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WHAT'S NEW IN GROWTH STANDARDS FOR DAIRY HEIFERS?

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Introduction

For the past 6-10 years it generally has been recommended that replacement dairy heifers should enter the herd at about 24 mo of age and at greater weights than formerly recommended. These newer recommendations emphasize the often observed positive associations between size at first calving with milk production. But it also tends to minimize any negative effects that more rapid growth rates may have on milk production. The most important goal in raising heifers is to do so with minimum expense and using management procedures that allows them to develop their full potential during their productive life. To accomplish this goal dairymen will need to (1) achieve good growth of heifers while maintaining them healthy and minimizing death losses, (2) maximize the growth of their mammary glands and be sure they have good body size at breeding and at first calving, and finally (3) to make sure they have high reproductive performance.

Each heifer inherits a genetically controlled lactation potential. Full expression of this potential can be affected by growth rates up to time of first calving, not only by how they are fed and managed during the lactation. Because we can regulate growth, and therefore age and size of the heifers at breeding and first calving, there is a strong interest in knowing how management schemes to raise heifers will affect their productive performance and also to establish growth standards that can be followed and will let us accomplish our goals.

Many factors, such as disease control, sire selection, nutrition, and general management affect lactation performance, but there is no doubt that age and weight of heifers at first calving are important in determining how well they produce during lactations that follow. If growth of heifers is erratic or poorly controlled, then they may be too large or too small at specific ages such as at first breeding or first calving and end up as poor replacements. The objectives of this paper are to describe some of the relationships between heifer rearing rates and subsequent milk production, to describe target weight gains at specific ages, and to describe opportunities to raise heifers at greater rates considering some possible limitations to more rapid rearing of heifers and earlier ages at first calving, and finally to discuss optimizing heifer growth and developing new growth standards for the future.

Growth Rates and Standards

Growth is a pliable function so it is possible to accelerate or decrease growth rates of dairy heifers by different feeding programs (low, medium or high nutrient or energy intakes) in ways that will not affect mature body size. There are multiple effects of feeding growing dairy heifers different levels of energy and protein in their diets (plane of nutrition). The age heifers reach puberty is approximately inversely related to plane of nutrition (Reid et al., 1969) so it will likewise be accelerated or delayed. Heifers reach puberty at about 40 to 50% of mature body weight and the time delay to reach puberty can be very long where heifers are raised on low energy diets which support very low average daily gains (ADG). Because the age to reach puberty is longer, it is likely that growth of the mammary glands also is delayed compared to that of heifers that reach puberty earlier. Although it is possible to modulate heifer growth rates, the goal of having them large enough to breed at 13 mo or younger so they will calve at 24 mo or earlier requires certain minimum growth rates throughout these time periods. Current recommendations for Holsteins (NRC, 1989) are for ADG of 1.3-1.7 lb. Clearly these growth rates are not sufficient to allow us to calve heifers earlier and at sufficient body weights. An ADG of at least 1.7 lb/day will allow heifers to reach desired weights at desired ages for a 24 mo calving age but not earlier. For example, if we expect Holstein heifers to reach puberty by 8 to 11 mo at 40-50% of mature body weight, be bred at 13 mo at about 50 to 60% of mature body size, have conceived on average by 15 mo and calve at about 24 mo and be 1200 to 1250 lb, excluding newborn calf and placenta, then they need to add 50 lb of body weight per month from birth to first calving (ADG of 1.7 lb). ADGs of 1.3 lb clearly are too low because they will add only 40 lb/mo to an average birth weight of 90 lb. Puberty and breeding will be delayed and calving at 27 to 28 mo is probable. When slower, but more realistic growth rates (ADG) are achieved during the first 2 mo of life (1.2-1.4 lb/day), ADGs required during the remaining months until puberty and breeding will need to be greater than 1.7 lb/day (Table 1).

$\frac{1200 \text{ lb}}{24 \text{ mon}} =$ 50 lb/month

Table 1. Body weights at different ages and average daily gains required for different time periods for dairy heifers of different mature sizes

	Body weights (lb)				Average daily gains (lb)[a]	
Breed	Birth	13 mo	24 mo	Maturity	Birth→13 mo	Birth→24 mo
LARGE						
Holstein or Brown Swiss	90	810	1300	1600	1.91	1.70
		750	1150	1450	1.73	1.47
MEDIUM						
Guernsey or Ayrshire	70	750	1180	1250	1.81	1.56
		640	1025	1150	1.48	1.33
SMALL						
Jersey	60	570	900	1050	1.36	1.18
		500	790	1000	1.15	1.02

[a]Calculated assuming ADGs of 1.5, 1.3 and 1.0 lb for ***LARGE***, ***MEDIUM*** or ***SMALL*** breeds from birth to 2 mo of age.

Heifer growth standards were developed from measures of growth of heifers made over 40 to 60 years ago. Results largely were from growth of heifers at university experiment station herds. Those published by Ragsdale (1936), Matthews and Fohrman (1954) and Davis and Hathaway (1956), among others, were used as recommended guides of heifer growth. More recent growth data for Holstein heifers on commercial dairy herds in Pennsylvania (Heinrichs and Hargrove, 1987) or Wisconsin (Hoffman and Funk, 1992) and from multistate sources for Guernseys and Jerseys (Heinrichs and Hargrove, 1991) show today's Holstein and Guernsey, but not Jersey, heifers are growing more rapidly. Body weights and skeletal size are greater than seen in the 1930s to 1950s. Some of this increase is due to greater birth weights, as well as greater growth rates, especially during the first 6 mo. Overall, the increase probably is because of genetics, management and nutrition, as dairymen move breeding and calving ages lower. The major way to do this is by growing heifers faster because gestation length is fixed in a rather narrow range,

Newer growth standards compiled from several sources are in Table 2. These data can be used to monitor growth of heifers (weight and height) and to make sure growth is not erratic (Heinrichs, 1992, 1993). It is important to include some measure of skeletal growth. Weight alone is not a perfect measure. Excess accumulation of lipid vs lean (muscle) can occur in fast-growing heifers. Differences in gut-fill occur in heifers fed different high roughage diets. Gut-fill can vary from 10 to 25% of body weight depending on roughage (Waldo et al., 1988). Increases in weight alone can be misleading and should be coupled with other physical measures of growth, such as height at withers. body length, of width of hooks and pins.

Growth data for Holsteins (weight and height at withers) have been graphed (Figure 1). This, and other graphs which can be made for other breeds using data in Table 2, includes numbers around the population averages. They can be used as standards of growth and, in particular, to make sure the ratio of skeletal growth is in line with body weight. The upper line bounding the shaded area for weight and height is not the maximum that can be attained, but is a good rate to use as a goal so that heifers are large enough at first calving. It may or may not be economical to raise heifers faster than this. Going below the lower line

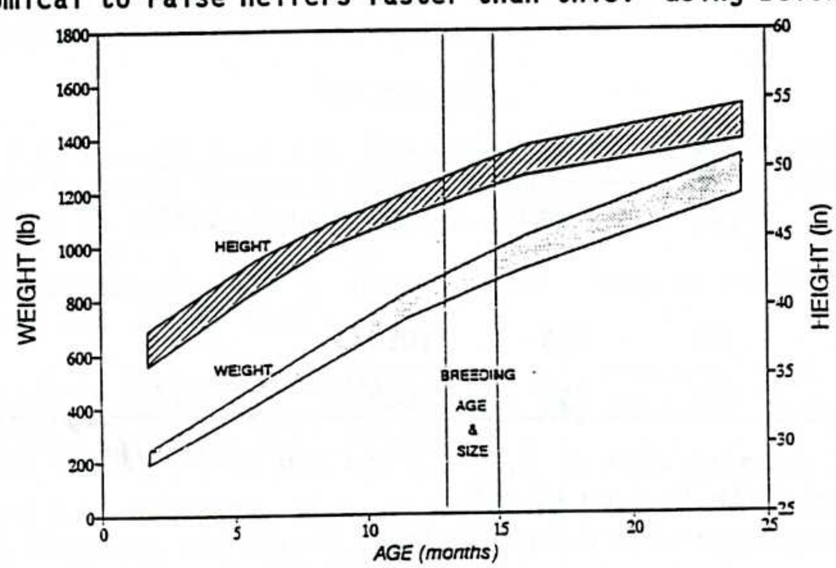

Figure 1. Growth chart for Holsteins. Plotted from data assembled in Table 2.

will not allow heifers to reach target weights at breeding and first calving. Wide deviations outside of the shaded area are undesirable and indicate underfeeding, overfeeding or other problems. Comparing heifer growth with charted growth guides will allow growth rates to be monitored by dairymen and nutritionists can spot problems in feeding and management of heifers while there still is time to take corrective action.

Table 2. Body weights and heights for dairy breeds during growth[a]

	Holsteins[b]		Guernseys[c]		Jerseys	
	Weight[d]	Height[d]	Weight	Height	Weight	Height
Age (mo)	(lb)	(inches)	(lb)	(inches)	(lb)	(inches)
Birth	85-100	29-30	65-75	26-27	50-60	25-26
1	130-155	31.7-33.2	120-143	31-33	93-108	26-29
2	170-209	33.5-35.2	160-193	32-35	122-146	30-33
3	225-263	35.2-37.1	203-233	35-37	155-177	32-34
4	270-319	36.9-38.8	250-299	37-38	183-217	34-36
5	320-375	38.4-40.4	299-354	38-41	233-278	35-38
6	368-430	39.8-42.0	366-439	40-42	259-321	36-38.5
7	417-486	41.1-43.3	384-448	41-43	300-360	38-40
8	466-540	42.3-44.5	430-503	42-44	335-410	39-41
9	510-597	43.4-45.7	480-568	43-46.5	370-435	39.5-41.5
10	560-652	44.0-46.7	505-588	44-46	395-485	40-42
11	610-710	45.4-47.6	574-662	45-47	428-499	41-43
12	660-760	46.3-48.5	576-674	45.5-47.5	460-548	42-44
13	710-810	47.1-49.3	643-756	46-48	500-570	42.5-44.5
14	750-866	47.8-50.0	680-803	47-49	535-602	44-45
16	812-966	49.0-51.2	770-899	49-51	585-660	44.6-46.3
18	926-1060	50.2-52.1	860-1000	50-52.3	640-753	45.3-47
20	1005-1166	51.0-53.0	910-1046	51.2-52.9	698-813	46-47.6
22	1075-1228	51.7-55.0	996-1123	51.5-53.5	758-875	47-49
24[e]	1150-1350	52.2-56.5	1025-1178	51.8-54.5	790-900	48-51

[a] Adapted from Heinrichs and Hargrove 1987, 1991; Crowley et al., 1983, and Hoffman and Funk, 1992.
[b] May be appropriate for Brown Swiss.
[c] May be appropriate for Ayrshires.
[d] Ranges of weight and height.
[e] Calving expected at about 24 mo.

High milk production can be attained when heifers are large and calve at 24 mo. Managers of high-producing Holstein herds in Wisconsin (> 22,000 lb) raise heifers that weigh approximately 800 lb at 13 mo, calve at 24 mo, weigh 1350 lb (precalving weight) and are in good body condition (Hoffman and Funk, 1992). Surveys of milk production from 163 commercial herds in Pennsylvania showed heifers from higher-producing Holstein herds (> 16,000 lb) were heavier (23.5 lb) at 24 mo than those from lower producing herds (Heinrichs and Hargrove, 1987). Same trend was found for Guernseys, Jerseys, Brown Swiss, Ayrshires and Milking Shorthorns (Heinrichs and Hargrove, 1991, 1994). It is possible to attain high milk yields from Holstein replacement heifers that have high ADG (1.8 lb) and calve at recommended weights (Table 1). The same likely is true for other dairy breeds. In many ways dairymen may be ahead of those of us who research and/or advise them on the nutritional management that should be used to raise heifers at higher growth standards so that they will calve at younger ages but greater body weights and size. For example, on some dairy farms in Florida dairy managers are raising replacement heifers so that they calve between 20-21 months of age and these managers believe that these heifers are producing just as good as heifers calving at older ages but probably similar weights.

Effects of Age at First Calving

The recommendation that heifer replacements should enter the producing herd by 24 mo comes from a summary of results that were obtained over the past 6-10 years and even earlier. Importantly, lifetime milk yield, 305-day lactation yields and lifetime profit of replacement heifers are maximized when they calve for the first time between 23 to 25 mo of age. Although 24-mo has been widely recommended, actual calving ages of first-calf heifers are greater than this. Over the period from 1960 to 1986, Nieuwolf et al. (1989) found that mean ages at first calving for dairy breeds were greater than 26 mo (Ayrshire, 29.4; Brown Swiss, 28.7; Guernsey, 28.3; Holstein, 28.2; and Jersey, 26.8 mo). These calving ages probably have not decreased greatly during the intervening years but likely are moving down.

In general there appear to be advantages to the dairyman if heifers calve older than 24 mo. These heifers should be larger, better able to compete in the milking herd, and able to produce more milk than younger and smaller heifers. However, there are important disadvantages to having heifers calve older besides increasing the nonproductive life of the heifer and delaying returns of income from milk sales. It also will require the dairyman to increase the inventory of heifer replacements needed and will increase the generation interval because of the delay in bringing genetically superior replacements into the herd. If the annual culling or replacement rate in the milking herd is 34%, then for each 100 cows in the dairy herd, 34 good 2-year-old replacement heifers will be needed each year. This means about 40 heifers will be needed annually to provide these fresh 2-year-olds, assuming a 15% loss of heifers from birth to first freshening. For each 2 mo increase in calving age, an additional two or three heifers will be needed per 100 milking cows. So, unless other herd considerations favor calving heifers at older than 24 mo, it should be avoided.

One presumption of calving heifers at older ages is that they will be larger, but this will be true only if they are raised at faster rates, otherwise the size advantage will not be realized. Because heritability of age at first calving is low, it should be possible to calve heifers at about 24 mo, or even younger, and still have them attain high milk production. (Figure 1).

(2 mon/24 months) x 40 heifers = 3.3 heifers

Conversion factors to adjust milk production for heifer ages of 20 mo and older have been used for a long time to allow dairymen to evaluate potential mature milk production. These are seen by plotting data of Norman et al. (1974; Figure 2.). Increases in 305-day production are greatest where ages at first calving are increased from 20 mo or younger to about 25 to 26 mo. Actual increase in pounds of milk expected during a 305-d lactation when heifers are greater than 26 mo is less than 50 to 100 lb per month for Holsteins and Jerseys; less than .8 and .6% increases per month increase of calving age. Delaying calving ages beyond 25 mo really cannot be justified because increases in production are so small. These data also point out that heifers probably should not calve at less than 23 mo because lactation yields will be reduced by 300 to 400 lb for Holsteins and 200 lb for Jerseys for each month calving age is reduced. But this recommendation does not consider that the heifers may be larger because they were raised at faster rates of gain (ADG).

Another problem when heifers calve at less than 23 mo is increased risk of calving difficulty (dystocia). This largely occurs when heifers calve for the first time at smaller sizes. Replacement heifers with dystocia are as much as four times more likely to have retained placenta, metritis, and reduced physical condition and ultimately to be culled involuntarily (Hoffman and Funk, 1992). This poorer postpartum condition of heifers and the need for smaller heifers to utilize some of their feed nutrients to complete growth during first lactation probably are the major causes of lower production.

Whatever age we set as the goal for heifers to calve for the first time means we also will need to set target weights so they will be large enough (weight and height) to reach puberty and to breed younger and to calve at heavier body weights.

Effects of Body Weight at First Calving

There is a strong relationship between age at first calving and body size because body size at first calving is determined, in part, by age. If all the dairyman wants is larger heifers, it would be easy to delay time of first breeding and calving but, as indicated, this has negative economic consequences. The other option is to raise heifers faster because gestation length of animals is fixed within a narrow range. This brings up the important question of just how big do we really want our heifers to be when they calve and how much does it matter. In some cases, genetically heavier heifers at first calving produce less milk, protein and fat than lighter heifers. Heavier cows possess little, if any, superiority in feed efficiency over smaller cows but there is a positive relationship between body size at first calving and the first lactation milk yield. Good estimates of benefits in milk production attributable to body size are available. In a very large study including over 600,000 DHI records, Keown (1986) found that first lactation milk yields were about maximal for Holstein heifers when they weighed between 1350 to 1400 lb on first test date after calving (Figure 3). These results were adjusted for herd, heifer age, and month they freshened. Age was much less important than body weight. Increase in 305-day milk was about 2000 lb for heifers calving at 1350 to 1400 lb compared to those calving at about 900 lb. Rapid increases in milk production occur for calving weights between 1000 and 1200 lb. This reinforces recommendations that first-calf Holstein heifers should weigh at least 1200 to 1250 lb after first calving.

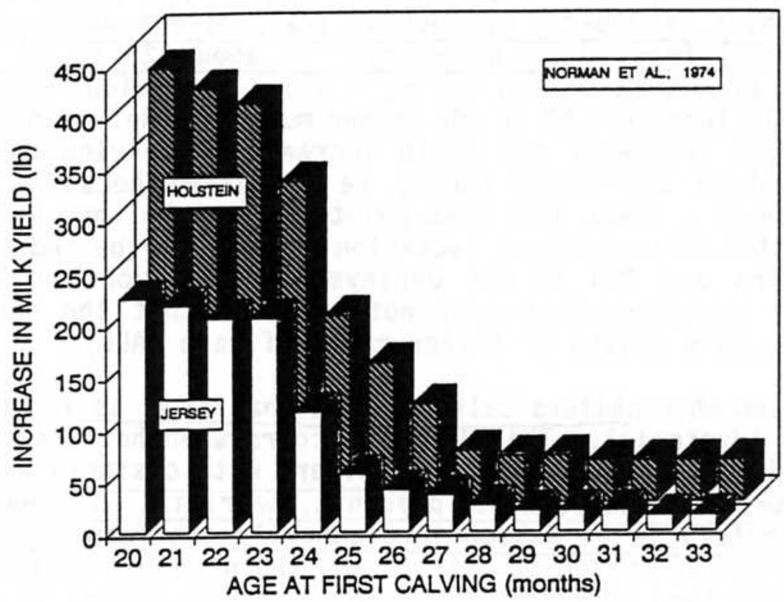

Figure 2. Effect of age at first calving on milk yield.

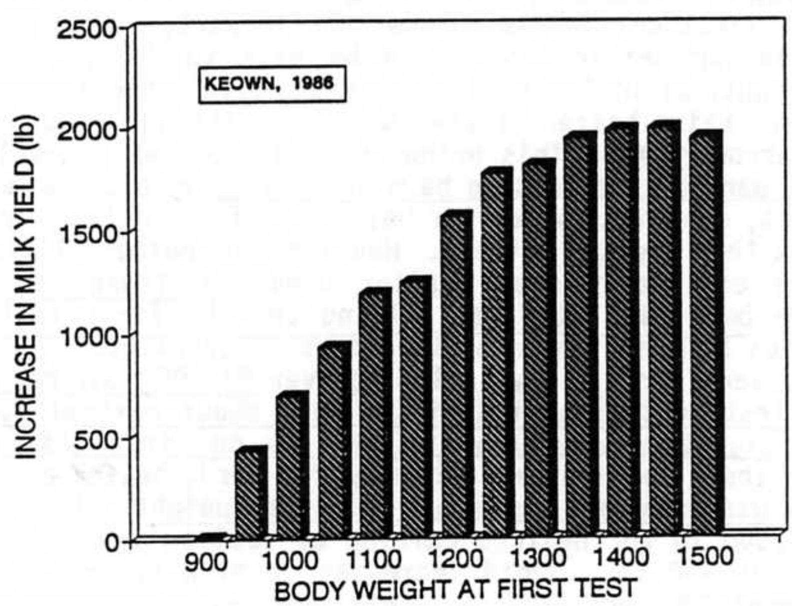

Figure 3. Relationship of body weight at first calving and milk production.

Growth Rates Affect Lactation

Experimental and field studies indicate that method of raising heifers affects their lactation performance. Extremes of growth rate are detrimental for lactation. Growth rates of dairy heifers can vary widely from birth until first calving. Because feed and labor inputs are required over essentially 2 yr before heifers calve it often may be difficult to maintain consistency. However, growth rates wanted should be established and the entire program should be monitored regularly. Heifers need to be weighed, if possible, or tape weights taken; either will provide measures needed to monitor the program at important ages. Measures preferably should be taken at birth, weaning, puberty, breeding and calving. Periods of underfeeding or overfeeding heifers that can affect lactation performance and their economic value when they enter the herd will be detected by taking measures at these times, if compared to target growth standards.

Underfeeding Growing Heifers. Underfeeding has several bad outcomes and clearly is not recommended. Importantly, heifers grow slower, reach puberty at older ages, and either will need to be bred at lighter body weights or at older ages. Heifers raised at ADG of 1.0 lb or less will not reach puberty until 16 mo or later. They may show quiet or less intense estrus, making it more difficult to detect, even though they ovulate and could be bred. Breeding heifers at lighter body weights than recommended results in smaller body size at calving, smaller mammary glands and greater incidence of calving difficulties. These heifers have lower milk yields during first and second lactations. The productive portion of the heifers' life will be shortened. By the end of the fourth lactation they will reach their expected size for age, but only if they are fed well after entering the milking herd. Clearly this is not an acceptable standard to raise dairy heifers. Nonetheless, it is not uncommon for deficiencies of energy, protein and minerals to occur for growing heifers. Seasonal variation in pastures, poor quality and quantity of roughages or inadequate feeding of grain supplements can be causes of low ADG. Under some management systems, where group feeding is practiced, dominant heifers eat more than their proportionate share of feed and others in the group will have less than needed. Ideally these problems will not be extreme nor for long periods of time, but can give ADG much less or greater than desired. Although generally there are no absolutes, if heifers are underfed by 15 to 40% for extended periods anytime during the first 2 yr of life, and it goes undetected, then the mammary glands will be smaller, puberty and breeding will be delayed, and the animals will be small for chronological age. If heifer growth is monitored, these problems will be detected early enough to take corrective action.

Underfed and undersized dairy heifers need to be managed and handled differently than those growing normally. If they are not they probably never will catchup and reach target weight. There are four options for handling underfed heifers and two of them are not really acceptable. The heifers can be culled, secondly, delayed entry into the milking herd can be accepted as inevitable. Where growth deficit is not large, an alternative is to increase their feeding to get higher growth rates. If before puberty, ADG of 1.7 to 1.9 lb appear to be safe and if after puberty or during gestation the target ADG can be up to 2.0 to 2.2 lb. A final option, if the growth deficit is extreme, may be to try and stimulate compensatory or catch-up growth.

Compensatory Growth. Domestic animals can experience compensatory or catch-up growth when a period of underfeeding is followed by a period of feeding high levels of nutrients in a well balanced diet. Heifers can compensate for periods of slow growth caused by underfeeding with periods of very rapid growth when they are fed diets high in energy, protein, minerals and other nutrients at about 15 to 40% greater than recommended (NRC, 1989). Example of growth rates during underfeeding and controlled overfeeding is in Figure 5 (adapted from Park et al., 1987. Full utilization of compensatory growth can allow a group of underfed and poorly grown heifers to reach breeding and calving ages on time. Several months or even several periods of several months each of compensatory growth may be needed for heifers to reach their target breeding or calving weights.

Overall, benefits of compensatory growth are growth rates 2 to 2½ times recommended (ADG of 3.7 to 4.7 lb) and improved efficiency of utilization of feed nutrients. Weight gains are much greater than otherwise expected for amount of nutrients consumed. Heifers raised as indicated with three periods of compensatory growth were just as large as normally raised heifers when calving at 24 mo and produced just as much milk (Park et al., 1989). The time to initiate compensatory growth depends on when slow growth of heifers is detected, but probably will not be earlier than 6 to 9 mo. Compensatory growth of heifers then and later has been observed (Park et al., 1987; Stelwagen et al., 1991) but use of compensatory growth earlier than 6 mo has not been evaluated fully.

Overfeeding Growing Heifers. Dairy heifers should not be fed to fatten at any age. Poorest lactation by replacement heifers occurs when they calve early but are fat. Swanson (1978) found that when one twin of identical pairs was grown on high-energy diets they became fat and produced below normal during the first two lactations compared to the other twins grown on a standard ration. He believed it resulted from overly fat udders. Attempts to accelerate body growth too much up to time of puberty caused reduced milk yields. The exact ADG prepubertal that resulted in this effect still is not known definitely. Danish workers concluded that heifers which have ADG > 1.32 lb during this time had reduced milk yields because there was incomplete mammary development. Later they suggested that prepubertal growth rates greater than 2.2 lb caused reduced mammary growth. A number of studies have seen no negative effect on mammary growth and milk yields when ADGs were at or near 1.9 lb/d.

There have been reports that overfeeding prepubertal heifers (3 to 9 mo of age) results in larger udders which had relatively more fat compared to parenchyma. Sejrsen et al (1982) showed that mammary parenchyma was reduced 23% but total mammary fat was increased 41% when Holstein heifers had ADG of 2.8 lb during the prepubertal period; a weight gain much greater than recommended or required to grow large heifers until they reach puberty and breeding age. Even though these heifers reach puberty earlier and were the same size at younger age compared to heifers with ADG of 1.4 lb, mammary gland parenchyma was reduced.

There seems to be some disruption in the allometric growth phase due to overfeeding that affects growth of mammary parenchyma. And it has been proposed that this carries over into later growth phases and affects milk-producing ability. Studies reported decreased mammary growth where heifers had ADG about 2.0 lb or greater prepubertal, but comparable rates of growth after puberty and during pregnancy was not detrimental to mammary development (Sejrsen et al., 1982). Indeed, higher ADG allowed heifers to catch up when they were underfed earlier. This gave greater body size and milk production. Cause(s) of decrease in mammary growth that occurs during allometric growth is not known. It seems to be associated with decreases in secretion of Somatotropin when energy intakes are high. Changes in Growth Factors, perhaps in developing parenchyma, and inhibition of cell divisions are implicated during allometric growth. Similarly, it is not known if detrimental effects of high energy feeding exist throughout prepubertal period. Neither it is known if the quality of body growth is similar to that when they grow at lower ADG.

Results from pubertal growth studies lead to recommendation to limit ADG during peripubertal period to avoid decreases in milk production. Because of often divergent effects of overfeeding prepubertal, the safe ADG to recommend during this time so as to avoid this problem is not known definitely. Growth rates recommended (Table 1.) already are less than rates which cause reduced milk yield except for results in Denmark and these results likely are not appropriate for today's large well-fed dairy breeds. Importantly, it has been possible to raise dairy heifers at ADG above 1.9 lb prepubertal and show no detrimental effect on milk production. These heifers were raised on the same diets and at the same ADG as that which causes a reduction in mammary growth (Waldo et al., 1988; Garcia-Gavidia et al., 1994, unpublished results). Describing the exact association between prepubertal mammary growth and milk production is difficult and not possible today.

Mammary Growth. The mammary gland as a component of the reproductive system is affected by hormonal changes that occur as the heifer develops, approaches and reaches puberty and undergoes pregnancy. Therefore, mammary growth and development likely will be affected by feeding or management and other factors that affect development and maturation of the reproductive system. This includes rearing systems and growth rates.

Mammary growth and development occur during several distinct phases from birth to first calving. Amount and type of growth of the mammary system that takes place throughout these growth periods can affect how much milk the heifer produces during lactations that follow. Major factors that determine how much milk she produces are (1) number of milk-secreting cells in the developed mammary glands, (2) synthetic capacity of these cells, and (3) ability of lactating animals to eat enough of the right nutrients and to partition these nutrients to the mammary glands and other important organs to ensure high levels of milk production.

Basic structures of the mammary glands are present at birth (teats, ligaments, vascular system and mammary fat pad). Three distinct phases of mammary growth are seen in growing heifers from birth until time of breeding (Sinha and Tucker, 1969). For example, in Holstein heifers from birth to 3 mo (up to about 200 lb), the mammary gland parenchyma (ductal tissue that gives rise to milk-secreting structures, measured by DNA) grows at about the same relative rate as general body growth (Figure 4). Growth measured by DNA is a good estimate because it represents changes in cell numbers and not just gross weight. Growth during this time is termed isometric. It is at this time that the mammary fat pad, vascular system and parenchyma increase. Between 3 mo and about 9 mo, or just before they reach puberty, relative growth of the mammary gland parenchyma is more than three times greater than general body growth. This is termed allometric growth and occurs when heifers are between about 200 and 600 lb. During this time the mammary fat pad and vascular system increase, and the ductal epithelium of the parenchyma expands into the fat pad. This growth is stimulated by various hormones and growth factors. Well-fed Holstein heifers should reach puberty by 8 to 11 mo and about 575 to 625 lb of body weight. After they reach puberty until time of breeding at 13 to 15 mo, mammary glands again show isometric growth. All internal structures of the mammary gland are growing at essentially the same relative rate as the body. This second period of isometric growth continues until heifers become pregnant. Only a small percentage of the total mammary growth that occurs by calving actually occurs during the prepubertal period (3 mo through puberty; Figure 4), but it still is very important and may have dramatic effects on type and extent of mammary growth that occurs throughout gestation. Inhibiting or stimulating growth of mammary glands during the prepubertal allometric growth phase may have important effects on subsequent lactation performance.

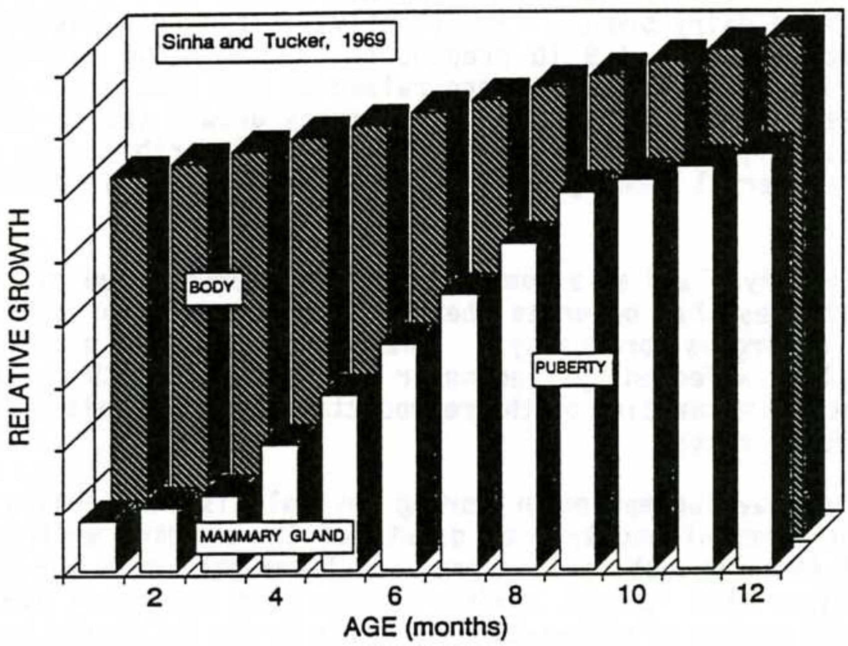

Figure 4. Comparison of relative growth rates of the body and mammary glands; using DNA measures for mammary parenchyma.

Once heifers are bred and become pregnant, the mammary glands are exposed to all the hormones of pregnancy. This stimulates a second period of allometric growth. During pregnancy growth of the ductal system adds to the fat pad; the lobuloalveolar system forms and it largely replaces lipid of the fat pad. By time of first calving, essentially all mammary growth for that pregnancy and lactation is completed and colostrum has accumulated until needed by the newborn calf. While mammary glands are growing during pregnancy, the heifer also gains weight and skeletal growth occurs. If fed well, they will have no problem maintaining ADG of 1.7-1.8 lb, weigh between 1200 to 1250 lb after calving, and be in good body condition. All this must occur so that mammary growth is optimized.

Opimizing Heifer Growth

Because research has shown that it is most economical for heifers to calve for the first time between 22.5 and 23.5 months of age, provided they are of adequate size and weight, we need to consider ways to achieve this goal. We may need to develop new growth standards for our heifers and develop nutritional programs that will allow us to achieve these standards without reducing mammary growth and subsequent milk production. Nutrient requirements for the growing heifer are constantly changing and the effectiveness of our nutritional programs are not easily evaluated, unlike the use of milk production for our lactating dairy cows. Many changes can be imposed to take advantage of the heifers natural propensity for growth during both pre and postpartum periods. Whatever scheme is developed we will need to maximize the use of feed energy and available protein (amino acids) to achieve the targeted weight and height gains desired. One factor that reduces our ability to accomplish this is how we should evaluate the effectiveness of the nutritional management we use to achieve maximum body growth. As we have seen it cannot be weight alone or even weight and height because of the potential detrimental effects on mammary growth and future milk production. The correct measure of our ability to raise heifers to greater sizes, and to do it more efficiently, in addition to body growth, is their milk production during first lactation, as well as their lifetime productivity.

A goal of ongoing research at Cornell has been to maximize the balance of nutrients provided to and required by growing heifers, especially the energy and protein fractions (Van Amburgh et al., 1992). Their studies incorporate needed measures of body growth along with measures of body condition to ensure that overconditioning does not occur during any growth phase and then to follow these heifers as they enter the lactating herd. Indeed, measures of milk production are those most often lacking in studies to evaluate heifer growth rates. Incorporating measures of productivity with enough animals to obtain reliable results is the major way to determine whether the growth rates desired really results in heifers that are good replacement animals.

A variety of factors have been considered relative to effects on heifer growth and at which life growth stage (prepubertal, peripubertal, postpubertal, early or late pregnancy) they can be modified or controlled. Without being exhaustive, among the most important for now and perhaps the future may include:

1. amount (%) protein in the diet.
2. amount of UIP in the diet.
3. energy content of the diet.
4. use of growth regulators, - somatotropin, steroids.
5. use of partitioning agents, - β-agonists.
6. photoperiod
7. combinations of the above.

We have looked at the effects of energy and use of bST during the peripubertal growth period in a series of heifer growth studies (Garcia-Gavidia et al., 1994). Sixty-four and 188 heifers were raised in groups of 10-16 and fed TMRs with different energy levels and some heifers also were injected with BST from 7-10 months of age; ages that include puberty. Our intention has been to evaluate growth and to link this to first lactation milk yields. Results are only partially complete but it is clear that we have been able to increase growth rates (height and weight) of heifers by injecting BST, but increases were not great (+24 kg total difference in weight gain and 1.11 cm in height). For the 53 heifers in the 64 group that completed their first lactation it is clear that milk yields were neither reduced or improved when they were raised at nearly 2.0 lb/d from 3 mo to 1 year of age nor was it improved or reduced by injecting them with BST compared with heifers raised at about 1.6 lb/d and not injected with BST. Milk yields of another 188 heifers on similar growth trials now are accumulating. Interestingly, heifers raised rapidly and injected with smaller doses of BST than the two groups just described, were sacrificed at about 1 year of age and were found to have less mammary parenchyma than uninjected control heifers. And so the actual link between amount of mammary growth in the peripubertal period and subsequent milk production has not been proven. As indicated, several studies have shown that heifers raised at greater ADGs than NRC (1989) recommends do produce well during first lactation. Heifers fed energy at 115% of that recommended by NRC (1989) had greater skeletal growth and heavier body weights but they produced the same amount of milk but they did reach breeding age and calving ages about 45 days earlier than those heifers fed at 100% of NRC (Bortone et al., 1994; Daccarett et al., 1993).

Bethard et al. (1994) reported that increases in the UIP in the diet fed to growing heifers (6-13 mo of age) resulted in increased feed efficiency when the heifers also were fed high energy diets. On the other hand, sheep fed higher CP in the diet and injected with a β-agonist did not produce more milk, although there were positive trends for the sheep fed the higher dietary CP to have more mammary tissue and greater milk yield but the B-agonist effect was the opposite. In growing steers implanted with Synovex-S and injected with BST there was improved efficiency of protein accretion as more energy was partitioned to carcass protein and muscle fiber types were affected differently by Synovex-S and bST (Rumsey et al., 1994; Ono et al., 1994).

It is clear that additional studies are needed to better describe growth of the mammary system, skeletal growth, body weight increases and subsequent milk yield. Importantly, it will be necessary to determine the changing requirements as the heifers age and determine the most desirable growth rates throughout the various time periods up the time of first calving in order to maximize the growth potential of the heifers and have them reach target weights at early ages so they can enter the producing herd at younger ages.

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