Economics and Effects of Accelerated Calf Growth Programs

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Introduction

Feeding the dairy calf and heifer can be likened to a double-edged sword; we want to feed the heifers as much as possible to get rapid growth so that they begin lactating early in life, with a large body size at calving relative to their mature weight. However, there are issues related to rapid growth and a high level of feed intake that can go against the benefits and economics of such practices.

Growth and Development

As we look at dairy replacement growth, we know that the dairy heifer grows at its fastest rates in terms of body weight (**BW**) and skeletal growth from birth to puberty (Brody, 1945). For many of today's Holstein heifers, this rapid growth period extends to 8-10 months of age. At puberty, growth rates tend to decline on a percentage basis and composition of the growth shifts from predominately muscle and skeletal tissues to the accumulation of some fat (Brody, 1945).

The mammary gland also develops at a rapid rate during puberty and can be affected by animal growth rates during this time period (Tucker, 1987). Growth from weaning to puberty has been extensively studied, and a meta-analysis has shown that the optimal average daily gain (**ADG**) to grow a pre-pubertal heifer is about 1.75 lbs/d (800 g/d; Zanton and Heinrichs, 2005). At this stage heifers can gain 1.7 to 1.9 lbs/d with no appreciable losses in potential production.

Once puberty is reached, multiple data sets show that ADG does not affect milk production, as long as heifers reach an adequate size by the time they have their first calf. The goals are a BW of approximately 85% of mature BW and height at about 95% of mature stature. While data are less recent and discerning on this topic, there are supporting studies that show this effect (Fisher et al., 1983; Keown and Everett, 1986).

The digestive system of the calf is also maturing during the pre-weaning period, as the calf is maturing from a monogastric to a ruminant animal. The most notable change in the principal metabolic processes during ruminal development is the shift from a glycolytic to glucogenic liver (Baldwin et al., 2004). As the rumen begins to develop and microbial fermentation increases, less carbohydrate is available for postruminal digestion and the dietary supply of glucose diminishes. Research has shown that there is a substantially reduced rate of gluconeogenesis from lactate in

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ruminating calf liver cells, and data show a large decrease in the capacity to metabolize lactate to glucose as calves undergo rumen development (Baldwin et al., 2004). This transition results in tremendous metabolic ramifications to calf growth rate, as tissues must convert from reliance on glucose supplied from milk to the metabolism of short-chain fatty acids as primary energy substrates. Studies show that calves can effectively use propionate for glucose synthesis in the liver starting in early life (Donkin and Armentano, 1995). Once the rumen is developed, the calf can efficiently digest less costly starch- and fiber-based feedstuffs. While the most dramatic physical changes occurring during development are associated with the ruminal epithelium, changes in intestinal mass and metabolism are also happening in response to dietary changes. In addition, it has been shown that butyrate, an end product of ruminal digestion of starch, improves the development of small intestinal absorptive tissue (Gorka et al., 2011). To prepare the calf for weaning, it is important that the shift to ruminant digestion commence early in life and, once it begins, it needs to be developed at a reasonable rate to ensure efficient digestion and utilization of feedstuffs.

Factors Influencing Growth

Now, back to calf ADG as it relates to economics and production capability. If we look at what determines calf ADG, we know it is dry matter intake (liquid feeds, calf starter, and forage) and health (covering many issues that may affect the calf) (Place et al., 1998). A longitudinal calf growth study following heifers on 21 commercial farms from birth through multiple lactations (Heinrichs and Heinrichs, 2011) showed that dry matter intake at weaning positively affected first lactation milk production. Illness in the first 4 months of life had a negative effect on future milk production.

In a recent study looking at growth data across various calf nutrition experiments, the results suggest that pre-weaning growth rate is an important factor impacting future milk yield (Van De Stroet et al., 2016). After calving, heifers were categorized based on their weight and height as calves and their lactation performance was compared. In this analysis, calf starter was the primary source of differences in nutrient intake, since milk replacer was constant between the studies compared. This study showed that calves of shorter stature produced less milk in their first lactation after accounting for BW differences in the first lactation. Animals with medium BW as calves produced more milk in early lactation than those with high BW as calves, after accounting for differences in height. Calves that grew more quickly, ate more, and weighed more were heavier as first-lactation cows and as mature cows. Calves with the shortest stature had the lowest milk production potential and were the least likely to remain in the herd until first lactation. Pre-weaning ADG may be indicative of metabolic efficiency; therefore, it is possible that metabolically efficient calves continue to be metabolically efficient as adults (Van De Stroet et al., 2016).

Growth Rate and Future Milk Production

Feeding rate or nutrient intake has also been indicated as a factor that may influence first lactation milk production. In the past 5-10 years, there has been a trend for feeding more milk or milk replacer due to accounts that this practice not only supplies more nutrients needed for rapid growth, but also may allow the animal to produce more milk in their first lactation. Multiple studies have addressed this question. A recent meta-analysis (Gelsinger et al., 2016) shows results from peer-reviewed research published in the past 20 years that measured the effect of milk or milk replacer intake, calf starter intake, and ADG before weaning on milk production from those calves in their first lactation (**Table 1**). While individual papers generally concluded that there was no effect, combining them in a meta-analysis revealed some additional information. While the results did show a positive impact of ADG on first-lactation milk production, it is important that we note the overall influence of ADG as a factor affecting production was small. The calf feeding program accounted for less than 3% of the variation in first-lactation milk yield within these studies. There are many factors that can affect the health and growth of heifers and their performance in the milking herd. Regardless, feeding program did have some impact, and the importance of feeding starter along with milk or milk replacer was evident. Increasing dry matter intake from milk or milk replacer by 0.2 lb/d (100 g/d) resulted in 145 lbs (66 kg) more milk in the first lactation. The same increase in milk or milk replacer resulted in 585 lbs (139 kg) more milk when combined with a 0.2 lb/d (100 g/d) increase in intake of calf starter.

These results emphasize the importance of providing readily available energy and protein in a liquid diet alongside a fermentable solid feed that can provide the end products and nutrients necessary to stimulate rumen development. It is important to ensure that nutrient requirements for maintenance, growth, and rumen development are met within the confines of calves' intake capacity.

One of the great advantages of pre-ruminant calves is their efficiency at converting nutrients to growth. While research confirms that increasing growth rate prior to weaning can improve milk production, there are two important questions to consider before setting out to maximize growth. First, will the expected increase in milk production offset the cost of the increased milk or milk replacer necessary to achieve high rates of growth? With the ever-increasing price of high-quality proteins used in milk replacers, this is especially pertinent for farms that feed milk replacer.

Consider the example of moving your calves from an average growth rate of 1.1 lb/d to 1.3 lb/d using the previously described meta-analysis (Gelsinger et al., 2016). We used NRC values and based the comparison on a typical milk-based, 20:20 milk replacer (**Table 2**). Capturing an extra 0.2 lb/d of ADG would require feeding an additional 12.8 lb of a 20:20 milk replacer, 12.3 lb of an accelerated milk replacer(27:17), or 10.4 gallons of milk over an 8-week pre-weaning period. Assuming $80 and $100 per 50-lb bag of 20:20 or accelerated milk replacer, respectively, and a milk price of $18/cwt, the cost of increasing growth from 1.1 to 1.3 lb/d is $20.45 (20:20), $24.53 (27:17), or $16.14 (saleable milk) per calf (**Table 3**). If a farm can feed all of their calves on 100% waste milk (valued at $4.50/cwt), the cost decreases to $4.04/calf. In contrast, the expected increase in milk income from these heifers is $3.09/heifer. This example assumes the milk price doesn't change in the two years it takes to get the heifer from weaning to calving.

Next we will consider the economics of using starter feed to increase pre-weaning growth rates (**Table 4**). In this case we assumed that there was sufficient milk being fed to meet maintenance needs of the calf and that the additional calf starter will go only towards growth. We do not have data separating maintenance from gain using starter in young calves, nor would it be realistic to only feed starter. Using the same growth comparisons and NRC data, we made similar comparisons. Achieving those gains is far less expensive due to the cost differences between milk products and calf starter (plus these gains do not account for maintenance). The change in production and value of the increased milk production is the same, but it costs far less to achieve these gains and actually can show a positive return if the gain is from 1.5 to 2.0 lbs/d since the return is roughly a 2 to 1 rate. This comparison also assumes that increasing calf growth rate does not change age at breeding or age at first calving, which could have dramatic economic benefits. Obviously feeding more to calves will cost money, but the comparison shows that grain feeding is far less costly than milk feeding and the ADG outcomes are the same, with the exception that feeding grains will increase ruminant digestion and intestinal development. Increasing heifer growth rates, regardless of the feeding strategy, will increase the possibility of decreasing age at calving, which can dramatically decrease heifer costs.

Conclusions

We conclude that gains in first-lactation production accomplished by increasing calf ADG pre-weaning are small and account for less than 3% of the variation in first-lactation milk production. Genetics, health, and other farm management practices will account for 97% of the actual milk production that we observe. Furthermore, any improved ADG that we want to accomplish in pre-weaned calves is far cheaper to do by increasing calf starter intakes in combination with a reasonable milk/milk replacer program.

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Table 1. Summary of studies included in the meta-analysis by Gelsinger et al. (2016).

Study	Comparison	Effect on first-lactation milk production [1]
Castells et al., 2015	Milk replacer with vs without oat hay supplementation	No difference
Kiezebrink et al., 2015	Whole milk feeding at 4 L/d vs 8 L/d	No difference
Margerison et al., 2013	Whole milk only at 4 L/d vs whole milk (4 L/d) with supplemental plant carbohydrates vs whole milk (4 L/d) with supplemental plant carbohydrates and amino acids	Greater in supplemented animals
Davis Rinker et al., 2011	Low vs high milk replacer feeding rate	No difference
Moallem et al., 2010	Conventional milk replacer vs whole milk	Greater in animals fed whole milk
Morrison et al., 2009 [2]	5 L/d vs 10 L/d of milk replacer	No difference
Raeth-Knight et al., 2009	Conventional milk replacer vs various intensive feeding programs	No difference
Terré et al., 2009	Low vs high milk replacer feeding rate	No difference
Shamay et al., 2005	Conventional milk replacer vs whole milk	No difference

[1] Treatment effects declared at $P < 0.05$.
[2] Morrison et al. (2009) also compared high and low milk replacer protein content; however, this comparison was not included in the current analysis.

Table 2. Effect of preweaning growth rate on metabolizable energy (ME) requirement during the preweaning period and predicted milk yield in first lactation.

	Preweaning growth rate (lb/d)				
	1.1	**1.3**	**1.5**	**1.8**	**2.0**
Birth weight (lbs)	99	99	99	99	99
Weaning weight (lbs)	161	173	185	198	210
Average preweaning body weight (lbs)	130	136	142	148	154
ME requirement for growth					
Daily (Mcal/d)	1.55	1.97	2.40	2.87	3.35
Total for 8 weeks (Mcal)	87.07	110.17	134.65	160.45	187.50
Total ME requirement					
Daily (Mcal/d)	3.68	4.17	4.68	5.22	5.77
Total for 8 weeks (Mcal)	206.3	233.6	262.3	292.2	323.3
Estimated 1st lactation 305-d milk yield (lbs)	26,581	26,599	26,638	26,701	26,786

Table 3. Estimated feed cost and value of additional milk produced in the first lactation if preweaning growth rate was increased by feeding more milk or milk replacer.

	Change in growth rate (lb/d)		
	1.1 to 1.3	**1.1 to 1.5**	**1.5 to 2.0**
Increased feed cost to support higher growth rate			
"Cheap" milk replacer ($80/50 lbs)	$20.45	$41.92	$45.73
"High quality" milk replacer ($100/50 lbs)	$24.53	$50.26	$54.83
Saleable milk ($18/cwt)	$16.14	$33.08	$36.09
Waste milk ($4.50/cwt)	$4.04	$8.27	$9.02
Estimated change in milk yield (lbs/lact)	17.2	57.0	147.7
Value of additional milk ($18/cwt)[1]	$3.09	$10.26	$26.58
Additional milk value minus increased feed cost[2]			
"Cheap" milk replacer ($80/50 lbs)	($17.36)	($31.66)	($19.15)
"High quality" milk replacer ($100/50 lbs)	($21.44)	($40.00)	($28.25)
Saleable milk ($18/cwt)	($13.05)	($22.82)	($9.51)
Waste milk ($4.50/cwt)	($0.95)	$1.99	$17.56

[1] Assumes same value for milk that is fed and milk that is sold.

[2] Does not include possible benefits from earlier age at first breeding/calving.

Table 4. Estimated feed cost and value of additional milk produced in the first lactation if preweaning growth rate was increased by feeding more calf starter[1,2]

	Change in growth rate (lb/d)		
	1.1 to 1.3	**1.1 to 1.5**	**1.5 to 2.0**
Total calf starter for higher growth rate (lbs/calf/d)	2.63	3.22	4.48
Additional calf starter (lbs/calf/56 d)	30.8	63.8	70.6
Cost of calf starter ($/calf)	$5.56	$11.45	$12.72
Estimated change in milk yield (lbs/lact)	17.2	57	147.7
Value of additional milk ($18/cwt)	$3.09	$10.26	$26.58
Value of additional milk minus cost of calf starter ($/calf)	($2.47)	($1.19)	$13.86

[1] Calf starter assumptions: 88% DM, 18% CP, 3.28 Mcal/kg, 57% available nutrients; cost $0.18/lb.

[2] Assuming all maintenance requirements are met by milk or milk replacer and all growth requirements are met by calf starter.

SESSION NOTES