Longevity of Holstein Cows Bred to be Large versus Small for Body Size

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Take Home Messages

- Two lines of Holstein cows that have been bred for over 25 years to differ for body size did not differ for production or calving ease.
- Cows in the large line had greater body weight, body dimensions, and birth weight of calves, and required more A.I. services to conception during first lactation.
- The lines differed for three reasons for disposal—udder conformation (favored the large line), legs and feet (favored the small line), and a miscellaneous category (favored the small line).
- Productive life to a maximum of 6 years of age was 87.7 days longer (15.4%) for cows in the small line than cows in the large line.
- Continued selection for larger Holstein cows in North America might not be economically justifiable.

Introduction

Holsteins in North America have been selected for increased body size for many years (Mahoney et al., 1986). Consequently, dairy producers in North America are milking dairy cows of larger size than during the 1960's. Likely reasons for selection for larger body size are numerous and include:

1. Scoring of conformation traits by Holstein Association USA and the Holstein Association of Canada continues to place more favorable ratings on cows with larger body size.
2. Some dairy producers believe that larger cows have more body capacity to consume more feed, which in turn might allow cows to produce greater volumes of milk.

3. Dissatisfaction with body size of heifers at first calving because of poor heifer growth leads some dairy producers to attempt to compensate for substandard heifer management by selecting for increased genetic potential for mature body size.

Despite the emphasis on larger body size in selection programs, especially by registered breeders, no research has documented that large cows have functional or economic advantages over small cows within breed. Previous studies have indicated that small cows are more feed efficient than are large cows (Yerex et al., 1988) and that small cows have fewer health problems, especially for digestive disorders than large cows (Mahoney et al., 1986). The major justification for including conformation traits in selection programs is to improve the productive life of cows. Many studies have documented the importance of udder traits to lengthen productive life; however, no evidence exists to support continued selection for larger body size of dairy cows.

▪ Development of the Genetic Lines

An experimental herd of Holstein cows at the Northwest Experiment Station, Crookston, of the University of Minnesota has been selected since 1966 for large versus small body size. During 1966, sixty Holstein cows in an existing herd were paired by sire and randomly assigned to one of two genetic lines—large or small. Cows not fitting into sire pairs were paired by producing ability for milk production. Progeny were assigned to the same genetic line as their dams. Except for sire selection, both heifers and cows were managed together and alike. Milking cows were housed in a tie-stall barn.

Service sires were selected from among the top 50% of active A.I. sires available in the USA (including some Canadian sires) for breeding value (EBV) for production. The actual production trait changed over the years of the study and, in time order, was 1) milk (kg), 2) milk-fat dollar value, 3) fat (kg) plus protein (kg), and 4) protein (kg). All other selection was based on body size of daughters, either large or small. Sires were selected on standardized EBV for stature, strength, and body depth with the body size index: 0.5(stature) + 0.25(strength) + 0.25(body depth). The three most extreme sires for transmitting large and small body size were selected once each year from the summer genetic evaluations of the USA Department of Agriculture (USDA) for production and Holstein Association USA for body size. Repeatability of EBV was required to be at least 70%. Cows within line were randomly mated to sires, except inbreeding coefficients were not allowed to surpass 6.25% and calving difficulty was avoided for virgin heifers.

Cows and heifers were periodically added to the herd, especially to facilitate an expansion in the capacity of the barn to 106 stalls during 1987. These cows were considered to be new foundation animals for the selection project for body size and were assigned to one of the two genetic lines; however, cows in this

study were required to have at least three generations of prescribed large or small sires.

▪ Data and Analysis

Cows used for this study were born after January 1, 1983. Data file 1 included cows born from January 1, 1983 to December 31, 1989, and all cows in data file 1 had the opportunity to be in the herd 7 years (84 months) and had been already culled from the herd. Data file 2 included all cows in data file 1 plus 59 cows born from January 1, 1990 to April 30, 1991, and all cows in data file 2 had the opportunity to be in the herd for 6 years (72 months). Data file 3 included all cows in data file 2 plus 121 cows born from May 1, 1991 to November 30, 1994, and many of these cows were still alive at the time the data was analyzed.

Data file 1 was used for the analysis of reasons for disposal and productive life to 84 months of age (PL84). Measures of productive life for this study were reported in days, and PL84 was essentially the same trait that is used by the Animal Improvement Programs Laboratory of USDA for the genetic evaluations for productive life released in the USA. Days in milk were summed across lactations, but individual lactations were allowed a maximum of 305 days. Data file 2 was used for the analysis of productive life to 72 months of age (PL72), which was similar to PL84 except that days in milk were summed only to 72 months of age. Data file 3 was used for the analysis of all other traits in this study, and data was specific to lactations of cows. Lactations initiated by abortions were eliminated from data file 3.

All cows were weighed immediately after calving, as were their calves. Body weight and four body dimensions were recorded one month after calving (provided cows remained in the herd):

- Height at the withers.
- Length of body from withers to pin bones.
- Depth of chest.
- Circumference of chest.

For lactations initiated with twin births of calves, body weight immediately after calving was excluded from the data, but body weight and body dimensions one month after calving were included in the data.

Calving ease was coded on a linear scale from 1 to 5, with 1 for no assistance and 5 for use of a mechanical puller. Production of milk, fat, and protein was actual production (kg) from routine milk recording. Production records were required to have at least 90 days in milk and were projected to 305 days. Also,

for both heifers and cows that conceived, number of A.I. services to conception was recorded.

Reasons for disposal of the 217 cows in data file 1 were assigned to twelve categories: low production, reproduction, calving complications, abortion, mastitis, udder conformation, udder injury, legs and feet, metabolism, digestion, respiration, and miscellaneous. Miscellaneous reasons included kidney infection, bladder infection, peritonitis, twisted intestine, split pelvis, slow milking, and less than four functional quarters. Cows were culled for one, two, or three reasons for disposal.

Because numbers of observations for cows in 4th lactation or later were limited, results from only the first three lactations of cows are reported. Details on methods of analysis are provided in Hansen et al., 1999.

▪ Response for Body Size

Table 1 has the numbers and ranges of observations and Table 2 has the averages for body weights and dimensions, which were regarded as the "direct" responses to selection for body size. As expected, the averages in Table 2 were significantly different for all body weights and dimensions across lactations. The ranges of observations for body weights and dimensions in Table 1 indicate that there was tremendous overlap across the two genetic lines. Despite high genetic control for traits related to body size, the cows in the two genetic lines had little difference for body size during the early generations of this selection experiment. Linear methods of scoring measures of body size (stature, strength, and body depth) coupled with more sophisticated methods of calculating EBV for sires successfully resulted in genetic lines that differed significantly for body weight and dimensions. However, the distributions of observed body weights and dimensions for the two genetic lines continue to have considerable overlap following more than 25 years of intensive selection for body size.

Cows in the small line had average body weight of 558 kg immediately after first calving. Most dairy producers probably would not regard this average weight as excessively small. On the other hand, cows in the large line had average body weight of 609 kg after first calving, which would be regarded as quite large by most dairy producers, especially when the average age of first calving of only 25.5 months is considered. Cows in both lines increased in body weight with lactation number; however, the difference of body size lines

Table 1. Number and ranges of observations for direct responses to selection for body size.

Trait	Lactation Number	Small Line				Large Line		
		no.	Min.	Max.		no.	Min.	Max.
After Calving			-----(kg)-----				----(kg)----	
Body weight	1	217	416	720		159	450	822
	2	126	488	731		93	514	834
	3	70	515	784		53	580	885
One Month After Calving								
Body weight	1	210	398	683		145	434	722
	2	135	429	667		93	503	748
	3	80	499	694		51	553	780
			----(cm)----				----(cm)----	
Height at withers	1	210	120	142		145	127	147
	2	135	121	141		93	128	146
	3	80	123	138		51	130	150
Length of body	1	210	125	153		145	129	152
	2	135	129	151		93	138	159
	3	80	134	156		51	141	163
Depth of chest	1	210	61	78		145	64	79
	2	135	61	75		93	66	80
	3	80	64	74		51	67	79
Circumference of chest	1	210	169	206		145	175	224
	2	135	174	201		93	187	221
	3	80	180	215		51	193	219

for body weight (both immediately after calving and one month after calving) became more pronounced with increased lactation number. In other words, the cows that were bred to be large continued to grow more after first calving than the cows that were bred to be small. Immediately after third calving, cows in the small line had average body weight of 641 kg, which is a very good size cow. In comparison, cows in the large line had average body weight of 720 kg after third calving. At time of dry off, cows in both size lines weighed much more than they did immediately after calving; in fact, some cows in the large line surpassed 900 kg at time of dry off. Once dairy cows reach an acceptable body size, continued growth beyond that body size might not be desirable economically.

Table 2. Averages for direct responses to selection for body size*.

Trait	Lactation Number	Small Line		Large Line	Difference
After Calving		**----------(kg)----------**			
Body weight	1	558		609	51
	2	596		664	68
	3	641		720	79
One Month After Calving					
Body weight	1	507		559	52
	2	555		625	70
	3	584		672	88
		----------(cm)----------			
Height at withers	1	129.0		136.1	7.1
	2	130.4		137.4	7.0
	3	130.9		138.6	7.7
Length of body	1	136.0		141.6	5.6
	2	141.3		147.6	6.3
	3	145.0		151.4	6.4
Depth of chest	1	67.1		70.9	3.8
	2	68.2		72.6	4.4
	3	69.5		74.2	4.7
Circumference of chest	1	186.2		195.1	8.9
	2	190.1		200.5	10.4
	3	194.0		205.7	11.7

*All differences were highly significant.

The magnitude of differences (kg and cm) in average body size in Table 2 might seem fairly small. However, the greater body weight of cows in the large line at one month after calving—10% (1st lactation), 13% (2nd lactation), and 15% (3rd lactation)—seemed considerable based on eyeball inspection. Although the increase in stature (height at the withers) was less pronounced than body weight on a percentage basis (5% to 6% across lactations), the difference of 7.0 cm to 7.7 cm also seemed to be magnified on casual observation. A point to be made from this is that published EBV for stature, strength, and body depth might lead dairy producers to believe that extreme sires for these traits will uniformly transmit extremely small or extremely large size to their daughters. Actually, the differences in observed body sizes of daughters of sires with extreme EBV will likely be much more modest than anticipated. For this study, consistent use for over 25 years of the most

extreme sires for transmitting small size resulted in cows that would be considered to be of adequate size by most North American and, especially, international standards.

Across years of this study (births from 1983 to 1994), body weights did not change with year for the small line, but had a significant increase with year for the large line. This conforms with our observation that, because of the continued emphasis on larger body size of Holsteins in North America, our small line has not changed for body size; however, the large line has continued to get larger. The continuing emphasis on larger cow size in North America began in the late 1960's. The ideal model cow of the Holstein Association USA was altered markedly in 1977, especially by increasing its body size. The small genetic line in this study might reflect the body size of the earlier ideal Holstein, which was developed in 1922. The average EBV for stature, strength, and body depth of the proven and available A.I. sires summarized by the Holstein Association USA during 1998 were all substantially positive on a 1990 fixed genetic base. Consequently, cows sired by A.I. bulls in the USA should continue to become larger in the future.

▪ Response for Production

The two genetic lines did not differ significantly for any of the three production traits during any of the first three lactations (Table 3). Herd average production from milk recording for the two lines has almost always favored the small line over time, but differences have probably never been statistically significant. Most feed consumed by milking cows is for milk production rather than for body maintenance. In a previous study of the genetic lines (Yerex et al., 1988), income over feed cost was greater for cows in the small line.

▪ Response for Number of Services, Calving Ease, and Calf Weight

Table 4 has averages for number of services, calving ease, and calf weight. Although differences were statistically significant only for reproduction during first lactations, all differences in line averages for number of services favored the small line. No explanation for the difference in reproductive performance for the body size lines was obvious. The lines did not differ significantly for calving ease. However, both lines had high levels of calving difficulty at first calving, with an average score of approximately 3.1 on a 1 to 5 scale. Whether this is a management-related problem or is a function of the opposing selection for body size is unknown.

Table 3. Averages for production traits.

Trait	Lactation Number	Small Line (kg)		Large Line (kg)
Milk	1	8535		8492
	2	9820		9578
	3	9687		9954
Fat	1	308		300
	2	337		325
	3	332		331
Protein	1	276		275
	2	315		307
	3	301		320

Number of observations for small line: 191 (1st), 127 (2nd), and 75 (3rd).
Number of observations for large line: 130 (1st), 87 (2nd), and 46 (3rd).
None of the differences were significantly different.

Table 4. Averages for number of services, calving ease, and calf weight.

Trait and Lactating Number	Small Line			Large Line		
	no.	Average		no.	Average	Difference
Number of services						
Virgin heifers	233	1.54		164	1.67	0.13
1	141	1.79		98	2.08	0.29*
2	88	1.91		59	2.08	0.17
3	48	2.02		25	2.24	0.22
Calving ease						
1	228	3.16		163	3.08	-0.08
2	130	1.51		96	1.43	-0.08
3	77	1.36		56	1.45	0.09
Calf weight		(kg)			(kg)	
1	222	39.4		163	42.0	2.6*
2	126	42.4		95	44.7	2.3*
3	73	43.0		54	45.5	2.5*

*These differences are statistically significant.
Average calf weight at birth differed for all three lactations, and the average difference was 2.6 kg, 2.3 kg, and 2.5 kg for lactations 1, 2, and 3, respectively.

The large line had calf weights that were approximately 6% greater than the small line, which is much less than the 10% to 15% difference in body weight of the cows in the lines after calving.

▪ Reasons for Disposal

Reproduction has been an ongoing management problem of this herd, which is reflected in the approximately 1/3 of cows in both lines culled due to reproductive problems (Table 5). Mastitis was the only other reason for disposal that surpassed 15%, and the two lines did not differ for this reason for disposal.

Averages for body size lines differed significantly for only three reasons for disposal—udder conformation, legs and feet, and the miscellaneous category. Differences for both udder conformation and legs and feet were easy to explain. Because cows in the small line had shorter legs, udders were closer to the ground and, therefore, more likely to have functional problems. Likewise, the legs and feet of large cows supported more body weight than the legs and feet of small cows and, consequently, could be expected to be under more stress and more prone to injury. Also, larger cows have a higher center of gravity than small cows and might be more likely to slip and fall. The greater disposal of cows in the large line for miscellaneous reasons is not as easily explained; however, cows in the large line seemed more predisposed to infections.

Table 5. Averages for reasons for disposal.

Reason	Small Line	Large Line	Difference
	----------(%)----------		
Low production	4.9	6.2	1.3
Reproduction	34.5	33.0	-1.5
Calving complications	8.8	7.6	-1.2
Abortion	8.0	4.3	-3.7
Mastitis	15.3	16.3	1.0
Udder conformation	11.9	5.3	-6.6*
Udder injury	0.9	2.2	1.3
Legs and feet	2.8	7.4	4.6*
Metabolism	4.0	5.4	1.4
Digestion	5.6	3.6	-2.0
Respiration	0.4	0.0	-0.4
Miscellaneous	2.8	8.7	5.9*

*These differences are statistically significant.

▪ Productive Life

Table 6 has the averages for the 217 cows contributing to PL84 and for the 376 cows contributing to PL72. For each measure of productive life, the difference between lines was approximately 88 days (2.9 months) and favored cows in the small line. The line difference for productive life was statistically significant for PL72, which was probably due to the larger number of cows contributing to the averages for PL72 compared to PL84. The 87.7-day difference for PL72 represents a 15.4% advantage for cows in the small line.

The substantial difference in productive life for the body size lines clarifies the greater need for replacement females for the large line versus the small line. Almost all of the new foundation females entering the herd after the 1966 initiation of the selection project were placed in the large line. Yet, cows in the small line have continued to outnumber cows in the large line.

Typically, advocates for placing emphasis on conformation traits in genetic improvement programs have argued that conformation traits are important for increasing the longevity of cows. The results of this study suggest that increased body size of Holsteins results in decreased longevity rather than increased longevity.

Table 6. Averages for length of productive life.

	Small Line			Large Line		
Measure	**n**	**Average**		**n**	**Average**	**Difference**
		(days)			(days)	(days)
PL84	125	712.5		92	624.0	88.5
PL72	157	658.3		119	570.6	87.7*

*This difference is statistically significant.

▪ Conclusions

Emphasis on increased body size of cows continues in North America. Therefore, the small line for this project has become, essentially, a control line of cows for constant body weight across time, whereas cows in the large line have continued to become larger with time. Smaller cows have less maintenance cost and, at least for this study, had longer productive life and perhaps enhanced reproduction. Of course, large cows have greater salvage value than small cows. Furthermore, a difference of approximately 2.5 kg for calf weight at birth is probably of some economic value, especially for those calves grown for veal or beef production. Yet, small cows almost certainly have economic advantages over large cows within breed.

Results from this study should raise the question of whether Holstein cows should continue to be bred to become larger. Dairy producers should not attempt to overcome deficiencies in heifer raising that result in inadequately grown heifers by selecting for larger mature body size. If most heifers grown by an individual dairy producer lack adequate body size, factors other than genetics are almost certainly the cause. Cows that are bred to be larger continue to grow more after first calving than cows that are bred to be less large. Once an acceptable size of cow is reached, continued growth beyond that size likely is not economically desirable.

If larger cows are needed to accommodate the demands of increased production, then selection for production should result in cows becoming larger as a correlated response. Only traits that have been documented to increase productivity and efficiency of production should be included in selection goals. Udder depth, disease resistance, and reproduction are examples of traits known to affect efficiency of production. Over the long term, selection for traits with documented positive impact on profitability should result in cows of near optimum size.

▪ References

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