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Abstract

A selection index combining milk and beef production traits, such that progress in aggregate economic value is maximized, was constructed for Holstein bulls. The index for milk was $I_M = 1.11X_1 + .997X_2$ while the index for beef trait was $I_B = .008X_1 + .619X_2$ where X_1 is the daughters' average lactation yield (kg) and X_2, bulls' body weight at 15 mo (kg).

The relative genetic progress from simultaneous selection for milk and beef traits with different emphasis was estimated. Expected genetic progress in beef production (body weight at 15 mo) declined with increasing selection on milk and vice versa. Expected genetic progress, however, did not fall below one-third of maximum genetic progress (100%) for either milk or beef, regardless of the emphasis of selection.

Based on current milk and beef values, ignoring milk and selecting solely for beef would give the highest genetic progress in total economic value but quite slow genetic progress in total protein production. Ignoring beef and selecting solely for milk would give the highest genetic progress in total protein production and a fairly high genetic progress in total economic value. A 1:7 beef to milk emphasis per standard deviation seems to be most appropriate since it results in large genetic progress in both total protein and total economic value.

Introduction

The present trend of increasing population pressure and consequent high land values and shrinking land areas available for food production would likely call for more efficient cattle production systems in the future than currently employed. Production of milk and beef in one herd could be an alternative system that may best fit economic conditions in the future. Most studies to ascertain relationship between milk and beef production in cattle have suggested positive correlations between milk and beef traits (1, 3, 4, 8, 9, 10, 11, 12), which favors simultaneous selection for both traits.

Relative economic values of milk and beef are likely to vary in different countries or regions with time and so would emphasis of selection. It is the purpose of this study to determine the effects of different degrees of emphasis of selection on genetic progress in milk and beef production, as well as in total protein production and total economic value, when both traits are simultaneously selected among Holstein-Friesians.

Materials and Methods

A selection index to combine milk and beef production traits such that progress in aggregate economic value is maximized was constructed according to Hazel (6). Variances and covariances for the two traits were for X_1, the daughters' lactation yield (kg/yr), and X_2, the bulls' own weight at 15 mo (kg). The variance for X_1 (Var_M) is equal to

$$\{[1 + (P_M - 1)(h_M/4)]/P_M\}\sigma_M^2$$

where P_M, the number of daughters, is assumed to be 26; h_M, the heritability for milk, .19; and σ_M^2, the phenotypic variance for milk production, 1,290,496 kg^2 (13). For X_2 the variance (Var_B) is 2,025 kg^2 and heritability (h_B) is .65 as determined by Calo et al. (2). The genetic correlation between milk and growth rate ($r_{G_{MB}}$) was .25 (3).

Variances and covariances were:

	X_1	X_2	G_M	G_B
X_1	108402	2277	122597	2277
X_2		2025	4555	1316

Selection equations were solved simulta-

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neously to determine the weights (b_i's) to calculate estimates of the genetic value for milk and beef traits. Their indices were:

$I_M = b_{M1}X_1 + b_{B1}X_2$

$I_B = b_{M2}X_1 + b_{B2}X_2$

The indices I_M and I_B were combined by weighting with the economic value per unit for each trait resulting in an overall index:

$I = V_M I_M + V_B I_B$

where V_M is the economic value for milk and V_B, the economic value for beef which Henderson (7) showed is equivalent to the index for aggregate genetic value,

$I = \beta_1 X_1 + \beta_2 X_2$, where:

$\beta_1 = V_M b_{M1} + V_B b_{M2}$ and

$\beta_2 = V_M b_{B1} + V_B b_{B2}$

To compute the effect of different emphasis of selection for the two traits, the value of milk per standard deviation (V_M) was kept constant while the value of beef per standard deviation (V_B) was varied from 1/10 to 10/1 the value of milk. Variance of the index was $\sigma_I^2 = \beta_1^2 Var_M + \beta_2^2 Var_B + 2\beta_1\beta_2 Cov_{MB}$. Genetic progress in milk and in beef was:

$\Delta G_M = [Cov(G_M I)/\sigma_I]D =$

$\left\{[\beta_1 Cov(G_M X_1) + \beta_2 Cov(G_M X_2)]/\sigma_I\right\}D$

$\Delta G_B = [Cov(G_B I)/\sigma_I]D =$

$\left\{[\beta_1 Cov(G_B X_1) + \beta_2 Cov(G_B X_2)]/\sigma_I\right\}D$

where D is selection intensity factor.

To predict genetic progress with selection jointly for milk and beef, relative emphasis of milk to beef in the formulas was from 10:0 to 0:10. Genetic progress from ignoring milk or beef and selecting solely for one trait also was estimated.

Estimates of h_B and $r_{G_{MB}}$ will influence projected changes in beef and milk production. As pointed out by Calo et al. (3), both estimates may have large sampling errors; nevertheless, h_B is similar to that for feedlot weight of beef breeds (5) and $r_{G_{MB}}$ lies within the range of those in several reports (4, 8, 9, 11, 12).

While there are several other traits of economic importance in cattle, only milk and beef production traits were considered in this study.

Results and Discussion

Selection considering milk and beef. Equations of weights for estimating genetic value for milk are $108402\ b_{M1} + 2277\ b_{B1} = 122597$ $2277\ b_{M1} + 2025\ b_{B1} = 4555$, and from these $I_M = 1.11\ X_1 + .997\ X_2$.

Equations to determine weights to estimate genetic value for beef from milk and beef records are $108402\ b_{M2} + 2277\ b_{B2} = 2277$, $2277\ b_{M2} + 2025\ b_{B2} = 1316$, and $I_B = .008\ X_1 + .619\ X_2$.

If a kilogram of milk was \$.11 and a kilogram of beef in liveweight was \$.75, the index for economic value would be:

$I = .11(1.11\ X_1 + .619\ X_2) + .75\ (.008\ X_1 + .619\ X_2) = .128\ X_1 + .574\ X_2$

For correlated responses in milk and beef from selection, the standard deviation of the index and its covariances with the genetic values for milk (G_M) and for beef (G_B) were:

Variance of index (I) $= (.128)^2\ (108402) + (.574)^2\ (2025) + 2(.128)\ (.574)\ (2277) = 2777.83$

Standard deviation of I = \$52.70

$Cov(G_M,I) = (.128)\ (122597) + (.574)\ (4555) = 18307$

$Cov(G_B,I) = (.128)\ (2277) + (.574)\ (1316) = 1047$

Thus, from selection for both milk and beef at \$.11 and \$.75/kg, the expected correlated response in milk is $\Delta G_M = (18307/52.7)D = (347.4\ kg)D$, and the expected correlated response in beef is $\Delta G_B = (1047/52.7)D = (19.9\ kg)D$, where D is the selection intensity factor.

Selection ignoring beef. The equation to find the weight for milk production to estimate genetic value for milk, ignoring beef, is:

$b_M = 1.131$

$I_M = 1.131\ X_1$, then with $V_M = 1$

The expected correlated response in beef production is: $\Delta G_B = [Cov(I_M G_B)/\sigma_{IM}]\ D = (5151.2/372.4)D = (13.8\ kg)D$

Selection ignoring milk. The equation to find the weight for beef production to estimate genetic value for beef, ignoring milk, is:

$b_B = .65$

$I_B = .65\ X_2$, then with $V_B = 1$

The expected correlated response in milk production is: $\Delta G_M = [Cov(I_B G_M)/\sigma_{IM}]\ D = (1480.1/29.2)D = (50.6\ kg)D$

Conversion of correlated response to an equal time basis is needed since the generation intervals for milk and beef are different. To put it on equal time basis, $\Delta G_B = 29.2D(6/2.25) = (78.0\ kg)D$ and $\Delta G_M = 50.6D(6/2.25) = (134.9\ kg)D$

Generation interval for milk was set at 6 yr and for beef, 2.25 yr.

Total protein and economic value. For practical purposes, one would be more interested in genetic response of total protein production and total economic value. These can be derived by:

Correlated response in total protein production $= \Delta G_B(.0925)\ (.75) + \Delta G_M(.031)$ where protein content in beef on a liveweight basis is 9.25% and in milk, 3.1%. Possible correlated change in protein content was ignored and presumed constant.

Correlated response in total economic value $= \Delta G_B(.75)\ (.75) + \Delta G_M(.11)$ where current liveweight beef is $.75/kg and milk, $.11/kg. The factor .75 was used in both formulas on the premise that 75% of the cattle would be slaughtered and 25% saved for herd replacements.

Relative genetic progress expected. The relative genetic progress for milk and beef at varying degrees of emphasis in selection, along with economic values, is in Table 1. The correlated response in milk and beef, when their respective values are $.11 and $.75/kg, corresponds closely to values when emphasis is four to one for milk and beef. As illustrated in Fig. 1, genetic progress in beef would decline with increasing selection emphasis on milk. Similarly, genetic progress in milk would decline when emphasis was shifted to beef; however, the decline in genetic progress, regardless of where the emphasis was shifted, did not fall below one-third the maximum progress in either trait.

Emphasis on milk (0:10) would give only 34.8% of full progress for beef while all emphasis on beef (10:0) would give only 35.8% as much progress for milk as compared to complete emphasis on milk. At equal emphasis (1:1), milk would show only 68.9% as much progress compared to all emphasis on milk while beef would have 92.1% as much progress compared to full emphasis for beef. The relatively higher predicted progress in beef may be attributed to the fact that beef production has higher heritability than milk production.

With milk completely ignored, genetic progress in milk would be only 36% compared to

TABLE 1. Relative genetic progress in milk and beef production when selection is simultaneous for both traits at different degrees of selection emphasis.

Selection emphasis (value per SD)	Genetic response per generation[a]				Relative genetic progress[b]			
	Beef	Milk	Total protein[c]	Economic value[d]	Beef	Milk	Total protein	Economic value
Beef:Milk	(kg)			$	(%)			
10: 0	29.4	133.9	6.2	31.2	100.0	35.8	49.6	63.1
10: 1	29.3	150.6	6.7	33.0	99.8	40.3	53.7	66.8
9: 1	29.3	152.3	6.8	33.2	99.8	40.8	54.2	67.1
8: 1	29.3	154.6	6.8	33.5	99.8	41.4	54.6	67.6
7: 1	29.3	157.4	6.9	33.8	99.7	42.1	55.4	68.2
6: 1	29.2	161.1	7.0	34.2	99.6	43.1	56.2	69.0
5: 1	29.2	166.2	7.2	34.7	99.4	44.5	57.5	70.1
4: 1	29.1	173.6	7.4	35.5	99.2	46.5	59.3	71.7
3: 1	29.0	185.5	7.8	36.7	98.7	49.7	62.2	74.2
2: 1	28.6	207.1	8.4	38.9	97.4	55.4	67.3	78.5
1: 1	27.0	257.3	9.8	43.5	92.1	68.9	78.9	87.9
1: 2	23.8	312.3	11.3	47.7	81.0	83.6	90.8	96.4
1: 3	21.2	337.5	11.9	49.1	72.3	90.3	95.7	99.1
1: 4	19.4	350.5	12.2	49.4	66.0	93.8	97.8	99.9
1: 5	18.0	357.8	12.3	49.5	61.4	95.8	98.9	100.0
1: 6	17.0	362.4	12.4	49.4	57.9	97.0	99.4	99.9
1: 7	16.2	365.3	12.4	49.3	55.2	97.8	99.8	99.6
1: 8	15.6	367.4	12.5	49.2	53.0	98.3	99.9	99.4
1: 9	15.1	368.8	12.5	49.0	51.3	98.7	100.0	99.1
1:10	14.6	369.9	12.5	48.9	49.8	99.0	100.0	98.8
0:10	10.2	373.6	12.3	46.8	34.8	100.0	98.5	94.6
Ignoring milk	78.0	134.9	9.6	58.7	265.8	36.1	76.8	118.6
Ignoring beef	13.8	372.4	12.5	48.8	47.2	99.7	100.2	98.5

[a] Selection intensity factor assumed as 1.

[b] Bases for 100% are 29.35 kg for beef, 373.62 kg for milk, 12.48 kg for total protein, and $49.49 for total economic value.

[c] Protein content: milk = 3.1%, beef (liveweight) = 9.25%. Only ¾ of offsprings used for beef.

[d] Current value per kg: milk = $.11. Beef (liveweight) = $.75.

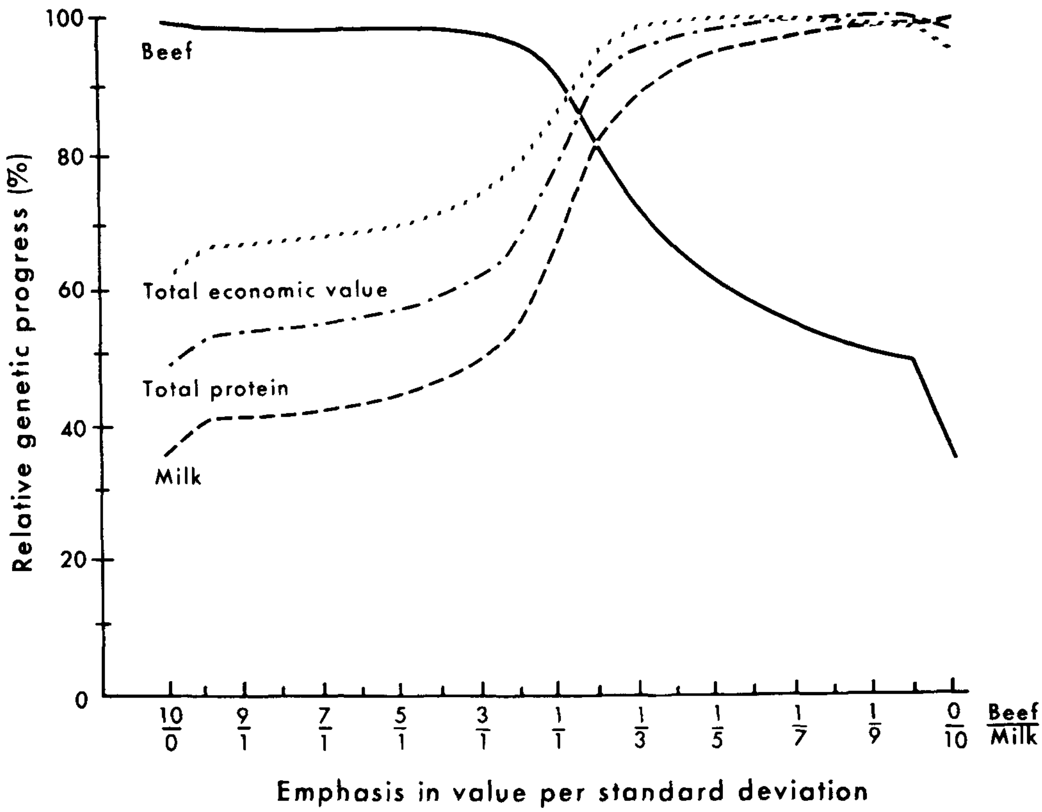

FIG. 1. Effects of different degrees of selection emphasis on genetic progress in milk, beef, total protein production, and total economic value.

all emphasis on milk, but genetic progress in beef would be 266%. The higher genetic progress in beef is expected because of the much shorter generation interval for beef. Selection of bulls solely for beef production by performance test would require a generation interval of about 2.25 yr. Simultaneous selection for both milk and beef production would increase generation interval to at least 6 yr. The advantage of a short generation interval is reflected by the high predicted progress in beef when milk is completely ignored. Selection ignoring beef, progress in milk would be close to 100%, but genetic progress in beef would be only 47.2%. However, ignoring beef completely and selecting only for milk production would bring about the most genetic progress in total protein production as shown in Table 1. None of the other combinations of emphasis changes output of total protein more.

Based on current milk and beef values, ignoring milk would give the highest genetic progress in total economic value (118%), but progress in total protein would be only 76.8%. Ignoring beef would give not only the highest genetic progress in protein but would show a fairly high genetic progress in total economic value, 98%. When all emphasis is on beef, genetic progress in total economic value would be only 63%. With all emphasis on milk, genetic progress in total economic value would be 95%.

As illustrated in Fig. 1, progress in total protein would increase with increasing emphasis on milk but would level off at a 1:5 beef to milk selection ratio. Likewise, progress in total economic value based on current milk and beef values would increase with emphasis on milk until reaching a peak at a 1:5 beef to milk ratio and gradually decline to 95% progress when all emphasis is on milk.

The ideal beef to milk emphasis would be one that would bring about large progress in both total protein and total economic value. It appears that a beef to milk emphasis of 1:7 would be most appropriate for current economic values for beef and milk. Progress in total protein would be 99.8% and that in total economic value would be 99.6%.

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