Where Does the Time Go?
Current Concepts in Time Budgeting for Dairy Cattle

Rick Grant
William H. Miner Agricultural Research Institute
1034 Miner Farm Road
Chazy, NY 12921
Phone: 518-846-7121 x116
Fax: 518-846-8445
Email: grant@whminer.com

Summary

The interaction between facilities and management routines determine the physical and social environment within which a dairy cow must perform. Dairy cows have environmental requirements to support natural behaviors, well-being, optimal productivity, fertility, and health. Dairy cows have a behavioral time budget that must be satisfied. The 24-hour time budget reflects the net behavioral response of a cow to environmental inputs. Deviations from benchmarked behavioral routines represent departures from natural behavior and serve as a basis for estimating performance and economic losses due to poor facility or management environment. The housing environment must provide each cow with unhindered access to feed, water, and a comfortable resting area. Major components of the cow's environment that a dairy producer may control include: ventilation and air quality, temperature-humidity index, photoperiod and light intensity, stall design and maintenance, space available per cow, feeding area design and management, flooring traction and compressibility, grouping strategies that build self-confidence, stocking density of stalls, low-stress animal handling and movement, and time spent outside the pen and away from resources.

This presentation will focus on the dairy cow's resting and feeding requirements, their relationship with productivity, and how the cow's management environment affects her ability to practice these natural behaviors. Negative environmental conditions such as improper grouping strategy and pen moves, overstocking stalls and manger space, and poor time budgeting compromise natural resting, feeding, and rumination behaviors. Spreadsheets are available to assess the impact of environment on cow behavior and milk production. A long-term goal is to incorporate environmental inputs into ration formulation models to better predict dynamic cow behavior, feed intake patterns, ruminal fermentation, and milk component output.

Dairy Cow Behavioral Time Budgets

Essentially, the 24-h time budget represents the net behavioral response of a cow to her environment. The functional environment comprises the housing facility and how the cows are managed within the facility. Even a well-designed facility with poor management such as overcrowding will result in unnatural behaviors and poor productivity and health. Deviations in a dairy herd from benchmarked behavioral routines represent departures from desired natural behavior and serve as a basis for estimating the performance and economic loss due to poor management strategies. A spreadsheet is available at the Miner Institute web site to analyze the time budget of dairy cows housed in free-stall barns (www. whminer.org).

A simplified daily time budget (Grant and Albright, 2000; 2001) for lactating Holstein dairy cattle housed in a free-stall environment is: 1) eating: 3 to 5 hours/day (9 to 14 meals/day), 2) resting (lying): 12 to 14 hours/day, 3) social interactions: 2 to 3 hours/day, 4) ruminating: 7 to 10 hours/day (both standing and lying, 5) drinking: 0.5 hours/day, and 6) time spent outside the pen for travel to and from the parlor, milking, and other management practices: 2.5 to 3.5 hours/day. It is clear that, since there are only 24 hours in a day, a management environment that keeps a cow outside the pen for greater than 3.5 hours/day forces the cow to sacrifice some behavior – inevitably resting or feeding time. Cows must perform these required behavioral activities each day, and we cannot allow our management routines to interfere. Improper grouping strategies that result in overcrowding, commingling of primi- and multiparous cows, excessive time in parlor holding pens, and greater than one hour daily in headlocks are common ways of disturbing the time budget and reducing herd productivity, fertility, and health.

Natural Resting and Feeding Behaviors of Dairy Cattle

An environment that allows natural resting and feeding behavior forms the foundation of dairy cow well-being and optimal performance.

Cows Have a Strong Behavioral Requirement for Rest

Jensen et al. (2004) demonstrated that cows have a very strong motivation to rest, and that this motivation to rest increases as the length of deprivation becomes greater. In fact, lying behavior has a high priority for cattle after even relatively short periods of lying deprivation (Munksgaard et al., 2005). Cows will sacrifice feeding in an effort to recoup lost resting time. Environmental factors that interfere with resting often reduce feeding behavior and vice versa. Metz (1985) evaluated cow response when access to either stalls or feed manger was prohibited. Cows attempted to maintain a fixed amount of lying time, and their well-being was impaired when lying time was restricted for several hours daily. An additional 1.5 hours/day standing time was associated with a 45-minute reduction in feeding time. A similar relationship was observed by Batchelder (2000) where cows experiencing a stocking density of 130% of stalls and headlocks preferred lying in free-stalls rather than eating post-milking and spent more time in the alley waiting to lie down rather than eating. Benefits of resting include: potentially greater milk synthesis due to greater blood flow through the udder, greater blood flow to the gravid uterus, increased rumination effectiveness, less stress on the hoof and lameness, less fatigue stress, and greater feed intake. Grant (2004) has proposed that each additional one hour of resting time translates into 0.9 to 1.5 kilograms more milk per cow daily. We need to manage the resting environment to ensure access to comfortable stalls for 12 to 14 hours daily.

Cows Have a Naturally Aggressive Feeding Drive

Natural feeding behavior of lactating dairy cows was characterized by Dado and Allen (1994) as higher producing, older cows that eat more feed, eat larger meals more quickly, ruminate more efficiently, and drink water more quickly than lower producing, younger cows. Some competition for feed is inevitable with dairy cows; even with unlimited access to feed, cows interact in ways that give some cows an advantage over others (Oloffson, 1999). Hansen and Pallesen (1998) documented the cow's naturally aggressive feeding drive by measuring the force applied to the feed barrier during eating. Cows willingly exert greater than 225 kg of force against the feed barrier in an attempt to reach as much feed in the manger as possible. Pressure in excess of 100 kg is sufficient to cause tissue damage. We need to manage the feeding environment such that the cow will not exert these amounts of force against the feed barrier while eating thereby resulting in reduced feed consumption. Delivery of fresh total mixed ration twice daily, feed availability after milking, timing feed push-ups to avoid excessive pressure, lower stocking rate, separate grouping of primi- and multiparous cows, and any environmental factor that reduces competition and displacements will enhance feeding time at the manger. Recent research from Europe showed that cows ruminate more when fed their diet three times daily versus only once daily.

Grouping Strategies, Social Environment, and Cow Responses

Boe and Faerevik (2003) reviewed social and performance responses of calves, heifers, and mature cows to changes in their environment. Conventionally, we assume that 1) cows fight to establish social hierarchy, 2) fighting stops once hierarchy is established, 3) dominant cows regulate access to the resources, 4) group size should not exceed number of cows an individual can recognize, 5) dominance hierarchy is rapidly established, and 6) the hierarchy is stable.

Contrast this static depiction of group interactions with a more dynamic and likely realistic scenario: 1) continual and fluctuating levels of aggression, 2) formation of subgroups within larger pens, 3) inability to recognize all peers when group size exceeds approximately 100 cows, 4) some individuals thrive, not by winning fights, but by not participating, and 5) stable hierarchy formed within 2 days for cows with previous social experience and within 4 days for cows with no previous experience, and 6) position in the pen social structure is a function of motivation for the resource. These basic attributes of group dynamics influence the response of cows to any set of environmental circumstances.

Social stability within a group of cattle is defined as the point when nonphysical agonistic interactions among group members predominate, and the ratio of physical to nonphysical interactions remains comparatively stable with time (Kondo and Hurnik, 1990). Social behaviors and locomotor activity return to baseline level within 5 to 15 d following a grouping change such as regrouping or commingling (Boe and Faerevik, 2003). For the first 1 to 2 days following regrouping, displacements from the feed manger increase up to 2.5x, feeding rate increases up to 50%, lying bouts and time decrease by 15 to 20%, grooming decreases 5-fold, and milk yield decreases up to 3 kg/day. We need to manage grouped cows such that rate of decline in physical interactions occurs rapidly and the period of social stability is maximized. Realistically, animals move into and out of pens continuously on many farms, and the challenge becomes managing the magnitude of increase in physical interactions that accompany regrouping and introduction of new animals into a pen. Critical examples are the close-up pen with weekly group changes and the fresh pen with a constantly changing social environment. Herds with greater than two pen moves during the transition period experience twice as many abomasal displacements as herds with 2 or fewer pen moves.

Grouping of Primi- and Multiparous Cows

A common recommendation is to group primi- and multiparous cows separately. Research confirms that primiparous cows penned separately have 10 to 15% greater feed intake, 20% greater resting time, and approximately 10% higher milk production than those in mixed groups (summarized in Grant and Albright, 2000). Since primiparous cows are smaller and less experienced they often have difficulty competing with mature cows for feed, water, and stalls. Important natural behavioral differences exist between primi- and multiparous cows. Younger cows take smaller bites and consume feed more slowly than mature cows. Dominant mature cows may displace younger cows from the manger, alter their time of feeding, or encourage faster feeding rates; separate grouping helps to ensure that heifers have enough time to feed throughout the day. Heifers housed separately also experience less body weight loss and greater efficiency of fat-corrected milk production during the first 30 days of lactation (Bach et al., 2006), greater rumination and drinking time, and higher milk fat percentage.

Resting behavior is affected by grouping environment. Cows do not perceive all stalls equally; for instance dominant cows prefer stalls nearest the feed manger. Subordinate cows avoid lying in preferred stalls and will ruminate less when forced to lie in stalls preferred by dominant cows (Grant, 2008, unpublished). It is possible that subordinate cows experience stocking densities considerably higher than the simple ratio of cows to stalls.

Stocking Density, Social Environment, and Cow Responses

Overstocking reduces the cow's ability to practice natural behavior, but it also improves the economic return on facility investments and consequently is a common limitation in the cow's environment. Research on stocking density (based on stalls primarily) indicates that at ~115 to 120% stocking density and beyond, resting time is reduced by 12 to 27% and idle standing in alleys increases. The negative response in resting is a function of pen size with greater reductions in resting observed for larger pens. We also need to understand more about the potential differences in the responses to stocking rate based on type of housing such as 4- or 6-row free-stall barns. Eating rate is often increased at higher stocking densities and meals times are redistributed later in the day, particularly for subordinate cows. Rumination may be reduced by as much as 25% at 130% stocking density (summarized in Grant, 2004). However, the goal is not elimination of competition, but management of competition in the cow's environment.

Stocking Density During the Transition Period

Creating the right environment for the transition cow encourages natural feeding and resting behavior, greater feed intake and milk yield, and fewer metabolic disorders. Feeding, resting, and ruminating activity all decrease, and standing time increases sharply, right at parturition. Management time typically increases from virtually none during the far-off dry period to as much as several hours per day soon after calving. Elaborate fresh-cow protocols that entail extended time in headlocks will interfere with the cow's time budget. To avoid disturbing the time budget, cows should not be locked-up for more than one hour continuously. Cows should not be denied access to feed or stalls for greater than 3.5 hours/day.

Cook and Nordlund (2004) found that when stocking density was greater than 80% of stalls and manger in a pre-fresh group of mixed primi- and multiparous cows, milk yield was reduced for the primiparous cows during the first 83 days in milk. For each 10% increase in pre-fresh stocking density above 80%, there was a 0.7 kg per day reduction in milk yield for the primiparous cows. When headlock stocking density exceeds approximately 90% in the close-up pen, or manger space is less than 61 cm/cow, feed intake is markedly reduced. Additionally, a strong positive relationship exists between headlock stocking density greater than 90% in the close-up pen and higher incidence of abomasal displacements after calving. Recent research at University of British Columbia and Miner Institute found that overstocking the feed bin increased the rate of eating for healthy, multiparous fresh cows. Stocking density greater than 80 to 90% of manger space in the pre-fresh and fresh pens results in lost milk production and greater fresh-cow health problems, especially for subordinate cows. The close-up and fresh cow is exquisitely sensitive to environmental constraints such as overstocking, limited stall or manger availability, and excessive competition.

Stocking Density for Cows Beyond the Fresh Period

A study at Miner Institute evaluated the effect of 100, 113, 131, or 142% stocking density of stalls and manger space in a 4-row barn on behavior and production (Hill et al., 2006). The stocking densities were obtained by chaining off stalls or closing headlocks. Consequently, alley space and social structure remained constant which may have mitigated the negative effects of higher stocking densities. Lying time was reduced by 1.1 hours/day when stocking density increased from 100 to 142%. At the same time, milk yield decreased from 43.0 to 41.5 kg/day. We have observed similar responses when stocking density was manipulated by adding cows to an existing pen in a recent study to better mimic on-farm environments. As stocking rate increased, idle standing time in alleys increased and time spent ruminating while lying decreased. In particular, idle standing increased 3-fold between 100 and 142% stocking density between midnight and 0400 h when cows ordinarily would be resting in stalls. Eating rate increased with greater stocking density, and milk fat percentage was depressed while somatic cell count increased. A recently completed study at Miner Institute (Krawczel, 2008, unpublished) confirmed the increase in mastitis risk with higher stocking density even for cows of similar hygiene score.

A differential response was observed between primi- and multiparous cows and lame versus sound cows. As stocking density increased, the difference in milk yield between younger and older cows grew from 2.7 kg/day at 100% stocking rate up to nearly 6.8 kg/day at stocking rates beyond 113%. Similarly, as stocking rate increased beyond 113%, the milk yield of lame cows was markedly reduced compared with sound cows. From 100 up to 131% stocking rate, the difference between sound and lame cows in milk yield rose to nearly 11.8 kg/day. The reductions observed in milk yield for primiparous and lame cows in mixed groups reflected reductions in resting and rumination activity. Even though it is often difficult to manage separate pens of primiparous cows and lame cows, we need to understand the potential magnitude of compromised well-being and lost milk production when these cows are commingled with older and healthier cows.

In summary, when significant overstocking is a component of the cow's environment, we may observe: 1) altered feeding behavior and greater aggression and displacements at the manger, 2) reduced resting time and greater idle standing in the alley, 3) decreased rumination, 4) potentially less milk production and lower milk fat percentage, 5) potentially higher somatic cell count at similar hygiene score, 6) greater metabolic problems, and 7) reduced fertility. Primiparous cows, lame cows, and other subordinate cows are most negatively affected by overstocking. The stocking density that optimizes productivity and economic returns will vary by farm, but it will likely be less than 120% for 4-row barns and closer to 100% for 6-row barns due to the added stocking rate of the feed manger. Expressing stocking rate as a function of stalls appears to be most appropriate for lactating and dry cows, except for transition cows for which stocking density appears best expressed as a function of manger space.

Conclusions

The cow's social and physical environment comprises the housing facilities and management routines. The term "cow environment" often refers solely to temperature-humidity index, ventilation and air movement, air quality, and photoperiod or light intensity issues. But, we cannot neglect the "social" environmental aspects that directly influence natural cow behavior such as time budgeting, grouping strategy, cow movement and handling, and stocking density. The resting environment needs to allow approximately 12 hours/day of lying in a comfortable bed. The feeding environment needs to allow up to 5 hours/day of unhindered access to fresh ration with minimal aggression, displacements, and potential for rapid feed consumption or sorting. Grouping and cow movement strategies are components of the environment that substantially impact natural behavior and performance. Stocking rate should not generally exceed ~120%, and should remain less than ~80% for transition cow pens. Many management factors, in addition to the ones discussed here, comprise the cow's environment. The environment modulates predicted output (primarily feed intake and milk yield) based on physiological inputs in models of cow performance. Dynamic models in the future need to incorporate key components of the cow's environment to most accurately predict feed intake, ruminal conditions, and milk output (Grant, 2004).

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