Nutritional Management of the Dairy Heifer to Maximize Growth and Productivity

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Abstract

The dairy replacement heifer has historically been considered to be only a cost to the dairy operation and not a potential profit center. Dairy heifers have a tremendous genetic capability to utilize nutrients in their diet to maximize growth and reach puberty at a much earlier age than previously thought. If heifers are provided with sufficient amounts of protein and energy in the right ratios, they can reach puberty and breeding height and weight by 11 months of age without adverse affects on ease of calving, reproductive efficiency or milk production. Heifers on this higher plane of nutrition also have a lower incidence of morbidity and mortality, thus increasing the number of heifers available as replacements on the dairy. This allows the dairy to expand internally without the purchase of outside animals for replacements, as well as increase the rate of voluntary culling.

Résumé

La génisse laitière de remplacement est depuis toujours considérée uniquement comme un coût pour la ferme laitière et non pas comme une source potentielle de profit. Or, la génétique des génisses laitières leur permet d'optimiser de façon remarquable les nutriments de leur régime alimentaire pour maximiser leur croissance et atteindre leur puberté à un âge beaucoup plus jeune qu'on l'estimait. Si on leur fournit les quantités suffisantes et les proportions adéquates d'aliments protéiniques et énergétiques, les génisses peuvent atteindre la puberté ainsi que la grandeur et le poids adéquats pour la reproduction dès l'âge de 11 mois et cela, sans compromettre la facilité de vêlage, l'efficacité reproductrice ou la production de lait. Les génisses nourries avec des aliments ainsi mieux formulés subissent également moins de morbidité et de mortalité, devenant ainsi plus nombreuses à pouvoir renouveler le troupeau. La ferme laitière peut alors s'agrandir en réduisant ses achats d'animaux venant de l'extérieur extérieur, et en réduisant le nombre d'animaux réformés volontairement.

Part 1: Nutritional Management of the Milk-fed Dairy Calf

Most dairymen and calf caretakers are well aware of the importance of colostrum management as it pertains to the health and immune status of the newborn dairy calf. Much research has been done on colostrum management recently, and many articles and chapters of books written on proper procedures for collection, storage, pasteurization, and delivery to the calf. I would refer those interested to these excellent resources on colostrum management. Colostrum also plays an extremely important role in the nutrient status of the newborn calf and has an influence on health status and growth rates for many months after its consumption. I would like to focus on nutritional management of the calf, following colostrum delivery to the time of weaning.

Years ago, it was common practice for the dairyman to leave the newborn calf on the mother for three days after calving, with the idea that this practice gave the calf a "good start" before it was changed over to milk replacer. Research has shown that this practice is contraindicated, both for the welfare of the lactating cow as well as the calf. It was unknown how much colostrum was consumed by the calf when left on the mother, and the cleanliness of the teat surface usually left a lot to be desired. Cows that were not milked out completely early in lactation gave less milk and were more likely to develop a new case of mastitis. However, the total amount of fat and protein consumed by the calf in this situation was definitely a benefit.

Whole milk is approximately 27% protein and 30% fat on a dry matter basis. The average 100 lb (45.4 kg) calf will nurse six to 10 times per day and consume between 16 and 24% of its body weight per day in milk. This would be 1.9 to 2.8 gallons (7.19 to 10.60 L) of milk per day. This results in about 2 to 3 lb (0.9 to 1.3 kg) of dry milk solids per day or 0.54 to 0.86 lb (0.2 to 0.4 kg) of protein and 0.6 to 0.89 lb (0.3 to 0.4 kg) of fat intake per day. This level of intake will provide the necessary amount of protein and energy required for maintenance and growth of the young dairy calf, regardless of environmental temperatures. The calf also has the option of increasing or decreasing intakes according to the demand for body heat or cooling during adverse weather conditions if left on the mother.

Milk replacer was developed with the thought that more milk would be available for sale, while at the same time the cost for feeding young calves would be decreased. It appeared to be a win-win situation. The nutritional requirements of the milk-fed calf were pretty much unknown, and had not been fully researched at that point in time. If the goal of feeding the calf for less money was to be accomplished, then whatever it was fed would have to consist of lower quality and/or quantity of nutrients. It became commonplace to see milk replacers formulated with products such as soy flour and soy protein isolate. It was not known at this time that young calves did not have the ability to digest these types of plant proteins. The dairy industry came to accept the fact that growth rates of 0.5 to 0.75 lb (0.2 to 0.34 kg) per day were normal, and that death losses of 5 to 10% on fairly well-managed farms were acceptable. Early research uncovered the fact that the ability to digest soy proteins in the young calf was extremely limited, so more digestible forms of soy protein were developed. It did not take long before the "all milk" products became established as the most desired products for calves.

The most commonly used milk replacer today is an "all milk" product that contains 20% protein and 20% fat. Following is a comparison between the nutrient content of a 20:20 milk replacer and whole milk:

Whole Milk	20:20 Milk Replacer
12.7% solids	11.4% solids (1 lb/gal of water) Water = 8.32 lb per gallon Milk replacer = 95% dry matter
27% protein	20% protein
30% fat	20% fat
0.285 lb protein/gallon	0.190 lb protein/gallon
0.317 lb fat/gallon	0.190 lb fat/gallon

From this comparison, it is obvious that a 20:20 milk replacer does not even come close to providing the same nutrients contained in whole milk. In fact, whole milk contains 50% more protein and 67% more fat per gallon than does the 20:20 milk replacer. It was originally calculated that 1 lb (0.45 kg) of milk replacer per gallon (3.8 L) of water would yield the same solids content as whole milk. However, it was assumed that water weighed 8 lb (3.63 kg) per gallon and that milk replacer was 100% dry matter. Since water actually weighs 8.32 lb (3.77 kg) per gallon and milk replacer is 95% dry matter, the solids content of 1 lb of milk replacer per gallon of water is only 11.4% solids.

It was also recommended that the calf be fed at a rate of 10% of its body weight per day. This was assuming that the average calf weighed 80 lb (36.4 kg) and therefore 1 gallon of milk replacer was approximately 10% of the calf's body weight. The average Holstein heifer today weighs 85 lb (38.6 kg) or more, and the Holstein bull calf averages 90 lb (41 kg) plus. Once again, we find that the original calculated feeding rate is less than expected and most calves are currently fed at a rate of less than 10% of body weight per day. It is important to remember that the calf left on its mother will consume 16 to 24% of its body weight per day in whole milk.

Therefore, the calf that is being fed 1 gallon per day of a 20:20 milk replacer mixed at a rate of 1 lb per gallon, is receiving less that 1/3 of the nutrients that a calf would receive if left on its mother. Calves that are raised on this type of program will only gain 0.5 to 0.75 lb (0.2 to 0.34 kg) per day, if the calf is in a thermoneutral environment. The thermoneutral zone for the calf has been defined to be the environmental temperature range in which the amount of body heat produced is balanced with the amount of heat lost from the body through condition, convection, radiant, and evaporative heat loss. The thermoneutral range for the calf has been determined to be 50° to 68°F (10° to 20°C). Temperatures above and below this range will affect the calf's efforts to maintain a constant level of body heat.

Higher environmental temperatures result in an increased water intake and a decreased appetite. Calves have the ability to regulate their body temperature at a fairly constant level until the environmental temperature reaches 80°F (26.6°C), at which point the core body temperature starts to increase and more energy is required to dissipate body heat by panting. Heat loss is achieved by sweating and by evaporation of water from the lung tissue while panting. Increasing the humidity results in a decreased respiratory evaporation rate, and in turn causes a more rapid rise in body core temperature. Therefore, high temperatures, especially with high humidity, will increase the required energy level but at the same time will decrease the calf's appetite. Calves may have a decreased growth rate or may even lose weight if severely stressed by high environmental temperatures. Therefore, since the calf's energy requirement may increase because of high environmental temperatures, it may be necessary to increase the amount of energy fed by increasing the solids content of the milk replacer and/or increasing the volume of milk replacer fed. All calves should have fresh, cool water free choice at all times in order to assist the calf in losing body heat through evaporation.

When temperatures drop below 50°F (10°C), more energy is required for the increased heat production necessary to maintain the body temperature. Cold temperatures also decrease the calf's ability to digest dry matter. The dairy calf has a much greater surface area per pound of weight than do larger animals. This results in a rapid increase in heat production when temperatures drop and in calves being more vulnerable to the stresses of low temperatures.

Even though individual outside calf hutches usually result in less disease, these calves are exposed to much lower environmental temperatures than are calves raised indoors. Steps must be taken immediately to increase the energy level in the calf's diet in order to compensate for the increased demands of heat production to maintain body core temperature. Increasing the energy level of the calf's diet can be accomplished in the following ways:

1. Increasing the percent solids when mixing the milk replacer, adding whole milk to the milk replacer or switching to whole milk.
2. Adding fat to the milk replacer or whole milk.
3. Increasing the feeding frequency from two to three times per day, or increasing volume per feeding.

During extreme weather conditions, the solids content of milk replacer can be increased to 15 to 18%. Concentrations above 18% may tend to cause an osmotic diarrhea. I have not had any problem with increasing the solids content up to the 18% level. Several supplements are available that contain 60% fat which can be added to whole milk or milk replacer to increase its energy density. A third feeding may be necessary in order to provide the energy level required by the calf to maintain its body temperature without losing weight. Calves raised at an environmental temperature of 39°F (3.8°C) had a 32% increase in energy requirement compared to calves raised at 50°F. When temperatures drop below 0°F (-17.7°C) it is conceivable that the energy requirement may more than double. It is especially important to warm the milk replacer or whole milk to 105°F (40.5°C) before feeding so the calf does not have to expend extra energy to bring the milk up to body temperature after ingestion.

If the extra energy is not supplied, the calf must utilize its own fat stores for energy. Fat deposits in young calves are usually not very large, and once they are used up the calf starts breaking down muscle protein for heat production and energy. Calves receiving insufficient energy in their diet start losing weight and become severely stressed. They then become more susceptible to disease and have much higher morbidity and mortality rates than do calves receiving the required energy and protein levels. If they survive, they are often stunted and require more feed and time before reaching their breeding size as replacement heifers. Following is a chart that shows the amount of a 20:20 milk replacer powder needed per day just to meet the maintenance requirements of a calf without any weight gain:

	Temperature (F)						
Body weight	68°	50°	32°	15°	5°	-5°	-20°
	20:20 Milk Replacer Powder (lb)						
60 lb	0.6	0.8	0.9	1.0	1.1	1.2	1.4
80 lb	0.8	0.9	1.1	1.3	1.4	1.5	1.7
100 lb	1.0	1.1	1.3	1.6	1.7	1.8	2.0
120 lb	1.1	1.3	1.5	1.7	1.9	2.0	2.3

From this chart it is evident that a 100 lb calf needs 1 lb of a 20:20 milk replacer powder per day just to meet maintenance requirements without any gain at 68°F (20°C). As soon as the temperature starts to drop, the calf does not have sufficient energy for maintenance and has to utilize its own body fat to maintain body temperature. This will result in weight loss instead of weight gain.

The following chart illustrates the amount of 20:20 milk replacer powder that is required per day to meet maintenance requirements plus gain 1 pound per day:

	Temperature (F)						
Body weight	68°	50°	32°	15°	5°	-5°	-20°
	20:20 Milk Replacer Powder (lb)						
60 lb	1.1	1.2	1.4	1.5	1.6	1.7	1.8
80 lb	1.2	1.4	1.6	1.7	1.9	2.0	2.2
100 lb	1.4	1.6	1.8	2.0	2.2	2.3	2.5
120 lb	1.6	1.8	2.1	2.2	2.5	2.6	2.8

(Charts courtesy of Dr. Mike Van Amburgh, Cornell University)

This chart indicates that a 100 lb calf has to consume 2.0 lb (0.9 kg) of powder per day in order to gain 1 lb if the temperature is 15°F (-9.4°C). The majority of calf caretakers do not change the amount of powder fed to the calves depending on the environmental temperature, so there are periods of time where the calf does not gain any weight, or perhaps even loses weight. The bottom line is that we are depending on calf starter consumption to make up the difference when the calf's requirements are increased due to adverse environmental conditions. Many calf caretakers have the false impression that the earlier the calf gets on calf starter, the better. However, the calf's rumen is not functional until it has been consuming a significant amount of calf starter for approximately three weeks. Sudden increases in calf starter consumption indicate that the nutritional requirements of the calf are not being met with the milk or milk replacer being fed.

Since the calf is trying to replace nutrients that are not being provided in the milk or milk replacer being fed, it would be advisable to have a calf starter that is similar in energy and protein content to whole milk. Many of the calf starters that are commercially available are only 17-18% crude protein. It has already been mentioned that whole milk is about 27% protein. These calf starters are supplying about 30% less protein than that required by the calf. It is no wonder that the growth rates of calves often suffer when they begin consuming larger quantities of calf starter containing much less protein. It is also common to see calves go through a period of no weight gain, poor-looking hair coats, or increased incidence of pneumonia, immediately after weaning when calves are depending solely on the nutrition received from calf starter.

If we expect calves to at least maintain the same rate of growth while on milk when they start eating calf starter, it only makes sense that the protein level in the calf starter should be similar to that of whole milk (27% on a dry-matter basis or approximately 25% on an as-fed basis). This protein should also be a high quality protein with a good amino acid balance, such as soybean meal. Poor quality, heat-damaged proteins such as distillers grains should not be used in calf starters.

A properly functioning immune system requires a substantial amount of energy and protein, well above that required for maintenance. Calves that are fed quantities of milk or milk replacer that are barely meeting maintenance requirements have a severely compromised immune system, and are therefore much more susceptible to disease. It is very common to see significant weight loss in calves that are currently experiencing a disease incident, because of lack of sufficient nutrient intake, even if the severity of the disease is mild. Morbidity and mortality rates can be significantly decreased, just by improving the nutritional status of the calf.

When a vaccine is administered to a calf, the same increase in nutrient requirements occurs as when the calf responds to actual infection. If these nutrients are not available, the calf does not have the ability to establish the necessary level of immunity to protect it against the disease for which it is being vaccinated. Many vaccine failures in young calves are due to lack of adequate nutrient intake at the time of vaccination. Likewise, the response to antibiotic therapy is highly dependent upon the animal's ability to mount an effective immune response against the invading pathogen. It is often assumed that the failure of antibiotic therapy is because of resistance of the invading pathogen to the antibiotic, when the actual problem is a compromised immune system. Appropriate antibiotic therapy is important when an animal is experiencing infectious disease. However, a properly functioning immune system is much more important in a successful recovery from disease than is the antibiotic being used.

It is obvious from the previous charts that a large amount of 20:20 milk replacer powder must be used in order for the calf to maintain at least a rate of gain of 1 lb per day, and also have an immune system that is functioning properly. Since the protein level is so low, these calves do not possess the ability to grow bone and skeletal muscle at the rate of which they are genetically capable. For this reason, high-protein milk replacers were developed. These milk replacers have often been called "accelerated formulas", but would be more accurately called "biologically appropriate" formulas. There has been a tremendous amount of research done recently to prove the benefits of these types of formulas. Following is a list of some of these benefits:

1. Increased efficiency of growth (more weight gained per lb of milk replacer consumed).
2. Higher lean tissue-to-fat tissue ratio (more skeletal growth and increase in frame size versus smaller stature animals with higher levels of fat).
3. Increased rate of growth (weight gains of 2-3 lb (0.9 to 1.4 kg) per day while on milk).
4. Decreased morbidity and mortality rates.
5. Decrease in medicine costs due to fewer treatments and shorter recovery periods.
6. Continued increase in growth rates following weaning.
7. Decreased age at puberty and first breeding.
8. Decreased age at first calving but with the same frame size as older heifers.
9. Increase of approximately 1,700 lb (773 kg) of milk during first lactation.

Most of the accelerated formula milk replacers will contain between 26 and 30% protein and 15 to 20% fat. The protein level is very similar to that of whole milk solids, but the fat level is somewhat lower. The purpose of this protein-to-fat ratio is to promote lean tissue growth rates. Fat also acts as a satiety agent and decreases the appetite of the calf, resulting in a decrease in calf starter intake. Research at the University of Illinois showed that the ratio of lean tissue to body fat was much greater and that the efficiency of gain was much greater in those calves fed the high protein milk replacer. These calves gained weight much faster, but also required less dry matter per pound of weight gain. This fact needs to be considered when evaluating the economics of an accelerated calf growth program. This same study fed three groups of calves a 26% crude protein, 18% fat milk replacer at a rate of 10, 14 or 18% of body weight per day. The corresponding growth rates were 0.79, 1.55, and 2.25 lb (0.36, 0.7, and 1 kg), respectively. I would like to emphasize again that the calves with the greatest growth rates had the highest lean tissue-to-fat tissue ratio. The higher protein milk replacer promotes more lean tissue gain.

Feeding recommendations vary slightly according to the manufacturer. Most researchers agree that during the first week of life the calf should receive 1.5 to 2% of its body weight in dry milk replacer powder. A good example of this would be to mix 0.9 lb (14.4 oz) of milk replacer powder in 2.5 quarts (2.37 L) of warm water per feeding. This would give a 90 lb (40.9 kg) calf a total of 1.8 lb (0.8 kg) of solids per day or 2% of its body weight. From week 2 to weaning, the calf would receive a greater amount of solids per day. An example of this would be to mix 1.3 lb (0.6 kg) of milk replacer powder in 3.5 quarts (3.31 L) of warm water per feeding. This would result in 2.6 lb (1.2 kg) of solids per day in a total volume of 7 quarts (6.62 L), which is a mixing rate of 18% solids. A general recommendation would be to mix the milk replacer at a concentration of 15 to 18% solids. There are many dairies and calf ranches that currently use bottles for feeding milk and milk replacer to their calves. Most of these bottles are two-quart size. This makes it impossible to deliver the 3.5 quarts per feeding. However, if one decides to utilize an accelerated milk replacer formula at the recommended feeding rate, the bottle system can still be utilized by increasing the number of feedings per day to three, or the dairy can utilize the newer 3-quart bottles which hold close to 3.5 quarts when filled to the top.

One of the main concerns about accelerated milk replacer formulas is that they may cause a nutritional diarrhea. It should be noted that the stools of calves fed these formulas will more than likely be softer than those fed a traditional milk replacer, but nutritional diarrhea has not been observed on any of the many research trials that have been conducted. Calf starter should still be offered free choice starting at three days of age, in order to encourage calf starter intake as soon as possible. Calf starter should be gradually increased as consumption increases with the leftovers being cleaned out on a daily basis. It was originally thought that calf starter intake would be greatly reduced since such a large amount of milk replacer was being fed at a rate of 18% solids. However, dry matter intake is proportional to body size. Since these calves are growing at such a rapid rate, their desire to consume calf starter also increases earlier than one would assume.

Calves should be weaned based on dry matter intake and not age. As soon as the calf consumes at least 2 lb (0.9 kg) of calf starter per day for three days in a row, it can be weaned. Even with feeding the higher volume of the 18% solids product, the average calf will be eating 2 lb of calf starter by the time it is seven to eight weeks of age. It is important to realize that if feeding a higher quality calf starter with 27% protein on a dry-matter basis, the calves may eat less of this than a product that is lower in protein since it is doing a better job of meeting the calf's requirements.

It is evident that the traditional program of feeding 1 lb of a 20:20 milk replacer in a gallon of water per day does not even come close to meeting the nutrient requirements of the milk-fed calf. Calves fed this diet can actually starve to death if exposed to adverse environmental conditions for extended periods of time. Increasing the solids content, feeding three times per day, and increasing the volume fed per feeding are ways to improve the nutrient intake of the calf, but still do not compare to whole milk or the accelerated formulas fed at larger volumes and higher solids content.

Pasteurized whole milk is an excellent way to feed calves. Feeding larger volumes of milk during cold weather can provide the energy and protein needed by the calf to meet its maintenance requirements as well as continue to grow. As long as milk prices are low, feeding whole milk is an excellent management procedure. Pasteurizing unsalable milk also is an excellent way to make use of a product that cannot be sold and still provide a high plane of nutrition to the calf. However, one must expect a lower level of calf starter consumption when feeding whole milk, because of the high fat content. Calves fed whole milk can be tapered off to one milk feeding per day for several weeks to encourage calf starter consumption and rumen development prior to weaning.

The higher protein milk replacers have been shown to provide additional benefits over whole milk. Researchers at Cornell University have shown that the amount of protein gain by the calf in the first 50 days of life has a significant effect on first-lactation milk production. Heifers raised this way gave approximately 1,700 lb (773 kg) more milk during the first lactation. Recent research has also shown that the young calf has the ability to utilize a tremendous amount of protein without wasting it, as long as adequate levels of energy are also provided. These "accelerated formulas" allow the calf to grow at an increased rate without excessive fat deposition, permitting the calf to reach its genetic potential for growth and disease resistance.

It is important to understand that a very high percentage of disease problems could be eliminated or reduced in severity by supplying the required nutrients for maintenance and growth of the milk-fed calf. Calf nutrition programs, properly designed, can consistently produce calves that gain 2.5 lb (1.1 kg) per day or more, with mortality rates of less than 1% while on milk. These calves will reach puberty, be bred, and can enter the herd by 21 months of age with no adverse effects on frame size, calving difficulty, first-lactation milk production, and survivability. This type of nutrition program is not "accelerated", but rather allows the calf to express its own genetic potential for growth and productivity.

Part II: Nutritional Management of the Dairy Heifer from Weaning to Breeding

The weaning process of the dairy heifer is very critical to its health and continued development. The dairy heifer should never be weaned according to its age, but rather by how much calf starter the calf is eating prior to being weaned. As discussed in the previous article on nutritional management of the milk-fed calf, it should have been on a high protein diet with at least a 27-28% protein milk replacer or whole milk which is also 27-28% protein on a dry-matter basis. The calf starter should also be around a 25% protein product on an as-fed basis, which approaches this 27-28% protein level on a dry-matter basis. This will satisfactorily meet the protein requirement of the calf at the time of weaning.

If on this type of program, the calf will easily double its weight and more by the time it is weaned. The goal is to have the calf consume at least 2 lb of calf starter per day for three days in a row. If the calf reaches seven weeks of age and still has not reached this level of calf starter consumption, the milk feedings can be cut back to once a day in order to increase the consumption of the calf starter. The majority of the calves that I work with will be consuming this much starter by seven weeks of age, even though they are receiving 3½ quarts (3.31 L) of a 28% protein milk replacer, mixed at a concentration of 18% solids. Those that are being fed pasteurized waste milk may take longer to reach the 2 lb level of calf starter consumption, since the high fat level in whole milk satisfies their hunger and decreases their appetite. It will be more likely to have to cut the milk feedings back to once a day when whole milk is being fed.

It is more difficult to determine the actual dry matter intake of calves that are on automatic group feeders. These calves should be weaned based on size and appearance, more than just on age. When calves are placed in group pens after being weaned, it is important that they are similar in size so they can successfully compete for the available feed. Calves that are smaller than herdmates of the same age should be held back and kept on milk for a longer period of time until they are similar in size to a future weaning group.

If calves are being raised in individual hutches, they should be left in those hutches for 10-14 days after weaning if possible. The caretaker can then monitor the amount of calf starter that is being consumed by the weaned calf to make sure that intake is increasing on a daily basis. Calf starter intake should increase to approximately six to 10 lb (2.72 to 4.54 kg) per day within one week post-weaning, depending on the size of the calf. Calves that are weaned and then immediately placed into small group pens cannot be monitored on an individual basis to determine the amount of calf starter consumed daily. It is difficult to detect calves that are eating well until they have already suffered significant weight loss or become ill. Waiting for 10-14 days after weaning to move calves into small group pens will greatly increase their chances to maintain good starter intake and continue to grow in weight and stature, instead of experiencing a "post-weaning crash" which is so commonly observed on dairy farms.

It is a common practice on many dairies to perform other management procedures on calves at the time of weaning or when moving to the first group pens. Dehorning, castrating, tail docking, and vaccinating should not be performed at this time. Even though it requires more labor and handling the calves more times, it is much less stress on the calves to perform these procedures at different times, particularly avoiding weaning or moving to group pens. Each time a procedure is performed on these calves, it creates stress which results in the release of the stress hormone, cortisol. Cortisol directly suppresses the animals' immune system, resulting in an increased susceptibility to infectious disease. Vaccinations should be done at a time when the calf is under the least amount of stress in order to receive the maximum benefit from the vaccine in establishing a high level of immunity to the diseases covered by the vaccine.

It is very common to vaccinate for respiratory diseases prior to moving the calf into its first group pen. This is the most common time to observe respiratory disease in the dairy heifer. This vaccine must be administered at least 10-14 days prior to moving in order to allow time for adequate antibody production in response to the vaccine. It is also important to remember that when the calf responds to a vaccine, the energy and protein requirements for that calf increase as well. The calf must not be stressed, and should be consuming the desired amount of high quality calf starter when vaccinated in order to gain the maximum amount of immunity from the vaccine used. It is often assumed that every calf that is vaccinated equally responds to the vaccine and is completely protected against that specific disease. This is far from reality. Calves respond differently depending on their nutritional status, genetics, and the amount of stress they are experiencing at the time of vaccination. Even if the calf responds well to the vaccine, it may still succumb to that disease if the amount of exposure to that particular disease is very high. The goal is to grow calves that have a high level of immunity with a low level of exposure to disease-causing organisms.

The diagrams in Figure 1 illustrate the point that disease can be caused by increasing the number of organisms that the animal is exposed to or by decreasing the level of resistance. The obvious goal is to always maintain the level of resistance above the level of challenge. In order to maximize the level of resistance, the calves must be on a high plane of nutrition at all times.

Ideally, the calves should remain on the calf starter for at least a week after being mixed into small group pens before being placed onto a grower ration. It is best not to utilize fermented forages in this age group of calves. Calves should remain on the grower ration until they are four to five months old. If high quality alfalfa hay is available, I like to mix the starter with 20% alfalfa hay and add 5% molasses to the mix. The molasses increases the palatability of the ration, but more importantly helps to decrease the amount of sorting that may take place when being introduced to forage in the ration. Whatever forage is being used, it is extremely important to use the highest quality available. These

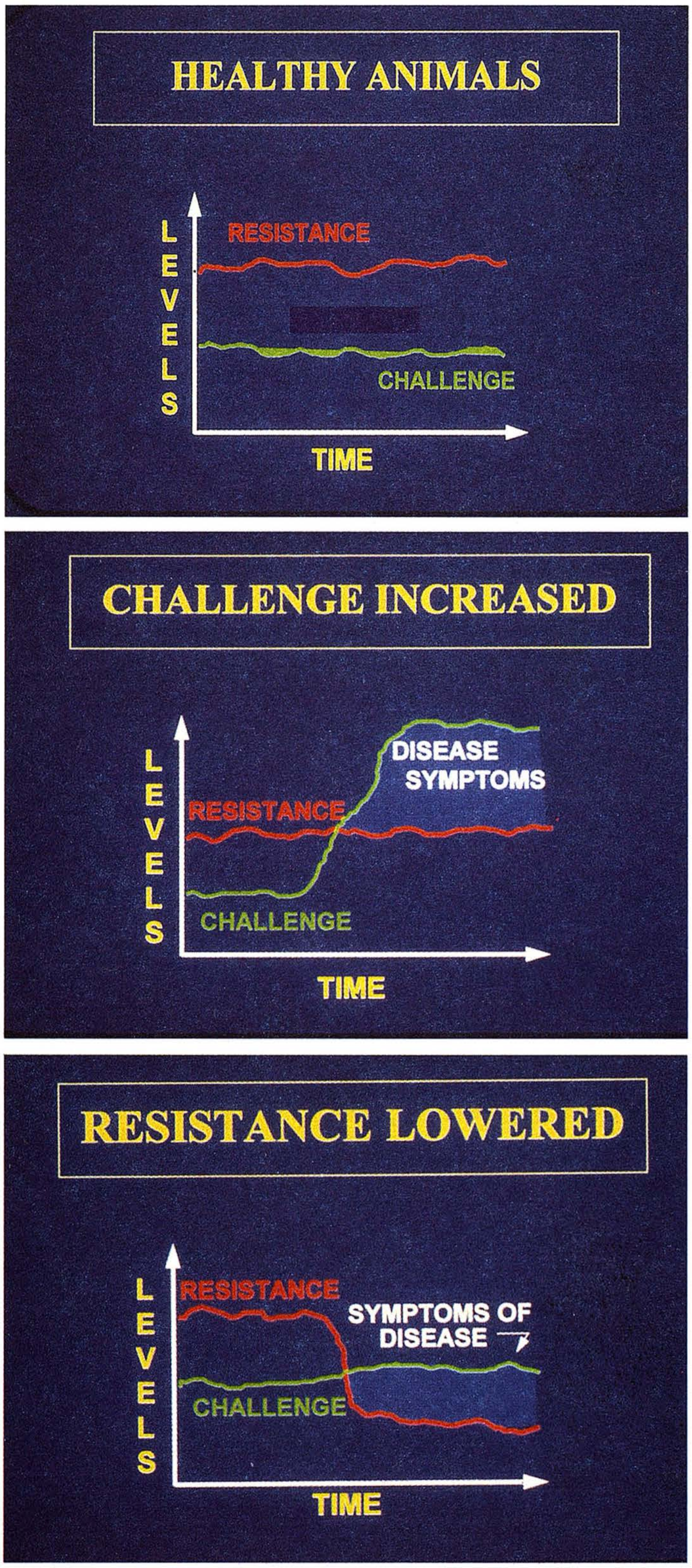


Figure 1.

calves are still developing their rumen, and need access to highly digestible forages in order to improve fiber digestibility and in turn, receive the necessary nutrients to maximize growth. The protein level of this ration must remain high, approximately 2-3% below that of the starter ration.

Fermented forages can be introduced in the ration when the calves are around five months of age. Once again, the quality of these forages should be the best available on the farm. It is also important to have an anti-coccidial product, such as Rumensin®[a] or Bovatec®[b], in the ration from birth until at least eight months of age. The dosage of these products must be calculated according to the intake of this group. If a wide age range exists in this group due to corral size or number of heifers on the farm, the dosage must be carefully calculated in order for the older calves not to receive a toxic level of inophore. Continuing with one of these ionophores is advantageous by improving feed efficiency as the heifers continue to grow. This ration will often be around 18% crude protein, depending on the actual amount of metabolizable protein available as determined by the ration-balancing software being used.

If the corral size and heifer numbers permit, the next ration usually includes heifers that are eight to 12 months old. Heifers that are grown on these high quality rations will often reach breeding size around 10 to 12 months of age. I prefer to use the measurement of 51 inches (129.5 cm) at the withers to determine if the heifer is ready to be moved into the breeding pen. These heifers are not moved to the next ration until they are confirmed pregnant. This ration will often be around 16-17% protein, again depending on the protein sources and the amount of metabolizable protein available. Instead of measuring each animal individually, it is satisfactory to measure 51 inches from the cement pad the animals stand on and place a mark on the stanchion at this location. Those in charge of breeding can then "eyeball" the height of the heifers and move them into the breeding pen when breeding height is reached. It is important not to change the ration while the heifers are in the breeding phase. They need to stay on an excellent plane of nutrition until conception occurs.

The number of heifers per pen and the age range of heifers in a pen is different on every dairy and obviously depends on the size and number of corrals available, as well as the total number of animals on the farm. Heifers should ideally be grouped according to age and size when possible. This allows each heifer to compete more successfully at the feed bunk and continue to grow according to its own genetic potential. If a heifer is not keeping up with its herdmates, it should be held back and placed with the next upcoming age group. If it needs to be held back twice, it should be culled. More than likely, this heifer has a chronic condition, such as abscessed lungs, preventing it from growing at a normal rate.

The traditional method of raising dairy heifers in the past has been to feed low quality feeds that were not fit for the lactating herd. These young heifers have a tremendous growth potential that has not been previously taken advantage of. Feeding high quality feeds will allow these heifers to dramatically increase their growth rates and shorten the time to breeding and first calving without compromising on frame size and milk production. The old requirements published by the National Research Council (NRC) overestimated the amount of energy and underestimated the amount of protein needed by growing heifers. This often resulted in heifers that were shorter in stature and over-conditioned when pushed on rations meeting these old requirements. However, the new NRC has revised these requirements, which allows feeding heifers in a way they can reach their genetic potential for growth without being undersized or over-conditioned. This improved plane of nutrition also results in a healthier immune system with less sickness and death in young heifers. This is one investment that pays big dividends to the producer by providing a large-framed heifer that is healthier, calves into the first lactation sooner, and produces more milk during the first lactation.

Part III: Nutritional Management of the Dairy Heifer from Breeding to Calving

One of the most common mistakes made on the dairy is to initiate the breeding process according to the age of the animal. The single most important factor that will help ensure that the heifer is large enough at calving is the size of the animal at breeding. It has been generally recommended that the Holstein heifer be between 48 and 52 inches (121.9 and 132.1 cm) in height at the withers when bred. However, this size will vary somewhat depending on the mature weight of the animals in that particular herd. Holstein heifers should weigh approximately 55% of mature weight at the time of breeding. Breeding strictly according to age will increase the range of variability in size of the heifers and result in some animals being too small at the time of breeding. The nutritional status of the animal after breeding will also have a significant influence on the size of the heifer at calving.

I have been working with accelerated heifer growth programs with my clients for more than eight years and have found that the wither height of 51 inches at breeding works best in our program. According to the growth curves that we have established from measurements taken from heifers on this program, 51 inches is the closest we can come for the weight of the heifers to be about 55% of the mature weight of the lactating cows. If 51 inches is used as the optimal breeding height, approximately 15% of the heifers will reach this height at 10 months of age, about 40% will be ready at 11 months, and the rest by 12 months of age. Even at 51 inches, some of the heifers will reach this height by nine months of age. We have established a minimum age at first breeding of 10 months old because of this. Following are the height and weight growth curves that were established from over 7,000 measurements taken over a two-year period on a 1,000-cow dairy (Figure 2). Notice that these curves are compared to standard curves currently available for the Holstein breed.

There will always be a few that are delayed in reaching their breeding height. These heifers must be critically evaluated and possibly culled. Instead of waiting until breeding age to evaluate heifers for possible culling, I like to do the evaluation at approximately 400 lb (180 kg). It is very easy to pick out heifers that are obviously stunted and/or in poor health when compared to their herdmates of similar age. Unless these heifers

Optimized heifer growth weight chart (birth to calving)

Optimized heifer growth height chart (birth to calving)

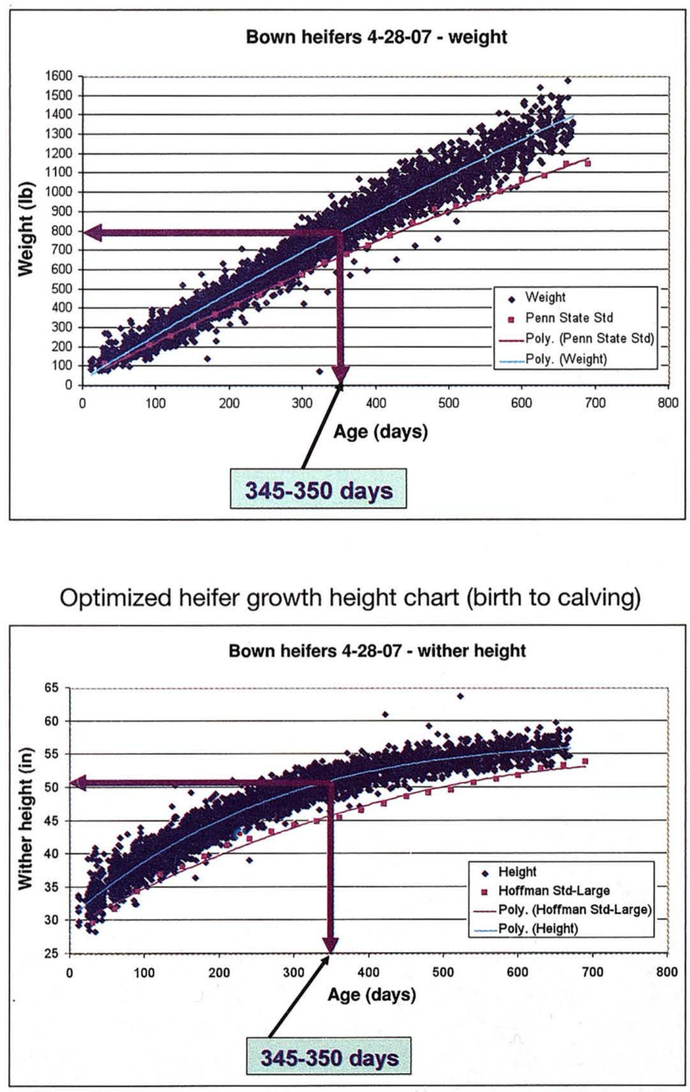


Figure 2.

are obviously sick, they can be sold for current heifer market prices without a loss. If kept in the herd, they often calve, produce poorly, and are then culled at beef price. The cull price is close to what would have been received if sold at 400 lb (181.4 kg), only without all the feed costs that were incurred in feeding the heifer to adulthood.

The single most common problem with breeding heifers on an accelerated heifer program is waiting too long to initiate breeding once the heifers have reached the appropriate breeding size. As heifers get older, the rate at which their frame size increases tends to slow down. If heifers are still several months away from calving when this process occurs, they tend to gain body condition. Heifers that were bred late or took longer to conceive could become over-conditioned when compared to heifers that conceived close to the time they reached the appropriate breeding size. If this occurs, the late-bred heifers would have to be put on a lower quality ration to prevent over-conditioning. It has also been my experience that heifers calving for the first time at 30 months of age or older do not milk well and do not return the money invested in them up to calving. These heifers are obviously problem breeders, and often are extremely difficult to get bred back after calving.

Once heifers have been confirmed pregnant, the metabolizable energy levels must be cut back while maintaining the level of metabolizable protein at or above requirement, or heifers may become over-conditioned. Since the growth curve has been shifted significantly to the left, the rate of growth slows down earlier in the gestation period when compared to a traditional program of calving at 24-28 months of age. It has been suggested that the ideal height for heifers at calving is 54.9 inches (139.45 cm) at the withers and weighing 1350 to 1400 lb (615 to 635 kg) pre-calving. Heifers raised on this program, which will allow them to reach their natural potential growth rate, will meet or exceed these goals set for a traditional program, will not have any increase in calving difficulties, and will produce as much or more milk during their first and subsequent lactations.

If at all possible, it is advantageous to keep springer heifers separated from the second lactation and older cows in the close-up dry cow pen. Heifers do not compete well with older cows, and often will not consume adequate amounts of dry matter for optimum health. Care should also be taken to provide adequate bunk space for heifers and to adjust the ration on a daily basis according to the number of heifers in the close-up pen. Recent research from British Columbia has shown that heifers and cows that have reduced dry matter intakes three weeks prior to calving are the same animals that experience the greatest incidence of metabolic disease after calving.[2] Close-up dry cow pens and fresh cow pens should be kept at 80% capacity in order to minimize competition at the feed bunk and maximize dry matter intake. The area where heifers calve, whether it is the close-up pen or a specific maternity area, needs to provide the heifer with adequate space so she can lie down and give birth without being disturbed. I have seen situations where the percent of calves born dead was cut in half simply by doubling the size of the close-up pen where the heifers were giving birth.

The number one concern pertaining to accelerated heifer growth programs is deposition of fat in the mammary gland, resulting in decreased first-lactation milk yield. However, these results were received by accelerating the weight gain on prepubertal heifers, without much attention paid to the protein requirements needed to increase frame size. There have also been several studies examining the mammary gland which have proven that there is no decrease in milk-producing tissue in fresh heifers that have been on accelerated growth programs with increased protein levels in the ration. The reduction in mammary parenchyma DNA that has previously been reported in heifers reaching puberty, is simply due to the fact that heifers on a higher plane of nutrition reach puberty at a younger age.[4] I have followed animals now for five lactations that were raised on an accelerated program, and have seen no adverse effects on their reproductive efficiency or production. In fact, data collected from these herds suggest that their longevity in the herd may actually be improved, as well as their first-lactation milk production.

Now that more is known about how to properly formulate rations to accelerate the growth in replacement heifers, or in other words, allow them to grow according to their own genetic potential, it is possible to have heifers calving at 20 months of age and still obtain the same frame size as 24-month-old heifers raised on a conventional ration. These heifers do not show a decrease in first-lactation milk yield, do not show any increase in calving difficulties, and will weigh 1,350 to 1,400 lb (615 to 635 kg) at calving.

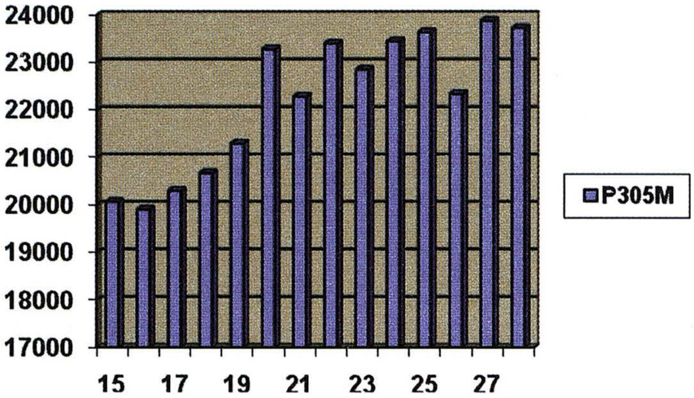
The following chart compares the projected 305-day milk vs the age at first calving for a 1,200-cow dairy on an accelerated heifer growth program (Table 1).

The heifers calving at less than 20 months of age were accidentally introduced to the bull before reaching the appropriate size. Those calving at 20 months on up had reached the appropriate size before breeding. It is fairly evident that once the heifers reached 20 months of age, age at first calving had little to no effect on the projected 305-day milk.

A review of the calving difficulty showed no difference between the earlier and late-calving age heifers.

Following is a table that illustrates the total number of heifer replacements needed per 100 cows in order to maintain herd size, taking into consideration the age at first calving and the herd's cull rate (Table 2).

Table 1. Projected 305-day milk vs the age at first calving.



If we assume that an average culling rate in today's large dairies is around 36% and that the current age at first calving is 26 months, the dairy would have to have 94 heifers per 100 cows on the farm from birth to calving in order to maintain herd size. If this is a 1,000-cow dairy, then 940 heifers would be needed. If the age at first calving was reduced to 22 months, then only 670 heifers would be needed to maintain herd size. That is a difference of 270 heifers needed on the farm. Approximately half of these heifers needed on the farm to maintain herd size would calve in one year; half of 270 would be 135. If these heifers had to be purchased at $1,500 per head, this would equal $202,500 per year on increased costs.

Let's look at this same situation another way. A 1,000-cow dairy with a 36% cull rate would need 360 replacement heifers per year. Assuming that 50% of the cows have heifer calves, that would yield 500 heifers per year. Since it takes approximately two years for the heifers to calve, about 250 of these heifers would calve per year. This still leaves a deficit of 110 heifers per year, even with an age at first calving of 24 months. However, if we also assume that there is at least a 12% death loss from birth to post-calving, there would be 30 heifers less calving per year. That would leave only 220 heifers or a deficit of 140 heifers per year that would have to be purchased in order to maintain herd size. At a cost of $1,500 per heifer, the cost of purchasing additional replacements would be $210,000 dollars per year.

It is evident that extending the age to first calving is extremely costly to the dairyman. It has been estimated that 15-20% of the total costs on the dairy farm are associated with heifer rearing.[3] It has also been stated that the single most important variable influencing costs associated with heifer replacements is the age at first calving.[1] After summarizing much of the available literature on accelerated heifer growth, Van Amburgh from Cornell[4] stated, "The economics are very strong that early calving, even at lighter post-calving body weight, improves farm profitability."

The increasing costs of heifer replacements, coupled with the fact that cull rates on large dairies often exceed 35%, emphasizes the importance of establishing a good heifer replacement program that will result in decreased death losses as well as decreasing the age at first calving.

In conclusion and summary, some of the nutritional considerations for establishing an accelerated heifer growth program are as follows:

1. Rations should be formulated that increase growth rate by increasing frame size without excessive body condition. In general, rations

Table 2.

	Age at First Calving*								
Cull rate	22 mo	23 mo	24 mo	25 mo	26 mo	27 mo	28 mo	29 mo	30 mo
20%	38	42	46	48	52	56	61	63	67
22%	42	46	50	54	58	63	67	69	73
24%	46	50	54	58	63	67	71	75	81
26%	48	54	58	63	69	73	77	81	87
28%	52	58	63	69	73	79	83	87	94
30%	56	63	67	73	79	83	89	94	100
32%	61	67	71	77	83	89	96	100	106
34%	63	69	75	81	87	94	100	106	112
36%	67	73	81	87	94	100	106	112	121
38%	71	77	85	92	98	106	112	118	127
40%	75	81	89	96	104	110	118	125	133

*Based on 12% heifer losses: deaths 0-12 months=5%; pre-breeding culls=3%; deaths 13 months to calving=1%; and post-calving losses 3%.

will have higher levels of metabolizable protein in comparison to traditionally raised calves.

2. In the past, most published heifer nutritional requirements have tended to overestimate the energy and underestimate the protein needed to accomplish accelerated growth without causing excess fat deposition.
3. Rations should be formulated to maximize rumen microbial growth, which improves feed efficiency as well as optimizing amino acid balance.
4. Maximize dry matter intake through better management procedures such as adequate feed bunk space, providing fresh feed and water at all times, utilizing good quality forages in heifer rations, and providing a clean, dry and comfortable environment.
5. Monitor the body condition scores as heifers mature to ensure that the rations are properly formulated to maximize frame size without the heifers becoming over-conditioned.
6. The herd nutritionist and dairy owner must work together to establish a program that works in correlation with the existing facilities and managerial ability that will allow the replacement heifers to reach their potential growth rate.

Accelerated heifer growth programs can be a valuable asset in increasing the overall profitability of the dairy operation if the time is taken to design the program to fit into the management scheme and the rations are formulated properly to maximize frame size without over-conditioning the heifers.

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