Title: Cow comfort through novel barn design

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Abstract

It is widely accepted that cow comfort leads to improved health, longevity, profitability, and productivity of the herd. There are fewer lame cows, fewer knee and hock injuries, increased milk yield, and healthy cows that stay in the herd longer when cows are provided with a comfortable place to rest. Rest can be optimized through appropriate stocking density, stall design, and ventilation and heat abatement. Understanding the importance of these elements in overall facility design leads to improved profitability of the farm and underscores the industry's drive to continuously improve.

Key words: Lying time, stalls, air speed, ventilation

Group Size and Stocking Density

Lying behavior is influenced by climate, resting space, stocking density, and the time available to rest when in the home pen. Group size plays an important role in allowing cows to rest when they want to, for as long as they needto. While parlor size and holding area capacity should be taken into account when determining group size, the maximum allowable time out of the pen spent milking each day should also be considered. The maximum allowable time out of the pen is 3 to 3.5hours per day based on the time budget of a freestall housed cow where 12 hours per day is spent resting (Figure 1). Transfer time to and from the parlor as well as milking time falls under the 3-3.5

hours spent outside of the pen each day. Lying time studies have shown that cows who spend more time milking spend less time resting[1]so cows outside of the pen for longer than 3.5 hours a day are less able to achieve the optimum 12 hours of rest per day.

Overstocking pens without changing parlor size and throughput may increase time spent milking, which reduces the amount of time cows have for essential activities in the pen such as eating, resting, and socializing. The competition that occurs as a result of overstocking has a negative impact on lying time[2].When stalls are stocked at 1.5 cows per stalls, cows lose about 15 percent of their lying time when compared to stocking densities of one cow per stall[3]. This is equivalent to a cow's average lying time being reduced from 12 hours per day to 10.2 hours per day – the same effect as moving cows from a sand-bedded stall to a mattress surface.

Stall Surface

Deep loose bedded stall surfaces, specifically sand, are best for cows as they provide cushion, support, and traction when cows lie down and get up, which is more important for older cows compared to younger fit cows. Herds with deep loose bedded stalls have fewer lame cows, less hock and knee injuries, and cows produce more milk[4,5]. Organic bedding materials, manures solids, and sand all constitutedeep loose bedding. These types of bedding materials relate to a difference in how non-lame and lame cows rest in stalls because they modify stall behavior. For instance, deep loose bedding promotes fewer, longer lying bouts[1], which is beneficial for lame cows who struggle with rising and lying down because of the pain associated with sore feet. Sand, in particular, normalizes lame cow behavior by allowing cows time to rest and recuperate as observed in a Finnish study[6] where lame cows housed on sand improved after 21 weeks compared to the group housed on straw.

With fewer lame cows, herds typically have a higher proportion of healthy multiparous cows that produce more milk. When these cows are allowed to rest for longer periods of time or for the optimum 12 hours per day, there is an improvement in blood flow and delivery of nutrients to the udder[7], potentially increasing milk production. In a survey of 176 DHIA herds looking at the benefit of sand, Wisconsin dairies using sand bedding produced seven more poundsof energy corrected milk per cow per day than dairies who had mattress stalls. This could be because of the longer resting times associated with deep loose bedding. One of the largest lying time studies found that sand allowed cows to rest for 11.7 hours per day compared to other surface types that averaged 10 to 10.5 hours per day[8].

Stall Design

Stalls should be appropriately sized to fit the resting imprint of the cows using them while permitting sufficient space for the cow to lunge forward when rising and lying, without the risk of injury. There are many critical dimensions for stall design that promote proper stall usage and optimize rest, including stall width, length, divider rail choice and placement, neckrail position, and distance from the brisket locator to the rear curb. Stall dimensions are based on the average body weight of the cows occupying the pen if size is uniform or sized to provide sufficient space for the largest 25 percent of the group. Target stall dimensions can be found on The Dairyland Initiative website under “Freestall Dimensions.”

Cows spend more time lying down and less time standing up in stalls that provide sufficient resting space due to fewer disturbances from cows in adjacent stalls. Stall width plays a critical role in optimizing rest. Tucker et al. (2004)[9] and Solano et al. (2016)[8]found longer resting times in wider stalls, and Westin et al. (2016)[10] saw more lameness in stalls that were too narrow for the size of the cows using them. A common concern is that stalls that are too wide will promote diagonally lying, resulting in a contaminated stall surface. Diagonally lying can happen when stall length is insufficient or there are obstructions at the front of the stalls that impede cows from lunging and bobbing forward when rising and lying, so if modifications are made to stall width, stall length should also be considered.

Fast Moving Air in the Resting Space

Once cows are provided with a comfortable place to rest, keeping them lying down in the stall when the temperature rises is important for protecting lying time during heat stress events. Cows will lose roughly three hours of lying time per day during a heat stress event[11]. This is because cows accumulate heat when lying down at about one degree Fahrenheit (0.5 degrees Centigrade) per hour of rest and dissipate heat at about a half of a degree Fahrenheit (0.25 degrees Centigrade) per hour[12]when standing, so while the number of lying bouts remains the same, the lying bout duration decreases[12]. Providing the minimum cooling air speed(MCAS) of 200 to 400 ft per minute (1 to 2 meters per second) at 1.5 feet (0.5 meters) above the stall surface protects lying time, keeps cow body temperature normal, and protects milk yield as the temperature humidity index increases[13]. Greater air speeds at cow resting height reduces the number of lying bouts per day, allowing cows to lie down longer without having to stand to cool off, and consistent air speeds throughout the stalls in the pen may lead to less variation in cow lying times[14].

Fans or baffles over the stallscan provide fast moving air in the cow's resting space. Barns that utilize mechanical ventilation or supplement natural ventilation with circulation fans see an increase in milk production of 5.7 to 9.2 pounds (2.6 to 4.2 kilograms) of milk per cow per day compared to barns with natural ventilation without fans[15]. Following the air speed mapping strategy outlined in Reuscher et al. (2024)[14], an anemometer can be used to measure air speeds at 1.5 feet (0.5 meters) above the stall surface to determine if the MCAS is being achieved in the stall microenvironment to optimize rest, and if not, fan placement, spacing, and angle may need to be adjusted.

Ventilation Systems

There are four criteria to effective barn ventilation design with providing fast moving air in the resting space as one of the criteria. The other three include providing sufficient air exchange to remove heat, noxious gases, and moisture from the barn, working well across all seasons, and being cost effective. While natural ventilation with fans over the stalls has been the most prevalent ventilation system in midwestern climates, interest in other types of mechanical systems has grown with positive pressure hybrid ventilation, tunnel or tunnel hybrid with fans over the stalls, and cross ventilation with baffles or fans over the stalls emerging as common types of ventilation system. The choice of ventilation system is based on many factors from social and economic, to facility design and preference for maintaining the system, to the associated running costs.If the four criteria for an effective ventilation system are met, then any of the six common ventilation systems can be considered to meet a barn's ventilation needs.

Conclusion

When cows are provided with a comfortable place to rest, they are healthier, perform better, and stay in the herd longer. Achieving cow comfort by optimizing rest comes from not overstocking pens, providing a soft surface to lie down, designing freestalls to fit the size of the cows using them, and ensuring fast moving air in the resting space during periods of heat stress. Barn ventilation and choice of system also plays a role in creating an environment for maximizing cow health through appropriate air exchange year-round while being mindful of the system's impact on herd profitability.

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Figures

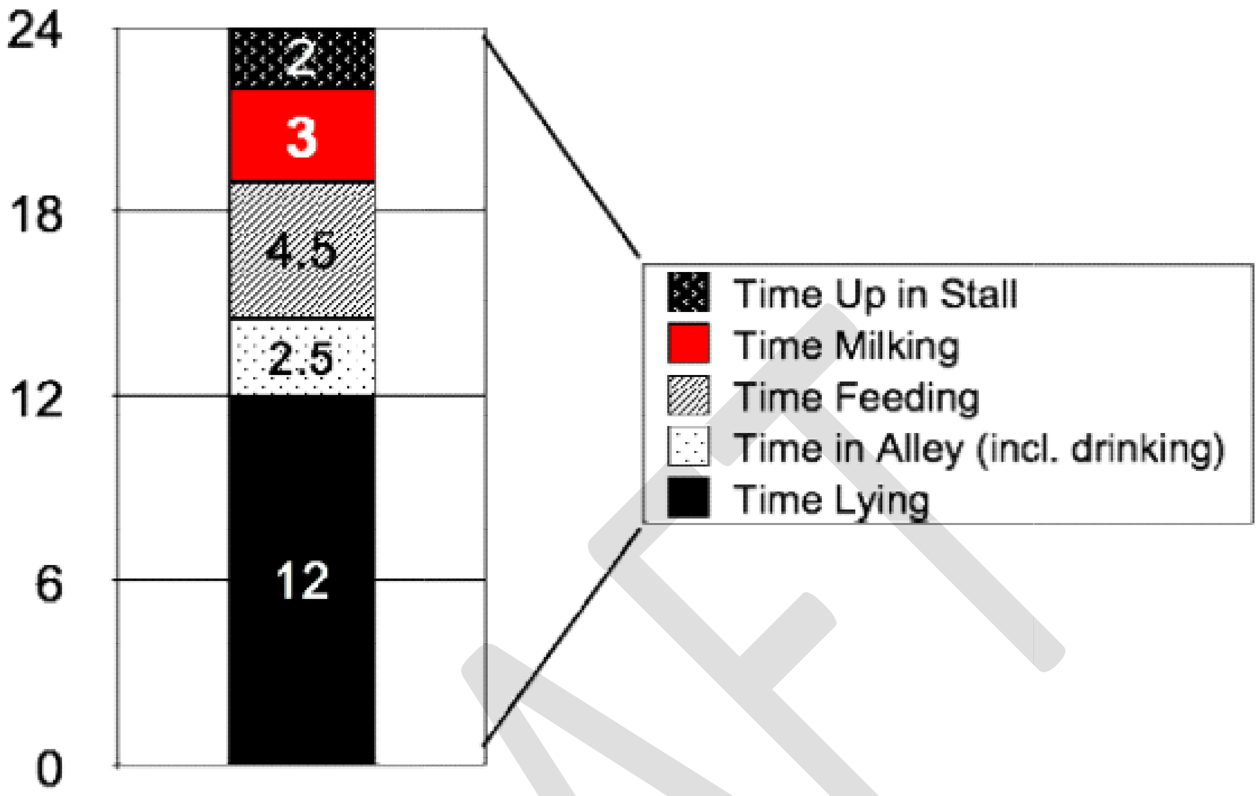

Figure 1: The daily time budget (in hours) of a freestall-housed dairy cow.