TRANSITION MANAGEMENT: GROUPING STRATEGIES

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SUMMARY

The period from three weeks before to three weeks after parturition in dairy cows, also known as the transition period, is characterized by significant changes in hormonal profile, feed intake, nutrient requirements, metabolism, and energy balance. These changes are known to dramatically affect immune function. In this manuscript we will discuss situations that accentuate immune suppression and predispose cows to health disorders. We will also evaluate how to improve health of transition cows through management in order to reduce health disorders.

INTRODUCTION

In the last weeks of gestation, significant changes in concentrations of cortisol, progesterone, estradiol, prostaglandin $F_{2\alpha}$, and prolactin occur (Stevenson, 2007). These changes are important for onset of colostrum production and preparation for parturition (Akers, 2002). Although increases in concentration of estradiol and prostaglandin $F_{2\alpha}$ in uterus increase blood flow to the uterus and theoretically the influx of immune cells, cortisol suppresses immune response because it down regulates the neutrophil expression of L-selectin and CD18, adhesion molecules involved in the trafficking of neutrophils from the endothelium to the site of infection (Burton and Kehrli, 1995a; Burton et al., 1995b; Burton et al., 2005). Cortisol is also produced in adverse conditions (e.g. transport, overstocking) that result in stress and circulating concentrations of cortisol has been used as an indicator of stress (Nanda et al., 1990). Simultaneously, feed intake in the last 14 d before parturition decreases by approximately 50%, reaching its nadir on the day before parturition (Grummer et al., 2004). Although feed intake starts to increase immediately after parturition, it is not sufficient to meet nutrient requirements for the rapidly increasing milk yield. Therefore, conditions that increase stress and exacerbate negative energy balance during the peripartum period may further suppress immune function of peripartum cows and compromise health and performance.

Cows are social animals and as such are highly susceptible to social interactions and hierarchical order. Once housed within a group, dominant cows display physical and non-physical aggressive behavior towards submissive cows. Situations that exacerbate these deleterious interactions among dominant and submissive cows have the potential to affect health and performance. Although group performance is the most common used parameter to evaluate management and protocols, often evaluation of averages masks the poor performance of subordinate cows in particular. Therefore, management should be focused to provide all cows with sufficient feed, water, and resting space to minimize the expression of subordinate behaviors.

PREPARTUM GROUPING MANAGEMENT AND TRANSITION COW HEALTH

Regrouping of dairy cows is used in dairy operations to maintain homogenous groups in terms of gestation stage to optimize nutritional management. Thus, in many dairy operations cows are housed as a group from approximately 230 to 250 d of gestation in so called “dry cow pens” and as another group from 251 d of gestation to parturition in so called “close-up cow pens”. Every week, cows from the dry-cow pen are moved to the close-up cow pen, which results in weekly disruption of social interactions and for many cows disruption of social interactions in the last days before parturition. Constant regrouping of cows changes the hierarchical order among them, forcing cows to reestablish social relationships through physical and nonphysical interactions and exacerbating aggressive and submissive behaviors (von Keyserlingk et al., 2008). Furthermore, because dry-cows and close-up cows are not producing milk, their management is often taken for granted resulting in overstocked pens, insufficient water and feed availability, and exposure to adverse weather conditions (i.e. heat stress). These managerial inadequacies that increase and prolong the negative energy balance during the peripartum transform the normal homeorhetic changes into metabolic diseases (i.e. excessively elevated fat mobilization, hepatic lipidosis, and ketosis) further suppressing immune function of dairy cows and predisposing them to health disorders, and compromised productive, reproductive, and economic performances.

SEPARATION OF PREPARTUM HEIFERS AND COWS

Smaller cows are in general more submissive than larger cows. Consequently, when prepartum heifers are housed together with mature cows they are more likely to expressive submissive behavior. In a study in which prepartum heifers were housed with mature cows during the prepartum or were housed alone, heifers housed with mature cows had reduced feed intake and reduced resting time during the prepartum and reduced milk yield compared with heifers housed alone (Table 1).

Table 1. Performance of primiparous when grouped separately from multiparous cows.

Item	Multipar. + Primip.	Primiparous Only
Eating time, min/d	184	205
Eating bouts / d	5.9	6.4
Concentrate intake, kg/d	10.1	11.6

Silage intake, kg/d	7.7	8.6
Lying time, min/d	424	461
Resting periods/d	5.3	6.3
Milk yield, kg/130d	2,383	2,590
Milk fat, %	3.92	3.97

Adapted from Grant and Albright (1995)

Therefore, we recommend that primiparous cows be housed separately from mature cows from at least 21 d before to 21 d after calving. If this is not possible, prepartum and postpartum pens should have a stocking density of < 80%.

STOCKING DENSITY PREPARTUM AND ITS EFFECTS ON BEHAVIOR, FEED INTAKE, AND IMMUNE FUNCTION

Situations of limited space or access to feed exacerbate aggressive and submissive behaviors. Two small but elegant studies conducted in research facilities of the University of British Columbia in Canada demonstrated the effects of overstocking of prepartum cows on behavior and feed intake. According to one of these studies, cows housed in pens in which the ratio of cows to feeding bin was 2:1 had altered behavior compared with cows housed in pens with cow to feeding bin ratio of 1:1 (Hosseinkhani et al., 2008). Similarly, the second study demonstrated that cows housed in pens with 30 cm/cow of feed bunk space had altered behavior compared with cows housed in pens with 60 cm/cow of feed bunk space (Proudfoot et al., 2009). These altered behaviors included increased rate of feed intake, fewer meals per day, increased feed sorting, decreased overall feed intake, increased standing time, and increased rate of displacement from the feeding area (Hosseinkhani et al., 2008; Proudfoot et al., 2009). The consequences of stocking density for dominant and submissive cows are likely to be distinct. Dominant cows are likely predisposed to ruminal acidosis when they have increased rate of feed intake, fewer meals per day, and increased feed sorting. On the other hand, submissive cows are likely predisposed to metabolic diseases such as hepatic lipidosis and ketosis because of reduced feed intake and lameness because of increased standing time and displacement rate. Therefore, overstocking of pens of prepartum cows, a common problem in dairy operations of all sizes, predisposes all cows to inadequate nutrient intake prepartum and consequently compromised immune function. Because cows have allelomimetic behavior, characterized by cows doing the same activity at the same time, it is fundamental to assure that space is available for all cows to eat at the same time without the expression of aggressive and submissive behaviors during the prepartum period.

A study conducted in Italy evaluated the humoral immunity and productive performance of dairy ewes that were housed in high or low stocking density conditions from late gestation to mid-lactation (Carporese et al., 2009). Ewes that were housed in high stocking density conditions had reduced anti-ovalbumin IgG concentration in response to an ovalbumin challenge compared with ewes housed in low stocking density conditions (Carporese et al., 2009). Further, ewes that were housed in high stocking density conditions tended to have greater number of aggressive interactions and had reduced milk yield and increased milk somatic cell count (Carporese et al., 2009).

In a recent experiment (Silva et al., 2014), prepartum Jersey were housed to attain 100% stocking density of headlocks (109% stocking density of stalls; **100SD**) or 80% stockings density of headlocks (87% stocking density of stalls; **80SD**). Although new cows entered the prepartum pen twice weekly in order to try to maintain a stocking density close to 80% and 100% the average headlock stocking densities were 74.1 ± 0.4% and 94.5 ± 0.3% for 80SD and 100SD, respectively ($P < 0.01$; Figure 1). The stall stocking densities were 80.8 ± 0.4% and 103.1 ± 0.4% for 80SD and 100SD, respectively ($P < 0.01$). Increased stocking density in the prepartum pen resulted in increased daily average displacement from the feed bunk ($P < 0.01$; Figure 2) but had minimal effect on average daily lying (Figure 3) and feeding (Figure 4) times.

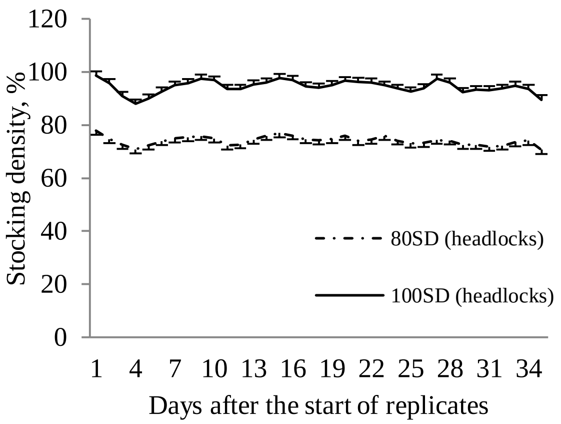

Figure 1. Headlock stocking density of heifers and cows submitted to the 80% and 100% stocking density treatments (Silva et al., 2014).

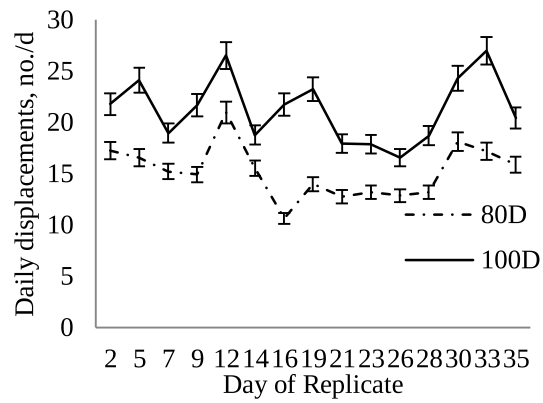

Figure 2. Effects of prepartum stocking density on daily number of displacements (Lobeck-Luchterhand et al., 2014).

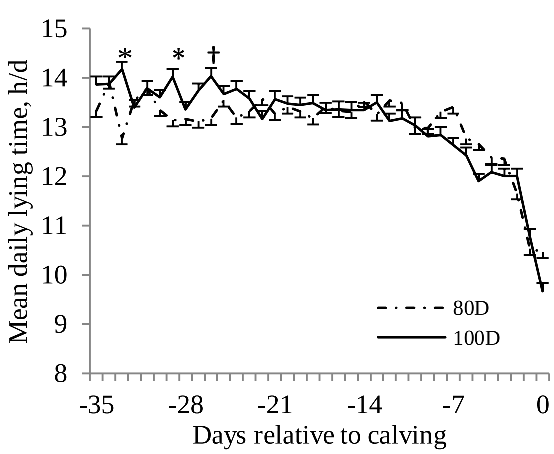

Figure 3. Effect of prepartum stocking density on daily lying time (Lobeck-Luchterhand et al., 2014).

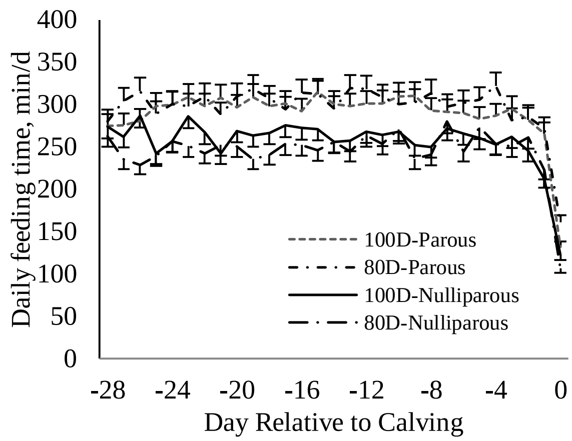

Figure 4. Effect of prepartum stocking density on daily average feeding time (Lobeck-Luchterhand et al., 2014).

Although there was a minor increase in NEFA concentration on d -4 relative to calving for animals in the 80% stocking density treatment compared with animals in the 100% stocking density treatment (Figure 5), metabolic profile of prepartum dairy cattle exposed to 80 and 100% stocking density was generally not different (Silva et al., 2014). Similarly, innate and adaptive immune functions were not compromised by 100% stocking density (data not shown). Not surprisingly, there was no effect of stocking density on incidence of periparturient diseases, removal from the herd within 60 d postpartum (Table 2), and yield of energy corrected milk (Figure 5).

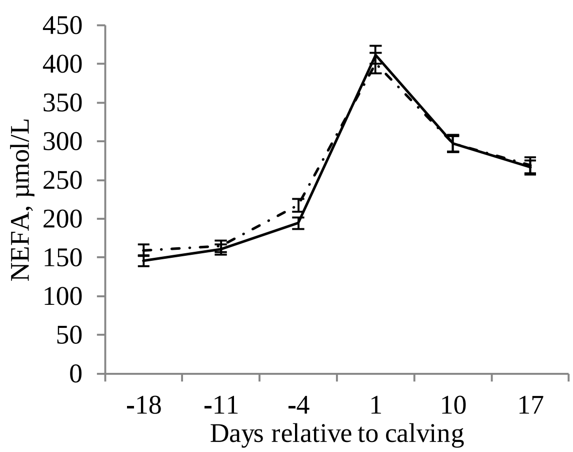

Figure 4. Effect of stocking density on NEFA concentration during the peripartum period.

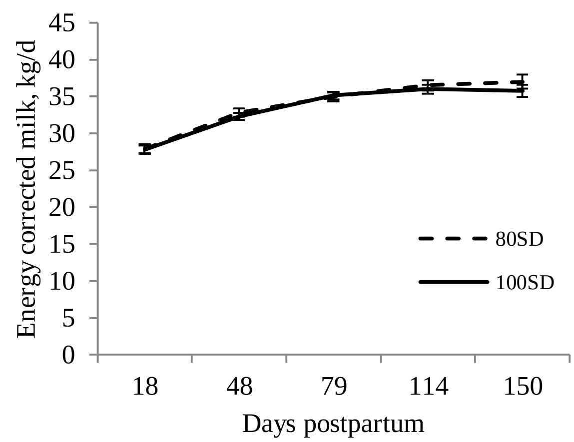

Figure 5. Effects of prepartum stocking density on yield of energy corrected milk.

Table 2. Effects of prepartum stocking density (80SD vs. 100SD) on incidence of postpartum health disorders, lameness, and removal from the herd within 60 d postpartum.

Items	80SD,	100SD,	*P* – value

	%	%	
Retained fetal membranes	5.1	7.8	0.19
Metritis	21.2	16.7	0.11
Acute metritis	9.9	9.4	0.64
Vaginal purulent discharge at 35 ± 3 DIM	5.8	7.9	0.35
Mastitis up to 60 DIM	2.9	4.6	0.18
Displacement of abomasum up to 60 DIM	1.0	0.7	0.78
Locomotion score > 2 at 1 ± 1 DIM	0.6	0.0	0.27
Locomotion score > 2 at 35 ± 3 DIM	3.8	2.6	0.37
Locomotion score > 2 at 56 ± 3 DIM	3.5	2.1	0.44
Removed within 60 DIM	6.1	5.1	0.63

Current recommendations indicate that stocking density during the prepartum should be 80% of headlock and at least 76 cm of linear feed bunk space per animal, depending on breed. In the experiment by Silva et al. (2014) and Lobeck-Luchterhand et al. (2014) we demonstrated that when parous and nulliparous animals are housed separately, when water is readily available, when the length of the "close-up" prepartum period is > 21 d, and when feed bunk management is appropriate, target stocking density on the day of regrouping may be as high as 100% of headlocks.

An issue that is often overlooked is the amount of water and access to water available to prepartum and postpartum cows. In general, it is recommended that a minimum 10 cm of linear water trough space per cow and 1 water trough per 20 cows per water troughs to assure that cows have sufficient access to water.

EFFECTS OF REGROUPING FREQUENCY ON BEHAVIOR, FEED INTAKE, AND MILK YIELD

Another situation commonly observed in dairy operations that may pose a risk to the health of peripartum cows is frequent regrouping during the prepartum period. Regrouping of dairy cows is used in dairy operations to maintain homogenous groups in terms of gestation stage to optimize nutritional management. Thus, in many dairy operations cows are housed as a group from approximately 230 to 250 d of gestation in so called "dry cow pens" and as another group from 251 d of gestation to parturition in so called "close-up cow pens". Every week, cows from the dry-cow pen are moved to the close-up cow pen, which results in weekly disruption of social interactions and for many cows disruption of social interactions in the last days before parturition. The effects of regrouping frequency of cows on behavior, feed intake, and health have been less studied and have yielded more contradictory results. In small elegant studies also conducted in Canada cows were demonstrated to have reduced feeding time, greater rate of displacement from the feed bunk and stalls, and reduced milk yield on the days following regrouping (von Keyserlingk et al., 2008). Although the question has not yet been definitively answered, cows may require 3 to 14 days after regrouping to reestablish social stability to pre-regrouping levels (Grant and Albright, 1995). This could be a significant problem for close-up cows because weekly entry of new cows in the close-up could result in social disruption and stress on the last days of gestation, compromising further dry matter intake (DMI) and immune parameters.

Coonen et al. (2011) evaluated dry matter intake, plasma NEFA concentration, and 30-d milk yield of close-up cows (14 to 28 d before expected calving date) that were housed in stable (no new cows entering the close-up pen) or dynamic pen (new cows entering the close-up pen twice weekly). The pens were relatively small (10 cows per pen) and the total number of cows used in the experiment was 85. In this small study no differences between ‘stable’ and ‘dynamic’ grouping systems in feed bunk displacement rate, DMI ($P = 0.53$), NEFA concentrations during the peripartum ($P > 0.32$), and milk yield ($P = 0.32$) in the first 30 DIM were observed (Table 2). The observations that DMI, NEFA concentration, and milk yield did not differ are novel and suggest that larger experiments are necessary.

In a recent study (Silva et al., 2013a and 2013b; Lobeck-Luchterhand et al., 2014) the hypothesis that constant disturbance of social order prepartum by weekly introducing new cows in a close-up pen was tested in a large dairy herd (6,400 lactating cows). Cows (254 ± 7 d of gestation) were paired by gestation length and assigned randomly to an All-In-All-Out (AIAO) or control treatments. In the AIAO (n = 259) treatment, groups of 44 cows were moved into a pen where they remained for 5 wk, whereas in the control treatment (n = 308) approximately 10 cows were moved into a pen weekly to maintain stocking density of 100% and 92% relative to stalls and headlocks, respectively, 7.9 m^2/cow. At the completion of 5 wk, cows in the AIAO treatment that had not calved by 5 wk were moved to a new pen and a new replicate was initiated. The data referent to these AIAO cows that had to be regrouped at the end of the 5 wk replicate were used for statistical analysis.Pens were identical in size (44 stalls and 48 headlocks) and design and each of the pens received each treatment a total of 3 times, totaling 6 replicates. Video recording cameras were placed above the feed lane for determination of feed bunk displacement activity (Lobeck-Luchterhand et al., 2014). Displacement from the feed bunk was measured, in both pens, during 3 h on the day cows were moved to the close-up pen (-30 d before expected calving date) at 13:00 ± 1:00 and following fresh feed delivery (05:00 ± 1:00) 1, 2, 3 and 7 d after cows were moved to control close-up pen. The average stocking density of the control pen was 87% (69.5 to 100%), whereas in the AIAO pen the average stocking density was 73% (7.3 to 100%; Figure 6; Silva et al., 2013a). A greater number of displacements (Figure 6) and a greater displacement rate (Figure 7) were observed in the control treatment than in the AIAO treatment (Figure 6; Lobeck-Luchterhand et al., 2014). Minimal changes in feeding time, however, were observed during the 5 weeks preceding calving (Figure 8; Lobeck-Luchterhand et al., 2014). Average percentages of cows at the feed bunk at different times of the day were similar between AIAO and control treatments (Figure 9; Lobeck-Luchterhand et al., 2014). Despite these changes in behavior, no changes in immune (innate and adaptive; Silva et al., 2013b) and metabolic parameters were observed (Silva et al., 2013a). Consequently, no differences in incidences of disease (Table 3) and yield of energy corrected milk (Figure 11) were observed.

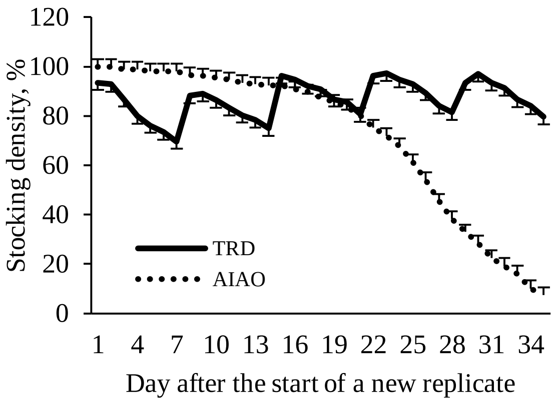

Figure 6. Effect of prepartum grouping strategy on stocking density of prepartum pens.

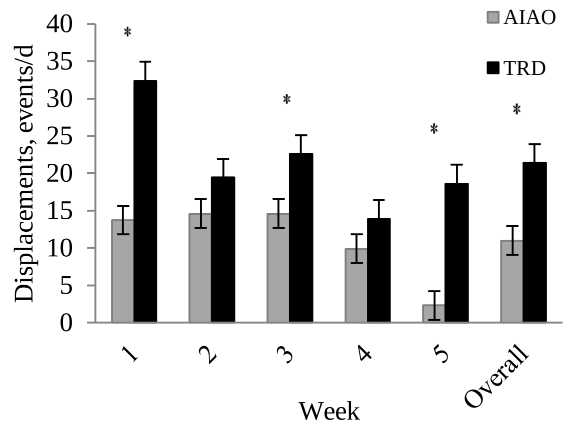

Figure 7. Effect of grouping strategy on average number of displacements during the prepartum period.

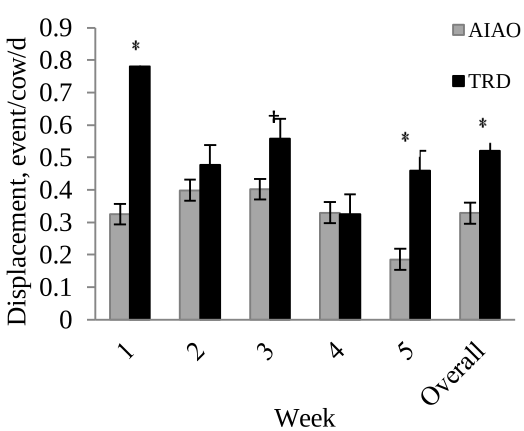

Figure 8. Effect of grouping strategy on average rate of displacement during the prepartum period.

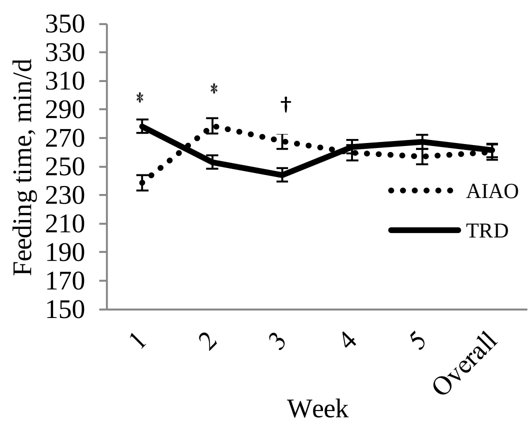

Figure 9. Effect of grouping strategy on average daily feeding time during the prepartum period.

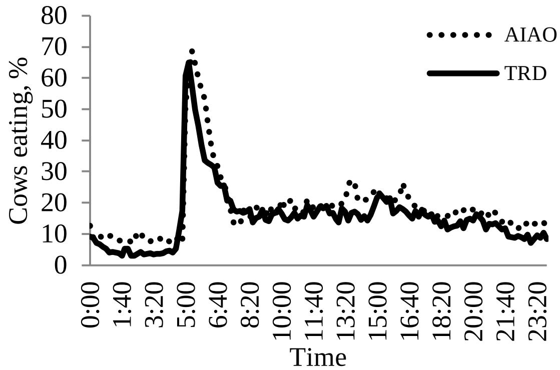

Figure 10. Average percentage of cows at the feed bunk during the prepartum period.

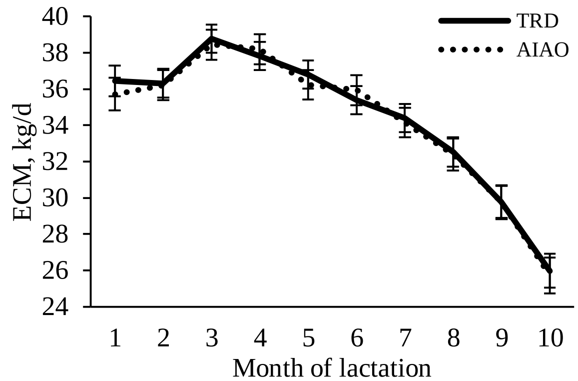

Figure 11. Yield of energy corrected milk (ECM) according to prepartum grouping strategy (TRD vs AIAO).

Table 3. Effects of prepartum grouping strategy (TRD vs AIAO)[1] on incidence of postpartum health disorders, lameness, and removal from the herd within 60 d postpartum.

Items	TRD[1], %	AIAO[1], %	*P* – value
Retained fetal membranes	10.9	11.6	0.82
Metritis	16.7	19.8	0.37
Acute metritis	1.7	3.6	0.22
Sub-clinical endometritis at 30 d postpartum[2]	20.7	24.1	0.42
Endometritis at 35 d postpartum[2]	10.3	10.3	0.96
Displacement of abomasum	3.2	1.7	0.38
Mastitis within 60 d postpartum	13.8	11.3	0.45
Lame at 1 ± 1 DIM	4.3	4.8	0.82
Lame at 28 ± 3 DIM	10.0	7.5	0.45
Lame at 56 ± 3 DIM	9.1	6.0	0.25
Removal from the herd within 60 d postpartum	9.1	8.9	0.94

There were 18 AIAO cows that did not calve within 5 wk and had to be mixed with other cows. The average interval between mixing of these cows and calving was 4.1 ± 0.6 d (Silva et al., 2013a). When compared with AIAO that calved within the 5 wk replicate and were not regrouped, AIAO cows that had to be regrouped at the end of the 5 wk replicate had greater milk yield, greater yield of fat and protein, and greater yield of energy corrected milk (Table 4; Silva et al., 2013a).

Table 4. Comparison of productive parameters and milk quality of AIAO[1] cows that calved within their replicate and AIAO[1] cows that had to be moved to a different

Items	AIAO that calved within their replicate	AIAO moved to a different pen	*P* – value
Milk yield, kg/d	28.10 ± 0.47	33.39 ± 1.56	< 0.01
Fat yield, kg/d	1.25 ± 0.02	1.49 ± 0.07	< 0.01
Protein yield, kg/d	1.05 ± 0.02	1.25 ± 0.05	< 0.01
3.5% fat corrected milk yield, kg/d	35.76 ± 0.58	42.59 ± 1.91	< 0.01
Energy corrected milk yield, kg/d	33.39 ± 0.53	39.70 ± 1.73	< 0.01
Linear somatic cell count	2.94 ± 0.08	3.18 ± 0.28	0.41

Weekly entry of new cows in a close-up pen is expected to cause more agonistic interactions in the feed bunk than stable pen. The increased rate of displacement from the feed bunk did not affect innate immune function, metabolic parameters, incidence of diseases, and reproductive and productive performances. It is interesting that even AIAO cows that underwent group change within 4.1 ± 0.6 d prepartum no significant increase in incidence of disease or reduction in reproductive performance were observed. Behavioral change is one of the four biological responses to stress (neuroendocrine, immune, autonomic). Stressors that only cause a transient change in behavior but have no effects on other responses to stress seem to have little importance to biological function of cows.

CONCLUSIONS

Transition cows are predisposed to immunosuppression because of changes in endocrine and metabolic parameters during the periparturient period. Prepartum cows and heifers should be housed separately when possible to reduce agonistic interactions and to assure that submissive animals (usually heifers) have proper access to water, feed, and resting space. A recently proposed system to reduce regrouping of prepartum cows (AIAO system) has not resulted in improvements in metabolic, immune, health or productive parameters even though it reduced the rate of agonistic interaction in the feed bunk. This indicates that regrouping of prepartum cows results in transient disruption of social interactions but it is likely insufficient to alter neuroendocrine and immune functions sufficiently to compromise biological functions. Although we recently demonstrated that managing prepartum cows/heifers to achieve 100% stocking density on the day of regrouping does not compromise immune function, health, and performance compared with a target stocking density of 80%, more studies are necessary to evaluate the ideal stocking density in the prepartum pens in different circumstances.

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