1981

Single and Multiple Trait Sire Selection. First Lactation Milk Yield and Composition, Conformation, Feed Intake, Efficiency, and Net Income

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Abstract

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Yield daughters produced 685 and 51 kg more milk and solids-not-fat but were .28% and .12% lower in fat and protein percentages than merit daughters. Energy intake of the ad libitum mix rations was nearly identical, but gross feed efficiency was significantly higher (.73 vs. .69) for yield daughters. Mammary conformation score was significantly higher for the merit group. A significantly higher number of merit daughters were coded acceptable for descriptive udder traits in the udder index. Net income per day was significantly higher for the yield group than for the merit group ($.25 vs. $.15). Much of this difference was due to the higher expense associated with a 21 day longer calving interval of merit heifers.

Disciplines

Agriculture | Animal Sciences | Dairy Science

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Single and Multiple Trait Sire Selection. First Lactation Milk Yield and Composition, Conformation, Feed Intake, Efficiency, and Net Income[1,2]

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ABSTRACT

Daughters of sires selected on Predicted Difference milk of first lactations (yield) were compared with daughters of sires selected on an udder index from among artificial insemination bulls with less than 10% of their daughters culled and with a Predicted Difference fat-corrected milk greater than 181 kg (merit). On latest proofs yield bulls were 425 kg higher than merit bulls for Predicted Differences of first lactations, whereas merit bulls had an average Predicted Difference Type, which was 1 point higher than yield bulls. Data were from first calving interval.

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INTRODUCTION

Numerous traits have been and continue to be considered in selection of dairy cattle. However, breeding values for sires are available only for yield and conformation traits (16). Vinson and Freeman (23) observed that most AI (artificial insemination) studs have exerted extensive selection pressure for milk, fat percentage, and total score. Other traits may have been included in selection, but no objective measure of selection intensity for these traits is available.

Estimated genetic gains in milk yield actually achieved in commercial populations have been short of theoretical expectations (4, 13). A primary reason for this is the failure to exert the intensity of selection possible. However, there is a need to verify experimentally that selection gains achieved are in accord with expectations.

Two early projects examined effects of selection in closed herds with progeny testing (6, 12). There is little evidence of observed correlated responses ("realized genetic correlations") accompanying selection for milk yield. In the one such report in the literature, Hickman and Bowden (8) reported correlated responses to selection for milk solids in small, closed populations of Ayrshires and Holsteins. Correlated responses in feed consumption, feed efficiency, growth, and body size differed in

Received March 24, 1980.

[1] Contribution to the NC-2 Regional Project, Improving Cattle through Breeding with Special Emphasis on Selection.

[2] Scientific Article No. A2736, Contribution No. 5786 of the Maryland Agricultural Experiment Station, Department of Dairy Science.

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the two breeds. Growth from 6 to 8 mo of age increased significantly in both breeds, whereas feed efficiency for production improved in Holsteins but not in Ayrshires. Feed consumption increased in Ayrshires. There was a decrease in wither height for Holsteins but not for Ayrshires. Direct responses agreed with expectation with slightly greater improvement in Ayrshires (6).

Kennedy and Moxley (10) reported annual genetic declines in fat and protein percents of .004% and .008% of the mean in a commercial population with an annual improvement in milk yield of 46 kg. Powell et al. (19) reported a faster genetic rate of decline in fat percentage (−.01% per year) for US Holsteins.

The NC-2 and S-49 Regional Technical Committees have initiated selection projects to determine direct and correlated response to selection among AI proven sires (24, 27). To form the foundation for their selection project Iowa State (3) selected open heifers for high and low breeding values for milk production. Regression of milk yield on breeding value at purchase was 1.03; the correlation between the two was .33. These results suggested the accuracy of pedigree selection within herd was close to theoretical expectation. Regressions of fat yield, fat percentage, and protein percentage of pedigree estimated breeding value for milk were .036 kg, −.00008%, and −.00009% (11). High pedigree heifers scored higher in dairy character and lower in mammary system than low pedigree heifers; however, there was little difference in their final scores (1).

Response to selection for milk in several of S-49 Jersey projects was in (20, 22, 25). In these projects, responses in selected lines were compared to control lines. Richardson et al. (20) found an annual genetic progress of 57 kg milk and 3.7 kg fat. Differences in body size for selected and control lines were small (15). Estimates of genetic changes for the Florida project were 48.6 kg milk and .94 kg fat. Correlated changes in constituent percentages were small (22).

Wilk and McDaniel (25) found an average difference between selected and control lines of 863 kg mature equivalent milk. The difference between selected and control lines increased with generation number from 606 kg in generation one to 924 kg in generation three. In general, the difference from controls of first lactation daughters of bulls selected for high PD milk was greater than expected. Fat and protein yield differences from controls were +22 and +27 kg, whereas fat and protein percentage were −.50 and −.22% lower than controls (26).

The project reported here was to evaluate and compare results of selection of sires for milk yield in first lactation with selection of sires for udder conformation, percentage of daughters culled during first lactation, and fat corrected milk yield. The ultimate goal was to compare cost of production or profitability for cows in two selection criteria groups.

METHODS

Purebred Holstein females in the Beltsville herd in 1970 were assigned randomly to the two selection criteria (SC) groups within genetic group (15), sire, and production subclasses. A total of 228 foundation females were assigned to the two groups. These animals and their resulting offspring remained in the same selection group for the duration of the experiment.

Sire Selection and Mating Design

Sires for the yield group were selected on their PD milk (herdmate comparison) based solely on AI daughters in first lactation from among bulls with repeatability for first lactations greater than 40%. The last two bulls were selected on Modified Contemporary Comparison proof based on all daughters in first lactation. Data on sire evaluations were obtained from the Animal Improvement Program Laboratory, Beltsville. Sires for the merit group were selected on an udder index from among the AI bulls with less than 10% of their daughters culled during first lactation (% incomplete originally and then % culled) and with PD fat-corrected milk (FCM) on all lactations greater than 181 kg and with repeatability greater than 40%. The udder index was calculated from the percentage acceptable for descriptive udder characteristics provided by the Holstein Friesian Association. Initially, the index used was the sum of the percentages acceptable for fore udder, udder support, teats, and udder quality, plus twice the percentage acceptable in rear udder. For the second and later selections, an index developed by J. E. Legates was used: $I = \Sigma W_i(X_i - \overline{X}_i)/\Sigma W_i$ where X_i are the percents acceptable for fore udder, rear udder, udder support, and teats; and W_i are index weights for relative importance of 2, 1, 4, and 1, and h^2 of .25, .24, .15, and .22. The W_i vary with number of daughters of the bull. The same bulls would have been selected in 1971 on both indexes.

Averages of the several selection criteria, PD milk, and PD type at time of selection and currently (1979) for bulls selected for yield and merit groups are in Table 1. At time of selection yield bulls exceeded merit bulls by 465 kg in PD 1st milk. This difference has decreased only slightly. The initial lactation difference in PD_{FCM} was considerably smaller (165 kg) but has increased to 234 kg due to the larger drop in the merit bulls. The difference in the change of the two types of proofs probably reflects greater stability of first lactation proofs based solely on AI daughters and also represents the greater regression toward the mean for the group in which the proof was a selection criterion. Also, the change from the herdmate to the modified contemporary comparison may have affected the two groups differently.

Based on proofs at the time of selection 4.6% fewer of the merit bulls' daughters were culled during first lactation. However, in the 1979 proofs, yield bulls had 1% fewer daughters culled during 1st lactation. This suggests the measure "% culled" is not very repeatable, especially when based on a small number of daughters in first lactation.

Merit bulls exceeded yield bulls by 22.8 units in udder index when selected. This difference was reduced to 14.1 units in the most recent type information (1975 was the last year descriptive type summaries were obtained to compute indexes on the bulls). At that time three yield bulls still had no information available for computing the indexes.

The difference between bull groups for all-lactation PD milk was only about one-half the difference in their first lactation proofs. The difference in current proofs has increased approximately 90 kg. Again this reflects the larger regression of the proofs of merit bulls and the change in method of calculating proofs. Both groups of bulls had negative average type proofs in the latest herdmate comparison.

TABLE 1. Means ($\bar{X}$) and standard deviations (SD) for the selection criteria, Predicted Difference (PD) milk, and type of the bulls selected for the merit and yield groups.

Proof	Time of selection[a]				Most current[b]			
	Yield		Merit		Yield		Merit	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Yield criteria								
PD first lactation (kg)	652	88	187	138	566	149	141	202
Merit criteria								
PD FCM (kg)	502	171	342	127	376	184	142	201
Percentage culled (%)	10.3	3.8	5.7	2.9	8.6	1.7	9.6	2.0
Udder index (units)	−5.7[d]	10.4	17.1	3.9	−2.9[e]	9.0	11.2	8.3
Other proofs								
PD milk (kg)	639	139	376	140	522	192	174	220
PD[f] type (pts)					−1.31	1.23	−.26	.826
PD[g] type (pts)					−.68	1.28	+.39	.749

[a]Or the first proof available, milk proofs mainly by herdmate comparison method.

[b]Milk proofs by modified contemporary comparison.

[c]Proofs based on 1st lactation AI daughters only through 1974 and all daughters in first lactation thereafter.

[d]N = 10 bulls.

[e]N = 13 bulls.

[f]Herdmate evaluation only available on 15 of 16 yield bulls.

[g]Proofs by best linear unbiased prediction.

However, the yield group was 1 point below the merit group. This difference remained nearly constant with the new BLUP type proofs (2), but averages were .6 to .7 higher than the herdmate proofs.

Mating Scheme B of Hickman and Freeman (7) was used within each SC group (Figure 1). Six sires were used in each group each year. Except for the first and last 2 yr, each sire was used for 3 consecutive yr. The study continued for 8 yr, and each year two new sires were added to each group. After the 1st yr of the project, semen from two sires in each group was withdrawn from service and stored for use during the final 2 yr of the trial. Likewise, two additional sires in each group were used for 2 yr at the beginning of the study and 1 yr at the end. A total of 16 sires were used for each group.

Service sires were assigned within each group by random number table. Randomization was restricted so that the number of cows assigned to each sire was nearly equal. Animals that failed to conceive after four services to the assigned sire were rescheduled to the year-mate of that sire. If conception was not achieved after eight services, or by the 305th day of lactation, or by 2 yr of age for heifers, the animal was released from the project. Problem breeders having a dry period in excess of 210 days also were released. Otherwise, cows were culled from the project only if they were unfit for handling under standard management procedures.

For each breeding year after all calves by a sire were born, five daughters were selected randomly for genetic evaluation. Three of the five in each sire group were designated as animals to be used in the study; two daughters remained in reserve. These project animals were not available for experiments possibly interfering with normal growth and development or future production. If the three primary animals successfully initiated their first lactations, the additional two animals were released. Otherwise, reserve animals were used. Cows culled after successful initiation of first lactation were not replaced.

Definition of Data and Models

Females born on the project calved initially in May, 1973, and the last cow calved in February, 1979. Only data from reserved animals under the standard management were used in any of the analyses. Approximately 3 more yr of first lactation data remain to be collected.

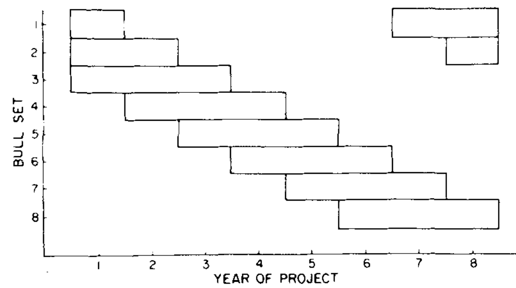

Figure 1. Bull set used across years of the project (Hickman and Freeman design).

Heifers were raised under standard dairy heifer management procedures. Close observation for estrus began at 12 mo of age. After the 1st yr of the breeding project, a change from 15 to 14 mo was made in the age at which breeding was initiated. Likewise, early in the project the postpartum breeding interval of cows was changed from 70 days to 55 days.

During first lactation, cows were fed 1.8 kg of grass-legume hay and a mix ration of concentrate (C), corn silage (CS), and grass silage (GS). These animals were fed individually, and daily consumption was recorded. Two mixed rations were used. They were started on a mix consisting of 44.4:44.4:11.2 C:CS:GS dry matter ratio and providing 15.5% crude protein and 1.57 Mcal net energy for lactation (NE_L). Cows continued on this ration for at least 90 days after calving and until their daily production dropped below 17 kg. At this time, a mix consisting of 22:50:28 C:CS:GS ratio and providing 13.1% crude protein and 1.47 Mcal NE for lactation was fed ad libitum. All rations were formulated weekly on dry matter determinations. The amount fed was weighed each day, and orts were removed and weighed every other day.

All cows were milked twice daily in a parlor. A milking schedule with 11- and 13-h intervals was used. Milk weights and clinical mastitis by quarter were recorded at each milking. Cows were dried to provide at least a 45-day period prior to their due date or when the average production for 5 days dropped below 6 kg.

Milk samples were taken monthly and tested for fat, protein, solids-not-fat content, and for leucocyte count as determined by Wisconsin Mastitis Test (WMT). All project animals were classified routinely by official classifiers of the Holstein Friesian Association (HFA).

Four data sets with varying numbers of animals were analyzed. The largest set contained mature equivalent (ME) extended milk yield, composition yield and percentages, and included in-progress and terminal incomplete lactations greater than 30 days (240 cows). The ME and extension factors previously calculated for this herd were used. The second data set included final score, breakdown, and descriptive type traits of 133 cows classified during first lactation. The third set included fat-corrected milk (FCM), average weight, weight change, estimated energy consumption, and gross feed efficiency of 167 cows completing their first lactation prior to January 1, 1979. Average weight was the average of the 10 monthly weights during the lactation. Weight change was the weighted average of the last 2 monthly weights minus the average of weights on the first 3 days postcalving. Energy consumption (NE_L) was the kilograms of mix consumed times the megacolories per kilogram for the mix, plus the kilograms of hay consumed times the megacolories per kilogram for the hay. The megacalories per kilogram for each feed source was adjusted for dry matter of the components at the time the feed was consumed. Gross feed efficiency was calculated as the kilograms of FCM divided by the megacalories of NE_L consumed. The fourth data set included estimated net income during first calving interval (CI) and milk per day of CI on 155 cows.

Net income per day of CI was calculated as (Income-Expense)/CI where,

Income = Milk Sold (kg)* .076

+ Fat Sold (kg)* 2.87

+ Protein Sold (kg)* 2.20

+ Calves Weight Produced (kg)[6] * 1.54

+ Salvage Weight (kg)* .77 [1]

[6] Includes a credit for the calf being carried.
[7] Average weight first 3 days following freshening.

and Expense = Age at 1st Freshening (d)* .27

+ $\dfrac{\text{Weight at 1st Freshening}^{7} * 448}{370.00}$

+ Estimated Energy Consumed (Mcal)* .06

+ Mastitis Treatments (no)* 2.00

+ Services (no)* 10.00

+ CI (d)* 1.65 [2]

The general model used to analyze these data included selection criterion (SC), sire within SC, year of freshening, month of freshening, and regression on age. For data set 1, the age regression was omitted, and for data set 2, year of classification was submitted for year and month of freshening. Approximate tests of significance were calculated from expectation of the mean squares for sire and error random and all other effects fixed (Henderson's method 3). In addition, a mixed model analysis using several ratios of σ_e^2/σ_s^2 for ME milk and using single ratios for the composition yield traits were run. Chi-square analysis was used to determine if there was a difference between merit and yield groups in the percentage acceptable for the four descriptive udder traits.

RESULTS AND DISCUSSION

Least squares means for ME yield and composition traits for the two selection groups are in Table 2. On an ME basis, the yield group produced significantly more milk and solids-not-fat than did the merit group but had significantly lower fat and protein percentages. Fat yields were nearly identical due to the negative relationship between milk yield and fat percentage. Similarly, differences in protein yield were smaller than milk differences due to the lower protein percentage of the yield group. The 685 kg difference in milk yield exceeded the difference in the averages of first lactation proof for the two sire groups. The greater than expected difference in the yield of the daughters of two selection groups was reported (17) and has been found in several of the other NC-2 selection projects (NC-2 Technical Committee, personal communication). Possible reasons for the greater realized differences are: a) under-

TABLE 2. Least squares means and standard errors for the two selection criteria (SC) groups for ME extended yield and composition during first lactation.

Trait	Yield[a]		Merit[a]		
	Least squares mean	SE	Least squares mean	SE	F[b,c]
Mature equivalent					
Milk (kg)	7798	174	7113	184	10.86
Fat (kg)	280	6.0	274	6.4	.59
SNF (kg)	665	14.9	614	15.7	9.10
Protein (kg)	244	5.5	232	5.8	3.70
Fat (%)	3.63	.058	3.91	.061	8.80
SNF (%)	8.51	.054	8.58	.057	.89
Protein (%)	3.14	.025	3.26	.026	8.57

[a]Yield group contained 123 cows and merit group contained 117.

[b]Mean square SC/mean square sires within SC.

[c]$F_{(.05,1,30)} = 4.17$; $F_{(.01,1.30)} = 7.56$.

estimate of h^2 used to calculate PD's; b) better than average environment magnifying the genetic differences; and c) misidentification of "daughters" in PD's.

The effects of an underestimate of h^2 could be substantial for bulls with low repeatability; however, virtually all bulls in the study had repeatabilities in excess of 90% for their latest proof. Thus, it had little effect on their estimated proof. McDaniel and Corley (14) demonstrated that in higher producing herds, genetic differences between sire groups tend to be expanded. However, the production by animals of this project was close to breed average, and the greater response (60%) exceeded estimates of McDaniel and Corley (14) for even the most extreme cases. Misidentification of daughters in the bull's proof may explain some of the greater than expected differences. For the group of sires being selected for highest PD milk available (yield) any animals mistakenly attributed to these sires would tend to reduce their milk proof. For the merit group, the average PD is near breed average, and they are not as likely to be biased upward or downward by unintentional misidentification. Although misidentification in field data may contribute to the greater than expected response, it is doubtful that its effect is large enough to explain the majority of the difference. This is an area which deserves further investigation.

Differences from the mixed model analysis between yield and merit selection groups for the production traits are in Table 3. Ratios of σ_e^2/σ_s^2 for milk corresponded to heritabilities of 1, .36, and .25. These ratios were used to demonstrate the effects of treating sires as random in the analysis. Differences between yield and merit selection groups were similar to those from the least squares analysis when ratios of 10 and 15 were used. Ratios for milk constituent traits were based on previously published estimates. Properties of mixed model tests are theoretically superior (5); however, in this case, estimates of the difference and results of the tests are nearly identical for the two methods. Comparison of Tables 2 and 3 suggest that sampling variance of the estimated differences between yield and merit groups is smaller when sires are considered computationally random in the analysis.

Least squares means of weight, FCM, energy intake, and gross feed efficiency are in Table 4. Average weight and estimated NE_L intake were nearly identical for the two groups. The merit group gained 20% more weight, but the difference was not significant. The yield group produced significantly ($P<.05$) more FCM and had significantly ($P<.01$) higher gross feed efficiency. The animals on this project were on ad libitum feeding of mixed rations. Although they were changed to lower density ration

TABLE 3. Results of the mixed model analysis of selection criteria (SC) differences for milk yield and composition.

Trait[a]	Ratio[b]	Yield-merit	SE[c]	Numerator sum of squares	F[d]
Milk (kg)	3	676	361	7,337,715	3.5
	10	661	258	13,827,653	6.6
	15	656	238	15,909,236	7.6
Fat (kg)	12	9	8.6	2,777	1.1
SNF (kg)	10	50	22.0	82,119	5.3
Protein (kg)	12	13	7.9	5,784	2.8
Fat (%)	10	−.238	.085	1.799	7.77
SNF (%)	8	−.042	.085	.0496	.24
Protein (%)	8	−.104	.038	.308	7.25

[a]Traits expressed as mature equivalent.

[b]σ_e^2/σ_s^2.

[c]SE of difference.

[d]$F_{(.05,1,188)} = 3.90$; $F_{(.01,1,188)} = 6.78$; Calculated F = Numerator SSq/Error SSq.

when production dropped below 17 kg (merit cows on the average were changed a month earlier than yield cows), the higher producing yield cows consumed only 1% more NE_L than did merit cows. Difference in energy intake in excess of that needed for maintenance and production is not reflected totally in the difference in weight gain of the two groups. This is possibly due to differences in body composition of the two groups at the end of lactation. Differences in FCM appear to have a much larger role in determining gross feed efficiency than in previous mating system comparisons where cows were fed according to need (9).

Least squares means for final scores in first lactations and major categories of the two groups are in Table 5. Scores for both groups

TABLE 4. Least squares means and standard errors for the two selection criteria (SC) groups for average weight, weight change, fat corrected milk (FCM), energy intake, and gross feed efficiency during first 305 days of first lactation.

Trait	Yield[a]		Merit[a]		
	Least squares mean	SE	Least squares mean	SE	F[b,c]
Average weight (kg)	498	6.4	496	6.3	.01
Weight change (kg)	50	8.1	60	8.0	2.83
Actual FCM (kg)	5264	172	4910	170	4.49
Energy intake NE_L (Mcal)	7158	193	7075	191	.31
Gross feed efficiency (kg/Mcal)	.73	.013	.69	.013	12.97

[a]Yield group contained 91 animals and merit group contained 76.

[b]Mean square SC/mean square sires within SC.

[c]$F_{(.05,1,25)} = 4.24$; $F_{(.01,1,25)} = 7.77$.

TABLE 5. Least squares means and standard errors for the two selection criteria (SC) groups for final score, general appearance, dairy character, body capacity and mammary system scores during first lactation.

	Yield[a]		Merit[a]		
Trait	Least squares mean	SE	Least squares mean	SE	F[b,c]
Final score (pts)	69.4	1.46	71.1	1.57	1.24
General appearance[d]	4.9	.173	4.8	.186	.14
Dairy character[d]	3.3	.179	3.5	.167	2.53
Body capacity[d]	3.9	.180	3.9	.167	.00
Mammary system[d]	4.8	.200	4.2	.215	7.06

[a]Yield group contained 72 cows and merit group contained 61 cows.,

[b]Mean square SC/mean square sires within SC.

[c]$F_{(.05,1,25)} = 4.24$; $F_{(.01,1,25)} = 7.77$.

[d]EX = 1, VG = 2, + = 3, G = 4, F = 5, P = 6.

are low. This is compounded by the least squares means for final score being slightly lower than the actual overall mean. As with milk yield, the difference in final score between the groups is nearly 70% greater than expected from the PDT difference of the sires. However, the difference was not significant because of the extreme variation within group. Much of the variation was from animals scored in the 40's and 50's. Unpublished work with classification data from this herd suggested that greater than expected differences in final score were from lack of culling for poor conformation and suggestion of a nonlinear relationship between score and conformation at low scores. Some changes recently have been made in the classification system that may remedy part of the lack of linearity.

Differences in general appearance and body capacity scores were small. Yield animals scored slightly higher for dairy character but were significantly ($P<.05$) lower for mammary system. Selection pressure on udder index, composed of HFA percentage acceptable of the descriptive udder traits, was at least partially effective.

Percentages of daughters of each selection criterion group classified acceptable for the four descriptive udder traits that were in the udder index are in Table 6. The percentage acceptable for all four traits was substantially below breed average for the yield group; however, the percentage acceptable for udder support and teats was slightly above average for the merit group. Chi-square analysis was used to determine if the percentage acceptable differed significantly between the two groups. Differences for fore udder, rear udder, and teats were significant ($P<.05$), whereas differences for udder support were highly significant ($P<.01$). Thus, the greatest difference occurred for the trait with the highest relative economic importance ($a_ih_i^2$) in the udder index. This further suggests that selection on udder conformation was effective. However, it is difficult quantitatively to relate observed differences to selection.

Least squares means of income (1), expense (2), calving interval (CI), net income per day of CI, and milk per day of CI for the two groups are in Table 7. Income in first lactation was $37 greater and expense was $50 less for yield cows than for merit cows. The greater income of yield cows primarily was from higher milk yield, whereas the higher expense of merit cows was mainly associated with longer CI (21 days). However, these differences were not significant. Thus, total net income per day was twice as great for the yield group as for the merit group. However, only about $.10 of the difference was from the added income of the yield cows. Milk per day of CI was 1.8 kg greater for the yield group. The longer CI of the merit group is hard to explain. It could be from chance selection of bulls with lower conception

TABLE 6. Percentage acceptable[a] for the four descriptive udder traits for the two selection criteria groups (SC).

	Yield		Merit		
Trait	Number acceptable	Number unacceptable	Number acceptable	Number unacceptable	$\chi^{2\,b}$
Fore udder (FU)	28 (38.9)[c]	44 (61.1)	34 (55.7)	27 (44.3)	3.76
Rear udder (RU)	20 (27.7)	52 (72.2)	28 (45.9)	33 (54.1)	4.70
Udder support	33 (45.8)	39 (54.2)	42 (68.8)	19 (31.1)	7.11
Teat size and placement (teats)	35 (48.6)	37 (51.4)	40 (65.6)	21 (34.4)	3.85

[a]Descriptive codes 1 and 2 considered acceptable for FU, RU, and Teats; Code 1 considered acceptable for udder support.

[b]$\chi^2_{1,.05} = 3.84$; $\chi^2_{1,.01} = 6.64$.

[c]Percentage of SC group.

rate for the merit group. This will be discussed further in (21).

CONCLUSIONS

Sire selection on milk in first lactation, in contrast to selection for udder index from among bulls above a set truncation point, for FCM, and percentage daughters culled, generated differences in their female offspring for milk yield, fat percentage, protein percentage, gross feed efficiency, mammary system score, percentage acceptable for the descriptive udder index, net income per day, and milk yield per day. In all cases the difference between the selection criteria groups was in the direction expected. However, for the two traits where sire breeding values were available (milk and type), the realized difference was 60 to 70% greater than expected. It is expected that for these two traits the explanation for the greater realized difference is different. Since similar results tentatively have been identified in other selection projects with dairy cattle, it is important that reasons for this deviation from expected response be determined in future research.

ACKNOWLEDGMENTS

Help of F. N. Dickinson, Chief, Animal Improvement Program Laboratory, BARC-East,

TABLE 7. Least squares means and standard errors for the two selection criteria (SC) groups for income expense, calving interval (CI), net income per day of CI (NIPD), and milk per day of CI (MPD) during first lactation.

	Yield[a]		Merit[a]		
Trait	Least squares mean	SE	Least squares mean	SE	$F^{b,c}$
Income ($)	2089.26	73.08	2052.28	66.56	3.56
Expense ($)	1893.94	46.64	1943.68	42.47	.27
CI (days)	373	12.81	394	11.67	1.40
NIPD ($/day)	.51	.12	.25	.11	4.76
MPD (kg/day)	16.65	.63	14.86	.58	7.35

[a]Yield group contained 80 cows and merit group contained 75 cows.

[b]Mean square SC/mean square sires within SC.

[c]$F_{(.05,1,25)} = 4.24$; $F_{(.01,1,25)} = 7.77$.

Beltsville, and Ray Kliewer, Holstein Friesian Association, Brattleboro, VT, in providing the information on which sire selection was based is acknowledged gratefully.

The authors also express their appreciation to M. Creegan and E. Allums for help in computer preparation of the data for analysis.

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