Comparison of Bull-Dam Herds, Progeny Testing Herds, and Other Dairy Herd Improvement Herds

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ABSTRACT

Michigan and Northeast dairy herds that produced young bulls for AI sampling from 1974 to 1981 and 1978 to 1981, respectively, and those involved in progeny testing were compared with their contemporary DHI herds. The 1985 lactation records of Michigan herds and 1980 to 1987 data of Northeast herds were acquired from respective DHIA data processing centers, and genetic evaluation results of sires and cows in those herds were obtained from USDA. Herd average milk production, intraherd SD for milk production, average sire PD of cows and average cow index in the herd, and intraherd SD of sire PD and of cow indexes were computed for each herd-year. These characteristics were used to compare the herd groups. Herds in which young bulls were sampled had greater average milk production, greater variance for milk production, and greater genetic variance than other herd groups. However, these herds were not genetically superior to other herd groups, except that the bull-dam herds in the Northeast have become a superior group since 1985, and the margin of superiority has increased over time. Herds participating in progeny testing of young bulls were by far the most superior group genetically in Michigan, especially those participating in the testing program for more than 10 yr. However, progeny testing herds in the Northeast were similar to herds not involved in sire sampling or testing programs in their average genetic merit.

(**Key words**: young sire sampling, progeny testing, herd characteristics)

Abbreviation key: **BDH** = bull-dam herds, **CI** = cow index, **MCC** = Modified Contemporary Comparison, **OH** = other herds, **PTH** = progeny testing herds for > 10 yr (+) or < 10 yr (–), **305-ME** = 305-d mature equivalent milk yield.

INTRODUCTION

Genetic improvement in dairy traits through selection takes place through four paths: sires of cows, sires of bulls, dams of bulls, and dams of cows. In an AI population, genetic improvement would be almost entirely due to selection through the three paths involving bulls. In milk production, the three paths contribute 95% or more of the total improvement; selection of parents of bulls accounted for more than two-thirds (12). The accuracy and intensity of selecting and proving the young AI bulls are keys to the genetic improvement. Current practices in young bull selection place much emphasis on matings contracted to produce young bulls. The intensity of selection is limited by the resources of AI organizations. Accuracy of identifying superior sires and dams relies on predictions of their breeding values. The bull-sires' genetic merit can be very accurately predicted with many daughters distributed in many herds, but improvement is needed in the accuracy of selecting outstanding bull-dams and in the accuracy of progeny testing the sampled young bulls.

When arranging a mating to produce a young bull for sampling, his transmitting ability is often predicted from those of his sire and dam. In many cases, on the dam side, only genetic evaluation of the maternal grandsire was used while ignoring the dam's own per-

Received April 16, 1990.
Accepted November 5, 1990.

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formance. This is done to guard against biased evaluations. When the sampled young bulls are being progeny tested, semen of these bulls usually is distributed and used according to designs that attempt to avoid sources of bias. The main source of bias is perhaps preferential treatment of favored animals, some evidence of which is listed below.

Prediction of breeding values of individual sires fluctuates markedly from one evaluation to the next (1, 13). Such changes are of particular concern because culling decisions on young bulls are made on initial proofs. Evaluations on "elite" cows from first lactation records are more accurate than are evaluations that use additional lactation records (9, 11, 14). Heterogeneity of intraherd variances has been well documented (3, 6, 8, 10). Failure to account for this may bias genetic evaluations (2, 7, 13, 15), decrease selection accuracy, and impede genetic gain. Biases due to preferential treatment cannot be corrected for individual animals even with the most sophisticated genetic evaluation procedures.

Henderson (5) suggested in 1964 first to select a superior group of herds and then to select bull-dams from within these herds. Van Vleck (13) proposed to develop methods of identifying cows with potentially biased evaluations as a more effective way of screening for bull-dams. The same basic ideas could be applied to progeny testing scheme of proving young bulls in that additional information could be used to screen herds and cows that may contribute biases to genetic evaluation. Such additional information could be genetic and environmental characteristics of herds.

The objective of this study was to characterize herds from which young sires were chosen to be progeny tested and herds in which they were tested. This included examination of whether the herds involved in the two stages of young sire selection programs are different from other herds in the same population; to identify characteristics that are most useful in distinguishing the two herd groups; to examine differences in herd group comparisons between two dairy cattle populations in US; and to examine if changes in genetic evaluation procedures would change the estimation of genetic characterizations of herds.

MATERIALS AND METHODS

Data

A total of 200,418 305-d mature equivalent (305-ME) milk yield records from 1984 to 1985 in 2508 Michigan DHI herds were used. From 39 of these herds, a total of 93 young sires born during 1974 to 1981 were selected by Select Sires, Inc. for sampling. One hundred eighty of these herds had participated in progeny testing program by using young sire semen for less than 10 yr, and 93 herds had participated for 10 yr or more. Michigan DHI herds were classified as bull-dam herds (BDH), progeny testing herds for ≥ 10 yr (PTH+), progeny testing herds for < 10 yr (PTH–), and other herds on DHI (OH). The numbers of records in each group are in Table 1.

More than two million 305-ME records from 1980 to 1987 in 10,788 Northeast DHI herds were also used. Eastern AI Cooperative sampled 251 young sires born during 1978 to 1981 from 187 of these herds, and they were progeny tested in a total of 3429 herds. Table 1 shows the number of records in BDH, PTH, and OH in the Northeast data set. All records used were identified by sires with their PD from Modified Contemporary Comparison (MCC) procedure. Progeny testing herds in the Northeast were not grouped by number of years involved in progeny testing program. In both Michigan and Northeast data, those herds identified as both BDH and PTH were included in both herd groups.

The PTA values of July 1989 from animal model procedure on both sires and cows from the Northeast were obtained from USDA. Also obtained were the most recent (January 1989) PD and cow index (CI) of the same sires and cows. After matching the PTA values available with our data set, the numbers of records and herds were considerably smaller, as shown in Table 1.

Characteristics of Herds

For each herd-year, the phenotypic characteristics computed were average and SD of 305-ME milk yield. The genetic characteristics computed were average and SD of cows' sire

PD. For Michigan herds, within-herd-year average and SD were computed for CI, calf's sire PD, and service sire PD, all of which were from MCC procedure. Not all PD or CI were reported in these herds, and percentage of herds and percentage records that had this information available in our data set are indicated for each herd group in Table 1. For Northeast herds, within-herd average and SD of PTA values for both sires and cows were computed.

RESULTS AND DISCUSSION

Phenotypic Characteristics

The greatest average of 305-ME milk yield herd averages was in the BDH group (Table 2), followed by the PTH+ group, and then the PTH− group in Michigan. All three herd types that participated in the sire sampling programs of Select Sires in Michigan had greater average production than an average Michigan herd on test. The BDH group also had the greatest intraherd variation for milk yield; the PTH− group ranked below an average DHI herd in Michigan in variance of milk production, and PTH+ had the smallest intraherd variation. All these differences were significant at $P < .01$.

In Northeast DHI population, BDH also had the greatest production average and the greatest variation within herd. The PTH group was greater in both measures than OH, but the differences were relatively small. These comparisons also were highly significant at $P < .01$. This ranking of herd groups were identical in each of the 8 yr (Figure 1). Herd production averages increased over the years as expected, but intraherd production variation declined initially, then increased to 1980 level.

TABLE 1. Numbers of young bulls sampled, herds and records in bull-dam herds, progeny testing herds, and other DHI herds.

	Bull-dam herd	Progeny testing herds ≥ 10 yr	Progeny testing herds < 10 yr	Other DHI herds
Michigan DHI records of 1985				
No. sampled young bulls born during 1974 to 1981	93			
No. herds	39	93 (4)[1]	180	2508
Report sire PD, %	100	100	99	100
Report CI,[2] %	100	100	98	64
Report calf's sire PD, %	80	98	95	70
Report service sire PD, %	31	36	39	36
No. records	3359	12,319	21,139	200,418
Report sire PD, %	87	84	68	47
Report CI, %	62	59	47	29
Report calf's sire PD, %	31	32	36	25
Report service sire PD, %	9	13	17	14
Northeast DHI records of 1980 to 1987				
No. sampled young bulls born during 1978 to 1981	251			
All cows identified by sires with PD values				
No. herds	187	3429 (90)		10,788
No. records	83,563	1,060,779		2,214,779
All cows with CI, sire PD, and PTA[3] values				
No. herds	179	2495 (90)		5344
No. records	28,456	149,477		366,260

[1]Number of progeny testing herds that also produced young bulls.

[2]Cow index (CI) from Modified Contemporary Comparison procedure.

[3]July 1989 animal model procedure.

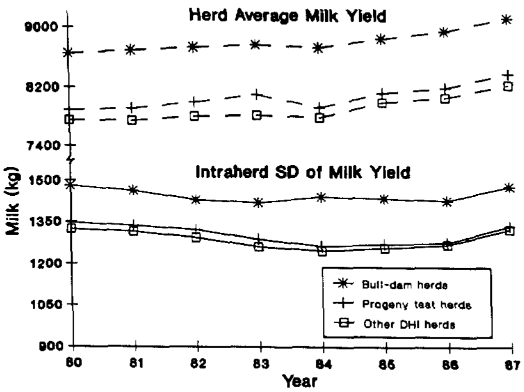

Figure 1. Change of herd average and intraherd SD of 305-d mature equivalent milk yield over time in bull-dam herds, progeny testing herds, and other DHI herds in the Northeast.

Genetic Characteristics

In Michigan, the greatest average cows' sire PD was observed in the PTH+ group with the PTH– group following closely (Table 2). The BDH group ranked third with average sire PD only slightly, but insignificantly, greater than that observed in the other DHI herds. The greatest intraherd variation for cows' sire PD was observed in the BDH group, followed by OH, PTH+, and then PTH–, and all differences were highly significant at $P < .01$. Herd average and intraherd variance of CI gave essentially the same comparison results except BDH group and PTH– group were not significantly different in herd average CI. For herd average calf's sire PD and herd average service sire PD, PTH+ again was significantly the greatest;

TABLE 2. Phenotypic and genetic characteristics of bull-dam herds, progeny testing herds, and other DHI herds, averaged over all herds in each herd group.

Herd characteristics	Bull-dam herds		Progeny testing herds ≥ 10 yr		Progeny testing herds < 10 yr		Other DHI herds	
	$\overline{X}$	SE	$\overline{X}$	SE	$\overline{X}$	SE	$\overline{X}$	SE
	Michigan DHI records of 1985							
305-ME[1] milk yield, kg								
Average	9203	32	8552	20	8409	16	7878	9
Intraherd-year SD	1552	5	1310	4	1362	4	1410	2
Cows's sire PD								
Average	279[a]	12	373	5	333	4	265[a]	3
Intraherd-year SD	681	5	596	2	562	2	632	1
Cow index								
Average	–95[a]	21	–44	7	–102[a]	7	–168	5
Intraherd-year SD	511	9	433	4	393	4	407	2
Calf's sire PD								
Average	751[a]	35	910	14	821	12	764[a]	8
Intraherd-year SD	553	14	517	5	487[a]	5	484[a]	3
Service sire PD								
Average	813[ab]	94	1117	46	921[ac]	39	904[bc]	21
Intraherd-year SD	362[abc]	43	402[ade]	13	369[bdf]	17	399[cef]	9
	Northeast DHI records of 1980 to 1987							
			All years					
305-ME milk yield, kg								
Average	8806	67	8054	19			7896	10
Intraherd-year SD	1443	20	1300	5			1282	3
Cow's sire PD								
Average	58	16	90	3			29	3
Intraherd-year SD	563	8	497	2			520	2

[a,b,c,d,e,f]Differences between herd groups with the same letter nonsignificant; other differences were significant ($P < .05$).

[1]305-ME = 305-d lactation, mature equivalent milk production.

BDH was the lowest but was not significantly different from herds in OH group. Intraherd variation of calf's sire PD was still the greatest in BDH group, but intraherd variation of service sire PD were not significantly different between herd groups.

Herd average sire PD was also the greatest in PTH group in the Northeast and was greater in BDH than in an average herd. Again, BDH group had the greatest intraherd variation in sire PD, followed by OH, with the PTH group trailing closely behind. All comparisons between herd groups were highly significant ($P < .01$). Over the years (Figure 2), however, the differences between herd groups in average sire PD were neither distinct nor consistent. The PTH group was greater than both BDH and OH groups prior to 1984, but BDH became slightly greater than PTH and OH in 1986 and 1987, the last 2 yr in our data set. However, BDH group consistently had greater intraherd variance in sire PD than either PTH and OH; OH was slightly greater than PTH.

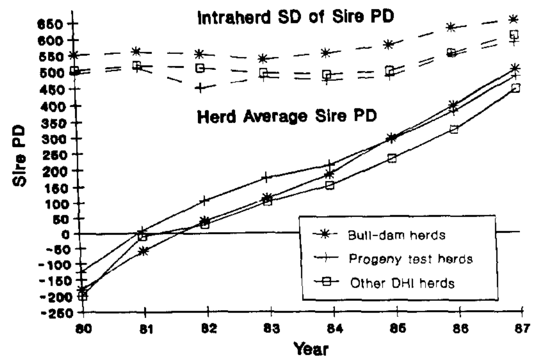

Figure 2. Change of herd average and intraherd SD of sire PD over time in bull-dam herds, progeny testing herds, and other DHI herds in the Northeast.

Genetic Herd Characteristics from Different Evaluation Procedures

Genetic characteristics were recomputed for those herds in the Northeast that had cows evaluated by MCC procedure in January of 1989 and by animal model procedure in July 1989. The MCC procedure provided PD for sires and CI for cows, and the animal model procedure provided PTA for both sires and cows. Results are shown in Table 3.

Herds that produced young bulls (BDH) increased their superiority in herd average sire PD over PTH and OH from 1989 proofs compared with 1987 values (Figure 2). The margin of superiority of PTH over OH also became greater. Herd average CI gave the same comparison results. Using PTA values, again the same results were obtained: both herd average sire PTA and herd average cow PTA indicated BDH group had superior genetic level over

TABLE 3. Genetic characteristics based on Modified Contemporary Comparison results of January 1989 [PD and Cow Index (CI)] and animal model results of July 1989 (PTA) for bull-dam herds, progeny testing herds, and other DHI herds in the Northeast.

Herd characteristics	Bull-dam herds		Progeny testing herds		Other DHI herds	
	$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
Cow's sire PD						
Average	125	17	70	5	4	4
Intraherd SD	640	8	579	3	592	2
Cow CI						
Average	−154	13	−222	4	−275	3
Intraherd SD	502	6	436[a]	2	438[a]	1
Cow's sire PTA						
Average	−151	18	−206	6	−268	4
Intraherd SD	680	8	616	3	623	2
Cow PTA						
Average	−425	17	−526	5	−592	4
Intraherd SD	596	7	515	2	508	2

[a]Differences between herd groups with same letter nonsignificant; other differences were significant ($P < .05$).

PTH group which in turn was superior over OH group. The margin of superiority was similar in both comparisons.

The intraherd variance of transmitting ability estimates, using either PD and CI or PTA, was the greatest in BDH group but was quite similar between PTH and OH groups. The difference between PTH and OH in intraherd SD from cow PTA was the only insignificant result.

CONCLUSIONS

According to 1985 DHI information, Michigan herds that produced young bulls for AI sampling had the highest average milk production, but genetically they were not superior to other herd groups. In fact, cows in these herds had sires, and were bred to sires, of similar genetic merit as those cows in herds not involved in sire sampling programs. The greater average production of these herds must, therefore, be attributed to better management. In the Northeast, the bull-dam herds also had the highest average milk production. However, beginning in 1985, the bull-dam herds also became genetically superior to other herds in the same population, and the margin of superiority seemed to increase in recent years.

Average CI in the bull-dam herds was greater than average CI in herds not involved in sire sampling programs in Michigan, but average sire PD of the two groups were nearly equal. Given the portion of CI attributed to pedigree information being equal, this would mean that the higher CI in the bull-dam herds must be due to greater contemporary deviations, which could be due to preferential treatment. However, the dams' genetic merit could be higher in bull-dam herds.

The bull-dam herds had the greatest intraherd variation both phenotypically and genetically in every case. This observation has added support to concerns (4, 7, 10, 15) over the bias in genetic evaluation due to heterogeneous intraherd variances and production levels and inspired further work (3, 16) on this topic using the same data sets.

In both geographical regions, production of herds used for progeny testing of sampled young bulls was higher than that of herds that were not involved in sampling programs but below the production level of bull-dam herds. However, in Michigan, by all measures of genetic merit, progeny testing herds were superior to all other herds, including those herds that produced the bulls to be sampled. The progeny testing herds involved in young sire sampling program for over 10 yr had the highest average genetic merit. In the Northeast, the overall average of the 7 yr indicated the same genetic superiority of progeny testing herds, but in recent years, they were surpassed by BDH and were not different from other DHI herds in average or intraherd variance of genetic merit. The animal model predictions gave the same relationships in genetic merit of herd groups as MCC.

The large intraherd variance in bull-dam herds may be an indication of the extraordinary preferential treatment in these herds. If so, it may contribute to the inaccuracy in selecting bull-dams. To reduce the influence of preferential treatment of bull-dams within a herd, perhaps young cows or even heifers should be used as bull-dams. Also, consideration of the herd characteristics, especially intraherd variance, may be useful in predicting the transmitting ability of young bulls (16). Animals may be ranked differently based on records from herds with large intraherd variance than those from herds with small intraherd variance (3). The genetic superiority of progeny testing herds may also influence the accuracy of initial prediction of young bulls' breeding value. If all of these influences can be taken into account adequately in genetic evaluation, the accuracy of initial proofs of young bulls could be greatly improved.

ACKNOWLEDGMENTS

National Association of Animal Breeders, Select Sires, Inc., and Eastern AI Cooperative, Inc. partially supported this study. Data were supplied by Select Sires, Inc., Michigan DHIA, Eastern AI Coop., Inc., Northeast Dairy Records Processing Center and USDA-Animal Improvement Programs Laboratory.

REFERENCES

1 Bolgiano, D. C., L. D. Van Vleck, and R. W. Everett. 1979. Fluctuations in sire evaluations. J. Dairy Sci. 62: 760.

2 Brotherstone, S., and W. G. Hill. 1986. Heterogeneity of variance amongst herds for milk production. Anim. Prod. 42:297.

3 Dong, M. C., and I. L. Mao. 1990. Heterogeneity of (co)variance components and heritability in different levels of intraherd milk production variance and of herd average. J. Dairy Sci. 73:843.

4 Everett, R. W., J. F. Keown, and J. F. Taylor. 1982. The problem of heterogeneous within herd error variances when identifying elite cows. J. Dairy Sci. 65(Suppl. 1):100.(Abstr.)

5 Henderson, C. R. 1964. Selecting the young sire to sample in artificial insemination. J. Dairy Sci. 47:439.

6 Hill, W. G., M. R. Edwards, M.K.A. Ahmed, and R. Thomas. 1983. Heritability of milk yield and composition at different levels of variability of production. Anim. Prod. 36:59.

7 Lofgren, L. D., W. E. Vinson, and R. E. Pearson. 1985. Adjustments to cow indexes for milk yield for effects of herd mean and standard deviation. J. Dairy Sci. 68: 3301.

8 Miranda, M. L., and L. D. Van Vleck. 1985. Trends in genetic and phenotypic variances for milk production. J. Dairy Sci. 68:2278.

9 Murphy, P. A., R. W. Everett, and L. D. Van Vleck. 1982. Comparison of first lactations and all lactations of dams to predict son's milk evaluations. J. Dairy Sci. 65:1999.

10 Powell, R. L., H. D. Norman, and B. T. Weinland. 1983. Cow evaluation at different milk yields of herds. J. Dairy Sci. 66:148.

11 Rothschild, M. F., L. W. Douglass, and R. L. Powell. 1981. Prediction of son's modified contemporary comparison from pedigree information. J. Dairy Sci. 64: 331.

12 Van Vleck, L. D. 1977. Theoretical and actual genetic progress in dairy cattle. Page 543 *in* Proc. Int. Conf. Quant. Genet., Iowa State Univ., Ames.

13 Van Vleck, L. D. 1986. Evaluation of dairy cattle breeding programs: specialized milk production. Proc. 3rd World Congr. Genet. Appl. Livest. Prod. Lincoln, NE 9:141.

14 Vinson, W. E., and J. M. White. 1982. Prediction of modified contemporary comparisons from pedigree information for artificial insemination and natural service bulls. J. Dairy Sci. 65:1578.

15 Vinson, W. E. 1987. Potential bias in genetic evaluations from differences in variation within herds. J. Dairy Sci. 70:2450.

16 Wilhelm, A. E., and I. L. Mao. 1989. Relationships between characteristics of herd of bull-dams and predicting transmitting ability of young bulls. J. Dairy Sci. 72:2395.