Grouping Strategies for Dry and Fresh Cows to Optimize Health and Performance

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Summary

Management of periparturient dairy cows has been identified as critical for health and performance. Ultimately, housing and management of periparturient cows must provide an environment that is free of stress, is conducive to natural behavior, and optimizes water and feed intake. Negative interactions of the cow with its environment, herdmates, and herdsmen may elicit behavioral changes, such as avoidance, separation/isolation, and reduced resting time and feeding time. If such behavioral changes are severe and prolonged, they may translate into impairment of immune and metabolic statuses, increased incidence of health disorders, and compromised reproductive and productive performances. In this presentation, physiological changes that occur during the peripartum that are associated with impaired immune function will be discussed. Furthermore, experiments that have evaluated how housing and grouping strategies affect behavior, immune and metabolic status, and performance will be presented.

Introduction

In 1983, Albright described the issues concerning public perception of animal wellbeing as: "People are calling for what are more "humane practices" in the treatment of animals … these concerned individuals are of nonfarm background and generally have been exposed to only a few farms (Albright, 1983)". This statement is still very relevant today. Growing pressure from consumers has resulted in legislators interfering on livestock husbandry practices. An example of such interference is the approval in 2008 of "California Proposition 2 (Standards for Confining Farm Animals)". This prompted the American Veterinary Medical Association to issue the following statement: "Proposition 2 is admirable in its goal to improve the welfare of production farm animals; however, it ignores critical aspects of animal welfare that ultimately would threaten the well-being of the very animals it strives to protect." "Proposition 2 may have negative impacts on animals, consumers, and the industry. More attention needs to be paid to the behavioral and social needs of food animals, …, but the standards in this ballot initiative fall short in improving animal welfare because they fail to adequately consider other factors. Animal welfare is a complex issue and demands that decisions be based on science …". Our ability to assure consumers that dairy products meet the highest standards of safety, quality, and animal welfare is vital to the sustainability of the US dairy industry. Thus, understanding management practices that affect animal wellbeing is crucial to produce the best practice guidelines to be adopted by dairy farmers and to demonstrate to the public that the utmost care is taken to provide dairy animals with

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a safe, comfortable, and health conducive environment. Nonetheless, we must not lose focus that dairy farms are profit driven as any other business.

Moberg (2000) described stress as being part of life and not inherently harmful to animals. As in humans, dairy animals have developed mechanisms to cope with stress and only in severe cases of stress do they present abnormal responses that may lead to disease and poor performance. The recognition that some management strategies may produce excessive stress or chronic stress and lead to disease has sensitized us for the importance of stress to dairy cow well-being. Once a stressor is identified, an organism may respond through neuroendocrine (pituitary-hypothalamic-adrenal axis, e.g., cortisol secretion), immune (innate or adaptive responses), autonomic (e.g., “fight or flight”), and behavioral (e.g., stress avoidance) changes. Each and every step of the response to stressors is important. Evaluating one response only may not be sufficient to understand the overall consequence of stressors to the animal.

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 (e.g., lack of feed or water, limited feed bunk space, and limited resting space) 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. Although much focus has been placed on behavioral responses to stressors, it is important to note that often behavioral responses are short lived and have minor implications to overall well-being, health, and performance. A holistic approach to understanding how cows respond to stressors and the consequences to health and performance may generate a more precise understanding of the relationship between these stressors and animal well-being.

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 days of gestation in so called “dry cow pens” and as another group from 251 days 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 re-establish 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 period 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 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). Therefore, we recommend that primiparous cows be housed separately from mature cows from at least 21 days before to 21 days 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 at 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 12"/cow of feed bunk space had altered behavior compared with cows housed in pens with 24"/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 a 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 cows were housed to attain 100% stocking density of headlocks (109% stocking density of stalls; **100SD**) or 80% stocking 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. 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 days postpartum (Table 2), and yield of energy corrected milk (80SD = 75.2 ± 1.1 vs. 100SD = 74.4 ± 1.1 lb/day; $P = 0.56$).

A recent experiment conducted in Canada evaluated the metabolic responses of cows housed at 80% stall stocking density and 35” of feedbunk space per cow (n = 24) and cows housed at 120% stall stocking density and 18” of feedbunk space per cow (n = 24) (Miltenburg et al., 2014). Group sizes were 6 and 10 cows per pen and the cows were enrolled in the experiment 21 days before expected calving date. Although cows housed in overstocked pens had greater albumin and bilirubin concentrations, they also had reduced β-hydroxy butyrate **(BHBA)** and non-esterified fatty acids **(NEFA)** concentrations compared with understocked cows. Stocking density had no effect on neutrophil function (oxidative burst). Number of cows in this experiment was small, but no differences between treatments were observed in incidence of uterine diseases.

Recently, our group conducted an experiment to evaluate the rumination, activity, and lying behavior pattern of periparturient dairy animals. During the experiment, stocking density of the pens, based on feedbunk space, was monitored, but it was not manipulated purposively to compare effects of stocking density on rumination, activity, and lying behavior. Evaluating the data retrospectively, however, we observed that different stocking densities in the last 7 days prepartum (range: parous = 63 to 103%, nulliparous = 90 to 120%) was not correlated with average rumination (min/d; Figure 5A and 5B) and lying time (min/d; Figure 6A and 6B) during the last 7 days prepartum (Chebel, personal communication).

Current recommendations indicate that stocking density during the prepartum should be 80% of headlock and at least 30” 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 days, 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 4 to 5” of linear water trough space per cow and 1 water trough per 20 cows 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 days of gestation in so called "dry cow pens" and as another group from 251 days 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 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 within a few hours after 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 re-establish 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 pen 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-day milk yield of close-up cows (14 to 28 days 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. 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 days 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 a stocking density of 100% and 92% relative to stalls and headlocks, respectively, 7.9 m2/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 days before expected calving date) at 13:00 ± 1:00 and following fresh feed delivery (05:00 ± 1:00) 1, 2, 3 and 7 days after cows were moved to the 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 7; Silva et al., 2013a). A greater number of displacements (Figure 8) and a greater displacement rate (Figure 9) were observed in the control treatment than in the AIAO treatment (Lobeck-Luchterhand et al., 2014). Minimal changes in feeding time, however, were observed during the 5 weeks preceding calving (Figure 10; Lobeck-Luchterhand et al., 2014). Percentage of cows at the feed bunk at different times of the day were similar between AIAO and control treatments (Figure 11; 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 12) were observed.

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 days (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 yields of fat and protein, and greater yield of energy corrected milk (Table 4; Silva et al., 2013a).

Weekly entry of new cows in a close-up pen is expected to cause more agonistic interactions in the feed bunk than the 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 days prepartum had no significant increase in incidence of disease or reduction in reproductive performance.

In a recent experiment conducted by researchers in Canada, however, the behavioral response to regrouping was dependent on stocking density, such that increased stocking density (100% of headlocks) resulted in more frequent antagonistic behavior in the feedbunk compared with reduced stocking density (50 or 25% of headlocks; Talebi et al., 2014). It remains, however, that behavioral changes are 1 of the 4 biological responses to stress, with neuroendocrine, immune, and autonomic being the other 3. Stressors that only cause a transient change in behavior but have no effects on other responses seem to have little importance to biological function of cows.

Grouping strategy during the postpartum period

Similar to the concerns described for the prepartum period, during the postpartum period cows must be offered the best environment possible. Although controversy exists regarding whether or not prepartum feed intake should be maximized, during the postpartum period cows should increase feed intake at a very fast rate to reduce the extent of negative energy balance. However, because of the difficulty in applying different management strategies to milking cows, limited experiments have compared housing and grouping strategies during the postpartum period.

In an observational study of 24 Canadian herds (66 to 570 lactating cows, mean = 161.8 ± 120 lactating cows), researchers evaluated risk factors for improved performance (Sova et al., 2013). In these herds, average feedbunk space was 21” (14 to 39”), but no description of grouping strategy (e.g., separation of primiparous and multiparous) was given. Nonetheless, factors associated with DMI were milking frequency and feeding frequency, such that 3x milking vs 2x milking increased feed intake by 3.12 lb/day and 2x feeding vs 1x feeding increased feed intake by 2.62 lb/day. On the other hand, managerial factors associated with milk yield were milk frequency, feeding frequency, and linear water space. Increasing milking frequency from 2x to 3x increased milk yield by 13.0 lb/day, increasing feeding frequency from 1x to 2x increased milk yield by 4.42 lb/day, and increasing linear water through space by 1 cm increased milk yield by 0.84 lb/day. Although this was not a controlled experiment, the findings of this observational experiment demonstrated that feedbunk and water through space are critical to maximize milk yield. The positive effects of increased milking frequency on DMI and milk yield also are very important; however, milking >4x/day may pose challenges to cow budget time, such that resting and feeding time may be compromised. Suggested cow budget time is 3 to 5 hr/day of feeding, 10 to 14 hr/day of lying in a freestall, and 7 to 10 hr/day of ruminating (Grant and Albright, 2001). Krawczel et al. (2012) evaluated behavior and production of cows subjected to 100, 113, 131, and 142% stocking density based on number of stalls and headlocks. Each cow was subjected to the different stocking densities for 14 days. Lying time was reduced as stocking density increased (100% = 12.9 hr/day, 113% = 12.8 hr/day, 131% = 12.2 hr/day, and 142% = 12.3 hr/day). Overall daily feeding and rumination time were not affected by stocking density, but greater stocking density was associated with reduced rumination while in a stall (100% = 95.1, 113% = 93.7, 131% = 89.6 and 142% = 97.3% of time in stall). There was a slight worsening of leg hygiene score after 14 days of exposure to high stocking density. There was a linear increase in displacement from the feedbunk as stocking density increased ($y = 0.27x - 18.5$; $R^2 = 0.60$; $P < 0.01$); however, stocking density did not affect cortisol concentrations or milk yield. Finally, regrouping of lactating cows produced several alterations in feeding behavior (feeding time – 15 fewer minutes in the first hour after regrouping; displacements from the feed bunk – increased 2.5x in the first day after regrouping), reduced resting time (3 hr fewer of resting time in the first day after regrouping; von Keyserlingk et al., 2008). Furthermore, regrouping caused a reduction in milk yield (8.8 lb) on the day of regrouping. Importantly, however, the consequences of regrouping were very short lived. Furthermore in this experiment, 1 cow was moved to a group of 11 cows. This is hardly the scenario observed in commercial herds where larger groups of cows are moved to larger pens, which means cows may have more means to avoid confrontation and may benefit from familiarization with herdmates before regrouping.

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.

References

Albright, J.L. 1983. Status of animal welfare awareness of producers and direction of animal welfare research in the future. J. Dairy Sci. 66:2208-2220.

Carporese, M., G. Annicchiarico, L. Schena, A. Muscio, R. Migliore, and A. Sevi. 2009. Influence of space allowance and housing conditions on the welfare, immune response and production performance of dairy ewes. J. Dairy Res. 76:66-73.

Coonen, J.M., M.J. Maroney, P.M. Crump, and R.R. Grummer. 2011. Short communication: Effect of a stable pen management strategy for precalving cows on dry matter intake, plasma nonesterified fatty acid levels, and milk production J. Dairy Sci. 94:2413–2417.

Grant, R.J., and J.L. Albright. 1995. Feeding behavior and management factors during the transition period in dairy cattle. J. Anim. Sci. 73:2791-2803.

Grant, R.J., and J.L. Albright. 2001. Effect of animal grouping on feeding behavior and intake of dairy cattle. J. Dairy Sci. 84(E.-Suppl.):E156–E163

Hosseinkhani, A., T.J. DeVries, K.L. Proudfoot, R. Valizadeh, D.M. Veira, and M.A.G. von Keyserlingk. 2008. The effects of feed bunk competition on the feed sorting behavior of close-up dry cows. J. Dairy Sci. 91:1115-1121.

Krawczel, P.D., L.B. Klaiber, R.E. Butzler, L.M. Klaiber, H.M. Dann, C.S. Mooney, and R.J. Grant. 2012. Short-term increases in stocking density affect the lying and social behavior, but not the productivity, of lactating Holstein dairy cows. J. Dairy Sci. 95:4298-4308.

Lobeck-Luchterhand, K.M., P.R. Silva, R.C. Chebel, and M.I. Endres. 2014. Effect of prepartum grouping strategy on displacements from the feed bunk and feeding behavior of dairy cows. J. Dairy Sci. 97:2800-2807.

Miltenburg, C.L., D. Bienzle, E. Scholtz, T.F. Duffield, and S.J. LeBlanc. 2014. The effect of prepartum housing on metabolic and reproductive health in dairy cows. American Association of Bovine Practitioners Proceeding 47:140.

Moberg, G.P. 2000. Biological response to stress: Implications for animal welfare. In The Biology of Animal Stress: Basic principles and implications for animal welfare, edn. 1, pp. 1-22. New York, NY: CABI Publishing.

Proudfoot, K.L., D.M. Veira, D.M. Weary, and M.A.G. von Keyserlingk. 2009. Competition at the feed bunk changes the feeding, standing, and social behavior of transition dairy cows. J. Dairy Sci. 92:3116-3123.

Silva, P.R., J.G. Moraes, L.G. Mendonça, A.A. Scanavez, G. Nakagawa, J. Fetrow, M.I. Endres, and R.C. Chebel. 2013a. Effects of weekly regrouping of prepartum dairy cows on metabolic, health, reproductive, and productive parameters. J. Dairy Sci. 96:4436-4446.

Silva, P.R., J.G. Moraes, L.G. Mendonça, A.A. Scanavez, G. Nakagawa, M.A. Ballou, B. Walcheck, D. Haines, M.I. Endres, and R.C. Chebel. 2013b. Effects of weekly regrouping of prepartum dairy cows on innate immune response and antibody concentration. J. Dairy Sci. 96:7649-7657.

Silva, P.R., A.R. Dresch, K.S. Machado, J.G. Moraes, K. Lobeck-Luchterhand, T.K. Nishimura, M.A. Ferreira, M.I. Endres, and R.C. Chebel. 2014. Prepartum stocking density: Effects on metabolic, health, reproductive, and productive responses. J. Dairy Sci. 97:5521-5532.

Sova, A.D., S.J. LeBlanc, B.W. McBride, and T.J. DeVries. 2013. Associations between herd-level feeding management practices, feed sorting, and milk production in freestall dairy farms. J. Dairy Sci. 96:4759-4770.

Talebi, A., M.A. von Keyserlingk, E. Telezhenko, and D.M. Weary. 2014. Reduced stocking density mitigates the negative effects of regrouping in dairy cattle. J. Dairy Sci. 97:1358-1363.

von Keyserlingk, M.A.G., D. Olenick, and D.M. Weary. 2008. Acute behavioral effects of regrouping dairy cows. J. Dairy Sci. 91:1011-1016.

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

Item	Multipararous + Primiparous	Primiparous Only
Eating time, min/day	184	205
Eating bouts/day	5.9	6.4
Concentrate intake, lb/day	22.2	25.5
Silage intake, lb/day	16.9	18.9
Lying time, min/day	424	461
Resting periods/day	5.3	6.3
Milk yield, lb/130 day	5,243	5,698
Milk fat, %	3.92	3.97

[1]Adapted from Grant and Albright (1995)

Table 2. Effects of prepartum stocking density (80SD vs. 100SD) on incidence of postpartum health disorders, lameness, and removal from the herd within 60 days postpartum (Silva et al., 2014).

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

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 days postpartum (Silva et al., 2013a).

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 days postpartum[2]	20.7	24.1	0.42
Endometritis at 35 days postpartum[2]	10.3	10.3	0.96
Displacement of abomasum	3.2	1.7	0.38
Mastitis within 60 days 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

[1]TRD (traditional prepartum grouping strategy) – weekly entry of new cows into the prepartum pen; and AIAO (All-In-All-Out prepartum grouping strategy) – no entry of new cows in the prepartum pen. Target stocking density was 100% of stalls and 91.6% of headlocks and 7.9 m^2/cow (26 ft^2/cow).

Table 4. Comparison of productive parameters and milk quality of All-In-All-Out (AIAO) cows that calved within their replicate and AIAO cows that had to be moved to a different pen (Silva et al., 2013a).

Items	AIAO that calved within their replicate	AIAO moved to a different pen	*P* – value
Milk yield, lb/day	61.6 ± 1.0	3.5 ± 3.4	< 0.01
Fat yield, lb/day	2.75 ± 0.04	3.28 ± 0.15	< 0.01
Protein yield, lb/day	2.31 ± 0.04	2.75 ± 0.11	< 0.01
3.5% fat corrected milk yield, lb/day	78.7 ± 1.28	93.7 ± 4.20	< 0.01
Energy corrected milk yield, lb/day	73.5 ± 1.17	87.3 ± 3.8	< 0.01
Linear somatic cell count	2.94 ± 0.08	3.18 ± 0.28	0.41

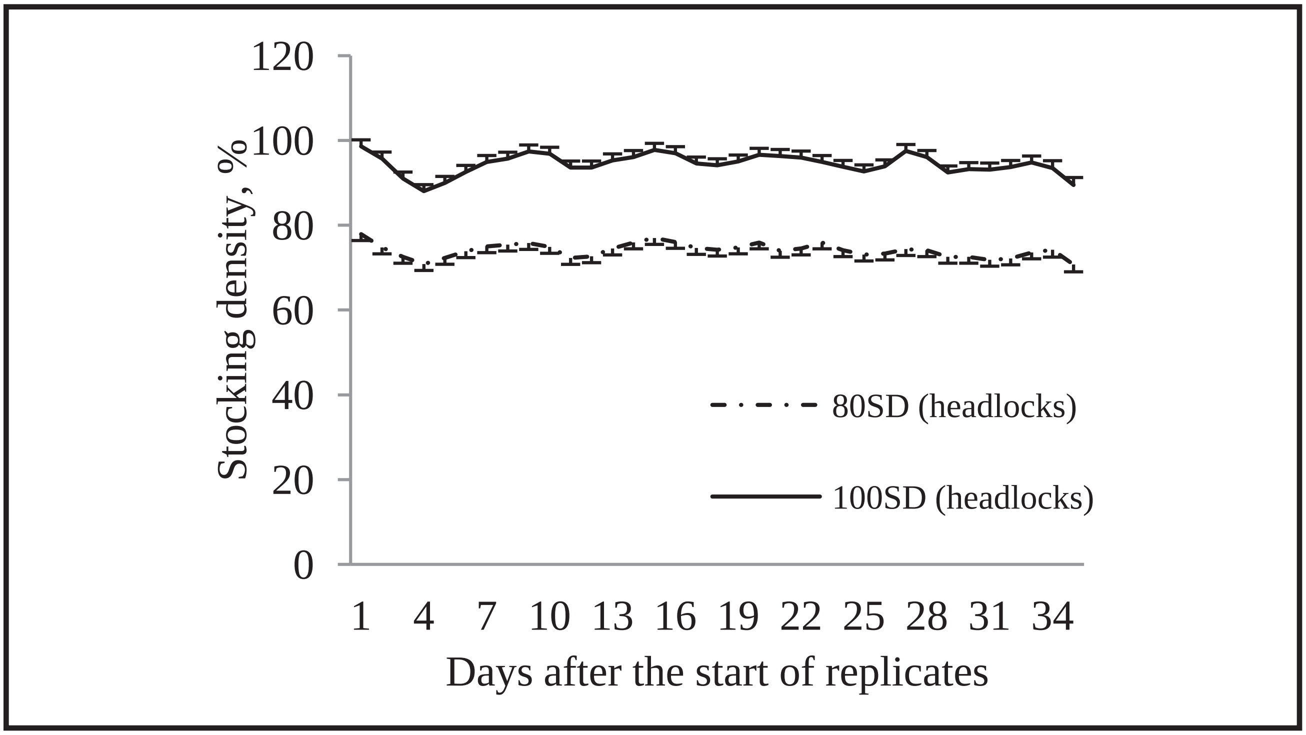

Figure 1. Headlock stocking density of heifers and cows submitted to the 80 and 100% stocking density treatments (Silva et al., 2014).

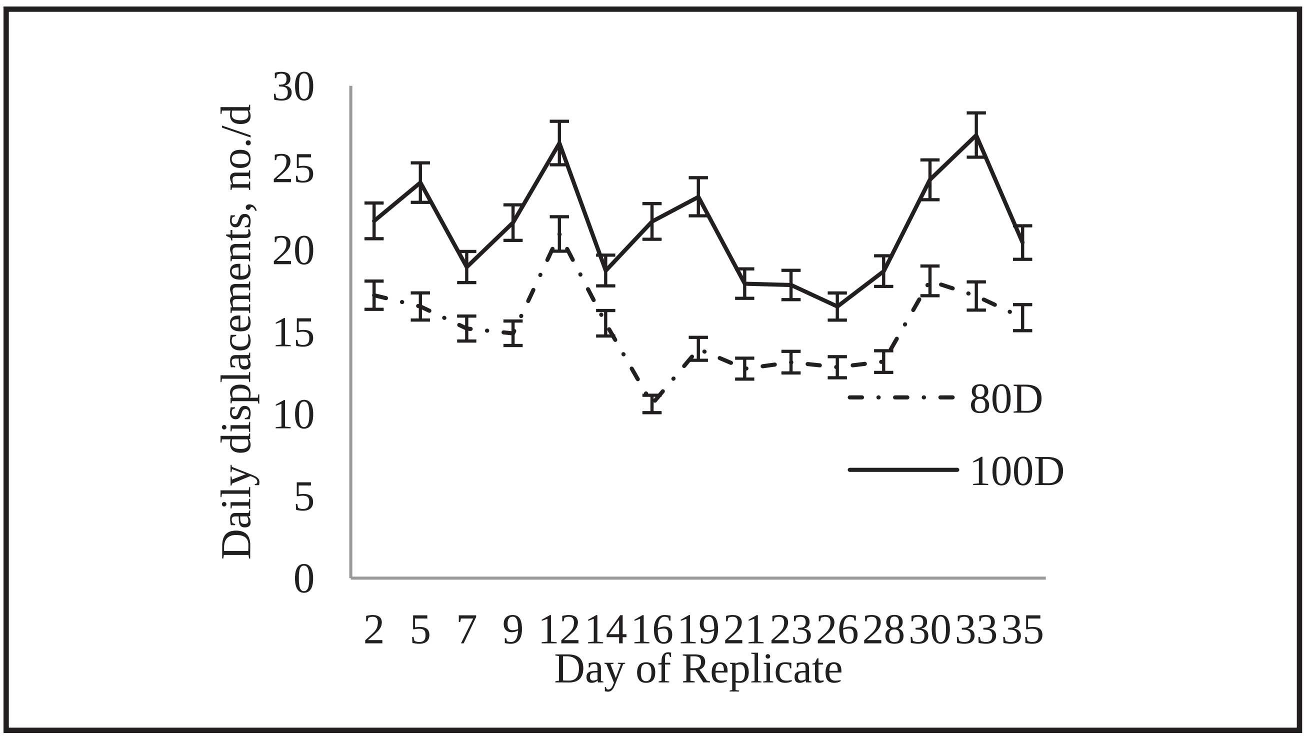

Figure 2. Effects of prepartum stocking density (80 or 100%) on daily number of displacements (Lobeck-Luchterhand et al., 2014).

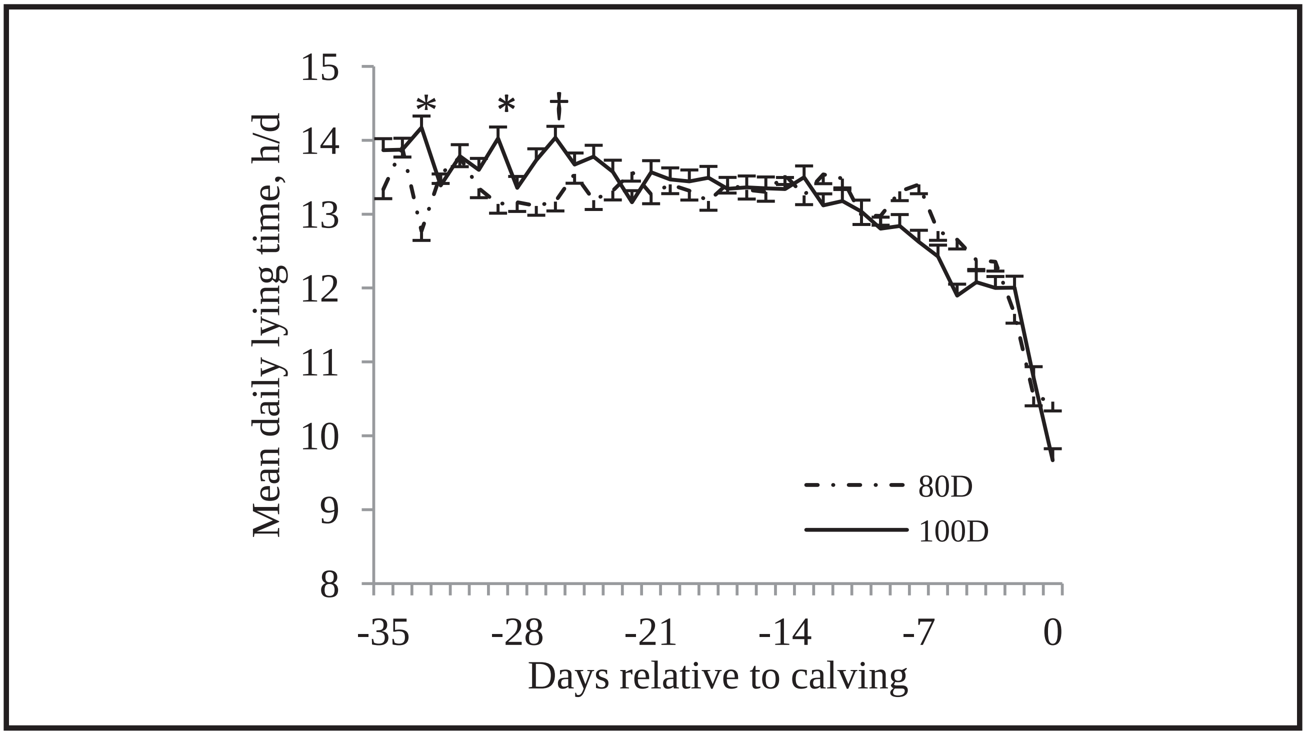

Figure 3. Effect of prepartum stocking density (80 to 100%) on daily lying time (Lobeck-Luchterhand et al., 2014).

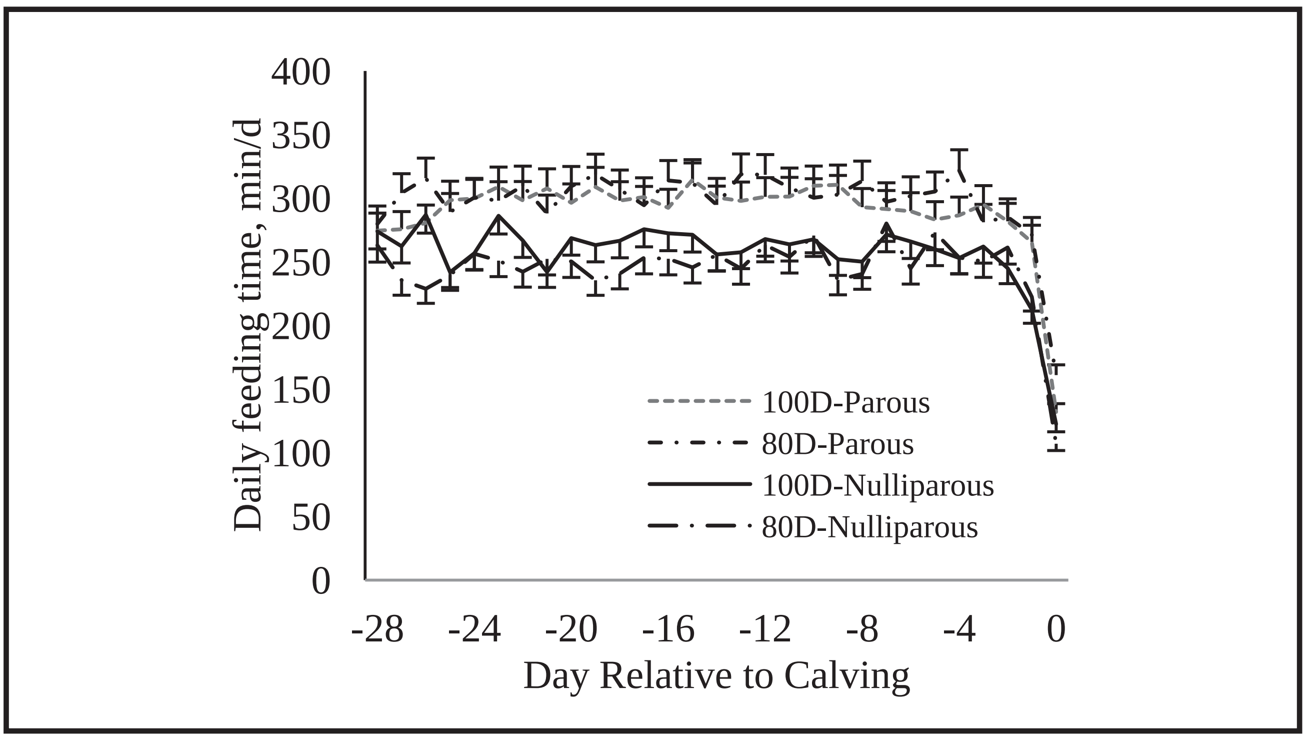

Figure 4. Effect of prepartum stocking density (80 to 100%) on daily average feeding time (Lobeck-Luchterhand et al., 2014).

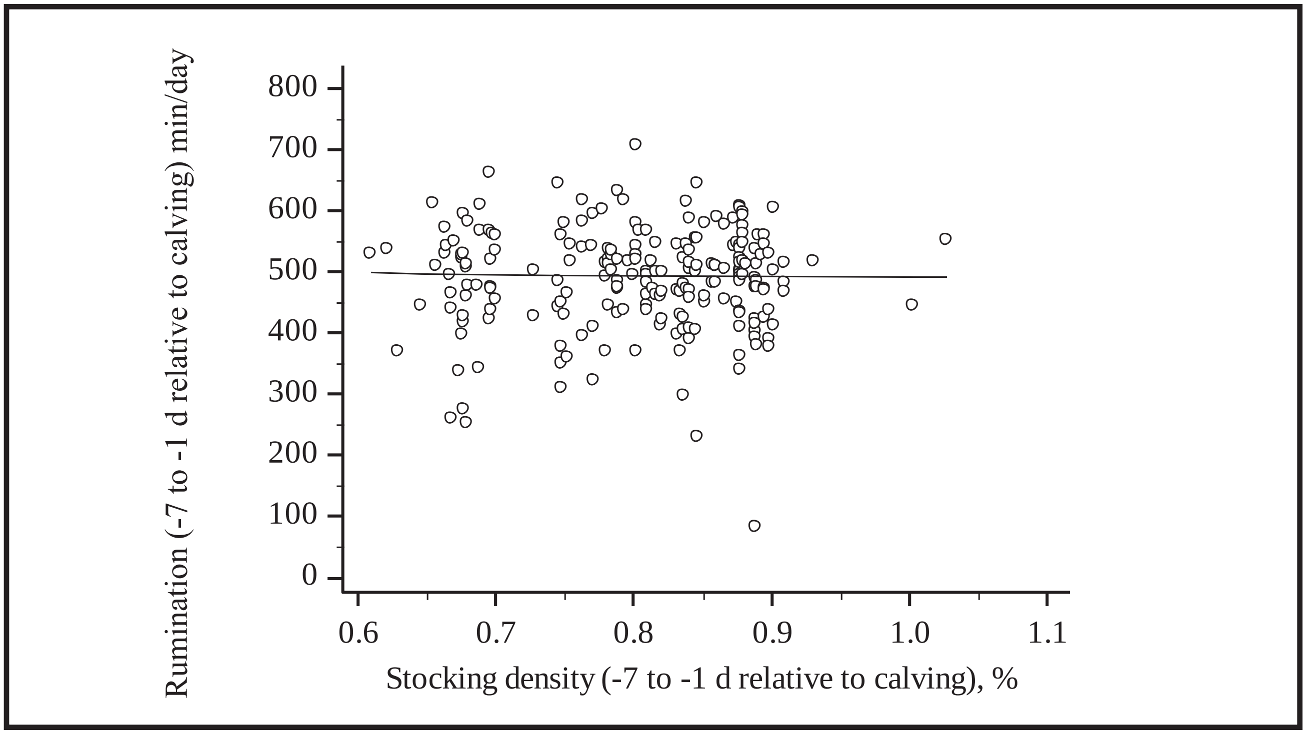

Figure 5A. Correlation between average stocking density (percentage feed bunk space) and rumination (min/d) during the last 7 days prepartum among parous animals (n = 219; *P* = 0.83, r = 0.01).

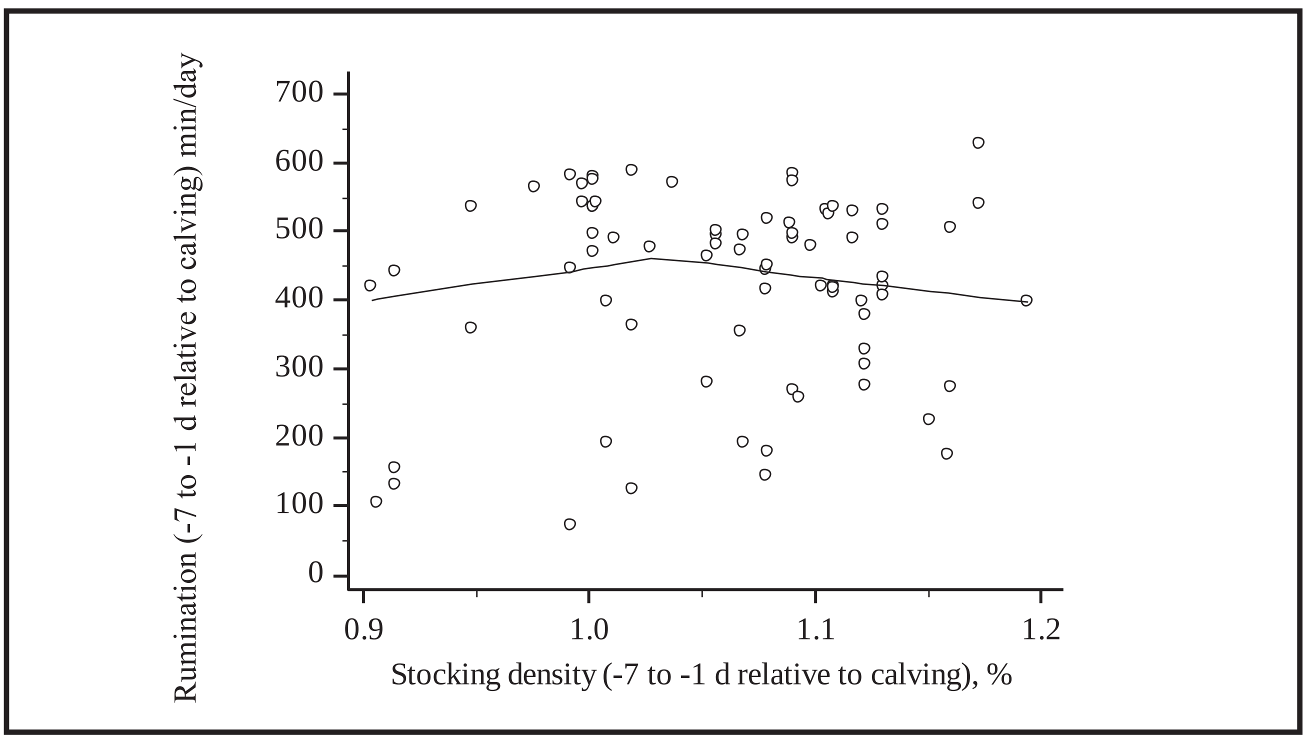

Figure 5B. Correlation between average stocking density (percentage feed bunk space) and rumination (min/d) during the last 7 days prepartum among nulliparous animals (n = 77; *P* = 0.42, r = 0.09).

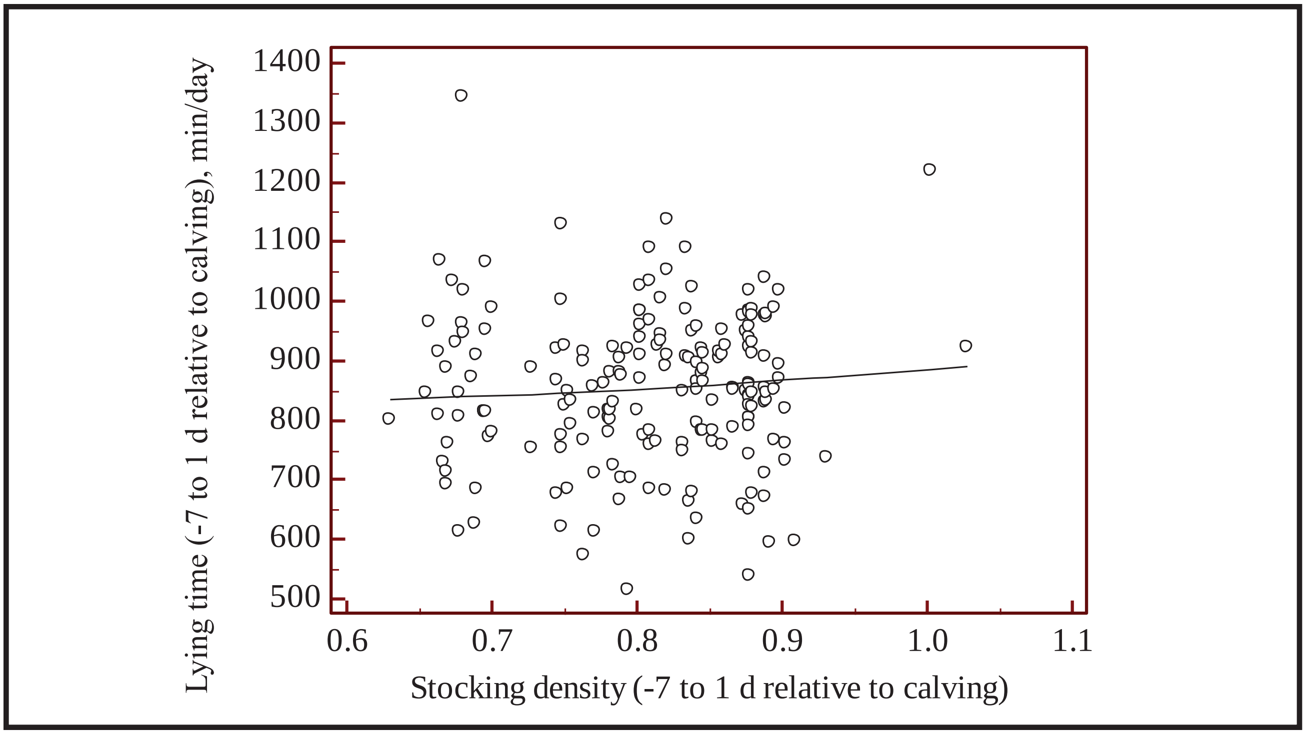

Figure 6A. Correlation between average stocking density (percentage feed bunk space) and lying time (min/d) during the last 7 days prepartum among parous animals (n = 219; *P* = 0.67, r = 0.03).

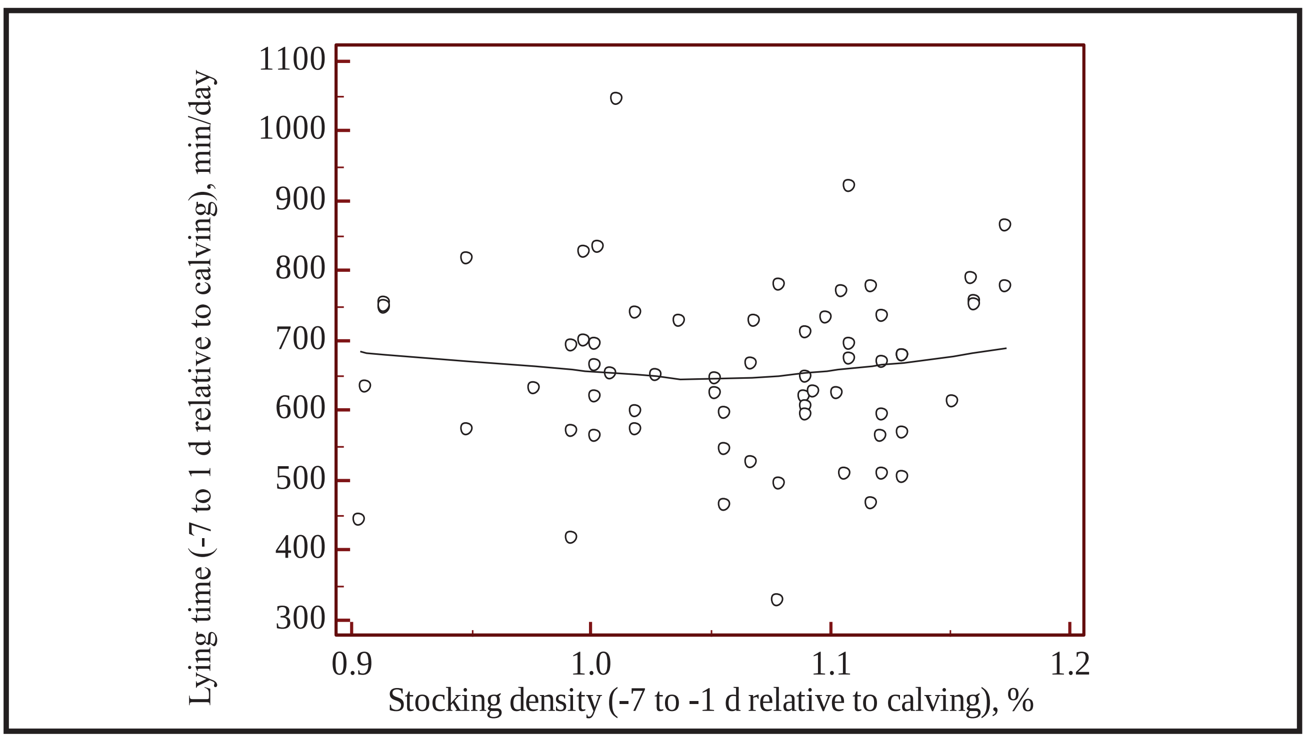

Figure 6B. Correlation between average stocking density (percentage feed bunk space) and lying time (min/d) during the last 7 days prepartum among nulliparous animals (n = 219; *P* = 0.83; r = 0.03).

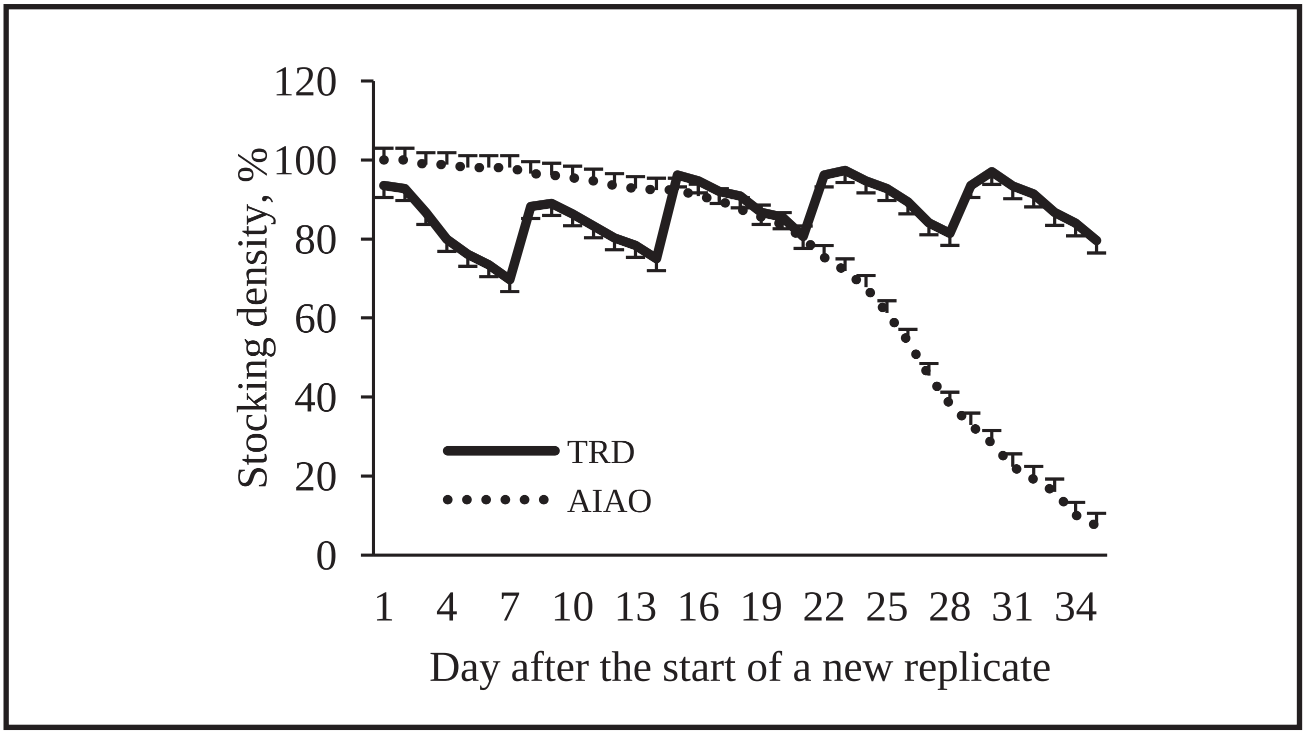

Figure 7. Effect of prepartum grouping strategy on stocking density of prepartum pens (TRD = traditional prepartum grouping strategy; AIAO = All-In-All-Out prepartum grouping strategy) (Silva et al., 2013A).

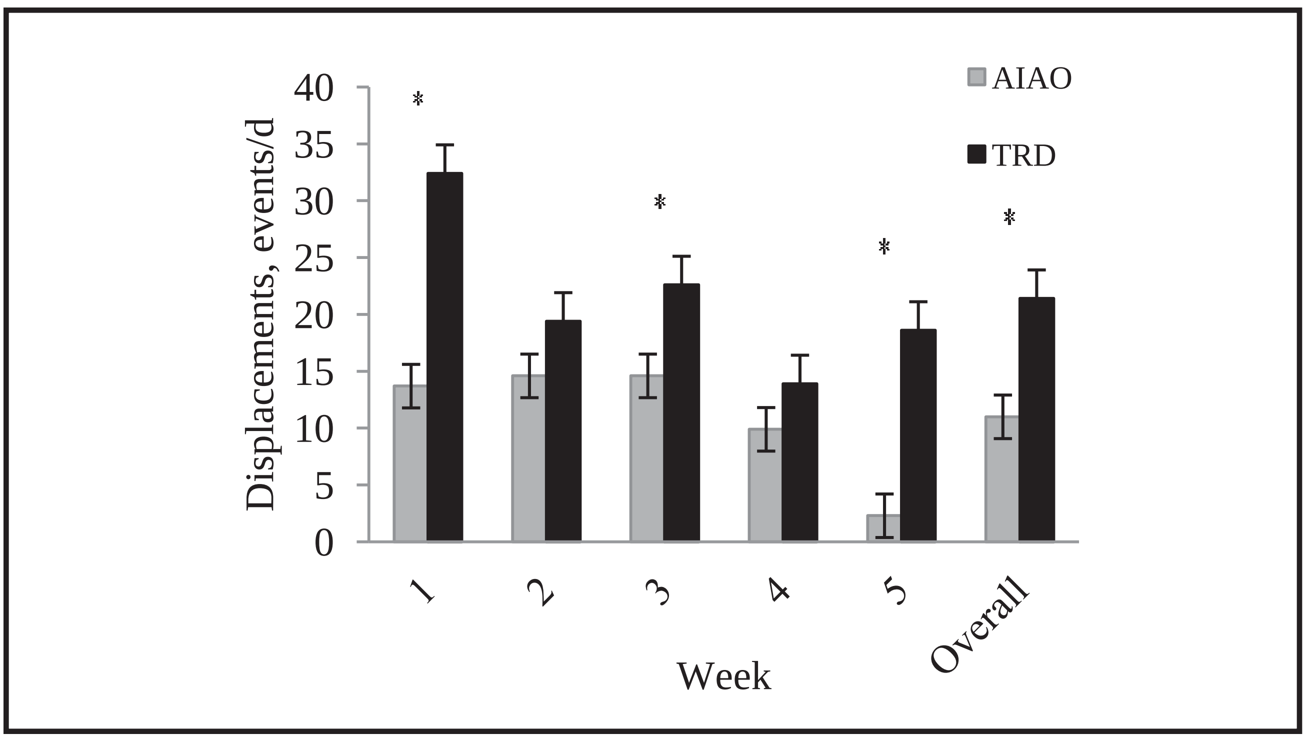

Figure 8. Effect of grouping strategy on average number of displacements during the prepartum period (TRD = traditional prepartum grouping strategy; AIAO = All-In-All-Out prepartum grouping strategy) (Lobeck-Luchterhand et al., 2014).

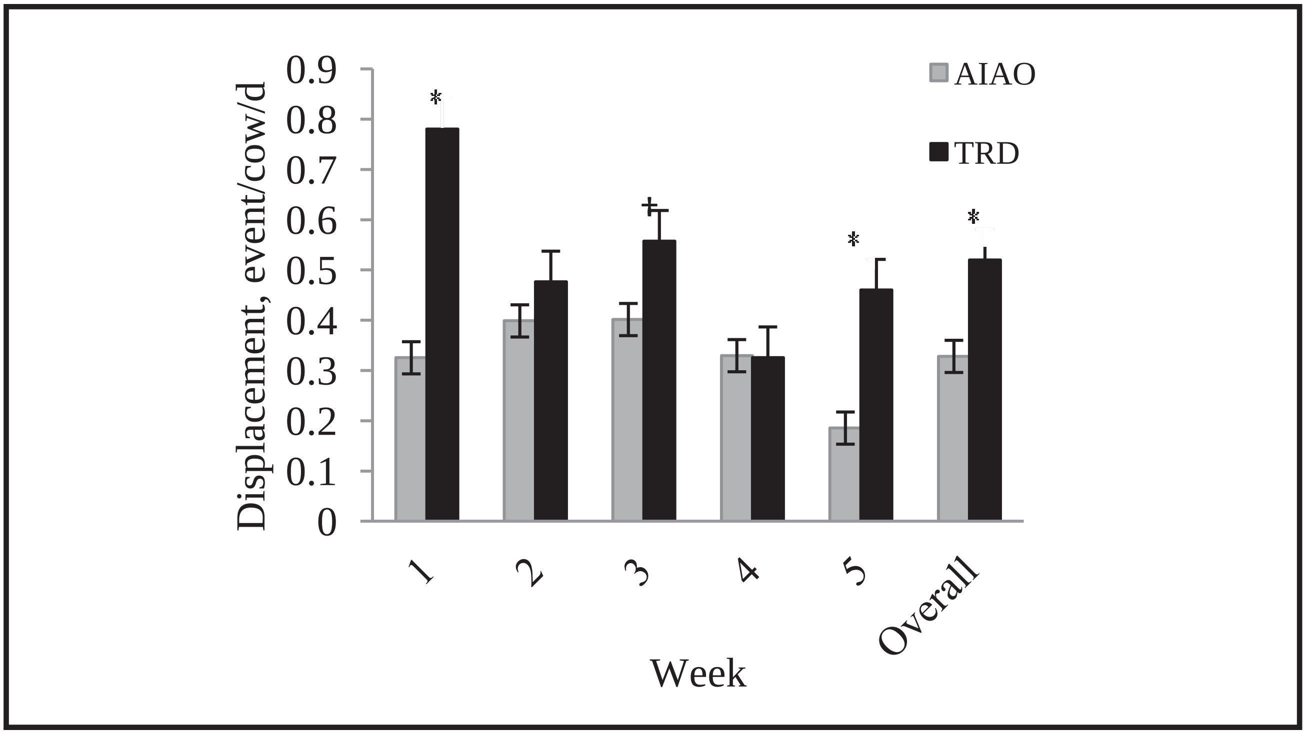

Figure 9. Effect of grouping strategy on average rate of displacement during the prepartum period (TRD = traditional prepartum grouping strategy; AIAO = All-In-All-Out prepartum grouping strategy) (Lobeck-Luchterhand et al., 2014).

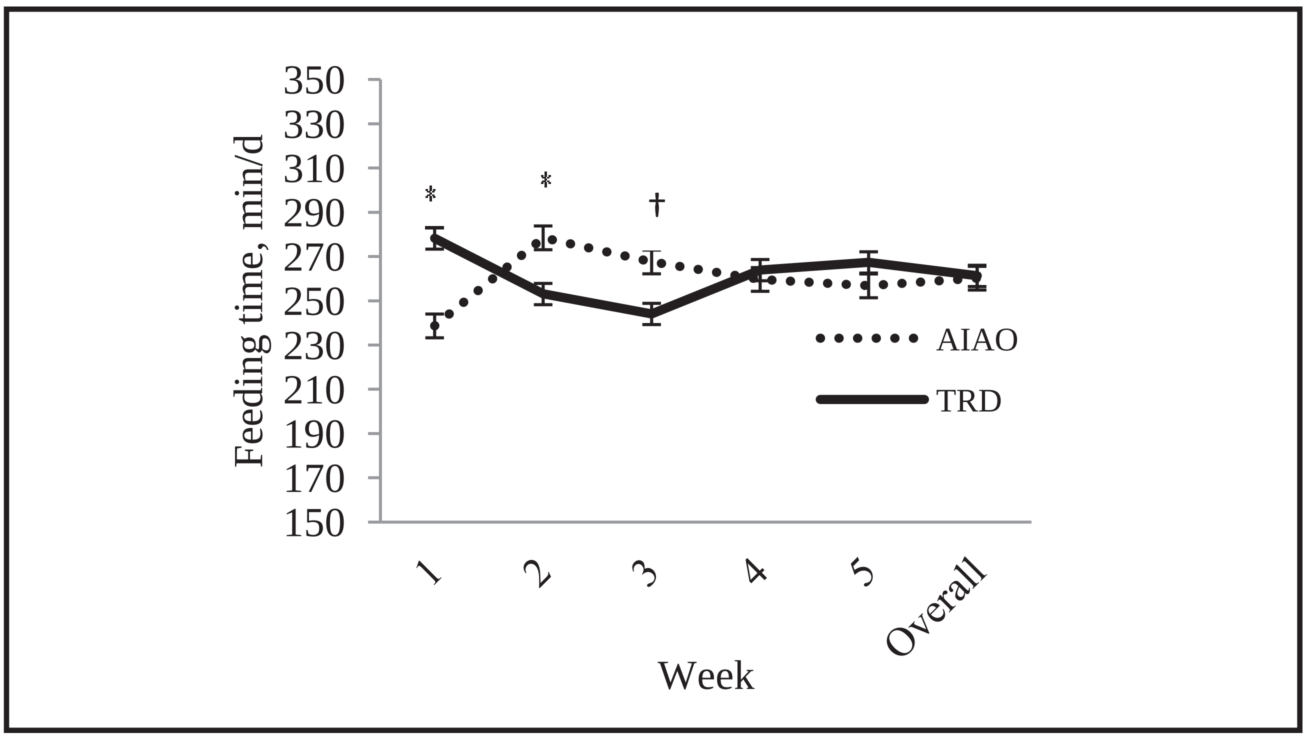

Figure 10. Effect of grouping strategy on average daily feeding time during the prepartum period (TRD = traditional prepartum grouping strategy; AIAO = All-In-All-Out prepartum grouping strategy) (Lobeck-Luchterhand et al., 2014).

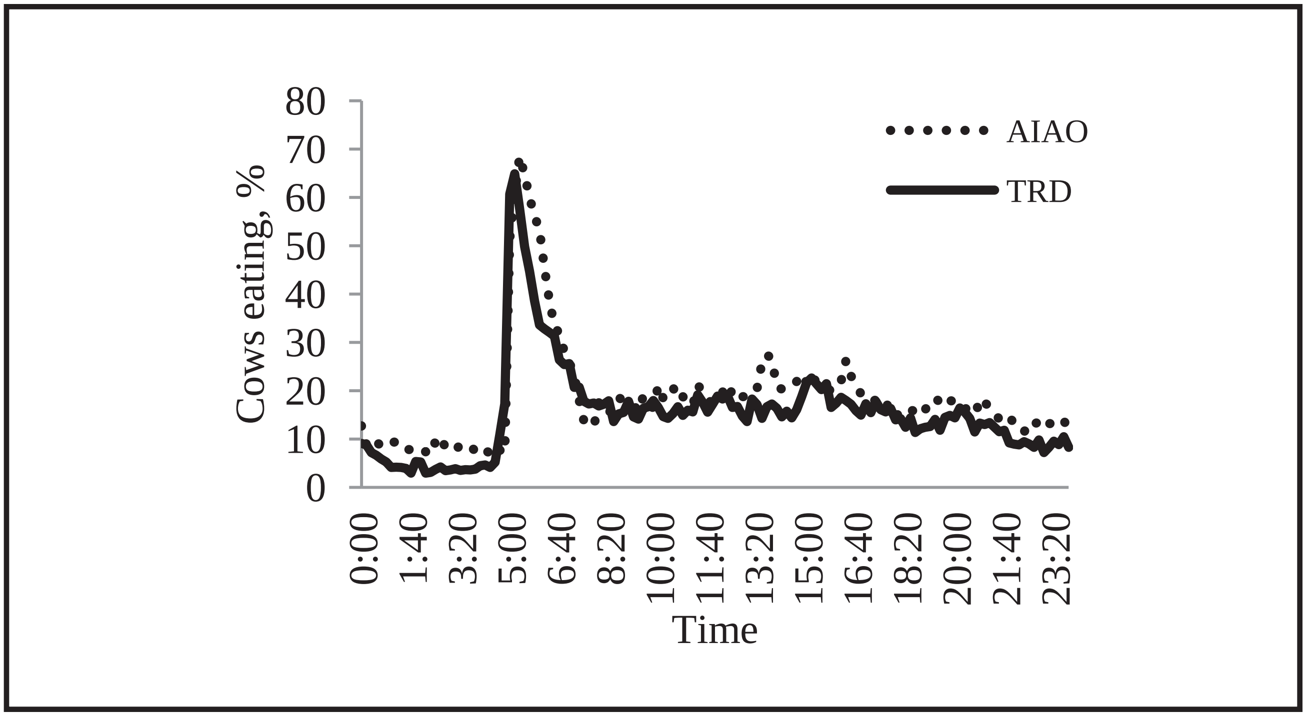

Figure 11. Average percentage of cows at the feed bunk during the prepartum period (TRD = traditional prepartum grouping strategy – weekly entry of new cows into the prepartum pen; AIAO = All-In-All-Out prepartum grouping strategy – no entry of new cows in the prepartum pen) (Lobeck-Luchterhand et al., 2014).

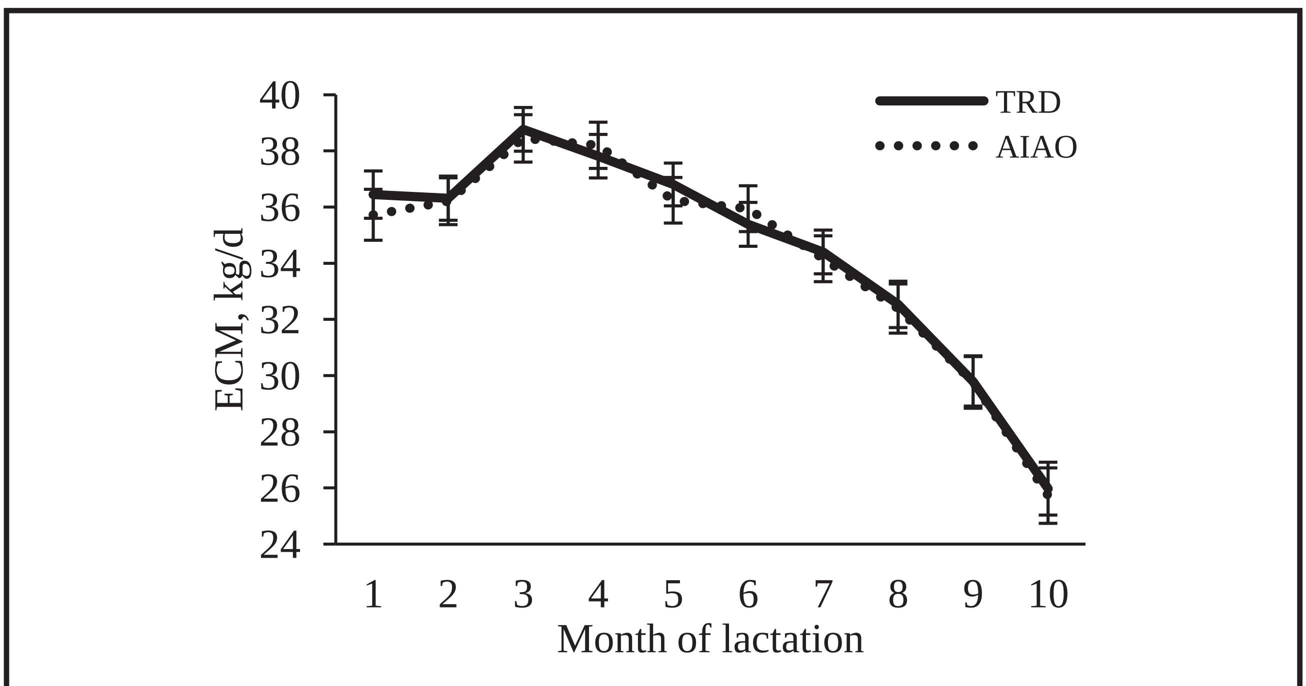

Figure 12. Yield of energy corrected milk (ECM) according to prepartum grouping strategy (TRD vs AIAO; TRD = traditional prepartum grouping strategy – weekly entry of new cows into the prepartum pen, and AIAO = All-In-All-Out prepartum grouping strategy – no entry of new cows in the prepartum pen) (Silva et al., 2013a).