Transition Cow Management: Focus on Regrouping Strategies
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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 the physiological changes that affect immune function and 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 and improve reproductive efficiency.

Peripartum Changes Associated with Immune Suppression and Disease

Peripartum hormonal changes and immune function: 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 in hormone concentrations occur mainly in response to increased production of monoamine oxidase by the fetus, an enzyme that breaks down serotonin. The reduction in serotonin concentrations results in increases in corticotropin releasing factor and adrenocorticotropic hormone concentrations in fetal circulation. Consequently, cortisol secretion by the fetus’ adrenal gland increases. Cortisol up-regulates the expression of 17-\(\alpha\) hydroxilase, an enzyme that increases secretion of estradiol in the placenta in detriment of progesterone production. Simultaneously, an increase in prolactin and prostaglandin F\(_{2\alpha}\) concentrations is observed. 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 results in stress and circulating concentrations of cortisol has been used as an indicator of stress (Nanda et al., 1990). Therefore, conditions during the prepartum period that increase stress are expected to increase cortisol concentrations and consequently further suppress immune function of peripartum cows.

Homeorhetic adaptations during the peripartum period and immune function: At the same time that dramatic hormonal changes are occurring, 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. Thus, cows suffer from negative energy balance for up to 8 to 12 weeks after parturition and must utilize body energy reserves to meet nutrient requirements for milk production.

Therefore, during the transition period cows go from a state of homeostasis to a state of homeorhesis, "orchestrated or coordinated changes in metabolism of body tissues necessary to support a dominant physiological state (Bauman and Currie, 1980)." For peripartum cows,
increasing milk production is the dominant physiological state as the utilization of nutrients by
the mammary gland of high producing dairy cows exceeds that of the rest of the body in the first
trimester of lactation (Bauman, 2000). Some of the homeorhectic changes observed in the
peripartum dairy cows are discussed below.

Before the decrease in feed intake prepartum starts, cows have low circulating
concentrations of growth hormone (GH) and high circulating concentrations of insulin and
insulin-like growth factor-I (IGF-I). Once feed intake starts to decrease and negative energy
balance occurs, GH concentration increases and insulin and IGF-I concentrations decrease
indicating a decoupling of the somatotropic-IGF-I axis because the liver, under the influence of
GH, is the main source of circulating IGF-I (Rhoads et al., 2004; Lucy, 2008). This occurs
because during negative energy balance the expression of GH receptor (GHR), particularly
GHR1α, is decreased (McCarthy et al., 2009). As cows return to positive energy balance hepatic
expression of GHR1α increases and hepatic IGF-I production starts to increase (Lucy, 2008).

Insulin-like growth factor-I is a fundamental factor that stimulates growth, differentiation,
and functionality of several different cell types. For example, IGF-I is likely to affect innate
immunity of peripartum cows because it regulates functionality (i.e. superoxide anion
production, oxidative burst, and degranulation) of neutrophils, the primary defense line against
infections (i.e. metritis and mastitis). Further, circulating concentrations of neutrophils and
production of antibodies (i.e. IgG, IgM, and IgA) are significantly increased in GH-deficient
humans and mice after GH-induced increase in concentrations of IGF-I (Kimata and Yoshida,
1994; Ibanez et al., 2005; Sohmiya et al., 2005). Pigs that were treated with IGF-I stimulating
compounds and were subjected to simultaneous weaning and transport had greater count and
concentrations of neutrophil in the blood than non-treated pigs (Kojima et al., 2008). Thus,
exacerbation of negative energy balance during the peripartum period is likely to affect innate
and humoral immunity because cows would be exposed to extended periods of time with reduced
IGF-I concentration.

**Energy sources, liver function, and resulting metabolites:** Ruminants have evolved to
substitute glucose by volatile fatty acids (i.e. propionate, butirate, and acetate) and their
derivative ketoacids as respiratory and lipogenic fuels (Bauman and Currie, 1980). Nonetheless,
glucose remains essential for normal brain and liver function and for production of lactose in the
mammary gland, being the latter the most important osmotic solute of milk production. During
early lactation and negative energy balance, insulin-dependent uptake of glucose by tissues other
than the mammary gland (i.e. muscle and adipose tissue) is reduced, in part because of increased
GH concentrations, assuring that glucose is available for production of copious amounts of
lactose and milk (Bauman, 2000; Lucy, 2008). In situations in which cows are exposed to severe
and prolonged negative energy balance large amounts of body reserves (i.e. glycogen, lipids, and
amino acids) are mobilized to provide the necessary substrate for milk production (Grummer et
al., 2004). A consequence of extreme adipose tissue mobilization during the peripartum period is
the increasing circulating concentration of non-esterified fatty acids (NEFA), which predisposes
cows to hepatic lipidosis (Grummer et al., 2004). Consequently, concentrations of ketone bodies
[e.g. beta-hydroxy butirate (BHBA)] may also increase because of compromised liver function
and incomplete oxidation of NEFA (Grummer et al., 2004).

**Association among feed intake, metabolites concentrations, immune function, and health
peripartum:** Amount of feed intake is inversely associated with plasma NEFA concentrations,
and the latter affects neutrophil function (Klucinski et al., 1988; Rukkwamsuk et al., 1999; Hammon et al., 2006). Hammon et al. (2006) demonstrated that cows that had reduced feed intake during the prepartum period had reduced neutrophil activity (phagocytosis and oxidative burst) during the peripartum and were more likely to develop metritis postpartum. This seems to be a consequence of the onset of colostrum/milk production and the simultaneous insufficient feed intake peripartum because cows that were mastectomized 4 months before parturition had greater expression of L-selectin prepartum, greater leukocyte count postpartum, and greater neutrophil killing activity postpartum than cows with intact mammary glands (Kimura et al., 1999).

Compromised immune function due to altered metabolic status predisposes cows to infectious diseases (i.e. metritis, endometritis, and mastitis). Postpartum hepatic lipidosis has been associated with increased length of bacterial shedding from mastitic cows (Hill et al., 1985) and prepartum increase in fat mobilization and serum lipoprotein metabolism resulted in increased risk of metritis and retained fetal membranes (Kaneene et al., 1997). In a recent large study, Ospina et al. (2010) demonstrated that increasing prepartum and postpartum NEFA plasma concentrations were associated with increased risk of retained fetal membranes, metritis, clinical ketosis, and displacement of abomasum. Accentuated negative energy balance accompanied by increased BHBA plasma concentrations during early postpartum also has been associated with increased risk of peripartum diseases (Erb and Grohn, 1988; Grohn et al., 1989; Correa et al., 1993). For example, higher milk acetone concentrations were associated with increased risk of endometritis (Reist et al.; 2003) and increasing BHBA plasma concentration was associated with increased risk of metritis and displacement of abomasum (Ospina et al., 2010).

**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.

The selection of cows for high milk yield has resulted in significant homeorhetic alterations that predispose them to immune suppression and more diseases postpartum. 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.

**Housing Strategies**

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.

**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 express 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>
<thead>
<tr>
<th>Item</th>
<th>Multipar. + Primip.</th>
<th>Primiparous Only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eating time, min/d</td>
<td>184</td>
<td>205</td>
</tr>
<tr>
<td>Eating bouts / d</td>
<td>5.9</td>
<td>6.4</td>
</tr>
<tr>
<td>Concentrate intake, kg/d</td>
<td>10.1</td>
<td>11.6</td>
</tr>
<tr>
<td>Silage intake, kg/d</td>
<td>7.7</td>
<td>8.6</td>
</tr>
<tr>
<td>Lying time, min/d</td>
<td>424</td>
<td>461</td>
</tr>
<tr>
<td>Resting periods/d</td>
<td>5.3</td>
<td>6.3</td>
</tr>
<tr>
<td>Milk yield, kg/130d</td>
<td>2,383</td>
<td>2,590</td>
</tr>
<tr>
<td>Milk fat, %</td>
<td>3.92</td>
<td>3.97</td>
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</table>

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 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 more likely to have metabolic diseases such as hepatic lipidosis and ketosis because of reduced feed intake and to develop 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 during the prepartum period to assure that space is available for all cows to eat at the same time without the expression of aggressive and submissive behaviors.

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).

Current recommendations indicate that stocking density during the prepartum should be 1 cow per stall and at least 76 cm of linear feed bunk space per cow. Event in herds in which prepartum cows are housed in good pasture conditions, prepartum cows should have sufficient access to feed bunk to assure that the whole group is ingesting the proper amount of feed and nutrients. An issue that is often overlooked in overstocked and non-overstocked conditions is the amount of water and access to water available to prepartum and postpartum cows. In general, we recommend that a minimum 10 cm of linear water trough space is available per cow and at least 2 water troughs per group to assure that cows have sufficient access to water.

Regrouping frequency and its effects 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 has been less studies and has yielded more contradictory results. In small 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. Cows were observed twice weekly for 1 h after feed delivery to evaluate social disruption in the feed bunk. In this small study no differences in feed bunk displacement rate, DMI, NEFA concentrations during the peripartum, and milk yield between ‘stable’ and ‘dynamic’ grouping systems were observed (Table 2). It is likely that the lack of difference in displacement rate from the feed bunk in this study was a consequence of the monitoring schedule used, but the lack of difference DMI, NEFA concentration, and milk yield are novel and important to evaluate in larger studies.

Table 2. Effects of stable and dynamic prepartum housing systems on feed bunk displacement, dry matter intake (DMI), plasma concentration of non-esterified fatty acids (NEFA), and milk yield [Adapted from Coonen et al. (2011)].

<table>
<thead>
<tr>
<th>Variables</th>
<th>Stable</th>
<th>Dynamic</th>
<th>P-value</th>
</tr>
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<tbody>
<tr>
<td>Feed bunk displacements</td>
<td>1.17 ± 0.52</td>
<td>1.69 ± 0.77</td>
<td>0.39</td>
</tr>
<tr>
<td>DMI postpartum, kg/d</td>
<td>25.5 ± 1.6</td>
<td>25.7 ± 1.0</td>
<td>0.53</td>
</tr>
<tr>
<td>NEFA, mEq/L</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; d -15</td>
<td>0.21 ± 0.04</td>
<td>0.18 ± 0.04</td>
<td>0.69</td>
</tr>
<tr>
<td>d -9 to -14</td>
<td>0.28 ± 0.04</td>
<td>0.21 ± 0.04</td>
<td>0.32</td>
</tr>
<tr>
<td>d -3 to -6</td>
<td>0.36 ± 0.04</td>
<td>0.32 ± 0.04</td>
<td>0.63</td>
</tr>
<tr>
<td>Lactation first 30 DIM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milk yield, kg/d</td>
<td>34.6 ± 1.4</td>
<td>36.9 ± 3.4</td>
<td>0.32</td>
</tr>
<tr>
<td>Fat, %</td>
<td>4.59 ± 0.16</td>
<td>4.54 ± 0.33</td>
<td>0.88</td>
</tr>
<tr>
<td>Protein, %</td>
<td>3.33 ± 0.12</td>
<td>3.39 ± 0.14</td>
<td>0.62</td>
</tr>
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</table>

In a recent study (Silva et al., 2012a) 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. Cows in the AIAO treatment that had not calved by 5 wk remained in the same pen until calving but new cows were added to the pen to achieve 100% stocking density relative to stalls. 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 et al., 2012). 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. Displacement rate was calculated as daily displacements divided by the number of cows in the pen to account for stocking density. Cows were examined at enrollment, calving, and 28 and 56 DIM for body condition score (BCS; 1 = emaciated to 5 = obese) and lameness and at 1, 4, 7, 10, and 14 DIM for retained fetal membranes (RFM) and metritis. Cows were observed daily for DA and mastitis until 60 DIM. Blood was sampled weekly from all cows from 21 d before expected calving date to 21 DIM for determination of non-esterified fatty acid (NEFA) concentration. Blood was sampled weekly from 14 d before expected calving date to 14 DIM from a subgroup of cows (n = 34/treatment) to determine neutrophil phagocytosis (PHAGO), oxidative burst (OXID), expression of CD18 and L-selectin, and for hematology. Milk production and components were measured monthly and energy corrected milk yield was calculated for the first 3 tests. Cows were examined by ultrasound for detection of corpus luteum (CL) at 39 ± 3 and 56 ± 3 DIM. Cows were presynchronized with three injections of prostaglandin F2α at 41 ± 3, 55 ± 3, and 69 ± 3 DIM, and those observed in estrus after 55 DIM were inseminated, whereas cows not observed in estrus were enrolled in an Ovsynch56 protocol at 81 ± 3 DIM. Pregnancy exam was conducted 38 ± 3 and 66 ± 3 d after AI.

In figure 1 we observe that the average stocking density of the control pen varied between 100 and 69.5%, whereas the average stocking density in the AIAO pen varied between 100 and 7.3% (Silva et al., 2012a). There were 17 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. The data referent to these cows is discussed later in this manuscript (Silva et al., 2012b).

![Graph](image)

**Figure 1.** Stocking density of prepartum pens with conventional or All-In-All-Out grouping strategy (Silva et al., 2012a).

A greater number of displacements was observed in the control treatment than in the AIAO treatment (22.0 ± 1.0 vs. 10.4 ± 1.0; P < 0.01; Lobeck et al., 2012). Similarly,
displacement rate was greater for the control than AIAO treatment (0.54 ± 0.03 vs. 0.31 ± 0.03; P < 0.001; Lobeck et al., 2012). Treatment did not affect BCS (P > 0.59) or lameness (P > 0.35) at any interval of the study (Silva et al., 2012a). Glucose (59.2 ± 1.3 mg/dl; P = 0.28) and NEFA (227.2 ± 3.2 μmol/L; P = 0.17) concentrations were not affected by treatment (Silva et al., 2012a). Percentage of neutrophil positive for OXID (P = 0.91) and PHAGO (P = 0.98) and intensity of OXID (P = 0.94) and PHAGO (P = 0.91) were not different between treatments. In addition, percentages of neutrophil expressing CD18 (P = 0.17) or L-Selectin (P = 0.83) were not different between treatments (Silva et al., 2012c). Number of leukocytes (P = 0.64), neutrophils (P = 0.33), and lymphocytes (P = 0.80) were not affected by treatment (Silva et al., 2012c). Similarly, treatment had no effect on incidence of RFM (P = 0.84), metritis (P = 0.35), acute metritis (P = 0.54), DA (P = 0.92), and mastitis (P = 0.47; Table 2; Silva et al., 2012b). Treatment had no effect on milk yield (33.1 ± 0.3 kg/d, P = 0.82), energy corrected milk (37.2 ± 0.3 kg/d, P = 0.66), and linear somatic cell score (2.9 ± 0.1, P = 0.28; Silva et al., 2012b). Percentage of cows with a CL on d 39 (P = 0.17) and 56 (P = 0.96) and percentage of cows pregnant after first AI (P = 0.47) were not affected by treatment (Silva et al., 2012b).

Table 3. Effects of a conventional and All-In-All-Out prepartum grouping systems on plasma concentration of non-esterified fatty acids (NEFA), incidence of postpartum diseases, culling, yield of energy corrected milk (ECM), resumption of cyclicity, estrous expression, and pregnancy to first postpartum AI [Adapted from Silva et al. (2012a), Silva et al. (2012b), and Silva et al. (2012c)].

<table>
<thead>
<tr>
<th></th>
<th>Conventional (n = 308)</th>
<th>AIAO (n = 259)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEFA from 21 d before to 21 d after calving, μmol/L</td>
<td>80.4 ± 8.2</td>
<td>62.9 ± 8.5</td>
<td>0.17</td>
</tr>
<tr>
<td>NEFA &gt; 100 μmol/L (21 d before calving), %</td>
<td>62.7</td>
<td>55.8</td>
<td>0.19</td>
</tr>
<tr>
<td>NEFA &gt; 130 μmol/L (7 d before calving), %</td>
<td>25.4</td>
<td>25.5</td>
<td>0.99</td>
</tr>
<tr>
<td>Retained fetal membranes, %</td>
<td>10.9</td>
<td>11.6</td>
<td>0.84</td>
</tr>
<tr>
<td>Metritis, %</td>
<td>16.7</td>
<td>19.8</td>
<td>0.35</td>
</tr>
<tr>
<td>Displacement of abomasum, %</td>
<td>3.2</td>
<td>1.7</td>
<td>0.92</td>
</tr>
<tr>
<td>Mastitis, %</td>
<td>13.8</td>
<td>11.3</td>
<td>0.47</td>
</tr>
<tr>
<td>Culling within 60 DIM, %</td>
<td>9.1</td>
<td>8.9</td>
<td>0.94</td>
</tr>
<tr>
<td>90-d ECM, kg/d</td>
<td>37.5 ± 0.4</td>
<td>36.8 ± 0.4</td>
<td>0.66</td>
</tr>
<tr>
<td>Cyclic by 53 DIM</td>
<td>90.1</td>
<td>90.2</td>
<td>0.96</td>
</tr>
<tr>
<td>Cows inseminated in estrus, %</td>
<td>93</td>
<td>91</td>
<td>0.52</td>
</tr>
<tr>
<td>Pregnant 63 d after first AI, %</td>
<td>36.3</td>
<td>40.0</td>
<td>0.47</td>
</tr>
</tbody>
</table>

Among AIAO cows, those that did not calve within 35 d after enrollment and had an additional change in group a few days before calving (average 4.1 ± 0.6 d) had similar incidence
of health disorders and reproductive performance compared with those that calved within 35 d after enrollment and were only regrouped once, at enrollment. Furthermore, cows with additional regrouping a few days prepartum had greater yield of ECM than those that did not have additional regrouping (39.1 ± 2.4 vs 32.3 ± 1.4 kg/d; P < 0.01).

According to the current experiment, even though in commercial herds where size of close-up pens is expected to be larger than in research facilities, weekly entry of new cows in a close-up pen is expected to cause more agonistic interactions in the feed bunk than stable pen. In the current experiment, however, the increased rate of displacement from the feed bunk did not result in compromised innate immune function or metabolic parameters. Correspondingly to these findings, increased social disturbance in the control treatment did not result in greater incidence of diseases or reduced 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. From the current experiment and from the experiment by Coonen et al. (2011) we conclude that conventional prepartum grouping strategy (i.e. weekly entry of new cows to the close-up pen) does not affect health of cows. These are important findings because the average stocking density of the control pen was 87%, whereas in the AIAO pen it was 73% (Silva et al., 2012a). Therefore, in a herd with 1,000 lactating dairy cows, with 110 calving per month, and a close-up period of 28 d, the dairy would need 126 stalls if a conventional system is implemented and 150 stalls if an AIAO system is implemented. If the cost of a stall is approximately $5,000, the additional cost to build the close-up pen for an AIAO system would be approximately $120,000.

*Heat Abatement*: Exposure of cows to heat stress during the prepartum period results in smaller calf birth weight (31 vs. 44 kg) and reduced milk yield throughout the lactation (7.5 kg/d less milk; do Amaral et al., 2009). In a study conducted in CA, prepartum cows (last 28 d before calving) were offered shade and fans in addition to sprinkler for heat abatement (Urdaz et al., 2006). Fans were 91.4 cm diameter with air speed of 317.2 m³/min and placed 2.4 m high, 6.1 m apart, and in 30° angles. Shades were 3.9 m (front) and 3.4 m (back) high and provided 95% shade. Sprinklers were 1.7 m high and 1.5 m apart, and provided 1.4-1.8 l of water per minute. Providing shade and fans resulted in reduced exposure of cows to heat stress from 60% to 48% of the time spent in the prepartum pen. Cows that had shades and fans in addition to sprinkler produced 84 kg more milk in the first 60 d postpartum (2408 vs. 2324 kg), which resulted in 95% profit per year over each dollar spent.

Therefore, heat abatement should be a goal for prepartum as well as postpartum cows to assure improved health and productivity.

**Effects of diseases on performance and reproductive efficiency**

Cows exposed to conditions that limit feed intake prepartum either because of physical impediment (i.e. overstocking) or because of continued social disruption (i.e. regrouping), common problems observed during the prepartum period, are at greater risk of immune suppression and metabolic diseases peripartum and health disorders postpartum, which are expected to reduce productivity of dairy cows and profitability of dairy operations. Severe economic losses are estimated to result from the following diseases: retained fetal membrane, $312/case (Laven and Peters, 1996); metritis, $300/case (Guard, 1998); displacement of
abomasum, $ 340/case (Guard, 1998); and, mastitis, $ 224/case (Steeneveld et al., 2011). These losses are the consequence of costs related to treatment, discarded milk, reduced milk yield, and increased culling. Because some of these references are nearly two decades old and because calculations did not account for negative effects of these diseases on reproductive performance, the costs associated with these diseases are much higher.

References


