Short Communication: Effect of Stocking Density on Indices of Cow Comfort

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ABSTRACT

The objective of this study was to evaluate the effects of increasing stocking density on indices of cow comfort measured over a 24-h period, during peak lying time (0000 to 0400 h), and 1 h after the afternoon milking. Holstein cows ($n = 136$) were assigned to 1 of 4 pens, and stocking densities of 100, 113, 131, and 142% were applied in a 4×4 Latin square. Video data were recorded continuously for 2 d after 5 d of acclimation to stocking density and analyzed with 10-min scan samples for the percentage of cows lying in a stall, standing in a stall, standing in the alley, and eating at the manger. Percentage of cows standing idly in the alley increased as stocking density increased above 113% (10.9, 12.0, 14.4, and 16.5% for 100, 113, 131, and 142% stocking density, respectively). Cow comfort index (CCI; cows lying down/cows contacting stalls) and stall standing index (SSI; cows standing in stall/cows contacting stalls) differed little as stocking density increased, but stall use index (SUI; cows lying in stall/cows in pen not eating) decreased beyond 113% stocking density (70.1, 70.2, 68.6, and 66.3 for 100, 113, 131, and 142% stocking density, respectively). During peak lying time, SUI decreased with increasing (80.3, 79.5, 74.8, and 69.6 for 100, 113, 131, and 142% stocking density, respectively) stocking density above 113%, whereas CCI and SSI showed little response. None of the indices varied by stocking density when they were assessed at 1 h after milking. These results suggest that more than 1 index of cow comfort may be needed at higher stocking densities to assess both stall usage and cows standing idly in an alley. At higher stocking densities, SUI was reduced, because it reflected not only stall usage but the number of cows standing idly in an alley and not actively feeding and unable to access a stall. The CCI and SSI appear to assess actual stall usage (% cows lying or standing) across the range of stocking densities evaluated in this study.

Key words: stocking density, cow comfort, behavior

Growing interest in assessment of cow comfort has led to the development of several indices that can be used to measure the acceptability of a free-stall dairy barn environment to dairy cows. These indices include the following: 1) cow comfort index (CCI), the number of cows lying in a stall divided by the total number of cows in contact with a stall (Nelson, 1996); 2) stall standing index (SSI), the number of cows standing in a stall divided by the total number of cows in contact with a stall (Cook et al., 2005); and 3) stall use index (SUI), the number of cows lying in a stall divided by the total number of cows in the pen not eating (Overton et al., 2003).

Previous empirical research has not found a relationship between any of these indices and mean daily lying time but established a relationship between time spent standing in a stall and the SSI (Cook et al., 2005). This relationship was strongest when SSI was determined 2 h before removal from the pen for the morning or afternoon milking, which differed from the recommendation of Overton et al. (2002) to measure SUI approximately 1 h after returning to the pen from milking.

More recently, a relationship was established between lameness and CCI (Espejo and Endres, 2007). The prevalence of lameness for herds in the top quartile for CCI was approximately 50% less than for herds in the bottom quartile. The monitoring of cow comfort, or specifically stall standing and lying activity, may provide useful information on the state of the herd. Nevertheless, no information exists on how these indices should be utilized under different stocking densities that encompass the range observed on commercial dairies. Previous studies have used stocking densities ranging from 89% (Overton et al., 2002) to 108% (Cook et al., 2005), which are not reflective of the range found on dairy farms. Although Espejo and Endres (2007) evaluated CCI on farms with a wide range of stocking densities, the mean stocking density (109%) was similar to Cook et al. (2005). The 2-h reduction in daily lying time and decreased latency to lie down observed when stocking density was increased from 100 to 150% (Freg-

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Table 1. Comparison of mean 24-h score for cow comfort index (CCI), stall standing index (SSI), and stall use index (SUI) at stocking densities of 100, 113, 131, and 142%

Comfort index	Stocking density (%)				SE	P
	100	113	131	142		
CCI	80.7	81.9	82.9	82.6	1.1	0.066
SSI	19.3	18.1	17.0	17.3	1.1	0.066
SUI	70.1 ^a	70.2 ^a	68.6 ^{ab}	66.3 ^b	1.2	0.016

^{a,b}Means within a row without a common superscript differ ($P < 0.05$).

onesi et al., 2007) demonstrated that increased stocking density altered stall usage. Because of these results, it may be appropriate to monitor the ability of the cow to access and utilize a stall for resting in addition to measuring the proportion of cows lying that are actually in stalls. Different indices of comfort may be required for monitoring each of these separate components.

It was hypothesized that the SUI would decrease with greater stocking density, because it measures the ability of the cow to access stalls and incorporates the proportion of cows standing idly in alleys and not actively eating. The CCI and SSI would remain unchanged with higher stocking density, because they are more strictly a measure of stall comfort and the preference for standing or lying within a specific stall. The objective was to evaluate the effects of increasing stocking density (stall and headlock basis) on indices of cow comfort during a 24-h period, between 0000 and 0400 h, and 1 h after the second (1200 h) daily milking. The first aim was to quantify changes in CCI, SSI, and SUI as stocking density increased incrementally from 100 to 142%. The secondary aim was to establish whether a more accurate estimate of cow comfort on a pen level resulted from measuring CCI, SSI, or SUI over 24 h, between 0000 and 0400 h, or 1 h after the second milking.

Holstein cows ($n = 136$) were selected for similarity in DIM and milk production at the William H. Miner Agricultural Research Institute (Chazy, NY) and had a mean locomotion score of 1.75 on a 1- to 5-point scale (Flower and Weary, 2006). Cows were housed in a 4-row free-stall barn with stalls measuring 1.3-m wide, 2.6-m long, and 1.3-m high at the neck rail. Bed surface consisted of a 1.7-m long foam-filled mattress (Foamat, Foxworthy Supply, Kent City, MI) covered by 10 kg of kiln-dried sawdust, and each stall was cleaned when cows were removed for milking. Milking occurred 3 times daily at approximately 0400, 1200, and 2100 h. Alley surfaces within the pens consisted of rubber mats (Animat Inc., Saint-Élie d'Orford, Québec, Canada) over concrete, which were cleaned every 2 h by an automated scraper system (J. Houle et Fils Inc., Drummondville, Québec, Canada). Cows were fed a TMR formu-

lated for 40 kg of milk production per day once daily and pushed up 6 times daily. Water was available for ad libitum consumption in troughs at the end of each pen and in the walkway between the pen and milking parlor.

Cows ($n = 34$) were housed in 1 of 4 pens containing 34 stalls and 47 headlocks. At 100% stocking density, 1 stall and 1 headlock were provided for each cow. Eliminating access to 0, 4, 8, and 10 of the 34 stalls and 13, 17, 21, and 23 of the 47 headlocks simulated the 100, 113, 131, and 142% stocking densities. Each treatment was implemented in each pen for 7 d. Behavioral data were collected for 2 d with the initial 5 d utilized as an adjustment period. The percentage of cows lying, standing in a stall, standing in an alley, or eating was recorded from video data. The data from each of the replicated 24-h periods were analyzed with 10-min scan samples for a total of 288 observations (6/h for 48 h) per variable. Over each time period, the video data were collected using a total of 12 cameras (ULTRA Pro Series B/W, CCD DSP camera, Central Alarm Systems Inc., Littleton, CO) equipped with a 0.83-cm, 5- to 50-mm DC F1.7 CS-mount lens and a digital recorder (DiGiCam 30 16-port Remote Surveillance and Digital Recording Package, version 7, Central Alarm Systems Inc.): 6 cameras were mounted to the periphery of each pen at 457-cm height to record activity within the free-stalls, and 6 cameras were mounted 467 cm above the feed bunk to record the number of cows feeding.

Comfort indices were calculated as: CCI = (number of cows lying in stalls/number of cows lying or standing within a stall) $\times$ 100; SSI = (number of cows standing in stalls/number of cows lying or standing within a stall) $\times$ 100; and SUI = (number of cows lying in stalls/total number cows – number of cows eating) $\times$ 100.

Data were analyzed during the following periods: 24 h, 1 h after second milking, and between 0000 and 0400. The measurement of a 24-h mean for cow comfort indices was based on the methodology of Cook et al. (2005). Assessing stall use and cow comfort during the period 1 h after milking was recommended by Overton et al. (2002). The period of peak lying behavior (0000 to 0400 h) for the farm corresponded to the period between the return from the third milking of the day and the daily delivery of fresh TMR (C. T. Hill, unpublished data). This period included the 2 h before the morning milking recommended by Cook et al. (2005) for observing stall use.

Treatment effects for indices of cow comfort and time spent standing idly in an alley were determined using a mixed model appropriate for a 4×4 Latin square design. Factors included in the model were pen, period, and stocking density. Pen was used as a random variable within the model. Analyses were computed using

Figure 1. The mean values of the cow comfort index (CCI), stall standing index (SSI), and stall use index (SUI) at each 10-min scan sample throughout a 24-h period at (A) 100% and (B) 142% stocking density. Milking occurred at 05:20, 13:20, and 21:20 h.

Table 2. Comparison of percentages of cows at stocking densities of 100, 113, 131, and 142% observed standing idly in the alley during the 3 observation periods that comfort indices were calculated

Observation period	Stocking density (%)				SE	P
	100	113	131	142		
24-h	10.9 ^c	12.0 ^c	14.4 ^b	16.5 ^a	0.9	0.001
1 h postmilking	7.4	9.7	13.7	12.5	1.40	0.055
0000 to 0400 h	5.3 ^d	7.4 ^c	11.6 ^b	15.3 ^a	0.5	0.001

^{a-d}Means within a row without a common superscript differ ($P < 0.05$).

the MIXED procedure of SAS (SAS Institute Inc., Cary, NC). When stocking density had an effect as a fixed variable ($P < 0.05$), differences between each stocking density of the study were separated using Tukey's procedure at $P < 0.05$.

When behavioral data were summarized over a 24-h period, there was no change in any index of cow comfort with increasing stocking density (Table 1), except for SUI. Yet, there was substantial variation throughout the 24-h period (Figure 1). To some extent, the small increase in cows lying down in stalls at higher stocking densities agrees with the recent findings of Fregonesi et al. (2007), who found a reduced latency to lie down in stalls as stocking density increased. Likewise, SUI was decreased ($P = 0.01$) at stocking densities above 113%, which reflected the greater proportion of cows standing in alleys as stocking density increased.

The 24-h average percentage of cows standing idly in the alley increased as stocking density increased ($P = 0.001$) beyond 113% (Table 2). During peak resting hours (0000 to 0400), cows standing idly in the alley increased by nearly 3-fold between 100 and 142% stocking density. At greater stocking densities, cows were forced to wait in the alley for a stall to become available and subsequently lay down more quickly once in the stall as demonstrated by Fregonesi et al. (2007).

Comfort indices were not affected ($P = 0.10$) when measured at 1 h after return to the pen from the milking parlor after the second milking of the day (data not shown). This competition for feed bunk access may have altered postmilking behavior, which subsequently limited the ability of the comfort indices to detect treatment differences in stall usage.

During peak stall use (0000 to 0400 h), there were statistically significant ($P = 0.03$) changes in CCI and SSI as stocking density changed, but the range was very small (84.5 to 86.7 for CCI and 13.3 to 15.6 for SSI) and likely had little biological significance (Table 3). At every stocking density, CCI was near the recommended target of at least 85% (Overton et al., 2002), and SSI never went beyond 20%, which was associated with excessive standing time in stalls (Cook et al.,

Table 3. Comparison of score for cow comfort index (CCI), stall standing index (SSI), and stall use index (SUI) from 0000 to 0400 h at stocking densities of 100, 113, 131, and 142%

Comfort index	Stocking density (%)				SE	P
	100	113	131	142		
CCI	85.4 ^{ab}	86.7 ^a	86.3 ^{ab}	84.5 ^b	1.2	0.033
SSI	14.6 ^{ab}	13.3 ^b	13.7 ^{ab}	15.6 ^a	1.2	0.033
SUI	80.3 ^a	79.5 ^a	74.8 ^b	69.6 ^c	1.4	0.001

^{a-c}Means within a row without a common superscript differ ($P < 0.05$).

2005). In contrast, the SUI decreased as stocking density increased above 113% ($P = 0.001$). At 131 and 142% stocking density, it fell below the recommended target of 75+% (Overton et al., 2003). The relatively small changes in CCI and SSI suggest that stocking density can be increased above 100% without having a marked effect on standing or lying activity of cows within stalls. This may be partially attributable to unused stalls that are found at a 100% stocking density (Wagner-Storch et al., 2003) becoming occupied as stocking density increases. But, the increase ($P = 0.001$) in the number of cows standing in the alley at increased stocking density indicates a substantial decrease in the ability to access a stall.

In conclusion, increasing stocking density above 100 to 113% clearly increases the proportion of cows standing in alleys and, therefore, compromises the ability to access free stalls when motivation to lie down is greatest. The CCI and SSI, calculated using only the cows standing or lying in a stall, remain relatively unchanged at higher stocking densities. As such, the SSI appears to be a good measure of standing activity for healthy and lame cows as proposed by Cook et al. (2005). Conversely, SUI accounts for all cows within the pen and reflects the ability to access the stall with higher stocking density. Last, the results provide evidence that cow comfort at higher stocking densities should be assessed during the time of peak lying behavior, which occurred between the third milking and the delivery of fresh TMR (0000 to 0400 h). Nevertheless, the time of peak lying behavior may well vary among farms depending on management routines.

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