Short communication: Effect of a stable pen management strategy for precalving cows on dry matter intake, plasma nonesterified fatty acid levels, and milk production

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ABSTRACT

During the close-up transition period, dairy cows are at risk for negative energy balance due to increasing energy demands and decreasing feed intake. This can result in postparturient health problems and decreased milk production after calving. Cows are frequently regrouped during this period, which can negatively affect feeding and resting behavior. The hypothesis was that housing in a stable pen during the close-up transition period should result in a more settled environment resulting in fewer displacements from the feed bunk, which would result in improved feed intake, energy balance [lower nonesterified fatty acid (NEFA) concentrations], and lactation performance. This study addresses precalving pen grouping strategies, which have the potential to affect feed intake and energy balance. A randomized complete block design with pen as the experimental unit was used to compare a stable (S) housing strategy (cows with similar calving dates added to a precalving pen at once) to the more traditional dynamic (D) housing strategy (cows added up to 2 times per week to a precalving pen). Twice-weekly blood samples were collected for NEFA analysis and cow interactions within the pen were observed. Dry matter intake (DMI), milk production, and postparturient health problems were recorded. Mean DMI for the duration of the 28 d of the study was not different (S: 25.5 ± 1.6 vs. D: 25.7 ± 1.0 kg/d), and when examined over time relative to calving, no treatment by time interaction was observed. Concentrations of NEFA were not different when cows initially entered the pens (S: 0.21 ± 0.10 vs. D: 0.18 ± 0.04 mEq/L) and remained not different for the time intervals closer to calving (d -9 to -14 : S: 0.28 ± 0.09 vs. D: 0.21 ± 0.04 ; d -3 to -6 : S 0.36 ± 0.10 , D 0.32 ± 0.05 mEq/L). Pen grouping strategy did not affect

DMI, plasma NEFA concentrations, or milk production.

Key words: nonesterified fatty acids, transition cow, grouping

Short Communication

The transition period is traditionally defined as the 3 wk before calving until 3 wk after calving. Cows tend to have decreased DMI before parturition despite this being a time of high-energy demand (Grummer, 1993; Drackley, 1999). If energy needs are not met, lipids are excessively mobilized from adipose tissue, which correlates with an increased incidence of periparturient health problems such as fatty liver, ketosis, displaced abomasum, metritis, and retained fetal membranes (Drackley, 1999; Huzzey et al., 2005). Huzzey et al. (2007) found that decreased feeding time and DMI were indicators of cows at risk for metritis. Periparturient health problems can result in immediate and prolonged negative effects on lactation (Drackley, 1999) and reproduction (Stevenson and Call, 1988).

The close-up, nonlactating cow group contains cows housed together for a relatively short period, where there may be continuous social change if cows enter the precalving pen approximately 21 d before estimated calving and are removed when they calve (Cook and Nordlund, 2004). When new cows are added to a group, increased social interactions occur, both physical and nonphysical, which can affect feeding and resting behavior (Kondo and Hurnik, 1990; Huzzey et al., 2005). Previous research on behavior related to the introduction of new cows to a pen indicated that adverse physical interactions were greatest for the first 2 to 3 d, but tended to last no longer than 7 d (Kondo and Hurnik, 1990; Grant and Albright, 2001; Nordlund et al., 2006).

Grouping of transition cows, especially heifers and subordinate cows with more dominant cows, could result in great and long-lasting adverse effects (Nordlund et al., 2006). An increase in social stress can affect

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access to bunk space and feed, which may contribute to decreased DMI. Potential negative interactions put close-up transition cows at risk for negative energy balance during the critical period immediately before calving (Grant and Albright, 2001; Bøe and Faerevik, 2003).

An alternative stocking strategy proposed by Nordlund et al. (2006) is a socially stable close-up precalving pen based on the all-in, all-out concept. A group of cows with similar calving dates is moved into the precalving pen and remain there until calving, with no new cow entries until the pen is empty. This strategy removes the stress caused by continual introduction of new cows and is beginning to be implemented on some farms (Curtis, 2010). Another advantage of stable close-up precalving pens is that there is less risk of interrupting parturition because cows are already housed in the pen in which they will calve. A drawback is that more space is required, which will be underutilized at times (Cook, 2009). Our hypothesis was that cows housed in a stable group would have improved prepartum DMI and NEFA concentrations and improved milk production. The objective was to determine if stable pen housing of close-up nonlactating cows improved DMI during the transition period, measured by plasma NEFA, postpartum health, and aggregate 30-d milk production.

The experiment was conducted at the Emmons Blaine Dairy Cattle Research Center, University of Wisconsin–Madison. The animal protocol was reviewed and approved by the University of Wisconsin–Madison College of Agriculture and Life Sciences Animal Care and Use Committee.

Cows, Diets, and Treatments

Eighty-five nonlactating Holstein and three-quarter Holstein $\times$ one-quarter Jersey crossbreds were allocated to 6 groups (2 treatments $\times$ 3 replications) balanced for parity and BCS. Animals carrying twins or having a lameness score of 4 or 5 out of 5 were excluded from the study (Locomotion Scoring of Dairy Cattle, Zinpro Corporation, Eden Prairie, MN). Twenty cows were used to initially fill 2 pens with 10 cows. Ten dynamic-housed cows (**D**) entered the pen 1 to 28 d before estimated calving date and 10 stable-housed cows (**S**) entered the pen 14 to 28 d before estimated calving date. This process was repeated 3 times. Twenty-five cows were used as replacement cows to restock the D pens to 10 cows twice weekly, based on the number of cows that calved. The S pen had no replacement cows added when cows calved. In both pens, cows were allowed to calve in the pen and were removed within 24 h. To allow for acclimation, cows had to be housed in the pens for at least 9 d to qualify. A defined period of 28 d from when

cows first entered into both pens was used to exclude cows with delayed calving or cows that entered the pen later as replacement cows.

Close-up transition cows were housed in an area with bedded-pack pens arranged linearly. Pens measured 12 m $\times$ 12 m (bunk space depth = 7.8 m, feed alley width = 4 m). Pens were deeply bedded with 20 to 30 cm of straw. Straw bedding was added 3 times weekly and box stalls were completely emptied and cleaned every 5 wk. Treatment groups were randomly assigned to 1 of 4 pens for each replication. A maximum stocking density of 10 cows per pen allowed each cow at least 9.6 m², which minimized overcrowding (Cook and Nordlund, 2004). The area available per cow in the stable pen increased over time as cows left due to calving. The available feeding area was adjusted 4 d/wk in both treatment pens to allow for only 0.76 m of headlock access per cow, consistent with recommendations (Cook, 2009). The number of available headlocks was rounded up to the nearest number when 10, 7, 6, 3, or 2 animals were in the pen due to the headlocks being 0.6 m wide.

A 45-d dry period was used on the farm, with the same TMR diet fed to cows in both the far-off freestall pen and the close-up pens. The TMR was mixed and fed once daily. The ingredients of the TMR (% DM) were corn silage (52%), wheat straw (24%), alfalfa hay (10%), high-moisture rolled shell corn (4%), soybean meal (6%), urea (1%), and vitamin and mineral supplement (3%). The DMI was estimated daily for each experimental pen by subtracting theorts from the amount of feed offered, and dividing by the number of cows per pen. Samples of feeds were obtained weekly and dried at 60°C for 48 h for DM determination to adjust the diet to maintain consistent ingredient composition on a DM basis. The ingredients of the fresh cow TMR (% DM) were corn silage (48%), alfalfa silage (23%), soybean meal-based protein (9%), high-moisture corn (9%), distillers grains (5%), alfalfa hay (3%), and cottonseed (3%).

Measurements

Six milliliters of blood was collected by coccygeal venipuncture into a K₂ EDTA tube (Vacutainer, Becton Dickinson, Franklin Lakes, NJ) twice weekly until calving. Collection occurred immediately after feed delivery by temporarily securing cows in headlocks. Samples were placed immediately on ice and then centrifuged at 1,425 $\times g$ for 15 min. Plasma was stored frozen at –18°C until analyzed. Up to 3 samples (d –3 to –6, d –9 to –14, and d –15 and greater relative to calving) from each cow were submitted to the Diagnostic Center for Population and Animal Health at Michigan State

University (Lansing). Quantitative plasma NEFA concentration was determined with an in vitro enzymatic colorimetric method assay (HR Series NEFA-HR(2) assay kit, Wako Chemicals USA, Richmond, VA) on an Olympus AU640 Clinical Chemistry Analyzer.

One person per pen observed the cows for physical interactions twice weekly. Observations were made for 1 h beginning when feed was delivered. Physical interactions were characterized as displacement from the feed bunk (initiation that results in removal of head from headlock); bunting (hitting with the head); pushing (hitting with anything but the head); and contact (head-to-head contact with no clear winner; Dickson et al., 1966). Feed bunk displacements were averaged based on the number of cows in the pen to account for differences in number of cows in each pen. The displacement observations were averaged and summed for the 3 repetitions for each observation day.

Following calving, cows were moved to a freestall pen within 24 h and fed a lactating cow TMR. Cows were milked twice daily, beginning at the first milking after they calved. Cows were monitored daily by the Emmons Blaine Dairy staff for at least 10 d after calving. Daily rectal temperatures were taken; ketosis was monitored using daily urine samples and a DiaScreen 1K dip-and-read strip test based on a reaction of acetoacetic acid with sodium nitroprusside (Chronimed, Minneapolis, MN); a retained placenta was classified as any placenta not expelled by 24 h after calving. Milk secretions and the udder were examined at each milking and mastitis was confirmed using the California Mastitis Test, if indicated by abnormal milk. Milk yield was measured daily for the first 30 DIM for cows that completed the trial, and mean daily milk yield was then calculated for each pen replicate. First DHI test data were used to evaluate percentage fat and percentage protein.

Statistical Analysis

The experiment was a completely randomized design with pen as the experimental unit. Individual cow data were averaged for each treatment replicate to obtain an average pen value for statistical analysis. Fat and protein percentages in milk were analyzed as single measurements using the PROC MIXED procedure of SAS (version 9.1.3, 2005, SAS Institute Inc., Cary, NC). The model used to analyze fat and protein percentages in the milk included treatment and DIM as a covariate. The remaining data were analyzed with repeated measurements over time using the PROC MIXED procedure of SAS (version 9.1.3, 2005, SAS Institute Inc.). For the data that had repeated measurements in time on the experimental unit (pen), a model that incorporated

treatment, time, and treatment by time interaction was used. In addition, an auto-correlated error structure was used, PROC MIXED Ar(1), to account for the nonindependent measurements. Least squares means are presented throughout. Statistical significance was declared at $P < 0.05$ and trends toward significance at $0.05 \leq P < 0.10$.

Of the 85 cows assigned to treatments, only 61 qualified for the trial (S: $n = 27$, D: $n = 34$). Cows were excluded from the trial if they calved within 9 d of movement into the pen. One cow was excluded due to development of lameness. Mean ($\pm$ SD) parity for S and D pens were 1.57 ± 1.37 and 1.58 ± 1.21 , respectively. Mean BCS for S and D pens were 3.61 ± 0.24 and 3.69 ± 0.19 , respectively. Milk production and illness analyses were performed only on 45 cows (S: $n = 24$, D: $n = 21$) due to the exclusion of cows that did not calve within the defined period of 28 d from the beginning of the treatment when pen management was no longer controlled. Mean parity for this subset was 1.46 ± 1.44 and 1.57 ± 1.40 for S and D pens, respectively. Mean BCS for this subset was 3.6 ± 0.3 and 3.7 ± 0.2 for S and D pens, respectively.

Feed Bunk Displacements

Physical interactions (bunt, contact, push, and feed bunk displacement) were recorded, but only displacements from the feed bunk were analyzed because this behavior directly affected feed intake. Mean displacements in the D pen did not differ significantly (D: 1.69 ± 0.77 vs. S: 1.17 ± 0.52 ; $P = 0.39$). A trend toward a day effect ($P = 0.06$) was observed, but there was no treatment by day interaction ($P = 0.63$).

Displacements were variable in both pens with no evidence of increased displacements on the days that new cows entered or exited the D pen (Table 1). This indicated that new cows entering the D pen did not affect feed bunk displacement behavior. The D-housed cows had 3 to 6 h to acclimate to the addition of new cows before observations were made when feed was delivered. Previous research indicates that the introduction of new cows to a pen results in adverse physical interactions for 2 to 3 d, with most occurring within the first 2 h of regrouping (Kondo and Hurnik, 1990; von Keyserlingk et al., 2008). Monitoring displacements of only the new cows added may have resulted in more similar findings to previous research (Grant and Albright, 2001; Nordlund et al., 2006), but that was not possible with the pen-based experimental design used in this study. Similar to von Keyserlingk et al. (2008), our study had 1 cow added to the D pen twice weekly on d 8 to 22 (range 0 to 2, Table 1). The small number

Table 1. Mean cow movements and feed bunk displacements observed twice weekly on days cows were added to the D pen¹

Day	Cows added		Cows removed		Displacements ²		SEM	P-value ³
	S	D	S	D	S	D		
1	10.0	10.0	0.0	0.0	0.7	1.5	0.48	0.25
4	0.0	0.3	0.3	0.7	0.9	1.3	0.48	0.56
8	0.0	1.0	0.0	0.7	1.6	1.4	0.48	0.81
11	0.0	1.0	0.3	1.0	1.6	2.3	0.48	0.31
15	0.0	1.0	1.0	1.0	1.0	1.7	0.48	0.29
18	0.0	1.0	1.7	1.0	1.1	1.8	0.48	0.29
22	0.0	1.0	1.3	1.0	1.4	2.3	0.48	0.20
25	0.0	2.0	0.7	2.0	1.1	1.2	0.48	0.88

¹D = dynamic housing strategy (cows added up to 2 times per week to a precalving pen); S = stable housing strategy (cows with similar calving dates added to a precalving pen at once).

²No statistical difference was observed in mean displacements in the D pen (D: 1.69 ± 0.77 vs. S: 1.17 ± 0.52 ; $P = 0.39$). A trend toward a day effect ($P = 0.06$) was observed, but there was no treatment by day interaction ($P = 0.63$).

³No significant differences were observed in mean displacements on each observation day.

of cows added to the D pen twice weekly may not have been enough to cause detectable changes in feed bunk displacements.

Another factor may have been that each cow had 0.76 m of space at the feed bunk, consistent with recommendations for precalving cows (Cook, 2009). Further research is needed to determine if a stable pen environment benefits cows housed at higher densities.

DMI

Mean DMI for the duration of the 28 d of the study was not different (S: 25.5 ± 1.6 vs. D: 25.7 ± 1.0 kg/d; $P = 0.53$). When examined over time relative to calving, no treatment by time interaction ($P = 0.38$) was observed. These results are consistent with the feed bunk displacement data and suggest that feeding was not affected by regrouping.

Plasma NEFA Concentrations

No treatment effect on NEFA was observed (S: 0.28 vs. D: 0.23 mEq/L; $P = 0.46$) and there was no treatment by time effect ($P = 0.75$). A time effect ($P < 0.0001$) was observed, with NEFA increasing as calving approached. Plasma NEFA concentrations were also examined at 3 time intervals based on actual calving dates (Table 2). Concentrations of NEFA were not different when cows initially entered the pens at d -15 or greater (S: 0.21 ± 0.10 vs. D: 0.18 ± 0.04 mEq/L; $P = 0.69$). Plasma NEFA concentrations remained not different for the time intervals closer to calving (d -9 to -14: S: 0.28 ± 0.09 vs. D: 0.21 ± 0.04 ; $P = 0.32$; d -3 to -6: S: 0.36 ± 0.10 , D: 0.32 ± 0.05 ; $P = 0.63$). These results do not support our hypothesis that cows in the S pen would have lower NEFA concentrations than those in the D pen, but were consistent with the displacement and DMI data that showed no differences.

Postpartum Illnesses

Incidences of ketosis, displaced abomasum, milk fever, mastitis, retained placenta, metritis, fever, and off-feed events were monitored. Nine of 24 cows (38%) from the S pen and 2 of 21 cows (9%) from the D pen were treated for 1 or 2 of the above illnesses. Insufficient replication precluded a statistical analysis of incidences of health disorders.

Lactation Performance in First 30 DIM

Treatment had no effect on milk production (S: 34.6 ± 1.4 vs. D: 36.9 ± 3.4 kg/d; $P = 0.32$). Fat and protein percentages (first test-date after calving) were not affected by treatment (fat %: 4.54 ± 0.33 vs. 4.59 ± 0.16 for D and S, respectively; $P = 0.88$; protein %: 3.39 ± 0.14 and 3.33 ± 0.12 for D and S, respectively; $P = 0.62$).

In conclusion, precalving cows are frequently moved between pens in the period leading up to parturition

Table 2. Least squares means plasma NEFA concentrations at 3 precalving time intervals¹

Day ²	NEFA (mEq/L)		SEM	P-value ³
	S	D		
-3 to -6	0.36	0.32	0.04	0.63
-9 to -14	0.28	0.21	0.04	0.32
>-15	0.21	0.18	0.04	0.69

¹S = stable housing strategy (cows with similar calving dates added to a precalving pen at once); D = dynamic housing strategy (cows added up to 2 times per week to a precalving pen).

²Samples were analyzed for plasma NEFA concentration (mEq/L) at 3 time intervals based on actual calving dates. Days listed are relative to actual calving dates.

³NEFA concentrations were not statistically different for any time intervals. A time effect ($P < 0.0001$) was observed, with NEFA increasing as calving approached.

to allow for changes in diet and for monitoring. This has the potential to increase social interactions, which may decrease feed intake and have a negative effect on postparturient health. Our results indicate that the S pen housing strategy, when following current recommendations for feed bunk and bedded pack space, was not advantageous. No significant differences were detected in precalving DMI and NEFA concentration or subsequent milk production.

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