An Economic Comparison of Conventional vs. Intensive Heifer Rearing[1]

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INTRODUCTION

Dairy replacement heifers are often viewed as simply another cost of doing business on a dairy. While replacement heifer programs usually rank as the second largest variable cost of milk production, normally trailing only feed costs, the expense associated with feeding and rearing heifers should be more properly viewed as an investment towards the future. Much like any other investment, money is spent today for a return that will not be realized until later - when the heifer calves and enters lactation.

Within the dairy heifer growing period, the highest daily expense is during the pre-weaning period and is a consequence of the liquid diet and the high labor costs associated with liquid feeding. As a result of the high up-front costs, many producers adopt management and feeding strategies that appear to save money up front, but result in diminished performance and greater lost opportunity costs in the future.

Conventional wisdom regarding the feeding of neonatal calves has been that one should slightly limit or restrict the caloric intake from the liquid diet in an effort to stimulate consumption of calf starter. The belief is that hungry calves will begin consuming starter grain earlier and in larger amounts than if early liquid nutrition is sufficient to meet or exceed their daily needs. However, while it is true that feeding larger amounts of starter grain costs less than milk or milk powder as traditionally fed, dairy producers that choose this approach typically fail to capitalize on the tremendous growth efficiency that young calves possess, if fed adequately, and they usually will see much higher morbidity and mortality in the young calves.

Our clinical impressions from working with many different calf programs suggest that there is often greater variability in growth and performance across a population of calves when a restricted milk feeding approach is used. When calories from milk are limited, as in a typical conventional feed approach, there is a greater potential for environmental stress induced morbidity and mortality. Also, calves that are slower in transitioning to benefiting from a functional rumen are at more of a disadvantage when reared in a conventional rearing approach.

The typical dairy that follows a conventional approach feeds a milk replacer that contains 20 - 22 % protein and 15 – 20 % fat at the rate of about 1 lb of milk solids/d (DM basis). Under thermoneutral conditions, this level of milk feeding allows approximately 200 g of body weight gain/d for a 90 lb calf; but during more stressful conditions such as cold, windy, or wet weather, results in a state of semi-starvation (Quigley III, 2001). Calves fed these traditional diets often suffer from significant weight loss or stunted growth during these times of environmental stress. Additionally, there are often outbreaks of diarrhea at 7 - 10 d of age and pre-weaning respiratory diseases that are caused (or at least worsened) by a compromised immune

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system and inadequate caloric and protein intake.

A major complicating issue to the conventional approach is the low protein content of the calf starter. The marginal level of calories serves to stimulate earlier and higher levels of starter grain consumption and can allow producers to wean calves at an earlier age, but these calves often crash afterward because of the low protein content. Remember, even if a conventionally reared calf increases its consumption of starter grain and is consuming the identical level of crude protein as a calf on a diet that provides a higher level of milk volume and/or solids, the digestibility of the two diets is different. Milk and milk replacer is generally more digestible than the proteins commonly found in most calf starters. Calves on a conventional diet usually have smaller frames and often have health issues that follow them through the remainder of the growing phase and into lactation. Also, with conventional rearing systems, the age at first calving may be between 25 and 28 mo and the impact is often a large delay in positive cash flow (milk production), requiring a greater number of youngstock to fill the gaps created by culling poor producing animals.

Intensive management programs have begun to receive a lot of attention in the last few years. These programs involve the feeding of rations that are higher in metabolizable protein without enough extra energy to promote fattening (Corbett, 2010; Soberon et al., 2012; Stamey et al., 2012; Van Amburgh, 2011; Van Amburgh et al., 2008, 2009). During the milk feeding period, calves are provided with larger volumes of more nutrient dense milk or milk replacer. Typical formulations are 28 % protein and 18 - 20 % fat and are fed at a rate of 0.33 - 0.65 lb/L of milk solids with a total of 4 – 10 L of fluid volume depending upon the size and age of the calf. Feeding higher levels of nutrients will allow 1.7 to 2.5 lb/d or more of body weight gain, depending on environmental conditions and volume of milk provided. Also, the higher level of nutrients provides a greater margin of safety during stressful environmental conditions and can allow calves to withstand more of these stressors without the consequences of weight loss and spikes in morbidity or mortality.

The downside of the approach is that the feed cost during the liquid feeding period is significantly higher and calves sometimes are slow to begin eating calf starter. The increased feed costs continue through the entire replacement rearing period. As calves grow and move through the various diet and pen changes, they are provided with rations that continue to be higher in metabolizable protein than comparable conventional rations and these larger heifers eat more feed per day due to their larger body size and higher growth rates. However, these well-fed heifers usually experience the advantage of a reduction in both morbidity and mortality, reduced impact of cold weather stress, an earlier age at first service and first calving, and improved feed efficiency since total days on feed is reduced but rate of gain is increased. In addition, there should be a reduction in the number of heifers required to enter the replacement stream since fewer animals are lost during the rearing process. Finally, there is the large economic advantage of higher levels of milk yield during the first and subsequent lactations that is the result of improved nutrition and management as heifers (Soberon et al., 2012).

ECONOMIC MODELING

A partial budget was created using Microsoft Excel® and the objective was to model and compare a conventional heifer rearing program with an intensive program from birth through calving. The model is divided into age groups based on feeding, housing, and management needs and consists of six different stages:

1) birth to 2 mo of age,
2) 2 to 4 mo of age,
3) 4 to 10 mo of age,
4)10 mo through breeding,
5) gestation, and
6) the last 2 mo prior to calving.

During all but the final stage, there are significant differences in nutrient composition, quantity consumed, and cost of feeds. During the final stage, there are no significant differences in nutrient composition, but there are still large differences in level of feed intake based on the difference in size of heifers between the two management approaches. One primary difference is the age at which the intensive heifers exit the fourth stage and enter subsequent stages when compared to conventionally reared heifers. Many management issues, such as vaccination protocols and housing needs are not different between groups; but are included in the model in order to more accurately calculate the true cost of heifer rearing.

The major management difference between the two heifer rearing approaches is the nutrition program. Throughout all but the final stage, intensively reared heifers receive rations that are higher in metabolizable protein, yet similar in energy density. As a result, the projected growth curves of the two groups are assumed to be different. The growth curve for the conventional program is based on data collected by Coleen Jones and Jud Heinrichs from Penn State University and was fit to mimic the growth characteristics of the median of the population (Jones and Heinrichs, 2004). The growth curve for the intensive program was fit from data collected by Dr. Robert Corbett from an intensively managed herd in the western U.S. This particular herd has been following the nutritional advice of Dr. Corbett and has fed for an intensive rate of gain for a number of years. The growth curve for each approach was derived by selecting the best fitting polynomial regression equation for each data set.

In stage 1, calves in both groups are assumed to weigh 88 lb at birth and are fed 3 L of colostrum at birth and again within 12 h. All calves are housed in individual fiberglass hutches and have free choice water and calf starter available beginning at 3 d of age. Calves in the conventional group receive 4 L/d, divided into 2 feedings, of 20 % protein, 20 % fat (DM basis) milk replacer containing 0.26 lb/L of milk powder of final volume. Calves receive the same amount of milk daily for 7 wk and then they are weaned from liquid feeding. Calf starter contains 18 % crude protein (as fed basis) and initially, the amount consumed per day is only a trace amount, but increases over time such that over the 7 wk liquid feeding phase, starter grain intake averages approximately 2.3 lb/d. For the final 2 wk of stage 1, conventional calves consume an average of 4.4 lb/d and by 63 d, these calves are projected to weigh 155 lb.

In the intensive group, calves are fed a 28 % protein, 20 % fat (DM basis) milk replacer containing 0.34 lb/L, but the volume fed varies over time. During the first week, calves are fed 4.8 L/d, but over wk 2 -

6, calves receive 6.7 L/d. With higher levels of liquid feeding, calves often do not consume as much grain starter and in order to encourage adequate consumption of grain prior to withdrawing milk completely, calves are cut back to half of the milk replacer volume for the seventh and final week of liquid feeding. The calf starter for this group contains 22 % crude protein (as fed basis) and costs more than the conventional starter. As with the conventional feeding approach, calves do not usually consume significant amounts of feed during the first week of life, and due to the higher nutrient intake from the intensive approach throughout the milk feeding period, these calves only consume about 0.8 lb/d of starter, on average during wk 2 - 7. However, with the reduction in milk feeding during wk 7 and the increasing body weight, starter intake increases and for weeks 8 and 9 in the hutch, grain intake increases to about 3.8 lb/d.

It is worth mentioning that in both the conventional and intensive approaches, weaning should occur once calves are eating sufficient dry feed to make a successful transition from the liquid diet to a grain-based diet. Standardizing the weaning time is necessary to accurately model the costs and opportunities associated with each approach. Upon exiting the first stage at 63 d, these calves are projected to weigh 192 lb after achieving an ADG of 1.1 and 1.7 for conventional and intensive, respectively.

Another key difference within stage 1 between the two approaches is the projected morbidity and mortality estimates. With conventional feeding and management, 40 % of calves are projected to experience a case of diarrhea and 35 % are expected to be treated for pneumonia. These morbidity estimates are the result of blended estimates from NAHMS 2007 data and from clinical experience. The mortality risk for this pre-weaning period is 7 %. Due to improved nutrition, the intensive calves only experience 20 % diarrhea risk and 18 % pneumonia risk with a period-specific mortality risk of only 3.5 %. Due to a reduction in respiratory disease in the first 2 mo, the intensive group is projected to experience a reduced incidence of pneumonia over subsequent stages and an overall mortality risk of 7 vs. 12 % in the conventional group for the entire rearing period.

At 63 d of age, calves move into the second stage and are moved into small group pens and fed a ration consisting of mostly grower grain with about 10 - 15 % good quality hay. The intensive group's grower grain is higher in crude protein and costs more per kg of dry matter than the conventional grain. Calves enter this stage weighing 155 lb and 192 lb for conventional and intensive, respectively, and in 2 mo, with an ADG during this stage of 1.9 and 2.2 lb/d, weigh 266 and 320 lb. The predicted DMI/d is a function of body weight and energy density of the ration and is estimated using the Nutrient Requirements of Dairy Cattle (NRC, 2001).

Calves move into larger group pens and are fed a total mixed ration (**TMR**) beginning at 4 mo. This move is the beginning of the third stage and it lasts until 10 mo. Due to higher protein levels, the intensive group's TMR costs more, and these calves eat more based on a larger body weight and frame. At the end of this stage, calves have achieved an ADG of 1.8 and 2.1 lb/d and weigh 588 and 705 lb for conventional and intensive groups, respectively.

The fourth stage is the period that encompasses the breeding period. Heifers enter at 10 mo of age, but the time at which they leave depends primarily upon when they reach the desired breeding height/weight and then successfully complete the breeding program. Both groups are eligible for breeding at 825 lb of body weight, but due to a faster rate of growth, the intensive heifers start breeding at an average of 12.2 mo of age while the conventional heifers begin breeding at 15.1 mo. Both groups are eligible for breeding for eight 21-d cycles and there is no difference in reproductive performance assumed between the two groups. The overall insemination risk is 65 % and the overall conception risk is 50 % for both groups. The average heifer conceives approximately 45 d after entering the breeding program and is confirmed pregnant 45 d later, when she is then moved into the next rearing stage. Approximately 6 % of the heifers that enter the breeding program are culled for failure to become pregnant. Thus, assuming equal reproductive performance between the two programs, the total length of time in this stage is dependent upon the time required to reach breeding weight, since the time required to become pregnant and the time required before pregnancy can be confirmed as the same. Conventional heifers leave this stage at an average of 18 mo having achieved an ADG of 1.5 lb/d and now weigh 966 lb; while the intensive heifers leave at 15.1 mo weighing 1017 lb with an ADG of 2.0 lb/d.

The fifth growth stage contains the pregnant heifers and lasts for 5 - 6 mo. The ration for the intensive heifer group continues to be higher in metabolizable protein and there is a corresponding difference in cost per pound of ration dry matter. The intensive heifers' daily feed cost continues to be higher due to the higher level of feed intake and the higher cost per pound.

Heifers are moved into the final group at 1 - 2 mo prior to calving weighing 1195 lb and 1347 lb for conventional and intensive, respectively, and the ration composition and cost is the same for both groups during the sixth and final stage. The major cost difference in this final month is the different level of feed intake predicted due to the difference in body weight. Conventional heifers are predicted to calve weighing 1267 lb while the intensive heifers should weigh 1459 lb. Over the course of the total rearing period, conventional heifers achieve an ADG of 1.5 lb/d while the intensive heifers realized an ADG of 2.0 lb/d.

Throughout each of the cycles, a variety of costs are assigned to the heifers other than feed costs and reproductive management fees. Specific costs that are included in the model include the upfront purchase cost of each heifer; the feeding, housing, equipment, reproductive management, labor, and health management costs of each heifer; and the interest or opportunity costs. All costs, including the costs attributed to the rearing expenses of the calves that die, are adjusted to the net present value expected at calving using a preset interest rate of 6 % and are distributed over the heifers that actually survive to calving. In other words, all expected costs for every calf that enters the rearing enterprise is redistributed over the surviving heifers. Thus, heifers from the conventional system that survive and calve carry more interest and mortality costs due to the longer time to calving and the higher mortality associated with this group. There is an initial investment cost per calf that is assumed to be the same between groups and the final investment cost is also time adjusted to the time of calving.

One benefit of intensive heifer programs that has been summarized by Van Amburgh and by Soberon et al. is the potential for increased milk production in the first lactation (Soberon et al., 2012; Van Amburgh, 2011). Heifers reared via an appropriately managed intensive approach are projected to produce an extra 1700 lb of milk during the first lactation. The model incorporates the extra milk as a source of value for intensive heifers, but makes adjustments for the returns that will occur in the future and for culling that occurs during the first lactation.

RESULTS AND DISCUSSION

Throughout each growth stage, the intensive system costs more per day, as shown in Figures 1 and 2, but the conventional system results in a higher total cost per heifer due primarily to the longer feeding period. The total rearing cost is estimated to be $2294 and $2290 for conventionally and intensively reared heifers, respectively. The $4 advantage for intensive rearing does not include the value of the extra milk predicted in the first lactation for the intensive heifers. After accounting for the delayed return for the extra milk production (after calving for first time), for the additional feed cost associated with the extra milk, and for the impact of culling during the first lactation, the net value per heifer is estimated to be $195 as shown in Table 1.

Figure 1. Cumulative costs throughout the heifer rearing period for conventional vs. intensive dairy heifers.

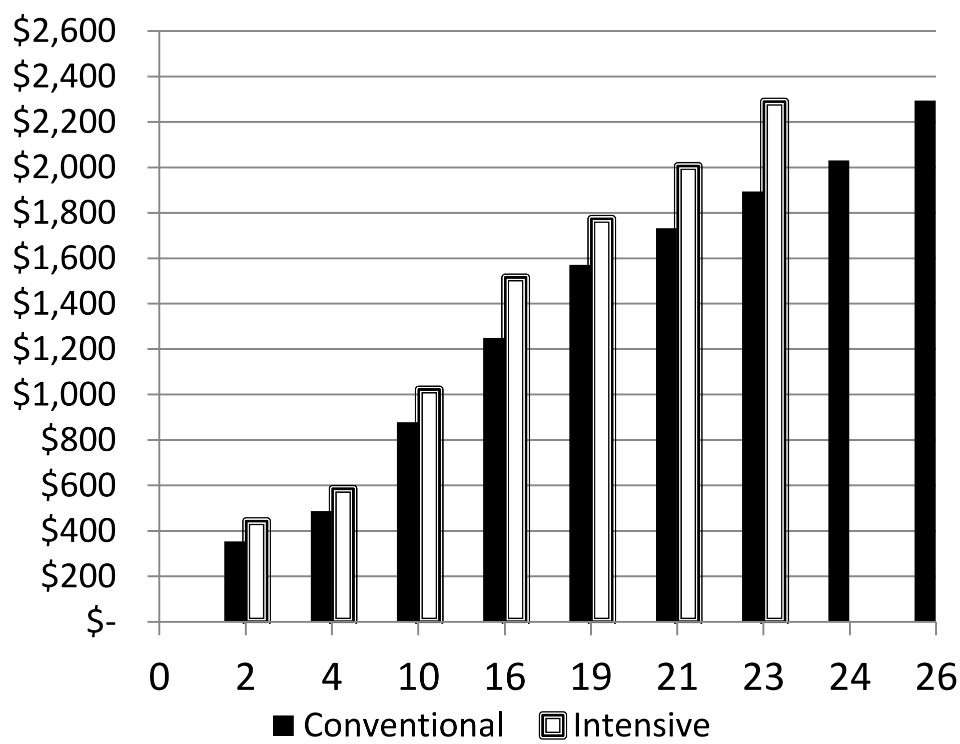
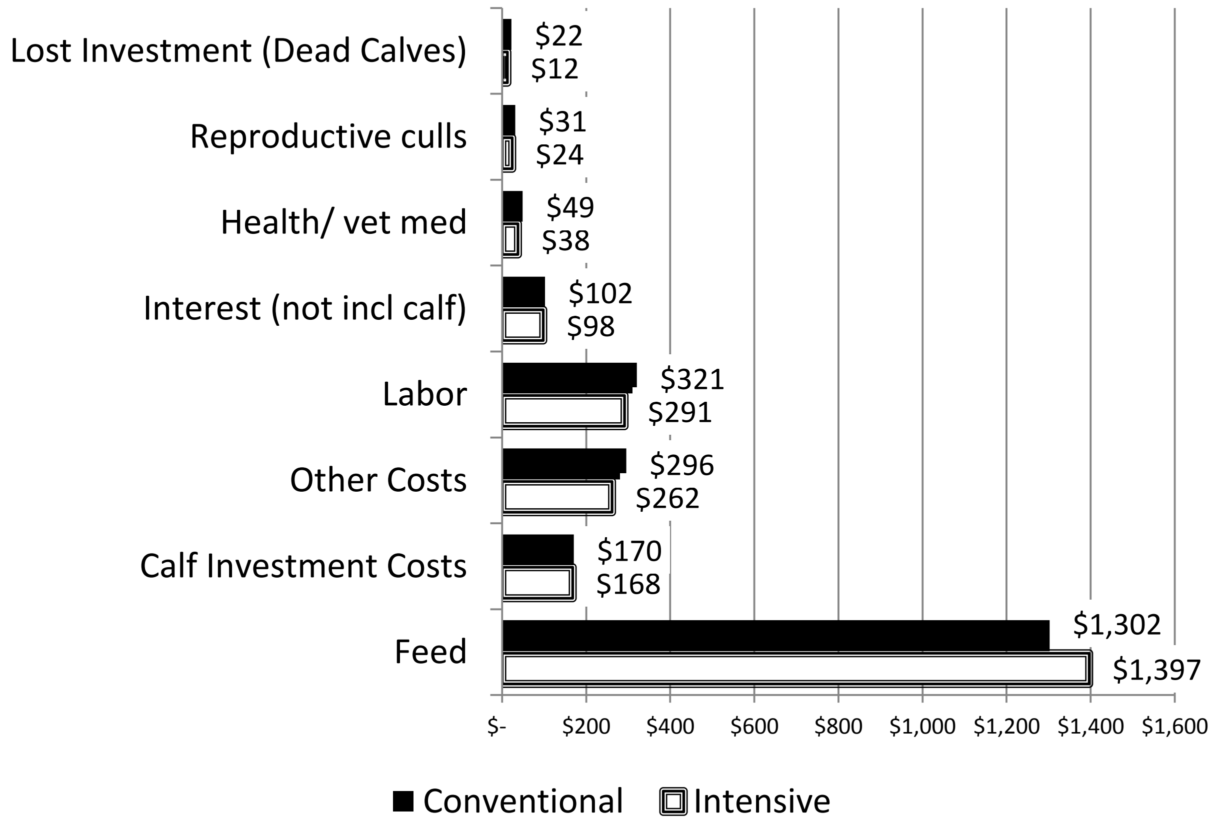


Figure 2. Total costs for conventional vs. intensive heifer rearing by category for the entire rearing period.



Based on the assumptions used in this model, the intensive approach results in $94 higher feed costs, but results in savings in all other areas:

- labor savings, $29;
- health and veterinary medicine cost savings, $11;
- interest cost savings, $4;
- reproductive cull cost savings, $7;
- dead or culled calves savings, $10;
- a net benefit in calf investment cost, $3; and
- a savings in housing costs, $34

for a net result of a *savings* (or reduction in net cost of rearing) of $4 per calf for the intensive program, not including the value of the additional milk. Addition of the predicted time-adjusted value of the extra milk results in a total economic advantage of $199 for the intensive program.

Within this model, attempts have been made to represent the true estimated costs and returns of each program as carefully as possible. As more systems implement the intensive heifer rearing approach, more data will be generated to help validate this model. Many people will likely be surprised at the total estimated cost of rearing heifers in either system, but this model reflects the current high feed costs that many have not considered over the entire rearing period.

A ***key take-home message*** from this work is that while the individual cost per day may be higher, capitalizing on improved growth efficiency that is possible with higher metabolizable protein rations, especially early in the growth and development of calves, results in a lower cumulative cost that is realized at calving due to a greater level of efficiency of growth and fewer total days of rearing.

Many people are skeptical of the projected increase in milk production that is attributed to the intensive program. However, the literature actually shows increased milk production not only in the first lactation, but also carrying over into the second lactation for heifers fed for intensive growth during the rearing period and this value is not captured by the model (Van Amburgh, 2011). Even without the projected additional milk in the first lactation, the advantage is still tilted towards intensive rearing.

Table 1. Summary of the net results for conventional vs. intensive rearing systems assuming an initial calf value of $125, interest cost of 8 %, and other previously described assumptions.

Outputs	**Conventional System**	**Intensive System**
Calf investment cost at calving	$170	$168
Age at first service	15.7	12.6
Average age at first calving	**26.3**	**23.3**
Average daily gain (lb/d)	**1.50**	**1.97**
Average cost/d	**$2.86**	**$3.24**
Number of days to calving	**801**	**707**
Total rearing cost/heifer (incl. interest + initial value + repro culls)	**$2,294**	**$2,290**
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Additional milk in 1st lactation		**1700**
Culling risk - 1st lactation	**28 %**	**28 %**
Add. milk value (1st lactation)	**$0**	**$195**
Net cost/heifer	**$2,294**	**$2,095**
Additional profit for intensive		**$199**

Another benefit not captured in the current model is the ability to either maintain fewer heifers in the replacement pipeline or to grow extra heifers for potential marketing benefits. By growing heifers faster and with reduced morbidity and mortality, fewer calves need to be placed each month in order to meet the required number for replacements each year. If additional heifers were maintained above the basic replacement needs, producers would have the luxury of either selling additional springing heifers or calving these animals and then culling more heavily from the lactating herd in order to make more rapid genetic progress. These additional marginal benefits were not considered in this version of the model; and yet the advantage is still clearly in favor of intensive rearing vs. the more conventional approach.

The model presented in this paper and its results were based on a combination of published data and from data generated on a large commercial dairy that works with Dr. Corbett. This private dairy generated thousands of calf weight (and height) data points that were used to develop an intensive management growth curve. Use of this curve allowed for the prediction of average growth expectations using specific milk and grain feeding approaches. Throughout the model, calf or heifer weight is used as the metric of choice. However, the critical unit for measurement on the farm level is actually wither or hip height. Use of body weight as the key metric was to facilitate an easier approach to modeling, since more work has been published in this area. A key underlying assumption used by the authors is that weight is used as a proxy for adequate frame growth.

However, the results presented here are quite conservative for the intensive calf rearing approach. Since this early work, Dr. Corbett has further refined his feeding approach and is now feeding even larger volumes of more nutrient-dense milk replacer and higher levels of protein in his heifer diets. As a result, Holstein calves are averaging over 2.2 lb/d of body weight gain, morbidity and mortality are substantially lower than reflected in the current model, and approximately 90 % of the calves have reached breeding weight and height by 11 mo of age. Results such as these further increase the advantage of the intensive heifer rearing program. However, even with what some would consider to be an overly conservative approach to modeling the two programs, there should be no doubt to the economic advantage of the intensive approach to rearing dairy replacement heifers.

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