Using Different Management Systems for Raising Dairy Heifers

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INTRODUCTION

The replacement enterprise is often overlooked as a critical component of a dairy farm. The economic importance of dairy replacements is twofold. By the time heifers are ready to enter the milking herd, they constitute a considerable economic input - in many cases, exceeding $1,200 per heifer. Improvements in management to minimize costs without sacrificing future lifetime production can significantly impact farm profit. Further, dairy heifers constitute the future genetic base of the herd. Proper management during the rearing period will allow heifers to express their genetic potential for milk production, whereas improper management during the rearing period may inhibit this expression of genetic potential.

Powell (19) reported that average ages at first calving for Holsteins and Jersey heifers calving between 1960 and 1982 were 27.5 and 26.2 months, respectively. Although recent reports (9) indicate that age at first calving is declining, the rate of change is slow. It is not clear why recommended age at first calving of 22 to 24 months is not widely accepted. However, recent developments affecting heifer management may further improve the way heifers are reared.

Current Management Systems

Current recommendations for growing dairy heifers are based on three basic assumptions:

1. Optimal age at first calving is approximately 24 months of age

2. Excessive rates of gain, especially prior to puberty, may result in reduced lifetime productivity

3. Costs associated with raising heifers are significant and should be minimized

Age at first calving. Many researchers have modelled costs and productivity of dairy cows that calved at various ages. In most studies, productivity, measured as milk production in one or more lactations has generally been maximized when heifers calves at 22 to 24 months of age (5, 7, 11, 12). Gill and Allaire (6) found that optimal age at calving to maximize lifetime production was about 23 months, and age for optimal profit was 25 months (slightly older heifers remained in the herd longer than heifers calving earlier).

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Prepubertal rates of gain. Research during the 1960's established that increasing the "plane of nutrition" resulted in reduced lactation after calving. Swanson (32) reported that increased energy in the diet increased rates of BW gain and subsequent deposition of adipose in the mammary gland. Deposition of adipose was in *preference* to deposition of secretory tissue, and it was concluded that increased rates of BW gain were associated with reduced lactation through substitution of mammary parenchyma with adipose tissue.

Sejrsen (24-28) further refined the effects of increased energy concentration in the ration and determined that ad libitum feeding prior to puberty reduced secretory tissue in the mammary gland by 23% and tissue DNA by 32% compared to restricted feeding. Accelerated rates of BW gain after puberty did not affect lactation to the same extent as prepubertal overfeeding.

More recently, Holstein heifers were fed 100 or 124% of NRC requirements for all nutrients from 3 to 6 months of age, then 100 or 115% of NRC requirements from 6 to 24 mo of age (3). Calves fed the increased nutrient concentrations gained more BW and had greater height, length, and heart girth, but were not overconditioned. These heifers were 7 wk younger at first service and conception than those fed according to NRC requirements. These data suggest that it may be possible to reduce the age at first calving, although neither lactational performance nor mammary tissue samples were evaluated. Others (3, 10) have suggested that accelerated rates of BW gain as a consequence of increased energy alone may result in depressed lifetime production, but increased density of all nutrients may allow heifers to fully express their genetic potential for BW gain.

Heifer raising costs. Under most conditions, it is expensive to raise dairy heifers. Although actual costs will vary with the situation, most estimates of total costs for raising a heifer to calve at 24 months range from $1,100 (PA) to $1,300 (WA). Most estimates assume above average management with little expense associated with items such as veterinary expenses, repeat breeding, etc. On the other hand, few data are available to evaluate costs of low-input management - ie., heifers raised on pasture with little or no concentrate feeding and calving at 28 to 30 months of age.

Alternative Management Systems

Ionophores

Ionophores are compounds that alter fermentation in the rumen. Currently, two ionophores are approved for use in rations of growing dairy heifers - monensin (Rumensin®, Elanco Products Co., Indianapolis, IN) and lasalocid (Bovatec®, Hoffman-La Roche, Nutley, NJ). These compounds have been used widely in diets of growing and finishing beef cattle for many years. Ionophores are classified as polyether antibiotics, which influence the transport of cations across cellular membranes.

Changes in ruminal fermentation. Numerous studies have shown that ionophores cause a shift in the production of volatile fatty acids (VFA) in the rumen. The primary effect is by reducing proportions of acetate and butyrate and increasing the proportion of propionate produced in the rumen, although numerous effects have been identified (Table 1).

Ionophores such as monensin and lasalocid inhibit gram positive bacteria (e.g., *Ruminococcus albus*, *Ruminococcus flavefaciens* and *Butyrivibrio fibrisolvens*) and allow growth of gram negative bacteria (e.g. *Bacteroides succinogenes*, *Bacteroides ruminicola*). The inhibition of gram positive bacteria promotes succinate-producing bacteria, which produce propionate acid from succinate and impede hydrogen and formate production, thereby inhibiting methane production (2, 22). Utilization of propionate and reduced methanogenesis results in increased efficiency of energy utilization by the animal. Further, propionate appears to increase nitrogen retention more than acetic or butyric acids; it is possible that a portion of observed responses to increased propionate may be mediated through a sparing of protein from gluconeogenesis.

Reduced methanogenesis can dramatically affect rumen dynamics and energetic efficiency. Lasalocid has been reported to decrease methane production by as much as 30%, which would allow the energy in methane (which would otherwise be lost) to be recaptured. Russell and Strobel (21) reported that methanogens are not particularly susceptible to ionophores, but the increase in propionate and succinate producing bacteria and a reduction in bacteria producing formic acid and hydrogen ions may be more important.

In addition to increasing the production of propionate in the rumen, the reduction of butyrate has been shown to reduce the production of ß-hydroxybutyrate (**BHBA**) by ruminal epithelial cells, which contributes to lower concentration of this ketone in the peripheral circulation (20). Both BHBA and acetoacetate are produced by the liver in response to an insufficient energy supply, but BHBA is also produced by ruminal epithelium in response to ruminal production of butyrate.

Addition of ionophores to diets of beef cattle improves BW gain and/or feed efficiency (7). Baile et al. (1) reported that monensin added to diets of dairy heifers increased rates of BW gain with little or no reduction in intake of DM. Therefore, efficiency of feed utilization was increased by nearly 13% when heifers were fed 200 mg of monensin per day. The basal diet used in this study was typical of intensive managed heifers - haylage (62%), corn silage (24%) and corn (15%) in quantities to permit .68 kg of BW gain/day. There was no effect on subsequent lactation after calving in this experiment (1).

In a more recent study, Meinert et al. (13) fed 40 Holstein heifers 0 or 200 mg of monensin/day. Diets were corn silage (2% of BW) or grass pasture for ad libitum consumption. A limited amount of grain was also offered. Although not statistically significant, BW gain in heifers beginning the study at 330 kg was increased by 12.5%, from .72 to .81 kg/day. Rates of BW gain in heifers that began the study at 217 kg were .76 and .78 kg/day for heifers fed 0 and 200 mg of monensin/day. In this study, intake of silage and pasture were not measured, so neither intake nor feed efficiency were determined. The authors reported no changes in estimates of body fat, protein, or body condition when monensin was fed (13).

Steen et al. (31) fed Holstein heifers (253 kg initial BW) 0 or 200 mg of lasalocid/day with or without added undegradable intake protein (UIP). Heifers were housed in a barn from 9 to 20 months of age. Concentrate (7 lb/day) was fed in addition to moderate quality fescue hay to maintain BW gain of .6 to .7 kg/day. Although not statistically significant, BW gain was increased by 4 and 6% (.64 to .66 and .67 kg/day) and feed efficiency was increased by 7.5 and 9% when lasalocid or UIP were fed separately. The authors also reported slight increases in heart girth and fat and muscle depths when heifers were fed 200 mg of lasalocid/day or high UIP (42% of CP as UIP) separately. There were no effects when high UIP and lasalocid were fed in combination. The authors concluded that high UIP and ionophores may provide insufficient degradable protein to the rumen of growing animals, and production of microbial protein may be compromised when the combination is fed.

On the basis of two studies that have evaluated body composition when ionophores were fed (13, 31), it does not appear that either lasalocid or monensin will adversely affect the body composition of heifers raised to gain .6 to .8 kg of BW/day. However, further research is needed to determine if animals gaining more rapidly (.8 to 1.0 kg/day) will be affected by ionophores particularly prior to puberty.

Protein sparing in the rumen. Ionophores have been shown to reduce the concentration of ammonia nitrogen (N) in the rumen (2). Reviews by Bergen and Bates (2) and Schelling (23) indicate that ionophores increase the flow of amino acid N to the small intestine by up to 55%, depending on the composition of the diet. Ionophores appear to function by reducing the degradation of amino acids to ammonia-N and branched chain VFA. Excess ammonia-N produced in the rumen is absorbed by the ruminal epithelium, transported to the liver, converted to urea, and excreted in the urine. Thus, excess degradable intake protein (DIP) can reduce efficiency of energy and N use (production and excretion of N is an energy consuming process) and contribute to environmental concerns associated with excretion of urinary N.

When DIP is not excessive, ionophores may inhibit microbial protein synthesis. Thus, an increase in dietary protein escaping ruminal degradation may be offset by reduced production of microbial protein, resulting in little change in amount of protein reaching the small intestine. In such cases, the amino acid profile of dietary protein escaping ruminal degradation becomes particularly important.

Spears (30) evaluated 28 experiments that measured apparent digestibility of N in ruminants fed monensin or lasalocid (Table 2). Over the range of available data, the improvement in N digestion was between 2.6 and 3.8 percentage units, depending upon the species and ionophore. These data clearly indicate that ionophores play an important role in influencing N metabolism both in the rumen and the whole animal.

Recent research by Yang and Russell (33) reported reductions of ruminal ammonia-N by >30% in Holstein cows fed low quality hay. The authors reported that monensin inhibited a type of bacteria that used amino acids as an energy source, thereby producing large amounts of ammonia-N. Amino acids spared from deamination by these bacteria may pass to the lower gut or could be directly incorporated into microbial protein, which would increase the efficiency of microbial protein synthesis.

Dairy heifers are often fed rations contain considerable amounts of DIP. Additionally, their requirements for UIP are high relative to total protein needs, particularly prior to puberty (15). Ionophores may improve efficiency of BW gain by reducing wastage of N from the rumen, thereby reducing excretion of N into the ecosystem. However, it may be possible to reduce available DIP too far. Research in our laboratory (31) indicated that when lasalocid was fed in combination with a diet of high UIP (42% of total CP), there was no change in BW gain or feed efficiency. However, when either UIP or lasalocid was fed separately, we observed increases in BW gain, feed efficiency, and body condition. Conversely, Paterson et al. (17) fed diets containing soybean meal with or without UIP (distillers grains and dehydrated alfalfa) and lasalocid (0 or 200 mg/day). Diets contained an average of 16% CP. There was no interaction of protein source and lasalocid on N or DM digestibility in lambs. Results of growth studies with lambs and steers suggested that UIP increased rates of BW gain, and addition of ionophores further increased BW gain (17). Clearly, further research appears necessary to determine the extent to which ionophores affect the passage of N through the rumen in dairy heifers.

Changes in mineral status. Ionophores act by modifying the transport of minerals (particularly sodium and potassium) across cell walls. Numerous studies have reported changes in mineral status of animals fed ionophores. Spears (30) summarized several studies that investigated apparent absorption of Mg and P in ruminants fed monensin or lasalocid. Apparent absorption of Mg and P have been consistently increased in ruminants by feeding either compound (Table 3). Reports of effects of ionophores on absorption of other minerals, namely Ca, K, and Na, have been less consistent. Some reports indicated that ionophores increased absorption of the minerals, whereas absorption in other cases was unaffected. Effects of ionophores on trace minerals are less clear, but current evidence suggests that ionophores may increase the absorption of Zn, Se, and Cu (30).

Changes in reproductive function. Reports of Steen et al. (31) with lasalocid and Meinert et al. (13) with monensin reported reduced age at first breeding when ionophores are added to diets of dairy heifers. These reductions in breeding ages were not dependent upon changes in BW gain or body composition, but may have been a result of a direct effect of the ionophore on reproductive function (13). Evidence exists that increased propionate produced in the rumen may initiate earlier maturation of the reproductive system (14).

Coccidiostatic effects. Ionophores have been approved for used in diets of dairy calves and heifers for control of coccidia. The coccidia *Eimeria bovis* and *Eimeria zuernii* are widespread and are commonly isolated in heifers with scours, particularly from 4 weeks of age (4). Both monensin and lasalocid are effective in reducing fecal excretion of coccidial oocysts (eggs) and improving rates of gain and feed efficiency. This may be particularly important during the critical growth period between weaning and puberty when calves are most susceptible to coccidial infection. Inclusion of an ionophore in the grain portion of the ration improved BW gain, intake, and feed efficiency in early weaned calves infected with coccidia (29).

Feeding recommendations. Lasalocid can be fed to replacement heifers to improve rate of BW gain, efficiency of BW gain, and control of coccidiosis. When heifers are reared on pasture, the recommended dosage is 150 to 200 mg/head daily. In a drylot management system, recommended dosage is 250 to 300 mg/head daily. The increased dosage when cattle are in a drylot is due to increased exposure to coccidia. Lasalocid is available in a wide variety of compound feeds, mixes, liquids, and blocks.

Monensin was approved in 1983 for use in diets of replacement heifers from 400 lbs. In 1990, it was approved for use in diets for calves of all ages as an anti-coccidial compound. Therefore, there is no "weight restriction" for use of monensin for calves less than 400 lbs if the use is for coccidial control or improved feed efficiency. Monensin is available in compound feeds, vitamin/mineral mixes, liquids, and blocks. Monensin may be fed daily (50 to 200 mg/head daily in at least 2 lb of feed) or in an alternate day program. For either program, monensin should be fed at a rate of 100 mg/head per day in at least 1 lb of feed for 5 days. Thereafter, it may be fed at 100 to 400 mg/head daily every other day in at least 2 lb of feed.

NOTE: Neither monensin nor lasalocid has been approved for use in diets of lactating dairy cattle. Such use is **not recommended** and illegal!

Economics of ionophore use. Currently, retail prices for recommended doses of either lasalocid or monensin are approximately $.02/day. If an ionophore is used continuously from 2 to 24 months of age, total costs would be approximately $13.20. If increases in BW gain and feed efficiency allow reductions in age at first calving by as few as 7 days, the cost of the ionophore will be recovered (assuming a cost of approximately $2 per day in costs for every day in delay in calving over 24 months of age). If use of ionophores can increase BW gain by 5 to 10%, it would be possible to reduce the age at first breeding by about 1 month and age at first calving by up to 1.5 months (assuming 26 month age at first calving, breeding at 16 months). It seems clear that ionophores are an economical method for increasing rates of BW gain in heifers. However, if age at first calving is delayed due to poor heat detection, nutritional imbalance, or other management problem, then use of ionophores will not materially influence feed efficiency or rate of BW gain. Also, there are few data to determine the effect of ionophores on reducing age at first calving below 24 months.

Stair-step growth

Compensatory gain. Compensatory or "catch-up" growth occurs when animals are limited-fed for a period of time. If the animals are later allowed full access to feed, they tend to become more efficient in growth, and tend to increase BW gain more rapidly than animals on a similar diet. The phenomenon has been reported in most species of animals, including beef and dairy cattle. Park et al. (16) fed heifers according to 100% of NRC requirements or according to a 5-2-5-2 month schedule in which nutrient density was either 15% below (5 months) or 40% above NRC requirements (2 months). Heifers on the compensatory growth regime gained more BW, consumed less feed, and had improved efficiency of growth over the entire trial (Table 4). Further, animals produced 2.1 kg of milk in the first lactation. This method of rearing has some inherent dangers - namely, delays in BW gain during the "maintenance" or slow growth periods increases the importantce of BW gain during compensatory growth. Any upset in management during compensatory growth - disease, weather stress, change in quality of forage, etc., may have markedly detrimental effects on the animal. In fact, they may not be able to "catch up" to animals raised under normal conditions. Also, rates of gain during compensatory periods can exceed 2 kg/day. Effects of these rates of gain on body condition, mammary development, and long-term animal health are not known.

BST

The use of BST in heifers around puberty increased the deposition of mammary parenchyma in Holstein heifers around puberty (28; Table 5). Further, injection with BST increased BW gain of Holstein heifers (8) up to .18 kg/day during the injection period (2 months prior to breeding, injected for 5 months). However, by 5 months after completing injections, control animals were similar BW. There was no effect of BST on reproductive function or on milk production after calving. However, because animals on this study had reached puberty (they began the study at 13 to 16 months of age) it is likely that BST treatment would not affect parenchymal development. Heifers treated with BST had a greater hip height and pelvic size, indicating improved growth of frame in treated animals. However, research to date suggests that BST administered does not affect milk production after calving (22). Further research is needed to determine if BST does indeed influence milk production when administered prior to calving.

Low-input techniques

Although most recommendations for age at first calving range from 22 to 24 mo, in practice age at first calving is approximately 28 mo of age (9, 19). A number of hypotheses have been proposed to explain this discrepancy: producers don't consider it economical to manage heifer nutrition programs for adequate growth, they use heifers to harvest forage from pasture that would otherwise be unusable, or the reproductive program is not managed to breed heifers by 14 months even if they are of sufficient size. It is possible that feeding and management programs to minimize inputs (particularly nutritional inputs such as concentrate) contribute to delayed age at first calving, but still be more economical than intensive rearing.

Pecsok et al. (18) evaluated heifer growth programs in relation to costs of forage and concentrate. The model included labor costs, housing prices, and prices of corn, soybean meal and orchardgrass hay. Only when the price of orchardgrass hay was less than

$28/ton was it profitable to reduce BW gain (by feeding less concentrate) to less than 1.8 lb/day. When the price of forage was greater than $28 per ton, it was more profitable to feed for BW gain of 1.8 lb/day. Therefore, the authors concluded that delaying the age at first calving by using low supplementation strategies would not be profitable if any type of harvested forage was fed. On the other hand, if prices of pasture (cost of establishment, fertilizer, maintenance, etc.) are sufficiently low, it may be economical to reduce rates of gain and delay age at first calving to maximize use of pasture.

SUMMARY

There are many different strategies for managing dairy replacement heifers. Whatever the method used by producers,it must be economical, provide the animal with sufficient nutrients for growth without fattening but with large body size and frame so that they can consume large amounts of feed and convert that feed to milk. Introduction of products such as ionophores can have a positive impact on animal BW gain and feed efficiency. Control of coccidiosis and improved reproductive status can further improve heifer management. When incorportated into a well-rounded management program, ionophores can improve the profitability of the heifer enterprise. Alternative rearing systems, including use of BST or stair-step growth patterns require further research prior to widespread adoption.

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TABLE 1. Summary of metabolic effects of ionophores on ruminal fermentation (2).

1	Decrease in acetate:propionate ratio
2	Increase production of propionate
3	Decreased ruminal proteolysis and deamination, resulting in lower ruminal ammonia-N
4	Many gram positive organisms are inhibited
5	Decrease in methane production
6	Depression of lactic acid production under feeding conditions conducive to acidosis
7	Most gram negative organisms are unaffected
8	Some evidence for depressed turnover of rumen contents
9	A mild inhibition of protozoa
10	Decrease in rumen fluid viscosity in bloated animals

TABLE 2. Apparent digestibility of N in ruminants fed lasalocid or monensin (30).

Ionophore	Species	Control	Ionophore	Range	No. expts.
		% digestibility			
Monensin	Cattle	62.2	65.7	0.3 to 8.0	15
	Sheep	64.8	67.5	0.2 to 7.3	8
Lasalocid	Cattle	70.8	74.6	3.1 to 5.2	3
	Sheep	66.9	70.2	0.2 to 7.2	5

TABLE 3. Apparent absorption of Mg and P in ruminants fed lasalocid or monensin (30).

Item	Species	Control	Monensin	Lasalocid
		% absorption		
Magnesium	Cattle	25.2	34.3	35.0
	Cattle	24.6	27.2	27.8
	Cattle	18.4	32.5	
	Cattle	25.3	30.9	
	Cattle	30.1		33.4
	Sheep	38.9	42.3	
	Sheep	53.7	64.4	
	Sheep	39.7	45.1	
Phosphorous	Cattle	47.8	58.6	
	Cattle	58.4		58.8
	Cattle	35.6	40.2	57.2
	Sheep	43.1	54.8	
	Sheep	8.0	25.8	

TABLE 4. Growth, intake, and BW gain in heifers fed control diet or by a stair-step method of growth (16).

Item	Treatment		SE
	Control	Stair-step	
BW, kg			
initial	281.2	278.5	4.5
final	554.0	576.3*	6.7
gain, kg/d	.68	.98**	.22
DM intake, kg/d	9.4	7.5**	.6
Gain : DM intake, g/kg	73.	130.0**	23
Gain : ME intake, g/Mcal	32.6	57.9**	4.5
Gain : CP intake, g/kg	542	965.**	121

*$P < .10$.

**$P < .001$.

TABLE 5. Effect of somatotropin on size and composition of mammary glands from dairy heifers (28).

Item	Treatment		SE
	Control	BST	
Total gland weight, g	1879**	1581	51
parenchymal tissue, g	454*	537	30
extraparenchymal tissue, g	1425*	1044	56

**$P < .05$.

*$P < .10$.