Accelerated Growth for Dairy Heifers: I'd Rather Bet on Blackjack

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The cost of raising Holstein heifers to first calving at 24 months is about $1,200, which is about 15 to 20% of the total costs for a dairy enterprise consisting of cows and replacement heifers. Many consultants have focused on trying to decrease the cost of raising heifers as a means to increase farm profitability. One way to decrease these costs is "accelerate" the growth and breeding of heifers so they calve earlier; in fact, some suggestions for age at first calving are as early as 20 months. But will accelerated growth result in increased lifetime profitability? To answer this question, we must examine the potential effects of rapid heifer growth on subsequent milk yield.

Level of milk production of a cow is determined by the (1) the ability of the mammary gland to produce milk, (2) the ability of the cow to provide the mammary gland with nutrients, and (3) the ability of the farmer to manage and care for the cow. The ability of the mammary gland to produce milk is largely dependent on its content of milk-secreting cells, which are found in the mammary "parenchymal" tissue. The number of milk-secreting cells is determined by genetics and by the environment during mammary development, especially during the rapid mammary growth that occurs before and during the time of puberty, between 3 and 10 months of age (Sinha and Tucker, 1969). A good heifer rearing program is critical to produce animals at first calving that have well-developed mammary glands capable of producing to the animal's genetic potential and that have good body size and body condition capable of high feed intake and delivery of nutrients to the mammary gland. The goals of this paper are to review the effects of nutrition on mammary development and growth of heifers and to make recommendations for feeding heifers from weaning to calving for maximum lifetime profitability.

The effects of body weight and body condition at calving on subsequent productivity have never been determined definitively in a "cause and effect" study. Most studies examining this relationship have done so using correlations; therefore, our current recommendations must be viewed with a healthy bit of skepticism. So what is the desired body weight? In high-yielding Holstein herds (>22,000 lb milk year), heifers typically conceive at 16 months of age weighing 910 pounds and calve at 25 months weighing at least 1,360 pounds before calving (Hoffman and Funk, 1992). Field correlations suggest optimal body weight is 1,200 to 1,300 pounds after calving and that lighter body weights result in lower milk production (Keown and Everett, 1986; Heinrichs and Hargrove, 1987). Van Amburgh et al. (1998b) found that heifers weighing ~1,260 pounds after first calving produced 700 pounds more milk in the first lactation than those weighing ~1,150 pounds. The potential problem with their data is that prepubertal body weight gain was confounded with calving body weight, and the reason that lighter weight heifers produced less milk might be that they grew too fast before puberty. Postcalving weights above 1,300 pounds for Holstein heifers may decrease milk production, perhaps because heavy heifers may have excess body fat. Animals with excess body fat before calving tend to eat less (Grummer et al., 1995) and probably mobilize more body fat before calving, which is associated with a greater incidence of dystocia, ketosis, and mastitis in the first month after calving (Dyk et al., 1995). Thus, we will assume that optimal body weight after calving is ~1,250 pounds for Holsteins (about 90% of mature body weight for other breeds) and optimal body condition score is 3.0 to 3.5. Optimal withers height is 54 to 56 inches (Hoffman, 1997).

Effect of nutrition on growth, mammary development, and milk yield

To achieve a body weight of 1,250 pounds after calving, heifers must weigh ~1,400 pounds before calving, and they must gain an average of 1.8 lb/day if they are to calve at 24 months. Because daily gains are slower in the first 3 months of life, gains thereafter must approach 2.0 lb/day. If calving at 20 months is desired, then gains at peak growth must approach 2.4 lb/day. High energy diets and rapid gains after breeding have little effect on subsequent milk production if calving occurs at optimal body size (Grummer et al., 1995; Hoffman et al., 1996; Sejrsen et al., 1982). Thus, this review will focus on the period of growth before breeding.

The period between 3 and 10 months of age is a critical time in mammary development. During this time, mammary growth is rapid and "allometric"; in other words, mammary tissues are growing at a faster rate than that of most other body tissues. The mammary paren-

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chyma extends into the mammary fat pad in a "broccoli-like" fashion and forms the daughter cells which are the foundation for later mammary development. The number of parenchymal cells present at puberty partly dictates the number of milk-secreting cells that will be present during lactation. The best method to assess the number of mammary cells is by measuring the amount of parenchymal DNA.

Growth of the mammary gland once again becomes isometric (same growth rate as other body tissues) shortly after puberty, about the 2nd or 3rd estrous cycle. When heifers are grown rapidly in the first year of life, puberty is attained 1 to 2 months earlier, and the allometric mammary growth phase likely is shortened. Rapidly-grown heifers have less mammary parenchymal DNA around the time of puberty, indicating impaired mammary development. For example, Sejrsen et al (1982) fed heifers at high or low intake of an energy-dense diet to gain 2.8 or 1.4 lb/day from 7 months of age to 700 pound body weight, and found that heifers fed high energy had 32% less mammary parenchymal DNA than those grown slowly.

However, the responses to diets which promote rapid body gains varies considerably, from decreases in parenchymal DNA as much as 50% in some studies to no decrease in others. For example, Capuco and coworkers (1995) observed a 48% impairment in mammary development when rapid gains were achieved from high intake of a corn silage-based diet but no impairment from high intake of an alfalfa-based diet. We conducted a study using the same laboratory techniques as Sejrsen et al., but using diets much higher in total protein and in rumen-undegraded protein (Radcliff et al., 1997). Diets were fed from 4 months of age to 2.3 months after puberty, when the heifers were killed. Compared to control heifers, heifers fed a high energy, high protein diet gained 2.7 lb/day, had more carcass and mammary fat, and reached puberty and were killed 1.6 months earlier, but, surprisingly, mammary development was not impaired as assessed by parenchymal DNA content.

Decreases in milk production have occurred in almost all studies in which heifers gained weight more rapidly than 2.0 lb/day before puberty, but the magnitude of the response has varied from 5 to 50%. Furthermore, decreased milk yields are not clearly related to impaired mammary development before puberty. For example, in a study by Little and Kay (1979), high gain heifers grew more slowly after puberty and thus calved at lighter body weight; therefore they devoted more energy to growth during their first lactation than control heifers. In later lactations, however, body weight was similar between groups, and rapidly-grown cows still produced 30% less milk and had 40% less mammary secretory tissue than control animals. In contrast, Capuco and coworkers (1995) found that rapidly-grown heifers fed a corn silage-based diet had 48% less mammary parenchymal DNA at puberty but subsequent milk production was only reduced 5%. Van Amburgh et al. (1998b) fed prepubertal heifers three different diets; the slowest group grew at 1.5 lb/day and calved at 24.5 months. The fastest group grew at 2.1 lb/day, calved at 21.3 months, and produced 5% less fat-corrected milk in their first lactation. We recently fed heifers a high forage diet or a high grain diet (high in energy and protein) from 4 months of age until confirmation of pregnancy (Table 1). Heifers fed high forage grew at 1.7 lb/day before puberty, calved at 23.4 months, and produced 19,540 pounds of milk (adjusted to 270-days) in the first lactatation. Accelerated heifers grew at 2.5 lb/day before puberty, calved at 20.4 months, and produced 10% less milk in the first lactation (17,600 pounds).

Does dietary protein make a difference?

We hypothesized that the ratio of protein to energy in the diet might explain some of the variation in effects of prepubertal diet on mammary development in heifers. Although we commonly evaluate diets based on protein as a percentage of dry matter, animals actually need a specific percentage of dietary calories to come from protein. So if the energy concentration of a diet is increased, the protein concentration also should be increased. According to the 1978 Nutrient Requirements for Dairy Catte developed by the National Research Council (NRC), prepubertal heifers should be fed diets with 54 g of crude protein (CP) per Mcal of metabolizable energy (ME). The 1989 NRC increased the recommended CP:ME ratio to 60 g/Mcal for heifers from 3 to 6 months of age and dropped it to 50 g/Mcal for heifers from 6 to 12 months of age. However, NRC recommendations were designed for growth rates of 1.6 to 1.8 lb/day, and they were based on optimal diets for body growth, not mammary development.

To determine if differences in dietary protein would account for some of the variation in mammary responses to high energy diets and rapid gains, I analyzed data from published studies in which rapid gains exceeded 2.0 lb/day and in which diets were adequately described (VandeHaar, 1997). Across the studies, mammary development of rapidly-grown heifers relative to their controls was positively correlated with the CP:ME ratio of the diets they were fed. Furthermore, CP:ME accounted for 51% of the variation in mammary parenchyma responses and 78% of the variation in milk yield responses to rapid growth rate.

This analysis suggests that inadequate protein might have been responsible for the impaired mammary development of heifers grown more rapidly than 2.0 lb/day in several published studies.

Dietary protein is only one among several factors that may explain the variation in mammary responses among different experiments. Potential sources of variation for responses in milk yield of 11 groups of rapidly-grown heifers also were examined in a multiple regression analysis. Three factors were most important in explaining the variation: weight gain of rapidly-grown heifers as a percent of controls, dietary metabolizable protein (MP) to metabolizable energy (ME) ratio, and calving body weight of rapidly grown heifers as a percent of controls. The average gain of control heifers in the studies was 1.6 lb/day. Based on this analysis, we would expect that if a heifer gains 2.0 lb/day and is fed a diet with MP:ME of 33 g/Mcal (~12% CP in a diet of 1.2 Mcal ME/lb), milk yield would be 89% of controls. If the heifers are fed high protein (~16% CP), the model predicts that milk yield would increase to 97% of controls. If heifers are fed a diet of 1.3 Mcal ME/lb and grow at 2.4 lb/day before breeding, milk yield would drop to 77% of controls if the diet was 14% CP (~33 g MP/Mcal ME), or 90% if controls if the diet was 20% CP (~42 g MP/Mcal ME). Finally, we predict that milk yield would drop another 6% if the rapidly-grown heifers weighed 50 lb less than controls at first calving. The implication of this model is that increasing the dietary protein of prepubertal diets may allow growth as rapid as 2.1 lb/day with mammary development that is essentially normal. This is consistent with the findings of Van Amburgh and coworkers (1998b).

Very few studies have been designed specifically to examine the effects of dietary protein on mammary development. Recently Lammers and Heinrichs (2000) fed prepubertal heifers diets with 46, 54, or 61 g of CP/Mcal ME beginning at 440 lb body weight for 20 weeks. They found that higher protein improved body weight gains from 2.2 to 2.4 lb/day and increased height, width, and girth by about 15%. High protein also increased teat length. However, data from our laboratory show absolutely no relationship between teat length and mammary parenchymal mass or DNA content.

We used 54 Holstein heifers to directly determine if high dietary protein would enhance mammary parenchymal development in prepubertal Holstein heifers fed a high-energy diet for rapid body growth (Whitlock et al., 1999). Heifers were fed either a low (14% CP), standard (16% CP), or high (19% CP) protein diet with the protein coming from expeller soybean meal (high in rumen-undegraded protein). All diets contained 1.3 Mcal ME/lb and were fed as a TMR from 3.5 months of age until slaughter at 6 weeks after puberty. Average daily gain for heifers on the low, standard, and high-protein treatments were 2.5, 2.6, and 2.6 lb/day, respectively. Dietary protein did not affect age or body weight of heifers at puberty, withers height gain, carcass composition, or mammary development. Heifers fed the high protein diet had 10% more mammary parenchyma at puberty but this was not statistically significant. We concluded that dietary protein does not have a major effect on mammary development of rapidly-grown dairy heifers. The data suggest that while feeding high protein may help, it will not prevent the commonly observed impairment of mammary development when prepubertal heifers are grown rapidly.

Is a genetic predisposition for rapid growth associated with decreased milk yield? The relationship of prepubertal growth and mammary development is further complicated by the interplay of genetics and management and whether the rapid growth is associated with lean or fat deposition. In the study of Van Amburgh et al (1998b), even though heifers grown at 2.1 instead of 1.5 lb/day produced 5% less milk, the correlation of prepubertal body weight gain and subsequent milk production of individual heifers was very poor. In the study of Radcliff et al. (2000), even though milk yield was decreased 10% by rapid growth, there was no relationship between milk yield and prepubertal growth rate of heifers within a dietary group. Based on data of Whitlock et al. (1999), heifers that naturally grow the fastest in a group tend to be the leanest, and increased body fat was associated with decreased mammary development. In fact, the correlation between lean body gain and mammary development was slightly positive.

We expect that within a group of heifers that are fed and managed the same, those that are the fattest at the time of puberty and breeding will produce less milk as cows. On the other hand, those that grow the fastest may produce as much milk if not more than their herdmates. These fast growing heifers might have the highest natural growth hormone concentrations, the greatest appetites, or the best immune systems, all factors which could result in more milk once they are cows. I occasionally hear the comment, “Our heifers grow fast and calve at 20 months, and they produce 20,000 pounds of milk in their first lactation. They obviously don’t have impaired mammary development.” The problem with this logic is that these same heifers might have produced 22,000 pounds if they had been managed to grow a little slower and calve a little later.

Our current understanding of mammary development is that heifers that are grown more rapidly than 2.0

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lb/day are at great risk for decreased milk yield in first lactation. The fact that decreased mammary development and subsequent milk yield are not always observed indicates that specific feeding and management practices might reduce this risk. But what these practices are is not clear. Based on our data and my analysis of the literature, I make the following conclusions and recommendations:

1. Heifers grown faster than 1.8 lb/day will likely produce less milk as cows if they are fed diets with protein at or below NRC recommendations. This is most commonly a problem when heifers are fed diets high in corn silage with inadequate protein supplementation.
2. Feeding high protein (60 to 65 g CP/Mcal ME) can reduce the risk of impaired mammary development and may enable gains as rapid as 2.1 lb/day with very little decrease in subsequent milk production. However, even with high protein, all available data show that feeding heifers for gains faster than 2.1 lb/day will decrease milk yield by at least 10%.
3. Accelerated growth programs, with a goal of calving at 22 months, require excellent management after puberty. Delayed breeding may cause overfattening in too many heifers. Also these heifers often grow slower than expected after breeding. Unless the heifers are fed and managed to maintain high rates of gain, they will likely calve at light body weights, which can compromise milk production.
4. Fat body composition may be a greater risk factor for impaired mammary development than is rapid growth. Furthermore, some heifers may have the genetic potential to gain at 2.2 lb/day without becoming fat and without impaired mammary development. But others may become fat and have impaired mammary development when growing only 1.8 lb/day.
5. The effect of rapid growth on younger heifers (from birth to 4 months) has been studied very little. Available data suggest that this is one time that a focus on faster growth may be beneficial, but more research is needed to show if mammary development is normal when heifers are grown rapidly from 6 to 16 weeks.
6. Heifers should be bred on size not age. If a group of heifers has already grown too fast and is already at the proper size for breeding at 10 months of age, go ahead and breed them-the damage has already been done. However, a major adjustment to the young heifer program should be made.

Effect of heifer feeding program on lifetime profitability

Although the cost of raising a heifer to first calving is not trivial, it is substantially less than the gross income generated from subsequent milk sales. Thus, in developing a cost-effective heifer rearing program, one must weigh the costs of heifer rearing versus the potential impact on net income of the animal after calving. Early calving may decrease heifer costs, but if mammary development or body size at calving is decreased, early calving may be an expensive mistake.

Some dairy management experts have attempted to examine the economics of early calving with a simple formula. They assume that if raising a heifer to first calving costs $1,200, then heifer costs are $50 per month. With this simple model, lifetime profit is increased $150 if calving is expedited from 24 to 21 months and there is no loss in milk production. But even if milk production is decreased 10% in the first lactation, early calving may still be profitable on paper with an average cost approach. For example, let's assume that the average cost of milk production is $2 less than the price of milk or that the average return to milk production is $2 per cwt of milk. With this logic, a 10% decrease in milk (about 2,000 pounds) would result in $40 less profit after calving, so the net lifetime gain would be $110 ($150 to $40). Even if the average return to milk was $3 per cwt and the decrease in first lactation milk production was 20% (4,000 pounds), the producer would still make $30 more on an animal that calved 3 months earlier.

The problem with this approach is that the marginal monthly costs for growing a heifer an extra month are much less than the average monthly costs to raise a heifer. And the marginal costs associated with producing an extra 100 pounds of milk are much less than the average costs to produce 100 pounds of milk. Thus the above simplistic analysis favors accelerated growth and early calving in two ways. It overestimates the cost savings of early calving and it underestimates the loss in net income of the heifer after calving. So lets consider an analysis using marginal costs.

Whereas early calving decreases housing costs and some other fixed costs, it does not decrease many types of heifer-rearing costs, such as the costs of feeding young calves milk, vaccination costs, and breeding costs. Furthermore, daily feed costs most certainly will increase with an accelerated growth program, and perhaps even some nonfeed costs will increase. For example, better housing and ventilation may be needed. So how much do we really save for each month of earlier calving? According to enterprise budget figures by Radcliff et al. (1997), the actual savings for each month saved in raising a heifer from 4 months of age up to breeding size of 800 pounds was $27, or about half the average monthly cost of raising a heifer. However, the standard growth heifers of Radcliff were fed relatively expensive stored forages. If grazing or byproduct feeds or restricted feeding of grains had been part of the standard growth system, the marginal cost savings would have been even less. In any case, let's assume that decreasing the age of calving by 3 months would save about $80 in a confined heifer-rearing system.

Now let's examine the marginal return to an extra 100 lb (cwt) of milk, which will be much greater than the average return to a cwt of milk. Compared to a cow that produces 20,000 pounds of milk, one producing 16,000 pounds will need less feed to make milk, but she needs as much feed to maintain herself. Furthermore, the low producer requires almost as much labor for milking, feeding, and bedding and she needs as much stall space in the barn and milking parlor. The marginal return to milk approaches the extra milk income minus the extra feed costs to make it (commonly called the margin or income over feed costs). Thus the loss in milk income when considering marginal costs for a cow is more typically $7 per cwt of milk (this obviously varies with changing milk and feed prices, but for simplicity, I will use the $7 figure as a typical value).

Possible returns from various responses to rapid growth are shown in Table 2. If calving 3 months early does not impair milk production, lifetime profit might increase $80. However, if milk production is impaired 10% (or about 2000 pounds) in the first lactation, then lifetime profits will decrease $60. And the decrease in lifetime profits can be even greater if production is decreased more than 10% or carries into later lactations as some research suggests. In any case, no study yet has shown that heifers can grow faster than 2 pounds per day or calve before 22 months without at least a 5 to 10% loss in milk for the first lactation. Until we discover how to eliminate the risk of impaired mammary development with accelerated heifer growth, it is risky business. It's kind of like blackjack, but with heifers, anything less than 22 months means you're busted!

Perhaps high protein diets before puberty can overcome this impairment, but more studies are needed before we can be confident that feeding high protein will eliminate the risk of impaired mammary development. Feeding more protein before puberty would cost ~$15 per heifer. At the present time, this $15 cost seems a reasonable investment given that in some studies even prepubertal gains of 2.0 lb/day have impaired mammary development at protein levels commonly used on farms.

One important factor in the decision on whether to breed heifers for earlier calving is the availability of space to house heifers relative to availability of space to house lactating cows. If heifer space is in short supply, perhaps earlier breeding even at a lighter body weight should be considered.

For most well-managed, intensive-feeding operations, the most profitable age for first calving is likely 22 to 24 months. First calving at greater than 24 months will likely reduce profitability, unless feed or fixed costs are unusually low, as may be the case for heifers grown on pasture. Pasture generally has a very low cost per Mcal of ME. Even in pasture systems, however, gains of 1.8 lb/day are attainable through intensive-grazing or grain supplementation, and 22 to 24 months may be most profitable.

Goals for heifer growth

Targets for heifer rearing in intensive management conditions are:

- Age at first calving = 22 to 24 months
- Body weight after calving = 1,250 pounds
- Height at calving = 56 inches at the withers
- Body condition score at calving = 3.0 to 3.5
- Growth rate from 3 to 10 months of age = 1.7 to 2.0 lb/day

To achieve these goals for calving, heifers should be compared to the recommended weights and heights of Figures 1 and 2, and bred at 13 to 15 months, standing 51 inches at the withers and weighing 850 pounds.

Feeding heifers to achieve these goals

Nutrition models are needed in evaluating diets to determine if the supply of nutrients from the diet matches the nutrient requirements of the animal. So how good are our models of heifer nutrition? The short answer is not very good.

In the study of Radcliff et al. (1997), we fed heifers diets with 75% grain or 90% forage ad libitum for rapid or standard gains. Heifers fed a high grain TMR ate 20% more than predicted by the 1984 Beef NRC, and slightly more than predicted by the 1996 Beef NRC, Spartan Dairy Ration program, or equations developed at VPI (Hubbert, 1991; Quigley et al., 1986). Heifers fed a high forage TMR ate less than predicted by the 1984 or 1996 Beef NRC models or equation of Quigley et al. and about the same amount as predicted by Spartan Dairy or Hubbert. Overall, the recent equation from VPI was reasonably accurate under the feeding conditions of our heifers.

More importantly, however, heifers fed the high forage TMR gained more than twice as much as predicted by the 1989 Dairy NRC. Predictions for gain were close to

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actual gains for heifers fed the high grain TMR. Van Amburgh et al. (1998a) recently published observed vs. expected gains for 270 heifers based on actual energy intake and found similar results. The 1989 Dairy NRC underpredicted gains of heifers grown at 1.3 lb/day by half, but was reasonably accurate for heifers gaining 1.8 lb/day. The Cornell Net Carbohydrate and Protein System (CNCPS), a much more mechanistic model than the 1989 Dairy NRC, was no better. So why do these models underpredict gains? The most likely explanation is that modern Holstein heifers fed high forage TMRs grow with more lean gain and less fat gain than expected and thus more total gain per unit feed energy input. Another possibility is that dietary forage is retained in the digestive tract longer than expected in heifers so that digestibility and consequently gains are greater than expected as well.

Most computer ration models also are not very good at describing the protein nutrition of heifers with the major problem being the prediction of microbial protein yield. Whereas the 1989 Dairy NRC underpredicts microbial protein for young heifers, the the CNCPS overpredicts microbial yield for prepubertal heifers (Van Amburgh et al., 1998a). But in any case, the crude protein system works fine for growing heifers if it is used with a bit of common sense. Heifers should be fed mostly true protein sources (such as soybean meal) as the CP supplements, but a little urea or other form of non-protein nitrogen is okay if fermentable starch is available.

Regarding our ability to feed heifers to meet growth targets, I conclude the following:

1. Dairy heifers fed high forage TMRs ad libitum are more efficient in using consumed energy than current models predict. Furthermore, current models are often inaccurate at predicting feed intake.
2. Under good environmental conditions and management, dairy heifers usually will grow considerably faster than expected when fed a TMR for ad libitum intake. In other words, if you balance a diet for 1.8 lb/day, the heifers may very likely grow 2.3 lb/day.
3. Under poor environmental conditions, heifers may grow considerably slower than predicted. Some models do try to account for such conditions; however, environmental conditions are often difficult to accurately define, so accuracy of the model may still be a problem.
4. Don't assume any computer program will accurately predict gains in Holstein heifers. Let the heifers be the judge of any feeding program. If weights cannot be measured with a scale, use a weigh tape. Height and body condition should also be assessed routinely. The critical times to evaluate are at weaning, at about 5 months, at breeding, and just after calving.
5. For prepubertal heifers, complicated models for formulating diets for heifers usually are no better than simple ones. For protein, the crude protein model as found in 1989 Dairy NRC can work well if most protein comes from true protein sources of average rumen-undegradability. Diets should contain 56 to 60 g of CP per Mcal of ME or ~100 g CP per Mcal NEm with rumen-undegradable protein at 25 to 35% of the total protein.

Recommended daily gains and dietary energy and protein concentrations are given in Table 3. These recommendations assume feed will be offered as a TMR for ad libitum intake. Although NRC works well when heifers are fed at restricted intake, NRC tables were not developed for ad libitum feeding. Ad libitum feeding may be desirable in group-feeding situations. Thus, my recommendations for dietary energy concentration are lower than those of NRC 1989 to achieve target gains of 1.8 lb/day. Instead the recommendations are based on data from the study of Radcliff et al. (1997, unpublished data), in which heifers were group-housed in a comfortable yet confined environment, were kept healthy, had water and feed available all day with plenty of bunk space, and were fed their diet as a TMR. In some situations, higher energy diets may be needed to meet the target gains.

Summary

A good heifer rearing program is critical to produce animals at first calving that have well-developed mammary glands capable of producing to the animal's genetic potential and that have good body size and body condition capable of high feed intake and delivery of nutrients to the mammary gland. Weight gains more rapid than 2.0 lb/day before puberty generally decrease development of the mammary gland and subsequent milk production. Feeding more protein when heifers are grown rapidly may reduce the risk for impaired mammary development and is probably worth the added expense when trying to achieve postpartum body weights of ~1,250 pounds and calving at 22 to 24 months. Although calving earlier than 22 months may decrease the costs of raising heifers further, odds are that future milk production will be impaired so lifetime profitability may actually decrease. The costs associated with heifer-rearing should be thought of as an investment, not just an expense. Trying to cut these costs with accelerated growth programs may work, but the risk is high that accelerated growth will be an expensive mistake. I'd rather take my chances at blackjack!

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Table 1. Accelerated growth and milk production (Radcliff et al, 2000).

	Control	Rapid Gain	Significant?
Diet ME, Mcal/lb	1.0	1.3	
Diet CP, % of DM	17	19	
Daily gain before puberty, lb/day	1.7	2.5	yes
Body condition score at 800 lb.	3.5	4.2	yes
Inseminations per heifer	1.4	1.8	no
Age at calving, mo.	23.4	20.4	yes
Body weight after calving, lb.	1,186	1,133	no
Body condition score at calving	3.7	3.5	no
Calving rate (heifers calved/heifers in treatment)	33/35	31/35	no
Energy-corrected milk yield (305 day), lb.	19,540	17,590	yes

Table 2. Marginal costs and returns in heifer raising.

Calving age (months)	Marginal heifer costs	Milk Response	Marginal cow net income	Lifetime marginal profit
24	$0	0	$0	$0
21	–$80	0	$0	+$80
21	–$80	–5% for 1st lact (–1,000 lbs.)	–$70	+$10
21	–$80	–10% for 1st lact (–2,000 lbs.)	–$140	–$60
20	–$110	–20% for 1st lact (–4,000 lbs.)	–$280	–$170
20	–$110	–10% for 3 lactations (–6,000 lbs.)	–$420	–$310

more →

Table 3. Growth goals and recommendations for feeding Holstein heifers ad libitum.[1]

Age months	Weight lb	Gain lb/day	Height inches[2]	ME[3] Mcal/lb	NE[4] Mcal/lb	% CP[5]	CP:ME g/Mcal[6]
2	167	1.76	34.1	1.33	0.80	18.4	63
4	279	1.96	37.6	1.27	0.76	17.6	63
6	398	2.00	40.8	1.18	0.71	16.4	63
8	517	1.97	43.9	1.12	0.67	14.8	60
10	634	1.93	46.7	1.12	0.67	14.8	60
12	748	1.89	48.7	1.08	.065	12.6	53
16	970	1.81	51.7	1.08	0.65	12.6	53
22	1,290	1.76	54.8	1.08	0.65	12.6	53
23	1,343	1.76	55.2	1.08	0.65	13.3	56
24 precalf	1,400		55.6	1.20	0.72	14.8	56
24 postcalf	1,250		55.6	1.30	0.78	18.0	63

[1]Targets for other breeds can be calculated with goal of 90% of mature weight at 24 months.
[2]Height at the withers.
[3]Concentration of metabolized energy in diets. ME is approximately NEm divided by 0.6.
[4]Special rumen-undegraded protein sources are not needed. Most supplemental CP should come from true protein sources as legume forages and soybean meal; however, urea could be used in limited amounts as long as the rumen-undegraded protein was 25 to 35% of total CP.
[5]To calculate the CP:ME ratio, multiply %CP by 10, divide by Mcal ME/lb, and divide by 2.2

Figure 1. Recommended body weights for Holstein heifers with calving at 24 months.

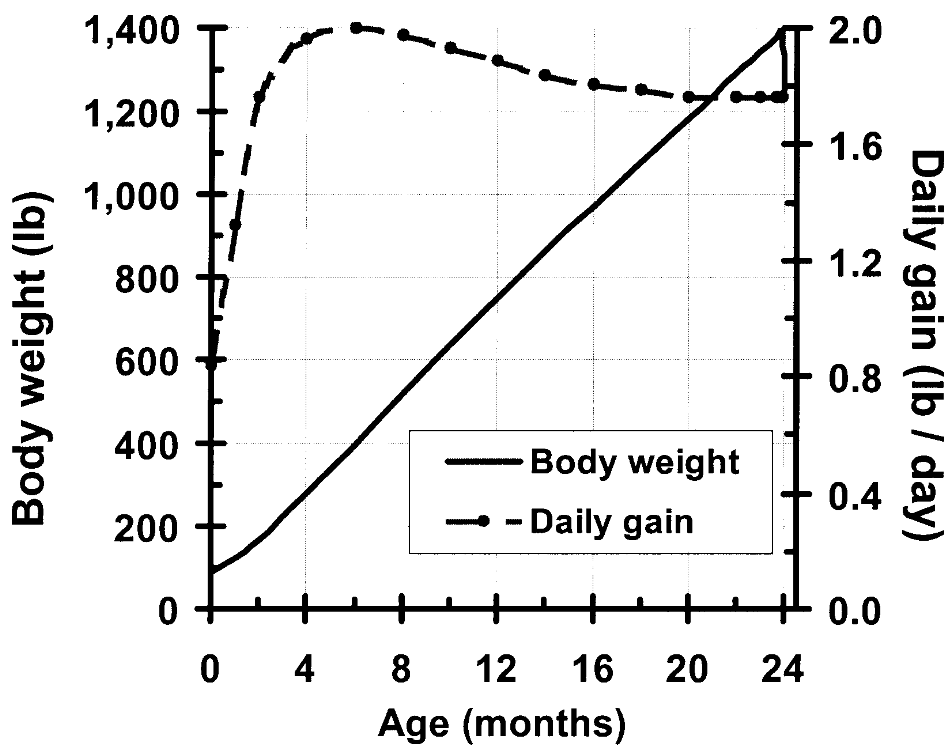

Figure 2. Recommended heights for Holstein heifers with calving at 24 months.