Early Life Management and Long-term productivity of Dairy Calves

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Abstract

The concept of “intensified feeding” has been applied for up to 10 years now. In that time, we have started to acquire and examine lactation data from calves’ feed greater amounts of milk replacer or milk. From these evaluations we are observing increased moderate to significant increases in first lactation milk yield. There appear to be two conditions necessary for generating the response. First, there appears to be a modest but positive effect of colostrum status on both pre-pubertal growth rate and lactation yield. Second, the data being generated suggest that energy intake within the first six weeks of life has some positive impact on first lactation milk yield, the mechanism of which is still unknown. This paper will review the available data and provide some general interpretation for application on farm.

Introduction

This topic of “intensified feeding or accelerated growth” has garnered a great deal of discussion. Several years ago, Dr. Jim Drackley from the University of Illinois suggested we call it “biologically normal growth” and on that point we completely agree. In essence, what we have been proposing is that we apply the same concepts of nutrition and management to the calf that we apply to all other classes of growing and lactating cattle. The calf has a requirement for maintenance and once maintenance requirements are met, growth can be achieved if enough nutrients and the proper balance of nutrients are provided to the calf. The nutrient requirements of the calf have been described in the current Nutrient Requirements of Dairy Cattle 7th Ed. (National Research Council, 2001) publication. The requirements can be easily actualized and are very useful for diagnosing the impact of temperature on the maintenance requirements of the calf through the computer program that accompanies the publication.

New data are now available that help us refine those predictions (Bartlett, 2001, Diaz et al., 2001, Tikofsky et al., 2001, Bascom et al., 2007; Blome et al., 2003, Brown et al, 2005, Meyer, 2005, Mills, 2005). The table below (Table 1) summarizes our current knowledge about the requirements for growth of the calf based on the body composition data derived since the 2001 NRC was published.

These values are consistent with the current publication, but have slightly lower energy requirements per unit of gain because the original equations were based on heavier veal type calves fed higher fat diets and depositing more fat per unit of weight gain. These predictions for energy requirements are consistent with dairy replacement calves being fed diets more typical of our system. The protein requirement is higher than the NRC publication due to an updated efficiency of use calculation. The 2001

NRC calculations suggested that absorbed protein was used with an efficiency of 0.80, whereas our latest calculations suggest the efficiency is closer to 0.70, thus the requirements are 10 to 12% higher than the current predictions.

These requirements are interesting because they reinforce the idea that what the cow would normally provide to the calf is the appropriate combination of protein and energy required by the calf. Thus, many milk replacers are not really replacing milk because they don't contain the same nutrient levels and they are rarely fed to equal the nutrient intake of whole milk. It further suggests that least cost milk replacer formulations should not be expected to provide much beyond maintenance energy.

Table 1. The energy and crude protein requirements of calves from birth to weaning (Van Amburgh and Drackley, 2005).

Rate of gain, lb/d	Dry matter intake, lb/d	Metabolizable energy, Mcal/d	Crude protein, g/d	Crude protein, %DM
0.45	1.2	2.4	94	18.0
0.90	1.4	2.9	150	23.4
1.32	1.7	3.5	207	26.6
1.76	2.0	4.1	253	27.5
2.20	2.4	4.8	307	28.7

However, to further this idea of nutrient status, data are available and emerging that suggest factors such as colostrum status and energy balance up to at least 8 weeks of age have long-term carry over effects that can be measured in the first lactation. Just like other neonates, it appears that calves might be affected by early life events and that "compensatory mechanisms" really don't exist for this stage of development. It also suggests that we need to alter how we view this stage of development especially as it relates to future productivity. This concept and data to support it is still being developed, but there appears to be a positive relationship with early life nutrient intake.

Early Development and Productivity

Colostrum Status

To maximize calf survival and growth, plasma Ig status and thus colostrum management is of utmost importance. This is obviously not a new concept and there are hundreds of papers describing the management and biology surrounding colostrum quality, yield and Ig absorption by the calf. Of interest are the studies have described decreased growth rate and increased morbidity of calves with low serum immunoglobulin status (Nocek, et al., 1984, Robison et al, 1988) and some have even indicated that milk yield during first lactation can be affected (DeNise et al., 1989.) Robison et al., (1988) indicated that calves with higher immunoglobulin status are able to inactivate pathogens prior to mounting a full immune response which allows them to maintain energy and nutrient utilization for growth, whereas calves with low immunoglobulin status must mount an immune response which causes nutrients to be diverted to defense mechanisms. How severe is this difference or for how long does it persist? The data of DeNise et al., (1989) demonstrated that for each unit of serum IgG content, measured at 24 to 48 hrs after administration, above 12 mg/ml, there was an 18.7 lb increase in mature equivalent milk. The implication is that calves with lower IgG content were more susceptible to immune challenges which impacted long term performance.

A more recent study suggested that impact of serum Ig levels was not nearly that great, but it did affect milk yield (Faber et al., 2005) and survival through the second lactation. Brown Swiss calves were provided either two or four liters of colostrum just after birth. The calves were monitored after calving for two lactations. At the end of the second lactation three major observations were made, first there was a 30% increase in prepubertal growth rates based on colostrum feeding level, under identical feeding conditions. Second, there was a 16% increase in survival to the end of the second lactation of calves fed the four liters of colostrum. Finally, the surviving calves fed the four liters of colostrum produced 2,263 lbs more milk by the end of the second lactation. Although somewhat subtle, these differences suggest that early life colostrum status is important for long-term productivity. If part of the mechanism is related to maintaining nutrient partitioning towards growth via high immunoglobulin status, then the concept of nutrient status should also demonstrate responses beyond the Ig status of the calf.

Nutrient status and long-term productivity

There are several studies in various animal species that demonstrate early life nutrient status has long-term developmental effects. For a more extensive discussion of this topic, a recent review of these concepts was conducted by Dr. Jim Drackley (Drackley, 2005). Aside from the improvement in potential immune competency, there appears to be other factors that are impacted by early life nutrient status.

There are several published studies and studies in progress that have both directly and indirectly allowed us to evaluate milk yield from cattle that were allowed more nutrients up to eight weeks of age. The earliest of these studies investigated either the effect of suckling versus controlled intakes or ad-libitum feeding of calves from birth to 42 or 56 days of life (Foldager and Krohn, 1994; Bar-Peled et al, 1997; Foldager et al, 1997).

In each of these studies, increased nutrient intake prior to 56 days of life resulted in increased milk yield during the first lactation that ranged from 1,000 to 3,000 additional pounds compared to more restricted fed calves during the same period (Table 4). The fourth study, Ballard et al. (2005), reported that at 200 days in milk, the calves fed milk replacer at approximately twice normal feeding rates produced 1,543 lb milk more than the calves that received one pound of milk replacer powder per day. Calving age in that study was not affected by treatment. Overall, averaging the studies, there is a 1,700 pound response to increasing nutrient intake prior to weaning. The significant point is that it appears this effect of intake level needs to be accomplished through liquid feed intake. There are at least three other studies underway at other institutions that will add to this positive

Table 4. Milk production differences among treatments where calves were allowed to consume at least 50% more nutrients than the standard feeding rate.

Study	Treatment Difference, lb
Foldager and Krohn, 1994	3,092
Bar-Peled et al, 1998	998
Foldager et al, 1997	1,143
Ballard et al., 2005	1,543 at 200 days in milk
Rincker et al. 2006	1,100 based on Proj. 305d milk
Moallem et al. 2006	2,500
Pollard et al., 2007	1,841

In the study by Rincker et al. (2006) the control calves were fed 1.2% of BW a standard 20% CP, 20% Fat milk replacer and starter to achieve 1 lb per day growth rate to weaning. The treatment calves were fed a 28% CP, 15% fat milk replacer at 2.1% of BW and a higher protein starter (24.5%) to achieve 1.5 lb per day gain prior to weaning. All calves were weaned by six weeks and fed similarly from 8 wks of age through the first lactation. Body weight at calving was not different (1,265 vs 1,241 lb respectively). Milk yield was only followed through the first 150 days of lactation and projected 305d milk yields were 1,100 lb greater for the heifers fed for the higher growth rates prior to weaning.

The response in the study of Moallem et al. (2006) is significant, specifically because it suggests that milk replacer quality is important to achieve the milk response, as is protein status of the animal post weaning. In that study, the calves were fed a 23% CP, 12% fat milk replacer containing soy protein or whole milk. Further, post-weaining the calves were fed similarly until 150 days of gain, and the diets were protein deficient (~13.5% CP). Starting at 150 days calves from both pre-weaning treatments were supplemented with 2% fish meal from 150 to 300 days of life. The calves allowed to consume the whole milk (ad lib for 60 min) and supplemented with the additional protein produced approximately 2,500 lb more milk in the first lactation.

Finally the data of Pollard et al. (2007) again demonstrates a positive response of early life nutrition on first lactation milk yield. In this study calves were fed either a conventional milk replacer (22:20) at 1.25% BW or a 28:20 milk replacer fed at 2% BW for week one of treatment and then 2.5% BW from week 2 to 5 and then systematically weaned by dropping the milk replacer intake to 1.25% for 6 days and then no milk repalcer. All calves were weaned by seven weeks of age and after weaning all calves were managed as a single group and bred according to observed heats. The heifers calved between 24 and 26 months of age with no significant difference among treatments. Calving weights were also not different and averaged 1,278 lb. Milk yield on average was 1,841 lb greater for calves fed the higher level of milk replacer prior to weaning.

My laboratory is also in the middle of a similar study, but our lactation data is too preliminary to make any evaluations. However, we started feeding our research herd for greater pre-weaning weight gains many years ago and have over 1000 weaning weights and 725 lactations with which to make evaluations outside of our ongoing study. Utilizing a Test Day Model (TDM) (Everett, R. W., and F. Schmitz. 1994; Van Amburgh et al., 1997) we analyzed the lactation data of the 725 heifers with completed lactations and ran regressions on several factors related to early life performance and the TDM milk yield solutions. Factors analyzed were birth weight, weaning weight, height at weaning, weight at 4 weeks of age and several other factors. What was most interesting and consistent with the data presented in Table 4 was that the greatest correlation with first lactation milk production was growth rate prior to weaning. In our data set, for every 1 lb of ADG prior to weaning, the heifers produced approximately 1000 lb more milk. The range in pre-weaning growth rates among the 725 animals was 0.52 to 2.76 lb per day. Further, 20% of the variation in first lactation milk production could be explained by growth rate to weaning. This suggests that the impacts of Ig status and nutrient intake are playing a significant role in the performance and variation in first lactation milk yield.

Regressions of the lactation data from these studies and the growth rates, when controlled for study, suggest that to achieve these milk yield responses from early life nutrition, calves must double their birth weight or grow at a rate that would allow them to double their birth weight by weaning (56 days). This further suggests that milk or milk replacer intake must be greater than traditional programs for the first 3 to 4 weeks of life in order to achieve this response.

What changes in the animal are allowing for these differences? There is no one answer to that question but investigations are looking for several factors. The most obvious area to look at is mammary development. There are a couple sets of data that demonstrate increased mammary cell growth based on early life nutrient intake. Brown et al. (2005) observed a 32 to 47% increase in mammary DNA content of calves fed approximately two versus one pound or milk replacer powder per day through weaning. Just like the milk production increases discussed earlier, this mammary effect only occurred prior to weaning. In fact, this increase in mammary development was not observed once the calves were weaned, indicating the calf is more sensitive to level of nutrition prior to weaning and that the enhancement mammary development cannot be "recovered" once we wean the animal.

Meyer (2005) observed a similar effect in mammary cell proliferation in calves fed in a similar manner. The calves on his study demonstrated a 40% increase in mammary cell proliferation when allowed to consume at least twice as much milk replacer as the control group prior to weaning. Sejrsen et al (2000) observed no negative effect on mammary development in calves allowed to consume close to ad libitum intakes. We could create a hypothesis about this cell development that leads to increased milk yield, but we are a long way from proving such a theory. However, the data provide an interesting look into the early developmental effects of early life nutrition.

Summary

Early life events appear to have long-term effects on the performance of the calf. Our management approaches and systems need to recognize these effects and capitalize on them. Obviously we have much to learn about the consistency of the response and the mechanisms that are being effected. However, it appears that there is some potential profit in spending more time and resources on the animal at this early stage of life.

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