Raising Dairy Replacements Objectively: The Value of Data-Based On-Farm Decisions

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Summary

Dairy replacement heifers not only define the long-term future of the dairy enterprise, but they also represent close to 10% of the costs associated with milk production. Optimizing heifer growth has an impact on herd profitability through cost rationalization and improved performance of the future herd. Potential areas for improvement appear early in life with the provision of adequate amounts of good-quality colostrum. In addition, there is evidence that growth rate during the first 2 mo of life is positively correlated with future milk production. Growth rate early in life can be accomplished by improving nutrient supply from milk or milk replacer and concomitantly fostering intake of solid feed through palatable starters, appropriate feeding devices, and social facilitation. At later stages of growth, regrouping slow-growing heifers by maintaining them in the same pen and introducing a relatively large number of unacquainted, younger, and lighter-weight animals results in improved average daily gain of the old slow-growing heifers. Because age at first calving (between 22 and 28 mo) has no relationship with future milk yield and incidence of calving problems, a logical target would be reaching first calving at 22 mo. However, since body weight **(BW)** at calving does have an impact on future milk yield, it is important that a minimum BW of 1550 lb is attained at calving (22 mo). This target implies gains around 1.87 lb/day. For some years, there has been some concern about fast average daily gain **(ADG)** and potential detrimental effects on udder development and future milk yield. However, recent evidence indicates that gains as high as 2.64 lb/day not accompanied by fattening, have no negative effect on future milk yield provided adequate protein to energy ratios are fed. Last, it has been commonly recommended that heifers are bred with BW equivalent to 55% of their mature BW. However, there have been no attempts to forecast the mature BW of a given animal at breeding time. A recent study indicates that mature BW can be forecast using growth data from an individual animal using a Gompertz non-linear model. Preliminary data suggest that small-frame heifers might produce more milk if bred at 55% of their predicted mature BW, whereas large-frame heifers would produce more milk if bred around 60% of their predicted mature body weight **(MBW)**. This article covers some of the above-mentioned aspects and other management and feeding strategies that can be implemented in heifer rearing to improve future milk yield and overall profitability of the dairy enterprise.

Introduction

Current intensive dairy production systems suffer, in many instances, from poor reproductive performance and relatively short productive lives of dairy cows. Therefore, producing quality replacement heifers, with the least mortality and greatest efficiency, is gradually receiving more attention. Nevertheless, replacement heifers are expensive to raise, and there is still some uncertainty

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about the optimum target weights, nutrition, and management.

The most common objective of raising Holstein dairy heifers is to have a first-calf heifer at about 22 months weighing about 1550 lb (or about 1380 lb post-calving) before calving and be 54 to 58 inches tall at the withers. However, the mean age at first calving **(AFC)** in the U.S. is about 27 months (Hare et al., 2006), and in Europe, it ranges between 25 and 29 mo. depending on the country (Berry and Cromie, 2009). Thus, the most commonly recommended target age is not often reached in practice. There are several reasons for this deviation, but the most significant one is a lack or insufficient information available to the producer to make appropriate management, reproductive, and nutritional on-farm decisions.

This article will illustrate how on-farm data can be used to helping in the decision-making processes associated with heifer rearing.

Importance of Data

Dairy producers generally make management decisions based on the evaluation of different types of data, ranging from milk yield and milk composition, to intake, reproduction, and body condition score. However, when it comes to heifer rearing, decisions are mainly made with limited data or no data at all. Data on BW, height, and intake should be the minimal aspects to be recorded in a heifer rearing system. But, accumulating unreliable data and using them to make decisions is probably worse than not collecting any data. Thus, it is important to put a system in place that facilitates accurate recording of BW, height, and intake. When analyzing data, it is common to look at average values, but the degree of spread around that average should also be also considered. For example, having an average AFC of 26 mo. with a spread from 24 to 28 mo. might actually be better than having an average AFC of 24 mo. with a spread from 18 to 30 mo. Also, it is important to acknowledge the type of average being considered. Averages may suffer from lag, momentum, and bias (Eicker et al., 2006). The lag of an average refers to the time lapsed between an action is taken and the average reflects the change, the momentum refers to responsiveness of that average to recent changes, and the bias reflects its deviation from a "more general" average due to exclusion or inclusion of data.

Data to Evaluate Immune Passive Transfer

It is well known that because of lack of placental transfer of immunoglobulin **(Ig)**, the calf is born with less than 10% of the immunity needed to provide protection against pathogens. Therefore, adequate amounts of good-quality colostrum should be fed as soon as possible after birth to provide protective immunity. Nevertheless, the estimated prevalence of failure passive transfer immunity (measured as serum Ig G concentration; IgG concentration should be e"10 mg/mL between days 1 to 7 of life) in US dairy heifer calves has been reported to be around 20% (Beam et al., 2009). Nocek et al. (1984) described a positive relationship between Ig G concentration and serum protein **(SP)** on 1, 4, and 11 days after birth. Other authors (Elizondo-Salazar and Heinrichs, 2009) have also described a positive relationship between Ig G and SP (although the relationship was much weaker than the one reported by Nocek et al. (1984)). This relationship has been used to estimate Ig G concentrations in calves using SP determinations (which is easier and less expensive to measure than Ig G). Beam et al. (2009) reported that herds that do not routinely monitor serum proteins are 13.8 times more likely to have failure passive transfer immunity than those that do. However, the SP concentrations might not be sufficient to allow predicting the risk of disease for a given animal. In fact, some studies have reported either no relationship between SP and health status or even an increased risk of disease in calves with high

(> 6 g/dl) than low (< 5.5 g/dl) SP concentrations (Tyler et al., 1999). Data collected from a contract heifer operation in Europe involving 204 calves arriving from 57 different herds with less than or equal to 6 days of age revealed that 41.2% of calves had a SP concentration equal to or below 5.5 g/dl upon arrival (Bach et al., 2007). This can be an illustration of the poor accomplishment at the farms of origin in providing colostrum to calves. However, despite the high proportions of animals with low SP concentrations, animal performance was not affected by the level of passive immunity. Furthermore, the risk of having pneumonia was only 8% numerically ($P = 0.61$) lower in the animals with a high SP concentration compared to calves with a low SP concentration. Similarly, there were no differences in the incidence of diarrhea between the two groups. Part of this lack of relationship between SP concentration and future incidence of disease could be due to: 1) real lack of cause-and-effect association, and 2) the hydration status of the calf that may have artificially increased (or diluted) SP concentrations. Therefore, although checking SP might be an indication about the quality of the colostrum feeding program, it may not be a good proxy to predict health status of calves in the near future. Emphasizing management and cleanliness may actually be more effective than checking SP concentrations in calves in terms of minimizing health problems.

Growth Data and Health Records

Most dairy replacement calves are housed in individual hutches during the first weeks of life. The main purpose of housing calves individually is to minimize spread of diseases and facilitate control of starter intake. The implementation of optimized management practices that reduce the spread of diseases or build calf immunity to fight pathogens when calves are grouped is especially important in contract heifer operations where animals from different origins are commingled. Reducing morbidity can be accomplished by: 1) reducing the amount of stress the calves undergo (stress induces immune-depression) and 2) maintaining a high level of hygiene and minimizing microbial load in the environment. To minimize the stress associated with weaning, it is commonly recommended to keep calves individually housed for an additional 1 or 2 wk following weaning. However, a study conducted at the University of Minnesota (Ziegler et al., 2008) compared performance of calves that were weaned and immediately moved to groups of 10 animals with those weaned and kept in individual stalls for an additional 14 days; the study reported no differences in performance during the first 112 days following weaning. A more recent study (Bach et al., 2010), involving 320 calves, reported that calves moved to groups immediately after weaning reached the target BW 6 days earlier and experienced a lesser incidence of respiratory afflictions and had a greater ADG than those grouped 6 days after weaning.

In a second experiment, Bach et al. (2010) used 240 female calves to assess the impact of grouping animals before weaning on ADG and health. Half of the calves were moved at 49 days of age (when milk replacer was reduced from twice to once daily dose) to superhutches holding 8 calves with an elevated trough that was used to continue delivering milk replacer until weaning; and the other half remained individually housed for an additional week after reducing the milk replacer offered from twice to once daily dose. Calves grouped at 49 days of age had a greater ADG and BW at 56 days of age as a result of a greater total solid feed consumption compared with those grouped at 56 days of age. In addition, calves grouped at 49 days of age had a lower number of respiratory cases than those grouped at 56 days of age. A common pitfall reported in many studies using enhanced-growth feeding programs is that calves struggle at weaning, and ADG during the week following weaning is reduced more than half compared with that achieved before weaning (Jasper and Weary, 2002; Terré et al., 2006), mostly as a consequence of the low starter intake during the pre-weaning period. Taking advantage of social facilitation to foster intake may prove to be an effective tool to ease the weaning process. Therefore, moving calves from individual hutches to groups coinciding with the reduction of milk replacer to one daily dose may be preferred over reducing milk replacer while calves are individually housed.

Another interesting aspect of using on-farm data involves deciding how to group calves when moving them out of individual hutches into groups. For example, a study conducted in Spain involving 140 female Holstein calves (BW 160 lb) from a commercial contract heifer operation (Rancho Las Nieves, Mallén, Spain) were assigned at the age of 2 mo into different groups of 8 calves based on their previous history of respiratory afflictions. Within each period, 2 super-hutches (20 x10 ft) comprised 8 calves with no record of previous respiratory problems (Low), 2 super-hutches were composed of 6 animals with no previous record and 2 calves that previously had an episode of respiratory problems (Medium), and 2 super-hutches housing 5 calves without a history of respiratory disease and 3 calves with previous respiratory afflictions (High). At time of grouping, none of the calves had a respiratory process. The incidence of respiratory afflictions was lower (P < 0.01) when calves that had no previous history of respiratory problems (3.7 cases/hutch) formed single groups after weaning than when 2 calves with previous history were mixed with 6 calves with no previous records (5.2 cases/hutch), and than when 3 calves with previous cases of pneumonia were mixed with 5 calves with no previous history (8.8 cases/hutch). When calves that had at least one respiratory episode prior to weaning were present in a group of 8 calves after weaning, the average time elapsed between commingling the animals and the appearance of the first respiratory case (10.8 days) was lower (P < 0.05) than when the group was formed with animals that never experienced a respiratory problem (17.9 days). Calves in the groups with no previous history were the ones with the numerically lowest initial BW. Nevertheless, the lower (P < 0.01) incidence of respiratory cases observed with these groups of animals resulted in the greatest (P < 0.05) ADG, followed by those groups formed with 2 animals with a previous history and 6 with no previous cases. Thus, forming groups of animals considering their previous respiratory history may minimize the incidence of overall respiratory cases.

Data Regarding Variation

An important goal when managing heifers is reducing variation. In this regard, there are two practices, among many others, that can be implemented: 1) manage the feed bunk, and 2) manage the animal composition of the different pens. For instance, the order of feed distribution may affect within-pen variation. Figure 1 shows how the coefficient of variation **(CV)** of ADG of different pens holding the same number of animals of similar ages increases following the same direction with which TMR is distributed in the feed bunk. The last pens receiving the TMR are the ones with the greatest CV. The increase in CV is most likely linked to weighing out errors. As the operator unloads feed in the feed bunk, unloading errors from the first pens accumulate in the last ones, resulting in excessive feed offered at some days and insufficient feed offered on the others. This variation could be overcome by alternating the order at which the TMR is unloaded every day.

Regarding pen composition, a recent study conducted in Idaho (Matuk et al., 2010) evaluated the effects of grouping calves post-weaning according to pre-grouping feed intake on animal performance using 752 replacement Holstein calves. Calves were classified as 2 high eaters2 (highest feeding level quartile) and 2 low eaters2 (lowest feeding level quartile) according to their individual feed intake during the last 3 wk that calves were individually hutched (until 56 days of age). When leaving the individual hutches, calves formed 6 groups: 20 animals randomly chosen without considering their level of feed intake (Control), 20 calves within the highest quartile of feed intake during the 3 wk prior to leaving the hutches **(HH)**, 20 within the lowest quartile **(LL)**, 5 calves from the lowest and 15 from highest feeding level **(LHH)**, 15 calves from the lowest and 5 from highest feeding level **(LLH)**, and 10 calves from the highest and 10 from lowest feeding level **(HL)**. Average DMI and ADG after grouping were greatest for HH and HHL, followed by Control, LLH, and LL. The CV of final BW (at 84 days of age) was lowest for HH and LL, followed by Control, LLH, HHL, and HL. Therefore, grouping calves according to pre-weaning intake improved overall animal performance and diminished variation.

Similarly, in large heifer operations, regrouping and moving animals is a common management practice used to ensure that the target weights and heights of heifers are met. But, calves and heifers establish social bonds among one another, and thus regrouping animals could cause some disruption of the social structure of the groups. However, Gupta et al. (2005) reported no differences in performance of 14-mo-old steers kept in pens of 6 animals that were re-grouped repeatedly, and Veissier et al. (2001) showed that calves adapted very well to repeated groupings. Bach et al. (2006) conducted a study that evaluated the effect of delaying a heifer that did not reach a specific target BW at each specific age, and keeping the animal in the same pen, but its cohorts moved up to the next group size pen, mixing the delayed animal with a new incoming group of younger heifers. Authors reported that regrouping slow-growing heifers by maintaining them in the same pen and introducing a relatively large number of unacquainted, younger, and lighter-weight animals resulted in improved ADG of the older heifers. (Figure 2).

Reproductive Data

Heifer fertility (or conception rate) usually ranges between 60 and 65%. However, there are several factors that may affect this performance. On one side, as it occurs with lactating cattle, any energy limitation will have a negative impact on reproductive performance. Poor energy availability is usually not a problem in heifers except in winter or cold season. Figure 3 shows how fertility was affected by ADG only during the cold season from a study conducted in Spain (Bach and Ahedo, 2008). Animals that were able to grow rapidly during the cold season had excellent fertility, whereas those growing slowly during the cold season showed a drastic decline in fertility. This was most likely due to an energy limitation in animals with relatively low dry matter consumption that was not sufficient to cover the energy needs for growing, maintenance and counterbalancing the cold conditions (Bach and Ahedo, 2008).

Another factor that may compromise heifer fertility is social stress. Heifers are commonly kept in pens and moved to a breeding pen around insemination time. This change of pens and social acquaintances may cause social stress to the animal, and this may in turn have a negative impact on reproduction. Figure 4 shows how fertility of heifers that were bred within 5 days after a pen movement was lower than that of heifers that were bred after 5 days since a pen movement. Therefore, it is recommended to move heifers to a breeding pen well ahead of the planned age for first insemination.

Monitoring Nutrition and Feeding

Feeding costs are the highest contributor to total costs associated with heifer rearing. Therefore, small improvements in feed conversion result in relative large savings. For this reason, it is important to continually monitor actual intakes and adjust the nutrient density of the ration to the maximum planned intake of the animals. For example, a diet with an energy density of 1.16 Mcal of metabolizable energy **(ME)**/lb, formulated to provide 25.5 Mcal of ME/day because the expected dry matter intake **(DMI)** is 22 lb/day could be reduced in cost per pound if the actual DMI of the animals was 23 lb/day because the energy density of the ration could then be reduced to 1.11 Mcal of ME/lb to continue supplying the same nutrients to the heifers. To apply this type of change in the ration, it is necessary to monitor feed intake by recording daily offers and refusals. When this feed monitoring system is implemented, in conjunction with routine observation and weighing of heifers, it is possible to feed to attain maximum growth while minimizing feed costs without over-conditioning the animals.

Recently, there has been some emphasis on limit-feeding heifers to improve feed efficiency and avoid potential fattening. Hoffman et al. (2007) suggested that limit-feeding a diet with a nutrient density greater than normal (to ensure provision of all nutrients required) to bred heifers could be an alternative to control over-conditioning and improve feed efficiency. In fact, Zanton and Heinrichs (2007) limit-fed young (290 lb) Holstein heifers for 35 wk a diet containing 25% forage and compared these heifers with similar ones receiving a greater allocation of a diet containing 75% forage. The authors observed no differences in ADG or skeletal growth between heifers in both groups. However, as the nutrient density of a ration increases, its cost per pound also increases. It is expected that 1 lb of a limit-fed ration, with a greater nutrient density than a regular ration, to be typically more expensive than that of the regular ration. Thus, a limit-feeding system is only economical if the increase in the unit cost of the ration is offset by the expected decrease in DMI. Another concern with limit-feeding is that it may potentially compromise future intake and thus milk yield. But, the study by Zanton and Heinrichs (2007) illustrated that future milk production of animals limit fed to 11.7 lb/day (11%) with respect to 13.1 lb/day did not differ (an 11% feed restriction). However, heifers of that age could be eating as much as 14.5 lb/day, and thus the "control" group was also "limit-fed" and more studies are needed that compare intakes around 14.5 lb/day with ≤ 13 lb/day.

Setting Goals

The most common objective of raising Holstein dairy heifers is to have a first-calf heifer at about 22 months weighing about 1550 lb (or about 1380 lb post-calving) before calving. Considering that Holstein calves are born with about 88 lb of BW, then an overall ADG of about 1.87 lb/day should be targeted. However, this overall average can be achieved with many different growth curves (i.e. growing slowly early in life, then fast, then slow again....), and setting ADG goals should take into account several aspects, such as feed efficiency at different ages, feeding costs, and biological consequences of the established growth rates. Heifers are much more efficient at young ages than around and after puberty. Thus, it would seem logical to attempt to grow heifers at a high ADG early in life. However, in the field, there is a generalized concern about excessively rapid growth of heifers. This concern comes primarily from one study (Sejrsen et al., 1982), involving 10 heifers and two levels of nutrition during the prepubertal period, in which heifers that grew at a rate of 2.86 lb/day had lower secretory cells than those that grew at a rate of 1.43 lb/day. There are also some other studies that have reported decreases in milk yield when applying rapid ADG to heifers (Swanson, 1960; Gardner et al., 1977; Little and Kay, 1979; Van Amburgh et al., 1998; Radcliff et al., 2000), but there are also several studies that reported no change in milk yield (Lacasse et al., 1993; Hoffman et al., 1996; Radcliff et al., 1997; Waldo et al., 1998) and others that reported an increase in milk yield (Peri et al., 1993; Stelwagen and Grieve, 1992). Recently, Daniels et al. (2009) evaluated the effect of ADG (ranging from 1.43 to 2.09 lb/day) on mammary development and concluded that BW and age are the most important factors affecting mammary development, with rate of growth having a minimal impact. The analysis of a dataset including data from 900 heifers raised in a contract heifer operation in Spain and followed into 3 different dairy herds revealed no negative relationship between ADG during the prepubertal phase (with ADG ranging from 0.81 to 2.47 lb/day) and future milk yield (Bach and Ahedo, 2008). In fact, a significant positive relationship between ADG and total milk yield during the first 305 days in milk **(DIM)** of the first lactation was found, with the fixed part of the model accounting only for 5% of the observed variation in milk yield (Figure 5), although the complete model (considering the random effects) was able to explain about 25% of the observed variation in milk yield. A recent study (Soberon et al., 2009) that evaluated the relationship between ADG and future milk yield of 792 heifers reported results coherent with those reported by Bach and Ahedo (2008), although Soberon et al. (2009) reported that ADG could account for a significantly greater proportion of the observed variation in future milk yield than in the current study (25 versus 5%, respectively). It could be concluded that growth above 1.76 lb/day during the prepubertal phases can be obtained without compromising milk yield, and that if a change in milk yield were to occur as a consequence of an ADG above 1.76 lb/day, it would most likely be a modest increase unless over conditioning occurred.

The MBW has been proposed as a measure to target weights for growing heifers (Van Amburgh and Meyer, 2005; Hoffman et al., 2007). Current recommendations indicate that optimum BW at breeding and after first calving to maximize milk yield should be 55 and 82% of the MBW of that animal, respectively (NRC, 2001). Using this concept, heifers should be bred at the target age with different BW (depending on their projected mature body size). Although the MBW of current mature cows (3rd lactation) in the herd could be used as a proxy to estimate future MBW of current growing heifers, there are several factors that influence MBW, and thus, MBW might have changed over the past 4 to 5 years (time needed for cows to reach their MBW). In addition, the use of MBW presumes that genetic variability among animals is low, but Hansen et al. (1999) illustrated that there is a large variation in MBW within the Holstein breed. An alternative method to predict MBW could be based on nonlinear modeling. A nonlinear mixed-effects model based on the Gompertz (1825) growth model was fitted to describe the evolution of BW across age using data from birth to 2 mo. before calving (about 650 days) from 1,820 heifers. This model allowed to estimating MBW based on BW between 0 and 250 days of life with an R^2 of 0.68. An example of this prediction is shown in Figure 6. A dataset including data from 650 heifers tracked into their first lactation where breeding BW as a percentage of predicted MBW of 647 heifers ranged from 51.0 to 64.5%, with an average of 57.7%, was used to determine optimum body size at breeding. The results from a mixed-effects model that combined the effect of MBW and BW at breeding (as a % of MBW) on future milk yield revealed that the greater the MBW, the greater the milk yield. However interestingly, there was an interaction (Figure 7) between MBW and BW at breeding (as a % of MBW) that implied that small heifers had the greatest milk yield when bred at about 55% of the predicted MBW, whereas as MBW increased, BW at breeding closer to 60 than to 55% of the predicted MBW resulted in the greatest future milk yields.

Conclusions

Recommended growth and age targets for heifers are not commonly attained in practice, mainly due to a lack or insufficient information available to the producer to make appropriate management, reproductive, and nutritional on-farm decisions. Putting systems in place that facilitate accurate recording of at least BW, height, and DMI may prove to be very profitable. The use of the data generated by these systems may allow concluding, for instance, that emphasizing management and cleanliness may actually be more effective than checking SP concentrations in calves in terms of minimizing health problems. Or, it could also illustrate that moving calves from individual hutches to groups, coinciding with the reduction of milk replacer to one daily dose, may be preferred over reducing milk replacer while calves are individually housed. Also, variation can be effectively reduced by considering previous respiratory history or intake levels of calves when comingling animals in groups. Another example would be improving reproductive performance by moving heifers to a breeding pen well ahead of the planned age for first insemination.

Collected data may also confirm that ADG during the first 2 mo. of life is positively correlated with future milk yield, and that mature BW can be estimated from BW at early ages, which may help in deciding the optimal moment to breed an animal.

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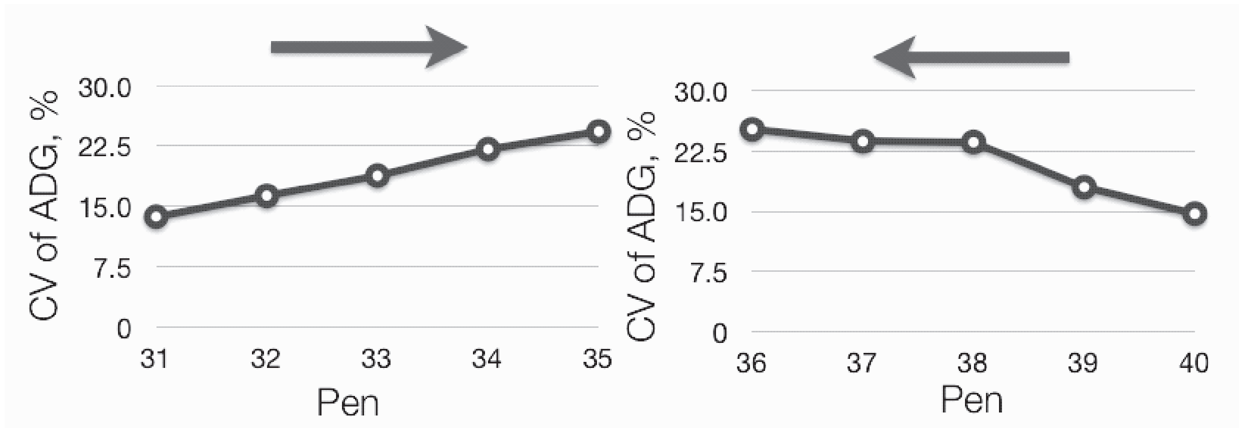

Figure 1. Coefficient of variation (CV) of average daily gain (ADG) as affected by feed delivery order (the arrows indicate feeding order).

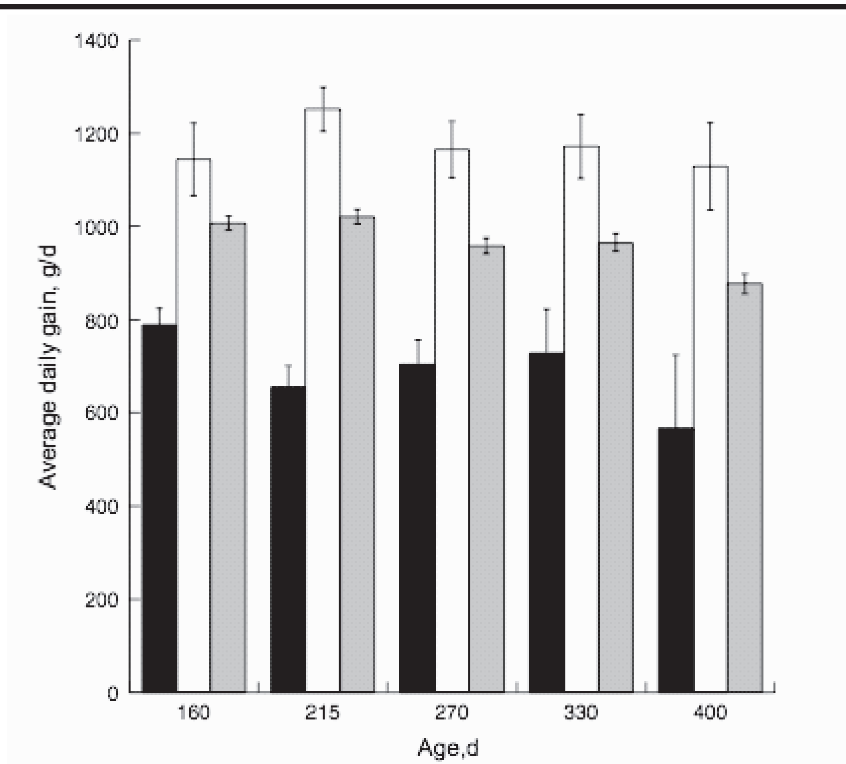

Figure 2. Average daily gain of non-delayed heifers (grey bars), and before (black bars) and after a regrouping (white bars) of delayed heifers (Bach et al, 2006).

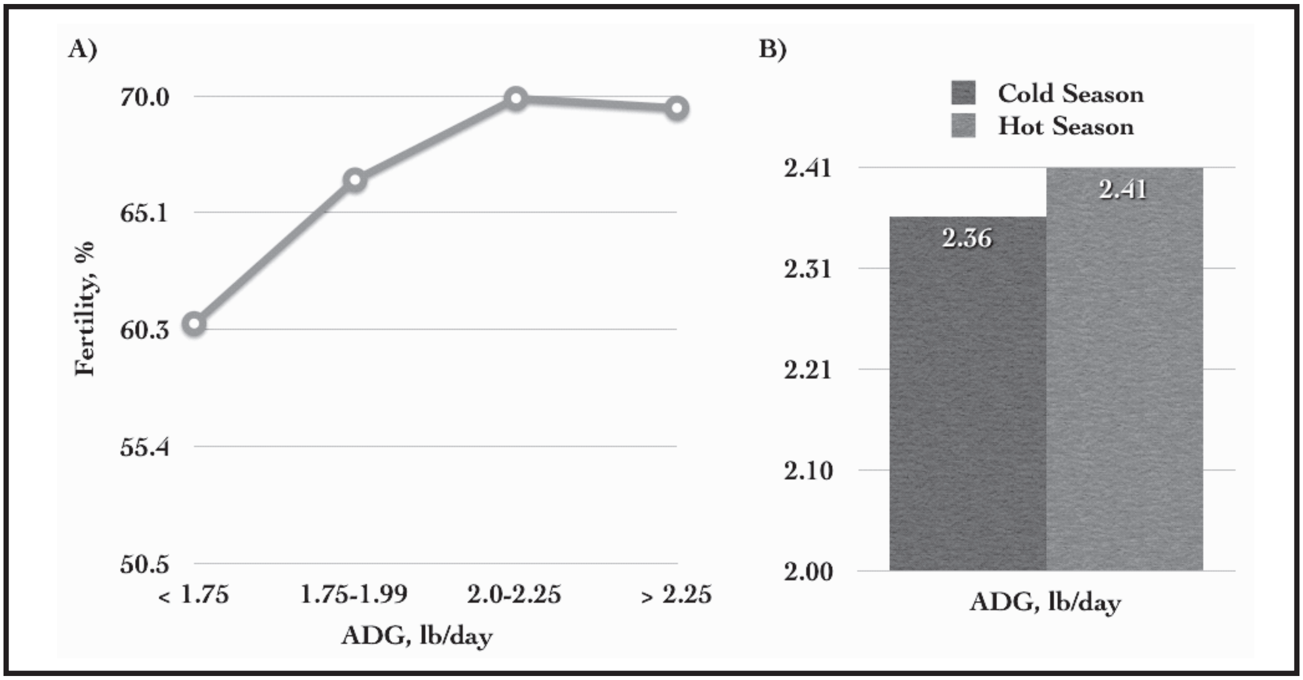

Figure 3. Relationship between fertility and average daily gain (ADG) of heifers during the cold season (Graph A)(Bach and Ahedo, 2008). There was no relationship between fertility and rate of gain in the hot season (Graph B).

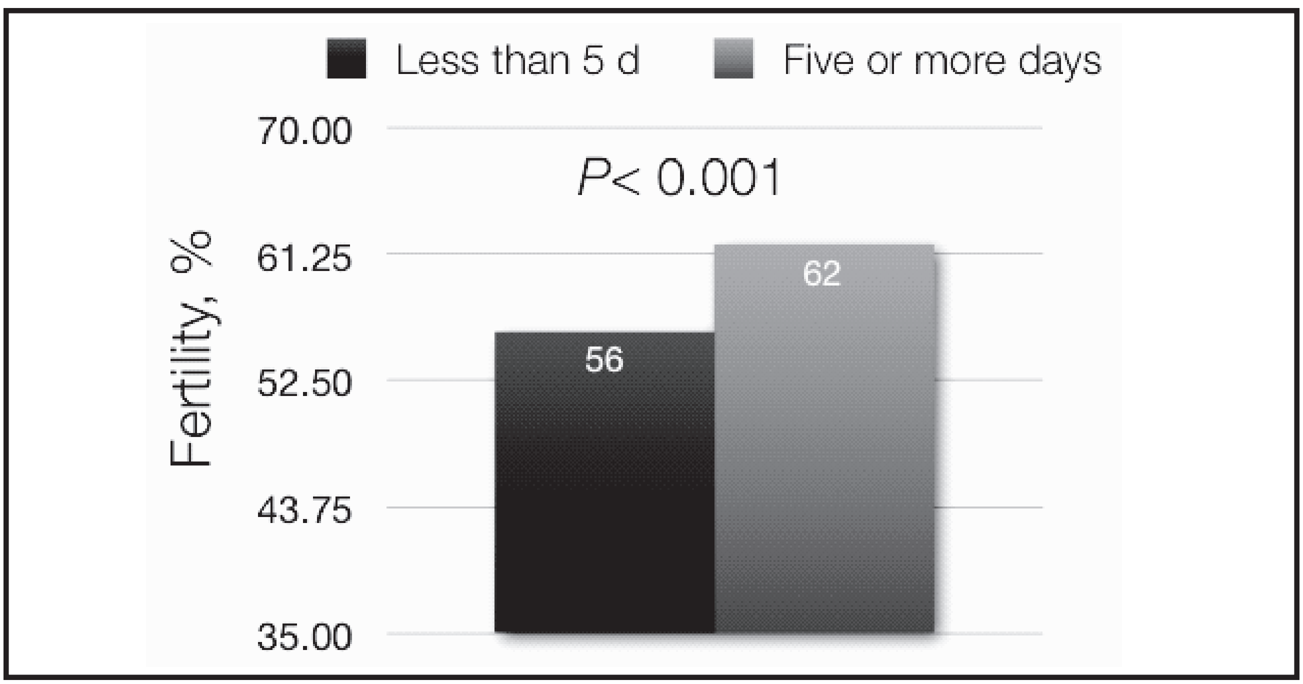

Figure 4. Fertility of heifers as affected by time of insemination after a pen movement.

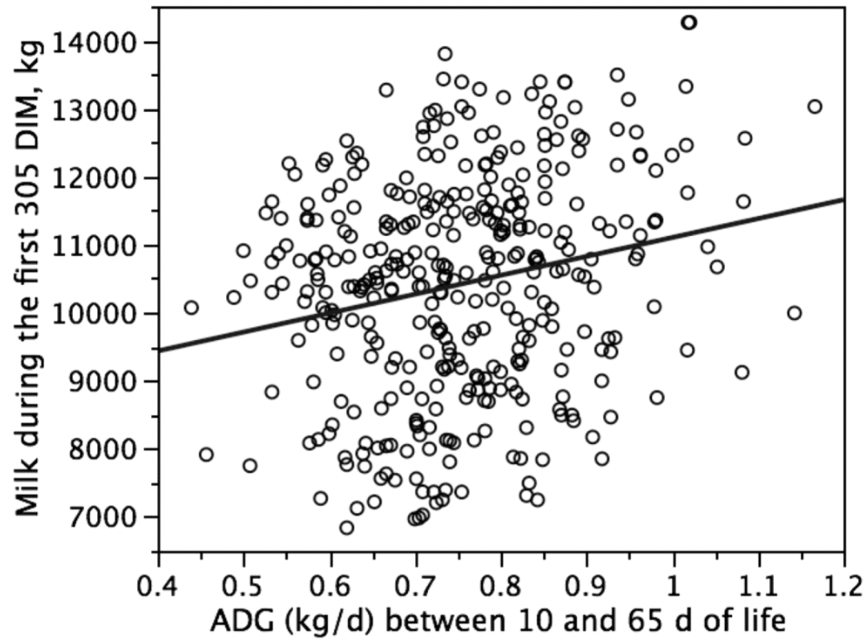

Figure 5. Relationship between average daily gain (ADG) during the first 2 months of life and milk production during the first 305 DIM of the first lactation (Bach and Ahedo, 2008).

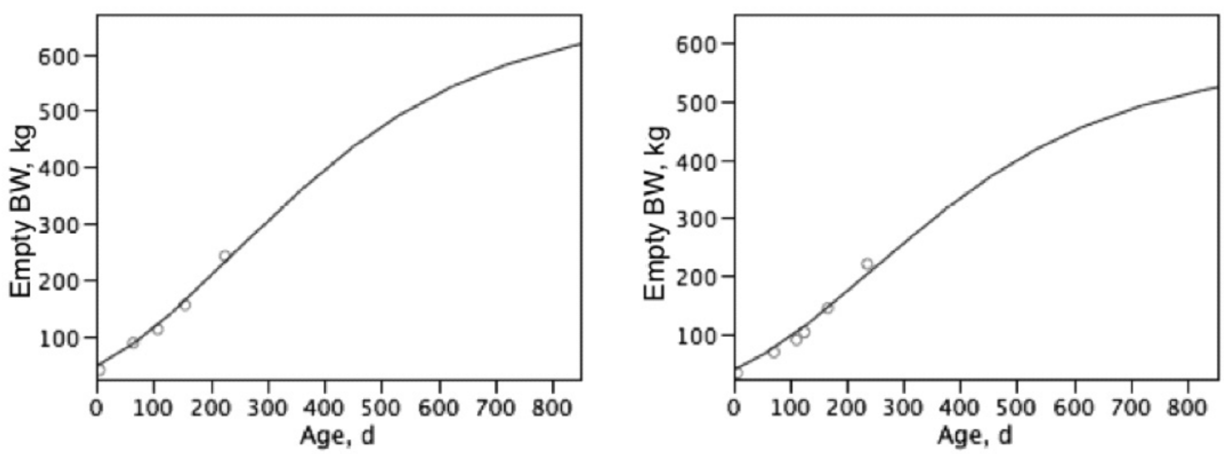

Figure 6. Prediction (solid line) of the evolution of empty body weight (BW) of 2 different heifers based on their rate of growth (circles) during the first 250 days of life using a Gompertz (1825) model.

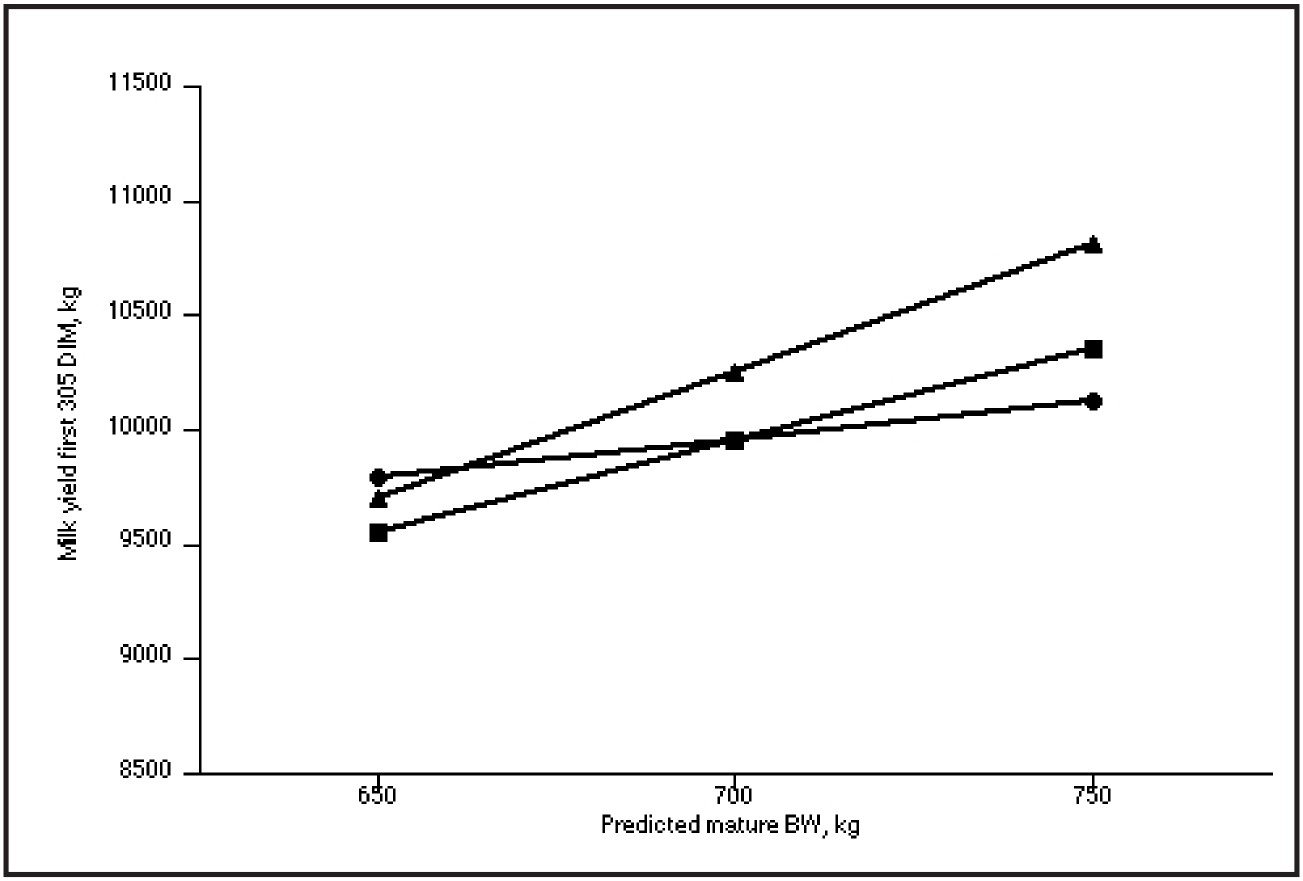

Figure 7. Interaction between predicted mature BW and BW at breeding as a percentage of predicted mature BW (circles: 55%, squares: 58%, triangles: 60%) on milk yield during the first 305 DIM, adjusted for the random effect of herd, year of calving, and season of calving.