evident. Interval and continuous observations were utilized in these trials to determine the temporal changes in various behaviors of feedlot cattle as daylength changed in a northern location.
Materials and Methods

The trials were conducted at the University of Saskatchewan feedlot at Saskatoon (52°N). All times are reported in local values (Central Standard Time) and times of sunrise and sunset were obtained from the Nautical Almanac Office (NAO, 1976). The minimum and maximum length of possible sunlight at this latitude are 7 h 45 min and 16 h 45 min, respectively. The mean time of solar noon is 1306 h.

Trial 1. Three hundred twenty-four purebred beef bulls (Hereford, Angus, Charolais, Simmental, Shorthorn, Galloway, Maine Anjou and Chianina breeds) were allocated in groups of 27 into 12 pens. At the time of entry into the feedlot in October, the bulls ranged from 155 to 245 d of age. Each pen measured 24 × 25 m and contained a 7 × 12 m open front shelter facing south. The pen surface was clay with a concrete apron along the 15 m feed trough. Water was available in a single heated water bowl for each pen and protection from the wind was provided by 20% porosity fences, 3 m high that surrounded the feedlot.

The bulls were fed twice daily, at approximately 0900 and 1600 h, in quantities sufficient to last until the following feeding. The diet consisted of 57% barley silage (IFN 2-00-512), 28% oats (IFN 4-03-377), 8% alfalfa hay (IFN 1-00-078) and 7% rapeseed meal (IFN 5-03-870), mineral and vitamin supplements. Straw was added to the area nearest the porosity fences of each pen three times each week. Data were collected hourly for 24 h during nine observations days at 2-wk intervals from January 27 to May 19, 1978. Because diurnal events such as sunrise and sunset shifted several hours during the trial, observations at 1-h intervals were considered adequate to detect seasonal changes in behavior patterns. The large number of animals observed allowed for an accurate estimate of time budgets (Mullen et al., 1980). The average weights of the bulls at the times of the first and last observation days were 366 and 505 kg, respectively. Observations were made from the feed alley to obtain data on the number of bulls eating and drinking (head within 1 m of feed trough or water bowl, respectively, with evidence of feed or water on the muzzle) in the 12 pens. In addition, the number of bulls standing and lying (excluding those eating or drinking) was recorded for six of the pens (162 bulls). The percentage of bulls engaged in each activity was calculated for each hourly observation. Hourly values of temperature were obtained from the Saskatchewan Research Council (SRC) meteorological station located within 1 km of the feedlot and general notes on precipitation were made at the time of each observation.

Data for the four activities were plotted on the basis of time of day to determine changes in behavior patterns as daylength increased. In addition, the data were plotted with reference to four environmental events which were postulated to serve as entraining agents for the bull’s activities (sunrise, sunset, morning feeding and afternoon feeding).

Trial 2. Eighteen yearling feedlot bulls were divided equally into two pens and observed on 10 occasions at 2-wk intervals between January 16 and May 22, 1979. On each occasion, bulls in one pen were observed continuously from 0600 h to 0600 h the following day. Alternative pens were observed every 2 wk. The clay base pens measured 12 × 24 m and had a 7 m feed bunk with concrete apron. A heated water bowl was located approximately 4 m from one end of the feed trough. The bulls were together for more than 2 mo before the trial and were fed ad libitum a complete diet including 50% chopped hay (IFN 1-00-078), oats (IFN 4-03-377) and supplements. Feed was added to the trough at 0900 and 1600 h daily. The average weights of the bulls at the beginning and end of the trial were 322 and 463 kg, respectively.

Individual identification of the bulls in each pen was accomplished by the use of various beef breeds and breed crosses representing nine distinct coat color patterns and by means of large tags placed in both ears. Because of the low level of supplemental lighting in the alley of the feedlot, a night viewing device4 was used to identify individuals on particularly dark nights. Recorded observations for each bull included the time of day when it was standing, lying, eating, drinking, licking itself, scratching itself (on a solid object such as a fence post), cross-grooming (licking others), mounting others and engaging in agonistic encounters. Total time spent eating and standing (not eating) were determined for each bull. In order to minimize observer effects only those agonistic encounters that involved physical contact were included. For purposes of quantification,
grooming activities that continued for more than 2 min were considered to be two grooming
events. Hourly meteorological values for temperature, wind speed, precipitation and barometric pressure were obtained from SRC and averaged for each day.

The behavioral data were plotted against time for each day for the determination of diurnal patterns. Correlations were determined for the daily means for total time spent eating and standing, and the frequencies of drinking, licking, scratching, cross-grooming and mounting with the meteorological data (Steel and Torrie, 1980). One-way analysis of variance (Steel and Torrie, 1980) indicated that differences between pens for frequency and total time devoted to behavioral activities were not significant and pen effects were ignored in subsequent calculations.

Results

**Trial 1.** The meteorological conditions (table 1) during the observations were representative of the seasons involved. Neither extremely severe nor mild conditions were encountered on the observation days. Precipitation, when it occurred, was always light. The time of sunrise and sunset shifted 3 h 51 min and 3 h 18 min, respectively, during the trial.

The overall means for percentage of bulls eating, drinking, standing and lying were 9.8, 1.9, 27.4 and 60.0%, respectively. The hourly means, standard errors and the values from the first and last days of observation for the activities are presented in figure 1. Activity patterns shifted with the times of sunrise and sunset as indicated by the differences between the first and last observation days. The shifts in activity patterns were evident after the first three observations and continued until the end of the trial. The patterns for eating, drinking and standing were very similar while the lying pattern was the inverse of the other three.

Two major periods and one minor period of eating were identified. The mean peak in eating activity occurred at approximately 1000 h, which was shortly after feed was added to the troughs but the beginning of eating, drinking and standing occurred earlier on each successive observation day as sunrise was earlier. The proportion of bulls eating decreased to about 10% during the middle of the day when more of the bulls were lying. The second major eating period occurred in the late afternoon. Plots of the data from the late afternoon period in reference to the time of sunset as compared with time of day (figure 2) indicated the close synchronization between sunset and afternoon eating. Although feed was added at 1600 h, during the latter observation days the bulls did not increase eating until 2 h before sunset. Most of the bulls that were not eating or drinking were standing at this time.

Eating, drinking and standing activity was less than during the day, but a period of increased eating, drinking and standing occurred at approximately solar midnight (0100 h). This period of activity was greater in intensity and duration during the longer nights early in the trial (figure 1). Eating and drinking activities

### TABLE 1. METEOROLOGICAL CONDITIONS AND BULL WEIGHS

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature°C</th>
<th>Precipitation h</th>
<th>Time of sunrise h</th>
<th>Time of sunset h</th>
<th>Average weight kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>January 27</td>
<td>-25.9</td>
<td>0</td>
<td>0857</td>
<td>1742</td>
<td>366</td>
</tr>
<tr>
<td>February 10</td>
<td>-18.4</td>
<td>1</td>
<td>0835</td>
<td>1810</td>
<td>386</td>
</tr>
<tr>
<td>February 24</td>
<td>-12.5</td>
<td>4</td>
<td>0804</td>
<td>1836</td>
<td>406</td>
</tr>
<tr>
<td>March 10</td>
<td>-1.8</td>
<td>2</td>
<td>0732</td>
<td>1903</td>
<td>432</td>
</tr>
<tr>
<td>March 24</td>
<td>1.3</td>
<td>0</td>
<td>0701</td>
<td>1929</td>
<td>440</td>
</tr>
<tr>
<td>April 7</td>
<td>1.7</td>
<td>1</td>
<td>0633</td>
<td>1946</td>
<td>454</td>
</tr>
<tr>
<td>April 21</td>
<td>8.7</td>
<td>3</td>
<td>0600</td>
<td>2013</td>
<td>466</td>
</tr>
<tr>
<td>May 5</td>
<td>8.7</td>
<td>0</td>
<td>0530</td>
<td>2037</td>
<td>485</td>
</tr>
<tr>
<td>May 19</td>
<td>16.1</td>
<td>0</td>
<td>0506</td>
<td>2100</td>
<td>505</td>
</tr>
</tbody>
</table>

**Notes:**

- aMean of 24 hourly values.
- bNumber of hours when precipitation was recorded.
were at minimal levels in the early morning. This period shifted with sunrise and lasted from approximately 2 h before sunrise until shortly after sunrise. The lack of activity during this period was dramatic and during eight of the observation days more than 95% of the bulls were lying at this time.

**Trial 2.** Stormy weather characterized by high winds and(or) precipitation was encountered during observations 3, 5 and 7. The mean daily temperatures during the ten observations ranged from -24.0 to 11.6 C with an average of -9.1 C. The average wind speed during the observations was 14.2 km/h. Barometric pressure varied from 94.9 to 96.5 kPa, with a mean of 95.8 kPa. Precipitation occurred during four observations. Minutes of darkness (sunset to sunrise) decreased from 944 min during the first observation to 486 min during the last observation (table 2).

The bulls spent an average of 145 (SD=45) min/d eating, with a range of 32 to 279 min/d. Individual bulls averaged between 92 and 174 min/d eating. However, the time spent eating did not change with daylength (P>.05). Standing, exclusive of eating, accounted for 464 (SD=181) min/d, with a range of 75 to 1,050 min/d. Individual bulls averaged between 233 and 673 min/d standing. Bulls drank an average of 5.4 (SD=2.1) times/d, and individual bulls averaged from 3.4 to 7.8 drinking periods/d. All bulls were observed drinking at least once during each day, and a maximum of 11 occasions was recorded. The mean frequencies and standard deviations (SD) of licking, scratching, cross-grooming and mounting were 21.5
DIURNAL BEHAVIOR OF BULLS

(16.7), 5.8 (5.0), 4.0 (5.3) and 2.0 (4.1) instances per bull/d, respectively. The greatest frequencies observed for individual bulls were 74, 22, 35 and 23/d for licking, scratching, cross-grooming and mounting, respectively, and the minimum observed for all of these activities was zero.

The distributions of standing, eating and drinking activities for individual bulls during the observations are presented in figure 3. The bulls usually arose approximately 1 h after sunrise and began eating shortly thereafter. In the early observations, the animals were fed within the first hour after sunrise, and they stood and began eating at that time. After approximately 3 h of standing and eating, the bulls lay down. A similar standing and eating period began approximately 1.5 h before and ended 1.5 h after sunset. An increase in drinking activity was also associated with these periods. In the later observations, a period of standing, eating and drinking also occurred during the middle of the day. There were periods of minimal activity after the evening and before the morning eating periods. Short periods of standing were recorded throughout the day.

### Table 2. Meteorological Conditions during 10 Continuous 24-H Observations Conducted at 2-Wk Intervals between January 16 and May 22 (Trial 2)

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature, C</th>
<th>Wind velocity, km/h</th>
<th>Barometric pressure, kPa</th>
<th>Precipitation, mm</th>
<th>Darkness, min</th>
</tr>
</thead>
<tbody>
<tr>
<td>January 16</td>
<td>-23.6</td>
<td>11.4</td>
<td>95.3</td>
<td>.0</td>
<td>944</td>
</tr>
<tr>
<td>January 30</td>
<td>-24.0</td>
<td>9.3</td>
<td>96.4</td>
<td>.0</td>
<td>901</td>
</tr>
<tr>
<td>February 13</td>
<td>-22.6</td>
<td>23.4</td>
<td>95.4</td>
<td>16.3</td>
<td>847</td>
</tr>
<tr>
<td>February 27</td>
<td>-18.5</td>
<td>17.5</td>
<td>96.4</td>
<td>2.0</td>
<td>808</td>
</tr>
<tr>
<td>March 13</td>
<td>-9.9</td>
<td>23.0</td>
<td>96.4</td>
<td>.1</td>
<td>748</td>
</tr>
<tr>
<td>March 27</td>
<td>-10.0</td>
<td>4.6</td>
<td>95.6</td>
<td>.0</td>
<td>687</td>
</tr>
<tr>
<td>April 10</td>
<td>-2.0</td>
<td>12.3</td>
<td>94.9</td>
<td>9.5</td>
<td>628</td>
</tr>
<tr>
<td>April 24</td>
<td>3.7</td>
<td>12.7</td>
<td>95.6</td>
<td>.0</td>
<td>569</td>
</tr>
<tr>
<td>May 8</td>
<td>4.8</td>
<td>17.2</td>
<td>95.7</td>
<td>.0</td>
<td>516</td>
</tr>
<tr>
<td>May 22</td>
<td>11.6</td>
<td>11.0</td>
<td>96.5</td>
<td>.0</td>
<td>486</td>
</tr>
</tbody>
</table>

a Values represent 24-h means or totals.

b Expressed as equivalent rainfall.
each observation during which the bulls changed their resting position or orientation in the lying area. In figure 3, it is notable that during the inclement conditions of observation 3, the bulls stood throughout the day and much of the night.

The distributions of agonistic encounters, mounting, cross-grooming and scratching are presented in figure 4. Agonistic encounters and mounting were most frequent in the hours around sunset. Cross-grooming took place primarily during daylight, with only 8% of that activity occurring during darkness. The pattern for licking was similar to that for scratching; both activities occurred throughout the 24-h period but primarily during daylight.

Correlation coefficients for the behavioral activities and meteorological conditions (table 3) revealed few significant relationships. Eating decreased (P<.05) on windy days, while standing (exclusive of eating) increased (P<.01) on days of high precipitation. Scratching was nega-
AGONISTIC ENCOUNTERS

MOUNTING

CROSS-GROOMING

SCRATCHING

Figure 4. Diurnal patterns of agonistic encounters, mounting, cross-grooming and scratching for groups of nine feedlot bulls observed during 10 continuous 24-h studies at 2-wk intervals between January 16 and May 22. Times of sunrise and sunset are indicated by vertical lines. The size of dot represents the frequency of activity during each 15 min period. (Trial 2).

Table 3. Correlations between behavioral activities of feedlot bulls and meteorological conditions

<table>
<thead>
<tr>
<th>Item</th>
<th>Daylength</th>
<th>Temperature</th>
<th>Wind velocity</th>
<th>Precipitation</th>
<th>Barometric pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eating</td>
<td>.33</td>
<td>.38</td>
<td>-.73*</td>
<td>-.32</td>
<td>-.50</td>
</tr>
<tr>
<td>Standing</td>
<td>-.31</td>
<td>-.36</td>
<td>.61†</td>
<td>.90**</td>
<td>-.38</td>
</tr>
<tr>
<td>Drinking</td>
<td>.44</td>
<td>.35</td>
<td>.04</td>
<td>.53</td>
<td>-.48</td>
</tr>
<tr>
<td>Licking</td>
<td>-.35</td>
<td>-.34</td>
<td>-.01</td>
<td>-.34</td>
<td>.13</td>
</tr>
<tr>
<td>Scratching</td>
<td>-.61†</td>
<td>-.66*</td>
<td>-.27</td>
<td>-.02</td>
<td>-.62†</td>
</tr>
<tr>
<td>Cross-grooming</td>
<td>.57†</td>
<td>.57†</td>
<td>-.27</td>
<td>.03</td>
<td>.20</td>
</tr>
<tr>
<td>Mounting</td>
<td>.11</td>
<td>-.03</td>
<td>.61†</td>
<td>.51</td>
<td>-.16</td>
</tr>
<tr>
<td>Agonistic encounters</td>
<td>-.61†</td>
<td>-.63†</td>
<td>.41</td>
<td>.68*</td>
<td>-.38</td>
</tr>
</tbody>
</table>

*Ten days of observations.
†P<.10.
*P<.05.
**P<.01.

Tightly correlated with temperature (P<.05), while cross-grooming tended to be positively related to daylength and temperature but negatively correlated with precipitation (P<.10). Mounting tended to increase (P<.10) during windy weather and agonistic encounters were less frequent (P<.05) when precipitation occurred.
Discussion

Both trials were conducted during winter and spring in order that seasonal effects due to daylength and long term temperature changes could be observed. Superimposed upon these predictable conditions were those of short duration such as precipitation, high winds and day-to-day temperature variation. The observation days in trial 1 were essentially free from storms while several of the observations in trial 2 were made during conditions considered inclement for the season. Thus, while the results of both trials should represent seasonal changes in behavior patterns, reactions to short periods of inclement conditions would be expected more in data of trial 2.

The consistent patterns of eating, standing and drinking that were observed in both trials were similar to those reported in previous feedlot studies (Putnam and Davis, 1963; Hoffman and Self, 1973). The time spent eating (145 min) during a day was similar to that reported by Chase et al. (1976) for dairy steers, and by Hoffman and Self (1973) and Gonyou and Stricklin (1981) for feedlot cattle. The periods of eating and standing associated with sunrise and sunset were relatively independent of the feedlot schedule of feeding. In the later observations, when feed was added to the troughs in the morning, the bulls had already been eating for some time. The feed added in the afternoon was often left essentially untouched until sunset was imminent. In winter, most of the eating associated with sunrise and a portion of that associated with sunset was directed toward the feed provided in the morning. In summer, the evening and much of the morning eating periods occurred after the afternoon feeding. Hancock (1953) indicated that the proportion of grazing occurring after a fixed event in the evening (milking) increased with increasing daylength in a manner similar to that noted in our trials. Tribe (1949) reported similar results for sheep. In order to reduce freezing or spoilage of feed in the troughs, it would appear appropriate to change the proportion of feed given at each feeding or to change feeding times as the season progresses.

In addition to the major periods of eating associated with sunrise and sunset, there were minor periods of eating, standing and drinking in the middle of the night or at midday. The midnight feeding was not as evident in trial 2 as in trial 1. This may have been due to the larger group sizes and total numbers in trial 1, or the adverse weather of trial 2. The midnight eating observed when the nights were long is consistent with the report of Wilson and Flynn (1979). Christopherson (1973) did not observe a midnight eating period in a study conducted in Edmonton even when daylight was less than 8 h, but many of the cattle were on restricted feed or high concentrate diets, and that could have reduced eating time.

As daylength increased, it was possible for the bulls to substitute eating at midday for the midnight feeding. The shifting of eating times was accomplished without a change in total eating time although daylength changed dramatically. These findings support the results of Wilson and Flynn (1979) and tend to refute earlier suggestions by Wilson and Flynn (1975) and Bond et al. (1978) that eating time decreases during the shorter winter days. In addition to maintaining total eating time, the shift from midnight eating in the winter to midday eating in the spring represents a means of more evenly distributing the eating and resting periods throughout the day and yet still maintaining major eating periods closely associated with sunrise and sunset. During the winter, eating commonly interrupted the period of approximately 13 h from the end of the evening eating period to the beginning of the morning eating period. In late spring this period was reduced to approximately 7 h and eating more frequently interrupted the 10 h period from the end of the morning eating period to the beginning of the evening eating period. In this way extremely long resting periods between eating periods were avoided.

In both trials a notable period of inactivity occurred before sunrise, with very few bulls standing or eating. Cattle will also reduce eating at this time even if feeding space is severely restricted (Gonyou and Stricklin, 1981). The importance of this period may be related to rumination patterns (Gordon, 1958).

Although neither eating nor standing times were affected by the seasonal variables of temperature and daylength, both activities were influenced by the inclement weather encountered in trial 2. Bond and Laster (1974) reported that cattle with access to a windbreak decreased the time spent eating and suggested that this happened because the animals chose to remain near the fence during periods of high winds. A similar strategy was evident among the bulls in trial 2. Rutter (1968) stated that cattle stood more during precipitation, as they did in
Trial 2. Standing was most evident during the third observation, when the maximum precipitation and wind velocities were encountered.

The grooming activities, although more evident during the day, were not distinctly associated with sunrise or sunset. The frequency of grooming activities tended to be influenced by seasonal variables rather than short-term conditions. In contrast to the report of Gonyou et al. (1979), the bulls in the present study tended to decrease their licking and scratching as temperature increased. Because observations continued into late spring, shedding of the winter hair coat may have been completed during the later observations. Cross-grooming, which was observed almost exclusively during daylight, tended to increase with daylength but decrease during precipitation. Cross-grooming was frequently observed while the recipient was lying.

The social interactions of mounting and agonistic behavior were closely associated with the major periods of activity at sunrise and sunset. Christopherson (1973) reported similar results indicating a shifting of the activity peaks as daylength increased.

Eating, standing, drinking, mounting and agonistic encounters were closely associated with sunrise and sunset. In addition, the duration or frequency of these behaviors was generally more responsive to short-term meteorological conditions such as wind velocity and precipitation than to seasonal variables such as temperature and daylength. Although there was a trend for agonistic encounters to decrease during warm weather and increased daylength, these results may be confounded by the changing maturity of the animals. In contrast, grooming activities tended to occur throughout the daylight period and changed in response to variables such as daylength and temperature that were indicative of the season.

Daily schedules of personnel in feedlot operations change little during the year and are designed primarily for the benefit of the workmen, whereas our results indicate that cattle behavior patterns vary in a predictable but dramatic manner with the seasons. Modifying our feedlot schedules of feeding and handling to conform with cattle behavioral patterns would result in a more cattle-oriented management system and should be investigated in terms of productivity. In addition, observations on cattle behavior should be scheduled to coincide with cattle activity patterns rather than clock time.

**Literature Cited**


