Designing Heifer Systems That Work on Your Farm

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Take Home Messages

- Different dairy herds have mature cattle that vary in size; therefore, "one-size fits all" recommendations for heifer growth across farms do not optimize heifer growth on all farms and may predispose heifers to inadequate gain and/or accumulation of excessive fat prior to first calving.
- The 2001 Dairy NRC adopted the "target growth system" in order to determine farm-specific growth goals for heifers based upon the mature size of cattle in the herd.
- The target growth system also adjusts the energy and protein requirements per unit of gain based upon the composition of the body weight gain at different stages of maturity.
- Dairy farm managers should target heifers to be 55% of mature body weight at pregnancy and 82 to 85% of mature body weight following first calving in order to optimize growth and first lactation milk yield.

Introduction

The nutrition and management of dairy heifers from birth to first calving has attracted substantial research focus, yet management systems on commercial dairy farms have been slow to evolve. Despite the fact that implementing management schemes that decrease the age at first calving (AFC) and concurrently ensure adequate growth will decrease overall rearing costs of replacement heifers, decrease the payback time for the replacement heifer enterprise, and markedly decrease the number of replacements required to maintain herd size, many dairy producers and their herd service providers take a "one size fits all" approach toward heifer nutrition and management across a variety of dairy farms. In our opinion, this approach carries substantial risk of leading to the two major negative outcomes related to suboptimal nutrition and management of heifers on commercial dairy farms: 1) heifers calving at

insufficient size and weight relative to the size of the mature cattle in the herd and 2) heifers calving with excessive body condition score. Heifers that calve at insufficient size and weight relative to mature cattle in the herd will prioritize nutrients toward growth at the expense of milk yield during first lactation (NRC, 2001). Furthermore, heifers that calve in excessive body condition score will have increased susceptibility to metabolic disorders postcalving, similar to mature cows of excessive body condition score.

The Dairy NRC (2001) largely adopted the target growth system for dairy heifers that was outlined in more detail by Fox et al. (1999). This system also is incorporated within the Cornell Net Carbohydrate and Protein System (Fox et al., 2004) and CPM Dairy. This system calculates growth requirements for heifers based on their current age and body weight, target age at first calving and body weight, and their predicted chemical composition (based upon their current body weight in relation to the mature weight of cattle in the herd). The purpose of this paper is to outline further the rationale for employing such a system in designing custom heifer programs for individual farms and illustrate how the target growth system can be employed to optimize heifer performance.

■ Approaches to Evaluate Heifer Growth Performance

Dairy producers and nutritionists traditionally have used weight charts such as that depicted in Figure 1 together with height charts to evaluate heifer performance on dairy farms. Although these charts can be useful as a starting point when no evaluation of heifer growth performance has been conducted previously, they provide a disservice when used as a basis for development of heifer nutrition strategies on farms that have the management capability to more progressively manage the heifer enterprise.

As indicated above, the target growth system for dairy replacement heifers (Fox et al., 1999; NRC, 2001) provides a tool for dairy producers and herd service providers to evaluate current heifer growth performance and to develop herd-specific growth requirements for heifers.

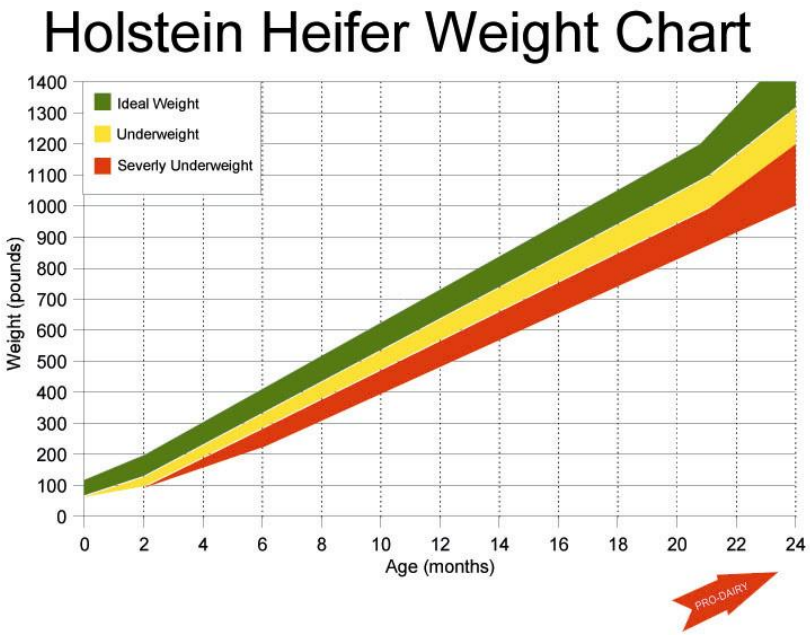

Figure 1. Example of body weight chart traditionally used to evaluate growth performance of replacement heifers. Courtesy of PRO-DAIRY, Cornell University.

The key tenets of the target growth system are as follows:

- Heifers should be managed to achieve target percentages of mature body weight at developmental milestones (i.e., breeding, first calving, second calving). Accordingly, herds that have mature cattle of greater body weight will have higher body weight goals for each of these milestones.
- The composition of gain (lean versus fat) will differ at the same body weight for cattle of higher mature body weight versus lower mature body weight. Therefore, the nutrient requirements for each unit of gain will differ and must be accounted for in ration formulation.

Failing to account for mature size of the herd can introduce significant differences in the amount of energy and protein required at a specific stage of growth (Figure 2). For example, if both heifers weigh 200 kg, then the heifer that will reach mature weight at 600 kg is 33.3% of its mature size whereas the heifer that will grow to 750 kg is only 26.7% of its mature size. Both of those heifers will contain approximately 28% fat in their empty body when they reach maturity. This might seem like a small difference, but the energy content of the tissue deposited will be quite different. The heifer with a mature weight of 600 kg will be depositing more fat per unit of gain at this stage because she is

closer to her mature weight. Because there is additional fat in the gain, the energy required for gain (NEg) will be higher at the same rate of gain. Conversely, if the heifers are consuming the same amount of energy at the same body weight, the heifer with the larger mature size will be gaining weight at a slightly higher rate because she is depositing more protein per unit of gain (or has a higher requirement for protein deposition). There are approximately 3.6 units of water deposited with each unit of protein; therefore, protein deposition results in greater weight gain because the specific weight of water is greater than fat. However, on a whole body percentage basis, as fat accumulates in the body, fat will displace water. The application of this concept is found in Tables 1 and 2.

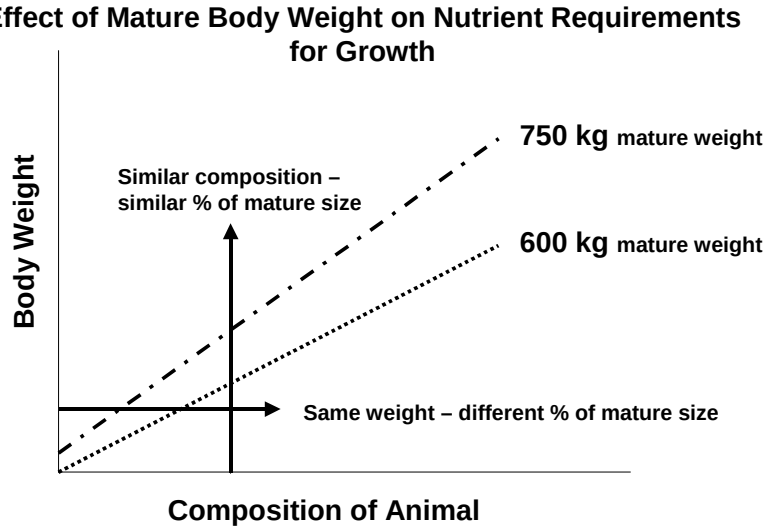

Figure 2. This diagram depicts the effect of different mature body size on composition of the animal at similar stages of growth. Calculations for energy and protein requirements for growth have generally used the current weight independent of the mature weight, thus estimating an inappropriate value for either nutrient requirements or endpoint targets.

Table 1. Target growth example and diet for a Holstein heifer with a measured herd level mature body weight of 600 kg and a desired age at first calving of 22 months.

Growth characteristics	
Current weight	170 kg
Current age	4 mo
Target age at first calving	22 mo
Target breeding weight	360 kg
Target pregnant age	13 mo
Diet (DM basis)	
Corn silage, kg	1.36
Alfalfa silage, kg	1.36
Corn grain, rolled, kg	0.58
Soybean meal, roasted, kg	0.36
Soybean meal, solvent ext., kg	0.10
Minerals and vitamins, kg	0.16

Table 2. Effect of mature body weight on energy and protein allowable body weight gain. The diet was designed for the average heifer in Table 1; however, the comparison is to a group of heifers from a herd with a larger mature body weight.

	Mature weight, kg	
Item	**600**	**750**
Energy allowable gain, kg/d	0.82	0.95
Protein allowable gain, kg/d	0.82	0.82

The diet as formulated for the 600 kg mature weight heifer is balanced for 0.82 kg/d liveweight gain on both an energy and protein allowable basis. If the same diet is applied to a group of heifers that are phenotypically larger, the heifers with a larger mature body weight are a smaller percent of their mature size and at the same weight will contain less body fat and have a higher requirement for protein per unit of gain. Since the diet was not changed, the larger mature size heifer will be penalized because there is not enough metabolizable protein supply compared to the energy allowable gain. Thus the larger heifer will use the extra energy to deposit body fat and the expected weight gains will be a compromise between the energy and protein allowable gains. We have determined that this effect can occur as early as the milk-feeding phase and indicates that the effect could compound with increasing body weight.

From this example it becomes obvious that a "one-size fits all" recommendation for first lactation post-calving body weight is most likely erroneous and will lead to situations where heifers are over or under fed nutrients in an effort to make them fit a target not suited to their genetic capabilities. To actualize the target growth approach in the field, we suggest that the third lactation cattle in the herd be weighed or taped and the weights be averaged. That weight will serve as a reasonable proxy for 96% of the mature size of the herd. Ideally the fourth lactation cattle should be measured, but under today's management strategies there are few cattle that age to be weighed. We do not recommend the use of cull cows since most cull cows are not of normal body condition and thus don't represent the average of the herd. Specific body weight goals for heifers in herds with varying mature body weights are calculated in Table 3.

Table 3. Example target weights for breeding weight, first, second and third calving weights based on percent of mature body weight. Percent of mature body weight for breeding is based on physiologic maturity and the percent mature weight at first calf is a post-calving weight where milk yield is optimized in the first lactation (Hoffman, 1997; Van Amburgh et al., 1998; NRC, 2001).

		Mature weight, kg		
	% of mature weight	**408**	**590**	**798**
Breeding	55%	224	326	439
First calf	85%	347	502	678
Second calf	92%	375	543	734
Third calf	96%	392	566	766

If heifers are being purchased from herds where little is known about their mature size, a reasonable starting point can be determined based on data presented by Hoffman (1997). Hoffman provided a reasonable range in post-calving body weights based the available literature data, and using this range in first lactation post-calving bodyweight (535 to 580 kg) the calculated mature bodyweight for Holstein cattle ranges from 654 to 707 kg with a mean weight of 680 kg. Within a herd it is not unusual to observe a standard deviation of 50 kg around the measured mature body weight.

■ Use of the Target System to Determine Energy and Protein Requirements

The data in Table 4 shows net energy (NE) requirements computed using the standard reference weight to scale the requirements of growing heifers of different mature body weights. Several important relationships are shown in this table. First, as weight increases, the energy content of the gain increases because more energy is deposited as fat at a given weight gain and body size.

Second, protein and fat content of the gain and expected body fat depend on the rate of gain at a particular stage of growth. As energy intake above maintenance increases, it is assumed that the rate of protein synthesis and accretion becomes the rate limiting step, and excess energy is deposited as fat. The fat dilutes body content of protein, ash, and water, which are deposited at nearly constant ratios to each other at a given age once the animals are functioning ruminants (Garrett, 1987).

Variation or errors in predicting the energy and protein requirements of growing cattle are likely due to one or more of the following factors: 1. choosing the wrong mature body weight; 2. short-term, transitory effects of previous nutrition; 3. variation in NE_m requirement. Also, it is imperative that the dry matter intake of the heifers be known and managed so that more accurate diet formulations can be provided to the animals.

Table 4. Relationship of Stage of Growth and Rate of Gain to Body Composition[1].

Mature weight	**Requirements during growth**						
	Shrunk body weight during growth (kg)						
478 kg	200	250	300	350	400	450	500
600 kg	250	314	376	439	500	565	627
650 kg	272	340	408	476	544	612	680
Shrunk weight gain, kg/day	*NE_g required, Mcal/d[2]*						
0.6	1.68	1.99	2.28	2.56	2.83	30.9	3.34
0.8	2.31	2.73	3.13	3.51	3.88	4.24	4.59
1.0	2.95	3.48	4.00	4.49	4.96	5.42	5.86
	Protein in gain, percent[3]						
0.6	20.4	19.5	18.8	18.0	17.3	16.6	16.0
0.8	18.7	17.6	16.5	15.5	14.6	13.6	12.7
1.0	17.0	15.6	14.2	13.0	11.7	10.5	9.3
	Fat in gain, percent[4]						
0.6	5.9	9.7	13.2	16.6	19.9	23.1	26.2
0.8	13.6	18.7	23.6	28.2	32.8	37.1	41.4
1.0	21.4	27.9	34.1	40.1	45.6	51.5	56.9
	Body fat, percent of shrunk body weight[5]						
0.6	11.6	10.8	10.9	11.5	12.3	13.4	14.5
0.8	11.6	12.5	13.9	15.6	17.5	19.4	21.4
1.0	11.6	14.2	17.0	19.9	22.8	25.6	28.5

[1]Adapted from Fox et al. (1999).

[2] NEg requirement is computed from the 2001 Dairy NRC.

[3,4]Computed from the equations of Garrett (1987), which were determined from the Garrett (1980) database.

[5]Computed from accumulated body fat when grown at the respective shrunk weight gain.

Summary

The nutrition and management of the dairy heifer requires a more systematic approach to meeting the targets for both body growth and energy and protein utilization. The system described in this paper provides a basis for a more systematic and mechanistic approach that deemphasizes universal age-weight relationships for dairy replacements. The application of this system should enhance our ability to successfully develop heifers that calve at appropriate size and body condition score, and with optimum milk producing ability. Furthermore, dairy producers and herd service providers can use this system to help evaluate farm-specific goals for age at first calving and also to evolve systems to decrease the age at first calving over time.

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