Feeding Behavior of Dairy Cattle

ABSTRACT

Feed accessibility may be more important to cows than the actual amount of nutrients provided. Competition for feed, water, and space can be reduced by fenceline feeding of TMR, which allows all cows to eat at once. Holstein cows that were fenceline fed a TMR of corn silage and concentrates ate 26% longer following feeding than the same size group eating from bunks around which they traveled. Many dairies practice fenceline feeding during which cows’ heads are in the natural grazing position. Cows eating with their heads in the downward position produce 17% more saliva, which directly affects rumen function, than cows eating with heads held horizontally. When fed in shallow, elevated bunks, 10% of cows exhibited year-round rooting, sorting, feed tossing behavior, and feed wastage (0 to 5%). Groups fed at ground level or in headlocks showed little or no feed tossing behavior. This apparent livestock engineering problem is remedied easily by feeding cows in the natural head down position. Concrete mangers renovated with epoxy-type finishes, wood, or tile aid feed consumption. Social facilitation strongly influences eating bouts and feed consumption in cows reared in group housing compared with isolated cows. Palatability has a major influence on feed intake in ruminants, and the sense of taste is highly developed in cattle. Pasturing supposedly would reduce stocking density, environmental pollution (waste disposal, odor, nuisance), energy costs, and use of housing. Detailed observations, using intact and ruminally cannulated cows, suggest a behavioral need for the cow to rest and to ruminate on her left side. (Key words: feeding, behavior, grazing, rumination)

Abbreviation key: REM = rapid eye movement.

INTRODUCTION

The primary concern of all animals is the gathering of food (1). All animals evolve as products of their dietary needs: the giraffe’s neck, the lion’s teeth, the cow’s stomach, and the suckling instinct in young mammals are all diet-oriented. An animal is not only what it eats, but it also is designed so that it can eat (29). Dairy cattle responses to various types of feeds and feeding arrangements differ. Dairy farmers can use knowledge of animal behavior to improve cow well-being and yield (6). For instance, feeding and watering systems must be placed where young or inexperienced animals can find them. Accessibility of feed may be more important than the actual amount of nutrients provided. Efforts must be made to reduce the competition for feed, water, minerals, and shelter. Also, cow space, cow density, and distribution of feed are closely related factors. Feed intake and consequent milk yield are improved by provision of feed when cows need and want to eat (88). When one cow eats, another might be stimulated to do likewise, whether she is hungry or not. This behavior is an example of social facilitation (38). When cows eat in groups, they eat more than when they are fed separately. Furthermore, cows kept in groups “are likely to be less fearful, and hence, more contented, healthier, and more
productive. The common practice of feeding and milking cows in groups thus has a sound psychological basis” (90).

Dairy cattle are social animals that operate within a herd structure and follow a leader (leadership-followership) to and from pasture, feedbunk, and milking parlor. Such behavior can be beneficial (e.g., following a leader onto a scale) or detrimental (e.g., a stampede) (21). Behavior becomes a balance of interacting driving forces: for newly mixed cows, aggression is dominant, but it soon diminishes as the social order becomes established and the feeding drive becomes dominant (43). Cows exhibit wide differences in temperament, and their behavior is determined by inheritance, prior experience, and training (37). Cows normally are quiet and thrive on consistency and gentle treatment by handlers (37). Handling procedures are more stressful for isolated cows; therefore, attempts should be made to have several cows together during medical treatment, during artificial insemination, or during movement from one group to another (17, 102).

Research on feeding behavior may be found in the reviews of Baile and Della-Fera (20) and Campling and Morgan (28). Aspects of feeding behavior relative to confinement housing, management, and innovations in feeding devices were reviewed by Coppock et al. (36).

This paper summarizes current and relevant knowledge of eating and feeding behavior; developments in feeding and grazing behavior because of the renewed interest in intensive grazing and seasonal dairying; and the behavioral aspects of rumination. Suckling behavior in calves—rates, patterns, and frequency—is a subject unto itself and has been covered earlier (54). Recently, drinking behavior and water intake and deprivation were summarized elsewhere (76).

Eating Behavior

The amount of grains and ground feed mixtures consumed is determined largely by the quantity offered. However, cattle on silage eat larger quantities of less nutritious feed than when on pasture, presumably because of the preclusion of selective choosing (54). Dry matter consumption is higher when cows are fed hay than when they are fed silage or pasture (54). Some evidence (62, 73) indicates that cattle eat less hay when fed individually than when group fed, possibly because of the increased anxiety exhibited by temporarily isolated cows. In joint research (16), group-reared calves spent a significantly ($P < .05$) greater percentage of a 24-h d eating than did calves reared in isolation (10.9 vs. 5.4%).

Cattle have a distinct diurnal grazing pattern, which includes a major meal beginning approximately at sunrise (47, 54, 56). Further, cattle are crepuscular, that is, most active at sunrise and again at sunset. In Kenya, approximately 35 km south of the equator, day length, sunrise to sunset, is 12 h and 8 min throughout the year. Arousal of cattle from a lying to a grazing state occurs predictably between 20 min before and 30 min after sunrise. The rate of arousal varies considerably and is related to the rate of increase of illumination and cloud cover. The maximum temperature of the previous day, humidity at 0700 h, wind, and radiation of the previous day do not affect behavior (50). Feeding behavior is affected by climate, condition of teeth, age of cattle, and nature and kind of feed. In general, feed consumption (in a controlled climate laboratory) is depressed by increasing environmental temperature (83).

Patterns of feeding vary according to the physical consistency of the ration. Cracked, ground, processed grains are usually offered to dairy cattle while they are restrained in a stanchion, headlock, or stall. Feed is put in front of them in a manger, from which the cattle eat by gathering feed up with the tongue and sucking it into the mouth. Most feed is in moderately small particles; thus, no biting action is necessary, although chewing movements take place. The major organs for prehension of feed are the lips, teeth, and tongue. The general direction of movement of the jaws during eating in the cow is the same as other mammals. Chewing movements in ruminants differ from those of most other mammals. At centric occlusion, only a narrow strip of their molars is in contact because domestic ruminants are highly anisognathous (having the upper jaw much wider relatively than the lower one) (89). For further details on eating procedures (i.e., jaw movements, teeth, and voluntary and involuntary swallowing), see the paper by Campling and Morgan (28).

Whole grain, pellets, silage, chopped forages, and small roots also are scooped into
the mouth by lip and tongue movements, followed by vigorous chewing. Cows discern quickly how to select the leaves from hay and how to figure out the transponder system to get what they want (e.g., hay rather than corn silage diets). Cattle bite and eat large tubers, roots, and fruits, such as potatoes, sugar beets, carrots, and apples, just as humans would. Salt blocks, still common on many farms and feedlots, are licked by cattle. Earth eating (geophagia) is widespread in Africa and in confined cattle the world over. Cattle are inquisitive creatures that supposedly go to earth kicks for salt because the Na content of herbage is often low. This hypothesis is not supported by chemical analysis (54). The reason why cattle eat earth is unknown. Also, cattle might associate sensory information about harmful phytochemicals (poisonous plants) with appropriate behavior through instinct, learning as an individual, learning as part of a social group, or combinations of the given behaviors (82).

Time spent masticating different rations varies directly with the total number of chews (54). In a series of papers (47, 48, 49), the number of chews per unit of time spent ruminating varied with diet. Campling and Morgan (28) have summarized the duration and pattern of eating in noncompetitive and competitive situations.

Noncompetitive Eating Situations

Metz (73) analyzed and described in detail the eating and ruminating patterns of seven dry, nonpregnant Dutch cows offered hay wafers for ad libitum intake. Among cows, the duration of eating ranged from 248 to 392 min/d (average 330 min/d), and this variability was not associated with either the amounts eaten or the BW of the cows. Daily rumination times ranged from 464 to 579 min/d (average 511 min/d), and daily number of rumination bouts ranged from 10.8 to 16.9 (average 14.0) Bouts of eating (meals) tended to be most frequent at the beginning and end of the daylight period; the cows were in a room illuminated continuously for 16 h. Daily feed intake averaged 14.7 kg and ranged from 10.3 to 18.5 kg. The number of meals varied between cows from 5.9 to 11.4/d (average 8.3). Metz (73) established that the prevention of rumination during 3 h of feed deprivation increased rumination in the subsequent period. This finding supports the assumption that feeding has priority over rumination whenever the causal factors of the two behaviors are in conflict. [However, earlier research (80) indicates that rumination can have priority over eating when the former is restricted.] Similar data on the duration of eating can be found in a study by Hafez and Bouissou (54) and summarized by Balch (23). Few data show the extent of variability between days in eating time by cows given the same amount of feed each day.

In an earlier 24-h observation study, Fuller (46) reported that cows in box stalls fed hay for ad libitum intake spent 6 h eating and 8 h ruminating, but cows in stanchions spent 3 h eating hay and 8 h ruminating. The number of jaw movements per minute eating for Ayrshire, Guernsey, Holstein, and Jersey cows were 94 for grain and silage, 78 for hay, with 55 for ruminating. A summary of approximate jaw movements was 4700 (eating grain and silage), 10,530 (eating hay), and 26,400 (ruminating) for a total of 41,630 movements/d. The effects of dietary NDF concentration on chewing and milk yield were assessed using alfalfa silage-based diets with and without supplemental long hay (24). Increased NDF resulted in a quadratic increase in ruminating and total chewing time from 344 and 558 for 26% NDF, to 403 and 651 for 30% NDF, and to 414 and 674 min/d for 34% NDF, respectively. Added hay increased milk yield by .7 kg/d but did not increase daily ruminating and chewing time; ruminating time per unit of NDF intake was reduced by hay supplementation (75.3 vs. 69.4 min/kg). Other relevant data on chewing and rumination can be found (24).

Another important factor influencing eating rate was the amount of feed offered to the cow. Milking cows took 1.6 min to eat 1.0 kg of pelleted concentrate, but, if presented with 4 kg, the eating rate was 1.05 min/kg (60). The authors suggest that smaller amounts of concentrates are more thinly spread over the area of the base of the manger than a larger amount, thus increasing the time and maneuverability by cows to gather the feed into their mouths. This idea has appeal in conjunction with the TMR concept. Campling and Morgan (28) summarized other work, concluding that lactating cows eat slightly more rapidly than nonlac-
TABLE 1. Effects of reducing manger space on visits, cow numbers, total feeding time, and manger space occupied for each 24-h observation period.

<table>
<thead>
<tr>
<th>Manger space per cow</th>
<th>.45 m</th>
<th>.3 m</th>
<th>.25 m</th>
<th>.2 m</th>
<th>.18 m</th>
<th>.15 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visits, no.</td>
<td>11.0</td>
<td>11.0</td>
<td>10.0</td>
<td>11.0</td>
<td>11.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Cows, no.</td>
<td>4.4</td>
<td>3.8</td>
<td>3.7</td>
<td>4.0</td>
<td>3.5</td>
<td>3.1</td>
</tr>
<tr>
<td>Total time feeding, 2 min</td>
<td>191.0</td>
<td>186.0</td>
<td>139.0</td>
<td>178.0</td>
<td>163.0</td>
<td>158.0</td>
</tr>
<tr>
<td>Mean manger space occupied, %</td>
<td>19.6</td>
<td>25.5</td>
<td>29.9</td>
<td>40.4</td>
<td>39.8</td>
<td>41.9</td>
</tr>
</tbody>
</table>

1 Five cows in estrus disturbed other cows while feeding.
2 Mean feeding time per cow = 169 min.

Competition for feed may develop when cows are kept in groups and when manger space is insufficient to allow all cows to feed at once. The critical length of manger space below which competition occurs depends on the time that feed is in the manger. Also, the presence of manger divisions may affect eating behavior of submissive cows, enabling them to eat longer (27). Friend et al. (44) examined the time that cows spent at the manger and their voluntary intakes when each cow was allowed .5, .4, .3, .2, or .1 m of manger space; a TMR including 25% ground hay was available for 21 h/d. Only when the length of manger was below .2 m were eating time and intake reduced. In another trial comparing mangers of .5 and .25 m per cow, time spent by the cows in using the mangers and feed intakes were similar (45).

Collis (1978, personal communication) conducted a similar study with 60 British Friesian cows comparing .1, .5, .3, .25, .2, .18, or .15 m of manger space. At the end of each week, before the reduction in manger space, this group of cows was observed continuously for 24 h. Visits to the manger, cow numbers, total feeding time, and manger space occupied are presented in Table 1. The 24-h milk yields (kilograms) of treatment and control groups for each observation period are in Table 2. Reduction in manger space had no effect on the mean number of visits. The mean total feeding times decreased during the 6-wk trial, but not significantly. No significant differences occurred between the treatment and control groups for percentages of cows observed standing, lying, or feeding. The mean milk yields of both groups decreased, but differences between them were not significant. How this short-term experiment with smaller numbers fits actual current herd conditions is not known. A gradual reduction in manger space for an established group of cows may be accepted more than adaptation of a new group to limited manger space.

TABLE 2. Effects of reduced manger space on 24-h milk yield for each observation period.

<table>
<thead>
<tr>
<th>Manger space per cow</th>
<th>1.07 m</th>
<th>.45 m</th>
<th>.3 m</th>
<th>.25 m</th>
<th>.2 m</th>
<th>.18 m</th>
<th>.15 m</th>
<th>1.07 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk yield, kg/d</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment group</td>
<td>21.9</td>
<td>22.4</td>
<td>21.3</td>
<td>20.4</td>
<td>21.2</td>
<td>20.8</td>
<td>19.3</td>
<td>19.9</td>
</tr>
<tr>
<td>Control group</td>
<td>23.6</td>
<td>23.6</td>
<td>22.7</td>
<td>21.6</td>
<td>22.3</td>
<td>20.9</td>
<td>19.6</td>
<td>19.9</td>
</tr>
</tbody>
</table>

In a Michigan herd of approximately 600 cows over 200 d, milk yield, conception, animal health, behavior, and labor input at 61 versus 46 cm of bunk space were checked, and there were no differences (5, 94). High building investments suggest that the most efficient use should be made of dairy facilities. Therefore, 46 cm of bunk should be provided instead of 61 cm of space per cow for heavy corn silage diets or complete feeds. With cows averaging 36 kg/d, no difference in milk yield was found, but Bickert (25), an agricultural livestock engineer, asks the question: “What is the effect if cows are averaging 45 or 57 kg/d of milk or more per day?” (page 17).

When a competitive situation exists at the manger, dominant cows tended to spend more time eating than did cows of lower social rank (27, 44, 45); this feeding situation led to a greater intake of feed by dominant than by midranked or submissive cows (44). The more competitive the situation was caused by reduced length of manger (from .5 to .1 m) available to each cow, the stronger was the correlation between intake and dominance value (45). With 12 dairy cows using a 10-variable model, time spent eating, time in free stalls, and individual DMI were described predominantly by yield variables (45). The social rank or dominance hierarchy, which is based on the number and strength of aggressive interactions between cows, is usually complex and difficult to describe as a simple linear function (13, 26, 33), and social rank may not adequately describe motivation of the cows and competition for feed (44, 45, 97). Studies have reported a weak correlation between social rank (13) and milk yield, although social rank sometimes has been associated directly with BW, age, or breed (33, 65, 87). Manson and Appleby (70) studied lactating cows fed diets offered for ad libitum intake in a feed trough divided into 44 feeding positions, each .65 m wide. Agonistic interactions were recorded, and cows were classified as low, medium, and high ranking. When from 4 to 14 cows were feeding, positions chosen were nonrandom. When <4 or >14 cows were at the trough, their distribution was not significantly different from random. Choice of position was affected by dominance relationships. Neighboring cows similar in rank were, on average, 3.0 positions apart; dissimilar neighbors (low and medium or medium and high rank) were further apart (3.8 positions); and most dissimilar neighbors (low and high rank) had the greatest separation (4.4 positions). When a competitive situation existed at the manger, dominant cows tended to spend more time eating than did cows of low social rank, leading to a greater intake of feed by dominant than by submissive cows (70).

Developments in Feeding

Several recent papers report the effects of feeding variables and additives upon feed intake and milk yield in dairy cows. In a multivariate data acquisition system to measure feed and water intake and chewing behavior continuously, Dado and Allen (39) found that cows at higher yields achieved greater DMI by increasing meal size while spending less time eating and ruminating per unit of intake. Nombekela and Murphy (77) suggested that cows ranked sweeteners (sucrose at 1.5% of dietary DM) over control, followed by sour, bitter, or salt flavors. In a second trial, control and monosodium glutamate ranked over anise, dehydrated alfalfa, and molasses flavors; therefore, the potential exists to enhance feed intake by exploiting flavor additive preferences in early lactation through free-choice feeding. Arana et al. (12) reported that flavomycin beneficially (but not significantly) affected milk yield and efficiency of feed utilization.

The sense of taste in dairy cattle is highly developed, and taste sensitivity of cows changes with feeding. Cows fed predominantly silages had decreased taste sensitivity to sour things and increased sensitivity to sweet ones (64). Hence, corn silage addition to complete feeds and TMR development were logical choices (59). With grass-legume-based TMR, DMI was higher for cows fed buffered TMR (P < .05) than for control cows (57).

Recently, considerable interest has developed in utilizing fat as an economical alternative energy source in lactating cow diets. Eating patterns were studied in two trials with lactating cows fed grain mixtures (50% of feed DM) containing 10% tallow or blended animal-vegetable fat. The number and use of spontaneous meals tended to increase when either fat source was fed so that daily feed consumption was not different. A word of
caution is recommended: because the first meal is smaller, high fat in the concentrate ration should not be used under feeding conditions with restricted time (58). The TMR help to mask flavors and, thus, provide an excellent means of incorporating high fat into the feeding system. Likewise, Megalac® (Church and Dwight Co., Inc., Princeton, NJ), a calcium salt of palm fatty acid distillate, which provides high energy (without rumen effects) when it is fed to milk cows and growing cattle, has initial palatability problems. However, most cows adapt quickly, and energy intake was not compromised (79). In order to facilitate adaptation, there are ample opportunities to use flavor compounds and TMR rations.

When cows calve during daylight hours, opportunity is greater for assistance; thus, night calving is a dairying disadvantage. Complete feeds given once daily for at least 2 wk to 129 dry cows altered their calving times. Morning feeding (0800 h) had 62.5%, and night feeding (2000 h) had a slight increase (68%), for cows that calved during daylight hours (0600 to 1800 h) (81). Three 24-h behavioral observations were made in a 1-ha grass-covered grove with 45 of the 129 cows being dry. Data collection was designed so that relatively inexperienced technicians could handle behavioral observations (7). General observations were that the two groups with differing feeding strategies and physically separated by a wire fence in the same wooded grove had significantly different herd behavior patterns. Cows fed at night stood longer and rested less than control cows. It has been reported elsewhere (31) that 55% of total lying time in dairy cattle occurs between the 6-h period of 2200 to 0400 h. In this study, control cows had 49%, and experimental cows fed at night had 40%, of their total rest during this same time span (7, 81). Cows fed at night spent 40% of their daytime hours lying, and the control group spent 25% lying. In both years following feeding of complete feeds once daily, significantly more (83%) control cows and 85% of cows fed at night calved from 0600 to 1800 h and from 0500 to 2100 h than the one-half and two-thirds random calving pattern expected (81).

Electronic grain feeders placed near the milking parlor exit in a loose housing barn were subjected to continuous winter month observations (two 72-h and three 48-h watch-es). After 3 d of continuous observation, 28 cows used the feeders regularly. The remaining 4 cows and all subsequent parturient cows were trained successfully to use the feeders by placing cows in the stall for 5 min. The feeders initially caused strong competition, and cows would accept vigorous repeated butts to the rear without backing out of the stall area, even though the feeder was not dispensing. During the 4-mo trial, cows became more willing to back out of the feeder even when concentrate was being dispensed. The position of a cow in the group social organization did not influence this response; cows backed out as readily for younger or subordinate as for older, dominant cows (34, 35). Computerized dispensing of concentrates, applied properly, can economize on consumption of concentrates when grouping and feeding of different rations are impossible (69).

Fenceline or auger feeding of TMR should be practiced to allow all cows to feed at once and to reduce aggression. Holstein cows fenceline fed a TMR of silage and concentrates ate for 26% more of the time following feeding than the same size group eating from a trough around which they had to travel (2, 5). Many visitors to the Purdue Dairy Research Center, at which weighed, complete blended (corn silage plus concentrates) rations were first fed with a mixer wagon 25 yr ago, have commented on how tame, docile, and relaxed the cows appear (8, 59). Much of the mechanization that underlies this system was developed for commercial cattle feedlots, especially those in Nebraska and Colorado in the 1960s. Universal application of this feeding system was inhibited somewhat by the lack of knowledge about how to formulate complete diets (78).

Many dairies practice fenceline feeding with cows eating with their heads in the natural grazing position. During her world milk yield record, US Holstein, Beecher Arlinda Ellen, ate hay at floor level (3). Evidence exists (67, 68) that cows eating with their heads in the downward position produce 17% more saliva than cows eating with their heads held horizontally, which directly influences the efficiency of ruminal functions. A 24-h behavioral watch (3, 104) has been summarized in Table 3.
Labor requirements tend to ease on weekends. Consequences of diet include reduced labor for silages. Diet did not affect feeding behavior in comparison to silages. Epoxy-type finishes or relining increase labor requirements for feed consumption. Cows exhibit more rooting behavior in shallow, elevated troughs. For calves, cats, humans; and idling. Resting salivation rate and volume varied between the two groups. Basal resting salivation rate was lower for early lactation dairy cows than wk 4 of lactation, even when corrected for milk yield. Saliva composition, but degree of feed ensalivation, was different between feeds. Haycrop silage produced while cows were eating or resting, or from the same trough at ground level, they chose the lower level. The group fed at ground level showed no feed tossing behavior. Consequences of feedbunk design include increased feed wastage from feed tossed over their backs or along their sides. Feed tossing occurred especially in summer during heavy fly concentration but took place in winter as well. When cows were given the alternative option of eating from an elevated feedbunk with the floor and top of the trough at a height of 28 and 76 cm from ground level, respectively, or from the same trough at ground level, they chose the lower level. The group fed at ground level showed no feed tossing behavior. This livestock engineering problem appears to be remedied easily by feeding cows so that they consume feed in the natural head down, grazing position.

Graves suggested eliminating feedbunks based on feeding observations. A reason some farmers give for not offering their high yielding cows more to eat is that they have to shovel the ors out of the bunk. Consequently, they only feed enough ration so that the cows clean it up every day, and this amount probably is not enough feed. By leaving some ors (5% or so), provided they are of good quality and not too wet, the cows have an opportunity to eat their fill at the bunk. The ors feed can be fed advantageously to weaned calves, heifers, and dry cows. In the long run, another construction option for feed bunks is flat feeding floors with headlocks in drive-through barns.

The floor of the trough should be level or slope no more than 1% along the length of the feed bunk. When troughs have slopes of 3 to 5% or more, cows shift and move in the direction of the slope. The cows keep shifting and moving. Likewise, with excessive slopes of 5% or more in holding pens, cows eventually become hesitant about entering the area as well as the milking parlor.

Low yielding boss cows should be culled. Hog rings can be placed in the poll of obvious boss cows. In order to eliminate fighting at the feedbunk, all cows should be dehorned to eliminate potential boss cows. Culling of weak, submissive cows as well as low yielding boss cows will result in a more stable herd. The effects of different types of physical barriers on side by side feeding times of hungry cows were classified according to dominance and submission status. Barriers provided for feed tossing behavior. About 10% of the cows participated in this rooting, sorting ritual. Feed wastage from feed tossed over their backs or along their sides was 0 to 5% each week. Feed tossing occurred especially in summer during heavy fly concentration but took place in winter as well. When cows were given the alternative option of eating from an elevated feedbunk with the floor and top of the trough 28 and 76 cm from ground level, respectively, or from the same trough at ground level, they chose the lower level. The group fed at ground level showed no feed tossing behavior. This livestock engineering problem appears to be remedied easily by feeding cows so that they consume feed in the natural head down, grazing position.

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ing complete protection of the cow's head allowed subordinates to feed for more than two-thirds of the test period, whereas partial protection allowed feeding for about half of the time (27).

Cows should be shifted from one group to another when necessary, and small groups of cows should be moved. Not only is there social pressure on the cow in her new group, but she also may have different amounts of feed, a new milker, and a different milking time (5). Handling procedures are more stressful for isolated cows; therefore, attempts should be made to keep several cows together during medical treatment, artificial insemination, or movement from one group to another (17, 102).

When corn silage is the only forage fed, hay should be provided, allowing 2.3 to 4.5 kg/d of long hay per cow. Accompanying the move to all or high corn silage diets in the US has been an increase in digestive upsets, displaced abomasums, and fat cow syndrome. Cows fed all corn silage diets or feed chopped too finely (92) do not ruminate for as long as those on hay diets. All corn silage diets need a great deal of buffering plus added protein to compare favorably with grass and hay crops such as alfalfa hay.

Previous research suggested that metabolic disorders, such as milk fat depression, may be induced by changes in rate and duration of chewing activities (93, 96, 100, 103). The effects of forage particle size upon behavior in dairy cows, especially chewing activity, have been reviewed and studied by Grant et al. (51, 52). They fed TMR differing in silage particle size (fine, medium, coarse), and they observed cow behavior at 5-min intervals during 24 h for each of three periods. Results indicated that decreasing particle size of the forage reduced time cows spent ruminating, whether standing or recumbent, and had no effect on rumination rate or number of rumination bouts per 24-h period. Eating time was unaffected by treatment. Effect of forage particle size upon baseline rumination activity appeared to be most pronounced from 0800 to 2000 h, although maximum rumination activity occurred during nighttime hours.

In a series of water experiments by Anderson (11), when eating time was restricted to 2.5 h at each feeding with no water during the first 2 h, feed consumption, milk yield, and water intake were significantly lower than when feed and water were available for 24 h/d. Anderson (11) also found that when pairs of tied cows shared a water bowl, the dominant cow ate, drank, and yielded significantly more than the submissive cow. It was hypothesized that the submissive cow suffered from chronic stress. The only way to be certain in all situations that cows have access to sufficient amounts of water is to have one water bowl per cow.

**Grazing Behavior**

Interest in grazing dairy cattle in the US has waned during the past 30 yr (14). Year-round drylot feeding, especially of the milking herd, has become the norm. Variation in performance when cows graze may arise from many sources, and variation is basic to drylot preference. Extensive grazing behavior information has been completed (1, 19, 54, 63, 75). Allen (10) recently published a helpful compilation of terminology used for grazing lands and grazing animals (10).

In New Zealand, 40 yr ago, animal behavior research with identical twins was initiated and conducted by Hancock (55, 56); this classical, detailed work on grazing behavior is summarized as baseline values in Table 4 (seven 24-h periods throughout one season).

Slightly less than 60% of the total grazing time was between 0700 and 1500 h, and slightly more than 40% was between 1700 and 0445 h. This ratio was fairly constant under all weather and pasture conditions. On average, almost 85% of the total grazing time was spent during daylight and only 15% during darkness. There generally were six cycles of grazing: four between morning and afternoon milkings, one immediately after the cows were let out on the pasture following milking at 1700 h, and one (sometimes two) during the night. Approximately 50% of the available time between 0700 and 1500 h was spent grazing. It seems that, even under ideal grazing conditions, dairy cows do not spend much more than half of the time between morning and afternoon milkings in actual grazing. The rest of the time is used partly for searching for food and partly for rest and rumination. Of the period following the afternoon milking (1700 to 0445 h), only approximately 25% was occupied with grazing.
Considering the distribution of all activities together, the habits of dairy cows in New Zealand are essentially diurnal, as best illustrated by the ratio of grazing to loafing (time spent standing or walking, not grazing) to lying down, which was approximately 5:2:2 during daylight compared with 1:1:8 during darkness (56).

Cows seldom stopped more than a few moments on the same spot but moved continuously, apparently searching for more palatable grass and frequently grazing as they walked along (56). Grass of poor palatability thus conceivably may increase the distance walked. When a cow felt the urge to drink, she would suddenly stop grazing and walk straight to the water trough, rarely pausing to graze on the way. Because all paddocks were of the same size, daily differences cannot be accounted for by variation in the distance to the trough. The frequency of drinking varied considerably from day to day, and this variation influenced the amount of walking. While grazing, the cows generally were spread quite evenly over the paddock. However, they tended to congregate in lying down. This tendency was especially noticeable at night when often only a few cows were grazing simultaneously; when a cow had finished grazing, she immediately returned to the area where the other cows were lying. This action sometimes was initiated by a short leap accompanied by a bellow. This was interpreted as play behavior. The twins provided a special case of gregariousness. Members of a set of twins, after having strayed some distance from each other while grazing, sought each other's company at frequent intervals. In general, identical twins tend to graze together and to behave similarly while at pasture (61). The differences in grazing times between identical twins was very small, averaging only 7.5 min, whereas the range among sets of twins was as great as 2.25 h (56). Also, single born calves that have been reared together in pairs usually are found together when they are turned out with a grazing herd (40).

Worldwide, the most continuous grazing periods occur in the early morning at sunrise and near sundown. Thus, in a given locality, the initiation of early morning grazing is correlated with the season of the year. Under some conditions, one or two periods occur during the night, but they are less sharply defined than the day periods. Night grazing may be more frequent during the summer and under tropical conditions because, under hot weather conditions, dairy cattle prefer to graze during the cooler mornings and evenings. In the hot midday, they seek cover, idleness, rest, or rumination. Seath and Miller (91) investigated the influence of air temperature on the grazing habits of dairy cows in Louisiana. Hot weather (30°C) lowered the grazing time by about an hour compared with time during cooler weather (22°C). Behavior patterns were different; during 30°C weather, cows grazed 1.9 h in the day and 6.5 h at night, and, during 22°C weather, they grazed 4.5 h in the day and 4.7 h at night.

The amount of time that a cow spends grazing can be recorded by a grazing clock strapped to a halter on the cow’s head. The swing of the pendulum in the clock is recorded as the cow's head moves through an arc of 60° to 80° while eating. [For further details about grazing clocks and grazing behavior, see the work of Kilgour and Dalton (63) and Stobbs and Cowper (95).]

Pasturing supposedly reduces stocking density, environmental pollution (waste disposal, odor, nuisance), energy costs, and use of housing for shorter periods (15, 98). Many dairy managers continue to pasture dry cows and heifers, but the trend is toward drylot management of the milking herd. Because data are limited on the long-term effects of intensive production systems, concern has been ex-
pressed about the comfort, well-being, behavior, reproduction, and udder, foot, and leg health of cattle kept on concrete. Whenever possible, many dairy producers let cows out of their barns in the middle of the day to sun and to groom themselves and each other, to stretch and exercise their limbs, and to show estrus behavior and overall health. As a safeguard, many cows are removed from concrete to dirt lots or pasture, at least during the dry period (6).

Rollin (84) noted that legislation in Sweden, which granted cattle the right to graze, indicates that "U.S. society will soon demand that agriculture back off, at least to some extent, from confinement and pay greater attention to agricultural animal comfort and happiness, and encode this demand in legislation" (page 3461). Pasturing has its problems, however, and may not be as ideal as animal rights activists perceive. Weather limits the grazing season (150 d or less) in several northern states. Pasture probably will not supply nutrients needed to maintain high milk yield because forage of uniform quality and quantity is difficult to provide. Shade, water, heat, insects, susceptibility to bloat, energy expended in grazing and travel to the milking parlor, and toxicity from soil are other considerations associated with pasturing. For example, high yielding cows spent much less time lying down and significantly more time grazing from the beginning to the end of the grazing season (15).

Rumination and Resting

Ewbank (41) speculated that rumination acts as an "anti-boredom" activity in the adult bovine. Considerable self-stimulation and "inwardness" occurs in cattle because of the rumination process. During rumination, whether lying or standing, cows are quiet and relaxed with their heads down and their eyelids lowered. Cows can ruminate while standing, but they usually lie down with their chests against the ground (6, 8).

It has been suggested (6, 8, 51) that left-side laterality is of strategic value to the ruminant animal for rest and to optimize positioning of the rumen within the body for most efficient rumination. Together with an upright posture, the esophageal opening is not allowed to fall below the ruminal fluid level, thus avoiding interference with rumination, eructation, belching of ruminal gasses, and, possibly, bloat. Although most nonruminants (i.e., horse, dog) sleep on their side, ruminants must maintain sternal recumbency (6, 32). Also, the self-stimulatory aspects of rumination may provide the physiological rest and rejuvenation normally provided by deep sleep. Cows spend much less time sleeping than do people, dogs, and horses. Cattle are drowsy for about 7 (71) to 8 h/d (85). Balch (22) concluded that, if cattle sleep, their sleep is of a short and transient nature. Merrick and Scharp (72), using electroencephalograph readings, concluded that cattle rest without loss of vigil or consciousness. Rukebusch et al. (86) present convincing evidence that cows do indeed practice REM sleep (rapid eye movement or "true sleep") in short 2- to 8-min periods. Theoretically, sleep serves two functions: recuperation for physiological and psychological restoration and increased response thresholds to prevent disturbance of rest from insignificant environmental stimuli. Some recumbency is necessary to prevent fatigue. Cattle deprived of resting (lying) compensate for loss of REM sleep by indulging in non-REM ("quiet") sleep while standing (14).

Cows aim to achieve a rather fixed amount of lying, and their well-being is impaired when lying time is restricted for several hours (74). Earlier, the variability in the behavior of individual cows in comfort tests appeared to be more influential on resting habits than was the type of stall—comfort, tie, or stanchion (42). (That study was conducted before invention of the free stall and technological improvements of comfort and tie-stall barns.) For further details on dairy cow comfort and resting behavior, see studies by Albright and Stricklin (8) and Curtis et al. (37).

Left-side ruminally cannulated cows are used in experiments that measure chewing activity and ruminal function. This observation raises an important, but largely overlooked, behavioral and physiological issue. Normally, cows exhibit left-side laterality; i.e., they prefer to lie on their left side on a level surface (9, 14, 99, 101). Prepartum dairy cows in a wooded lot spent 55% recumbency on their left side (7). Cows also exhibit increased (P < .01) left-side laterality as calving approached.
With increasing age and size, the tendency for cows to lie more on their right side shifts significantly (18). Such was the case with Beecher Arlinda Ellen (Table 3).

Six Holstein cows (three intact and three ruminally cannulated) were observed for 48 h to examine the effect of ruminal cannulation upon laterality and recumbent rumination activity (51). Cows were housed in a free-stall barn equipped with an individual feeding system that allowed continual access to feed (American Calan, Inc., Northwood, NH). The free-stall barn had an open exposure to the south and an upward stall slope of .7% from south to north. The slope was upward, right to left, from the cow’s perspective when facing into the stall. The free stalls were 2.3 m long and 1.1 m wide, and the slope was 5.5% from front to rear of the stall. A neck rail was located .36 m from the front of the stall at a height of .94 m. The dimensions of the stall alleyway and adjacent exercise lot were approximately 20 x 3.1 m. Stalls were bedded daily with dry sawdust.

Ruminally cannulated cows demonstrated increased right-side laterality (70%) compared with intact cows (47%), but the cows tended to ruminate while lying on their left side. The percentage of time spent ruminating while recumbent on the left side was similar (55%) for intact and cannulated cows (Table 5). The percentage of time ruminating on the right side was significantly less than the time spent ruminating on the left side. These observations indicate a behavioral need for the cow to ruminate on her left side. This concept is quite logical when the evolutionary significance of the cow’s upright resting posture and rumen positioning is considered.

To categorize postural differences in resting dairy cattle, Coe et al. (32) observed 80 bull calves at 20-min intervals from 1900 to 0330 h at 5, 10, and 17 wk of age. They also observed 68 (62 to 75) lactating cows at 15-min intervals from 1900 to 0330 h twice (3 mo apart) in winter in two barns in northern Indiana with 40 calves housed in stalls (93 m² each) and 40 calves in eight group pens (6.5 m² or 1.3 m² each), all with slatted wood flooring. Cows were housed in 64 free stalls (2.8 m² each) on bedded wood or bedded concrete. As part of a larger study, each calf was observed for various resting postures (Table 6). No significant differences existed between calf postures in stalls or pens, so those data were pooled. For both calves and cows, the results demonstrated that sternal recumbency with their eyes open is the most common resting position. Resting

### TABLE 5. Laterality in intact and ruminally cannulated dairy cows.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Latency</th>
<th>Laterality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intact</td>
<td>Cannulated</td>
</tr>
<tr>
<td></td>
<td>Left²</td>
<td>Right²</td>
</tr>
<tr>
<td>Lying, %³</td>
<td>53*</td>
<td>47</td>
</tr>
<tr>
<td>Lying, ruminating, %</td>
<td>55*</td>
<td>36</td>
</tr>
<tr>
<td>Lying, no chewing, %</td>
<td>45</td>
<td>64*</td>
</tr>
</tbody>
</table>

*Significantly different from 50:50 (P > .05).

1Lying on left side, dorsal process uphill, stall slope, 7%.
2Lying on right side, dorsal process downhill, stall slope, 7%.
3Data from three intact and three ruminally cannulated cows observed for 48 h.

<table>
<thead>
<tr>
<th>Postures</th>
<th>Cows</th>
<th>Calves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erect, eyes open</td>
<td>74.2</td>
<td>58.6*</td>
</tr>
<tr>
<td>Erect, eyes closed</td>
<td>10.0</td>
<td>7.2*</td>
</tr>
<tr>
<td>Head on neck</td>
<td>6.2</td>
<td>18.5*</td>
</tr>
<tr>
<td>Head on leg or flank</td>
<td>.4</td>
<td>13.2*</td>
</tr>
<tr>
<td>Head on stalls or floor</td>
<td>7.5</td>
<td>6.2*</td>
</tr>
<tr>
<td>Lateral, on side</td>
<td>1.7</td>
<td>1.9</td>
</tr>
</tbody>
</table>

*The t test for significance (P < .01) signified that values for calves were different from cows for various postures except lateral recumbency.
with the head on the neck, leg, or flank is less prevalent in the adult bovine. Lateral recumbency is similar in both calf and adult, but environment may influence this behavior. Upright posture was more prevalent with advancing maturity.

CONCLUSIONS

As herd animals, dairy cattle are adept and efficient at gathering of feed at the bunk or on pasture. They practice leadership-followership to and from the pasture, feedbunk, and other locations, and they practice social facilitation; thus, cows fed in groups eat more than individuals.

Dairy cattle are crepuscular; however, they are adaptable at fitting grazing into other times of the day as a result of hot weather and nutritive needs. They are consistent in biting, jaw movements, eating, and rumination times. The sense of taste in dairy cattle is highly developed and can be manipulated to suit the preferences of both nutritionists and cow.

Rumination acts as an “anti-boredom” activity in the adult bovine with considerable self-stimulation accompanied by a relaxed state. Left-side laterality is of strategic value to ruminants for rest and to optimize rumen positioning for efficient rumination.

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