1981

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Max F. Rothschild
Iowa State University, mfrothsc@iastate.edu

L. W. Douglass
United States Department of Agriculture

R. L. Powell
Unted States Department of Agriculture

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Abstract

Son's modified contemporary comparison Predicted Differences and modified contemporary deviations based on daughters' first lactations only and on all lactations were predicted for milk and fat yield and fat percent from pedigree information. Pedigree records included Predicted Differences and modified contemporary deviations for male relatives and modified contemporary deviations and Cow Index on first available records for female relatives. For a son's dam, however, first two and first three available records also were used. Models were chosen by a stepwise procedure with stopping when there was a change in the multiple correlation coefficient squared of less than 1%. Minimum repeatabilities of 40 and 70% for sons were required also to form two data sets.

Models for milk and fat included sire's and maternal grandsire's Predicted Differences and dam's Cow Index. Models for fat also included the modified contemporary deviation for the maternal grandsire. For fat percent, sire's Predicted Difference or modified contemporary deviation and dam's Cow Index were important. Multiple correlation coefficients ranged from .32 for fat percent and .31 for milk to .24 for fat. Two-variable models suggested that for milk and fat, maternal grandsire was more important than dam whereas dam was more important for fat percent. The dam's Cow Index on first available record was more important for milk and fat, but dam's Cow Index from first three available records was most important for fat percent. Results were similar for predicting son's modified contemporary deviations. Closer prediction of son's Predicted Differences to real Predicted Differences for yield of milk and fat could be accomplished by placing slightly more emphasis on the maternal grandsire, and for fat percent, by putting more emphasis on dam's later records.

Disciplines

Agriculture | Animal Sciences | Dairy Science

Comments

This is an article from *Journal of Dairy Science* 64 (1981): 331, doi:10.3168/jds.S0022-0302(81)82570-2. Posted with permission.

Prediction of Son's Modified Contemporary Comparison from Pedigree Information[1,2]

M. F. ROTHSCHILD,[3] L. W. DOUGLASS, and R. L. POWELL
Department of Dairy Science
University of Maryland
College Park 20742
and
Animal Science Institute, SEA-AR, USDA
Beltsville Agricultural Research Center
Beltsville, MD 20705

ABSTRACT

Son's modified contemporary comparison Predicted Differences and modified contemporary deviations based on daughters' first lactations only and on all lactations were predicted for milk and fat yield and fat percent from pedigree information. Pedigree records included Predicted Differences and modified contemporary deviations for male relatives and modified contemporary deviations and Cow Index on first available records for female relatives. For a son's dam, however, first two and first three available records also were used. Models were chosen by a stepwise procedure with stopping when there was a change in the multiple correlation coefficient squared of less than 1%. Minimum repeatabilities of 40 and 70% for sons were required also to form two data sets.

Models for milk and fat included sire's and maternal grandsire's Predicted Differences and dam's Cow Index. Models for fat also included the modified contemporary deviation for the maternal grandsire. For fat percent, sire's Predicted Difference or modified contemporary deviation and dam's Cow Index were important. Multiple correlation coefficients ranged from .32 for fat percent and .31 for milk to .24 for fat. Two-variable models suggested that for milk and fat, maternal grandsire was more important than dam whereas dam was more important for fat percent. The dam's Cow Index on first available record was more important for milk and fat, but dam's Cow Index from first three available records was most important for fat percent. Results were similar for predicting son's modified contemporary deviations. Closer prediction of son's Predicted Differences to real Predicted Differences for yield of milk and fat could be accomplished by placing slightly more emphasis on the maternal grandsire, and for fat percent, by putting more emphasis on dam's later records.

INTRODUCTION

Rate of genetic improvement per year depends on accuracy of selection, genetic variation, and generation interval. In addition to accurate evaluation of dairy sires, selection and mating of young bulls before their first evaluation is necessary to increase genetic progress. Estimates of the percentage of theoretical genetic gain expected from matings producing young bulls for artificial insemination (AI) range from 70% (12) to 76% (9) and indicate the importance of pedigree selection of young AI bulls.

Studies (1, 2, 4, 5, 6, 7, 8, 11, 12, 13, 14, 15) have examined which relatives are important in predicting a young sire's merit. Empirical relationships (regressions and correlations) between a son's Predicted Difference (PD) from the Herdmate Comparison (HC) and his sire's or maternal grandsire's (MGS) PD from the HC have been positive for yield of milk but less

Received May 16, 1980.

[1] Scientific Article No. A2760, Contribution No. 5810 of the Maryland Agricultural Experiment Station, Department of Dairy Science.

[2] Work in cooperation with the Animal Science Institute, SEA-AR, USDA, Beltsville Agricultural Research Center.

[3] Department of Animal Science, Iowa State University, Ames 50011.

than expected theoretically (1, 2, 13, 14). Relationships between son's HC PD and female members of the pedigree have been confined generally to son and dam (1, 2, 5, 13, 14, 15), and have been close to expectation. Relationships between a bull and his grandparents have been confined to son and MGS (1, 4).

The change from the HC to the Modified Contemporary Comparison (MCC) in 1974 has appeared to remove many of the biases that plagued the HC (10). The MCC includes information from the pedigree in the forming of similar genetic groups based on the pedigree index (one-half the PD of the sire and one quarter of the MGS's PD). Relationships between son's MCC PD, sire's and MGS's MCC PD, and dam's estimated transmitting ability (ETA) were close to expectation, and prediction of son's merit was more accurate than those using the HC (4, 7, 15). Everett (4) compared son's Northeast AI Sire Comparison (NEAISC) PD with predicted PD's based on sire, dam, and MGS. Partial regressions on dam ETA adjusted for days open were less than expectation (4).

Examination of similar relationships for fat yield and fat percent were less extensive. Relationships for kilogram fat were similar to those for yield of milk whereas for fat percent the son's relationship with his dam was higher than those for kilogram milk or fat (1, 2, 14).

Purposes of this study were to 1) examine relationships between son's PD and son's predicted PD based on estimates of relatives' genetic merit, 2) compare those relationships for different repeatabilities and the yield traits, milk and fat yield and fat percent, and 3) calculate empirical regression equations to predict bull's PD from relatives' records.

MATERIALS AND METHODS

Description of Data and Traits

Data on Holstein bulls and cows were from the Animal Improvement Programs Laboratory, SEA-AR, USDA, Beltsville, MD. Records were obtained from the bull (son), his sire, dam, MGS, paternal grandsire (PGS), maternal

TABLE 1. Prediction of son's first lactation Predicted Difference (PD) for milk from most important relatives' information.

Variables	Minimum 40% son repeatability				Minimum 70% son repeatability			
	1	2	3	4	1	2	3	4
	(r)[a]							
1) Son PD 1st	1.00	.46	.28	.24	1.00	.45	.29	.25
2) Sire PD all		1.00	.14	.26		1.00	.23	.16
3) MGS[b] PD all			1.00	.41			1.00	.45
4) D12 CI[c]				1.00				1.00
Mean[d]	95	275	181	186	75	215	141	172
Standard deviation[d]	243	272	232	153	273	295	232	163
Partial regression		.369	.141	.194		.370	.170	.209
Standard error of partial regression		.014	.018	.026		.022	.032	.044
Intercept[d]	−68.0				−64.3			
R^2	.26				.26			
N	3269				1356			

[a]All correlations significant at $P<.01$.

[b]MGS, maternal grandsire.

[c]D12 CI, cow index based on dam's first two available records.

[d]Kilograms.

TABLE 2. Prediction of son's all lactation Predicted Difference (PD) for milk from most important relatives' information.

Variables	Minimum 40% son repeatability				Minimum 70% son repeatability			
	1	2	3	4	1	2	3	4
	(r)[a]							
1) Son PD all	1.00	.51	.30	.26	1.00	.51	.28	.26
2) Sire PD all		1.00	.23	.15		1.00	.20	.12
3) MGS[b] PD all			1.00	.42			1.00	.41
4) D12 CI[c] (at 40% R)				1.00				
D123 CI[d] (at 70% R)								1.00
Mean[e]	138	273	177	185	126	235	157	213
Standard deviation[e]	249	274	233	154	259	277	225	166
Partial regression		.414	.145	.226		.435	.137	.249
Standard error of partial regression		.013	.017	.026		.018	.024	.032
Intercept[e]	−42.0				−50.9			
R^2	.31				.31			
N	3402				1936			

[a]All correlations significant at $P<.01$.

[b]MGS, maternal grandsire.

[c]D12 CI, cow index based on dam's first two available records.

[d]D123 CI, cow index based on dam's first three available records.

[e]Kilograms.

granddam (MGD), and paternal granddam (PGD). Records on male individuals in the pedigree included PD and modified contemporary deviation (MCD) for yield of milk and fat and fat percent. Records for female members included MCD and Cow Index (CI) and yield of milk and fat and fat percent. Each son had a PD based on daughters' first lactations (PD 1st), and on all daughters' records (PD all). The PD and MCD on sire, MGS, and PGS were based on all daughters' records. The CI and MCD on MGD and PGD included only first available records. Records on the dam included CI and MCD on first available record (D1), first plus second available records (D12), and the first three available records (D123). All records on males were from their most recent MCC for that animal. Proofs from MCC were used for all CI. Each son was required to have been sampled initially in AI and to have a minimum repeatability (R) of 40% for all daughters' records (PD all). There were 4495 bulls (sons) that met this requirement, and 1340 of those sons had records on all of the six pedigree members. There were 1287 sons that met the criterion of minimum 40% R and PD 1st and with records on all six relatives. No minimum R was required for sire or MGS. Records also were subdivided into a minimum 70% R for PD 1st and PD all.

Statistical Methods

Prediction equations for son's PD or MCD were developed from only those records of sons that had records on all of their six immediate ancestors. Equations were developed by stepwise regression techniques (3). Variables significant at $P<.5$ were allowed to enter, and variables could be removed at later stages. Imposed over this selection criterion was the stopping rule of accepting the last model prior to a change in

TABLE 3. Prediction of son's first lactation Predicted Difference (PD) for fat from most important relatives' information.

Variables	Minimum 40% son repeatability				Minimum 70% son repeatability				
	1	2	3	4	1	2	3	4	5
	(r)[a]								
1) Son PD 1st	1.00	.41	.22	.15	1.00	.40	.23	.17	.10
2) Sire PD all		1.00	.13	.03		1.00	.13	.01	.07
3) MGS[b] PD all			1.00	.39			1.00	.40	.79
4) D1 CI[c] (min. 40% R)				1.00					
D123 CI[d] (min. 70% R)								1.00	.45
5) MGS MCD[e] (min. 70% R only)									1.00
Mean[f]	1.83	8.29	5.64	4.50	2.09	7.42	4.86	8.40	6.15
Standard deviation[f]	8.01	10.00	8.55	4.66	8.75	9.93	8.17	6.52	11.62
Partial regression		.312	.127	.156		.329	.330	.199	−.181
Standard error of partial regression		.012	.016	.028		.022	.044	.038	.031
Intercept[f]	−2.17				−2.51				
R^2	.20				.22				
N	3440				1261				

[a]Correlations > .06, significant at $P<.05$, correlations < .08, significant at $P<.01$.

[b]MGS, maternal grandsire.

[c]D1 CI, cow index based on dam's first available record.

[d]D123 CI, cow index based on dam's first three available records.

[e]MGS MCD, maternal grandsire's modified contemporary deviation.

[f]Kilograms.

the multiple correlation coefficient squared (R^2) of less than 1% for the next model. Variables were removed at any time if they no longer were significant at $P<.5$. All regression coefficients were significant ($P<.05$).

Regression coefficients then were calculated for only those variables important for predicting son's PD in an expanded data set that included sons with the necessary information on ancestors for selected models. Two-variable models also were calculated with only sire's PD and dam's CI and sire's PD and MGS's PD. Estimates of expected correlations and regressions for comparison with results were calculated by (4, 15).

RESULTS AND DISCUSSION

Selected Models

Variables selected by the stepwise regression procedure for predicting son's PD 1st and PD all for yield of milk and fat and percent fat are in Tables 1 through 6. For yield of milk and fat at each repeatability, the chosen model included the sire's and MGS's PD and dam's CI, based on first two or first three available records. For fat yield, MGS's MCD was also important. Models to predict fat percent included sire's PD or MCD and dam's CI based on first two or first three available records. Information from the PGD, PGS, MGD was of little help in predicting sons' PD.

Means and standard deviations, correlations between the dependent and independent variables, and regression coefficients and their standard errors for the models selected (expanded data set), are in Tables 1 to 6. The mean PD of sons was the lowest, and mean PD for sire was the highest, suggesting greatest pedigree selection emphasis on sires of sons.

TABLE 4. Prediction of son's all lactation Predicted Difference (PD) for fat from most important relatives' information.

	Minimum 40% son repeatability				Minimum 70% son repeatability				
Variables	1	2	3	4	1	2	3	4	5
	(r)[a]								
1) Son PD all	1.00	.44	.24	.18	1.00	.46	.21	.18	.11
2) Sire PD all		1.00	.12	.04		1.00	.11	.01	.08
3) MGS[b] PD all			1.00	.38			1.00	.38	.82
4) D12 CI[c] (min. 40% R)				1.00					
D123 CI[d] (min. 70% R)								1.00	.41
5) MGS MCD[e] (min. 70% R only)									1.00
Mean[f]	2.69	8.45	5.65	6.75	2.61	7.43	5.19	8.21	6.27
Standard deviation[f]	8.23	9.96	8.54	5.64	8.55	9.59	9.04	6.22	10.89
Partial regression		.346	.140	.159		.431	.295	.247	−.172
Standard error of partial regression		.012	.016	.024		.021	.043	.035	.032
Intercept[f]	−2.10				−3.09				
R^2	.24				.23				
N	3402				1936				

[a]Correlations > .06, significant at $P<.05$, correlations > .08, significant at $P<.01$.

[b]MGS, maternal grandsire.

[c]D12 CI, cow index based on dam's first two available records.

[d]D123 CI, cow index based on dam's first three available records.

[e]MGS MCD, maternal grandsire's modified contemporary deviation.

[f]Kilograms.

Standard deviations for son's PD were slightly less than sire's PD but generally slightly more than MGS's PD. Dam's CI standard deviation was smallest. Average R for minimum 40% R and minimum 70% R was 70 and 84%, respectively.

Correlations of son's PD with sire's PD and MGS's PD ranged from .40 to .51 and .22 to .30; at 70% R, they were nearly the same as those at 40% R. This result suggests that the part-whole relationship from pedigree information in the calculation of son's PD is not important, since it would be expected to contribute more heavily for bulls at minimum 40% R. Correlations between son's PD 1st and information of all relatives were lower than son's PD all and all relatives' information, suggesting that first records may be influenced by genes different from later lactations. Everett (4) assumed an R of .65 for the son and .98 for sire, and MGS and expected correlations between son's PD and the sire's and MGS's PD and dam's CI were .42, .21, and .50, respectively. Correlations of sire's PD with MGS's PD and dam's CI were predicted to be 0, and the correlation between dam's CI and MGS's PD was predicted to be .58 (4). Though average R for sire and MGS were smaller in this study, observed correlations between son's PD and sire's PD were higher for milk and nearly the same for fat and fat percent. Correlations between dam's CI and son's PD were lower than expectation for all three traits though highest for fat percent. For milk and fat, the correlation between son and MGS was higher than expected. Correlations between son and

TABLE 5. Prediction of son's first lactation Predicted Difference (PD) for fat percent from most important relatives' information.

Variables	Minimum 40% son repeatability 1	2	3	Minimum 70% son repeatability 1	2	3
	(r)[a]					
1) Son PD 1st	1.00	.40	.32	1.00	.44	.35
2) Sire MCD all[b] (min. 40% R only)		1.00	−.01			
Sire PD all (min. 70% R only)					1.00	.02
3) D123 CI[c] (min. 40% R only)			1.00			
D12 CI[d] (min. 70% R only)						1.00
Mean	−.017	−.017	.006	−.007	−.005	.016
Standard deviation	.090	.103	.061	.109	.104	.058
Partial regression		.356	.481		.454	.631
Standard error of partial regression		.013	.022		.024	.042
Intercept	−.014			−.015		
R^2	.30			.31		
N	3100			1356		

[a]Correlations > .06 significant at $P<.05$, correlations > .08 significant at $P<.01$.

[b]Sire MCD all, sire modified contemporary deviation.

[c]D123 CI, cow index based on dam's first three available records.

[d]D12 CI, cow index based on dam's first two available records.

TABLE 6. Prediction of son's all lactation Predicted Difference (PD) for fat percent from most important relatives' information.

Variables	Minimum 40% son repeatability 1	2	3	Minimum 70% son repeatability 1	2	3
	(r)[a]					
1) Son PD all	1.00	.42	.34	1.00	.45	.34
2) Sire MCD[b]		1.00	−.01		1.00	−.02
3) D123 CI[c]			1.00			1.00
Mean[d]	−.030	−.017	.006	−.024	−.011	.012
Standard deviation[d]	.096	.103	.061	.120	.104	.061
Partial regression		.393	.532		.457	.600
Standard error of partial regression		.014	.022		.019	.032
Intercept	−.027			−.026		
R^2	.30			.32		
N	3224			1957		

[a]Correlations >.08 significant at $P<.01$.

[b]Sire's MCD, sire's modified contemporary deviation.

[c]D123 CI, cow index based on dam's first three available records.

[d]Kilograms.

dam and son and MGS for milk and fat suggest assortative mating. It appears, however, no such mating takes place for fat percent. For fat percent MGS did not play a role directly in the prediction equations; however, MGS is used to calculate dam's CI. The partial regressions of son's PD on relatives' information are also in Tables 1 to 6. The R^2 ranged from .26 to .31 for milk, .20 to .24 for fat, and .30 to .32 for fat percent. If the breeding value of the son and his sire and dam were known and with no selection, R^2 would be expected to be .50, and the correlation between a son's and his parents' breeding values would be .5. Everett (4) found R^2 of .30 to .32 for milk for models with sire's MCC PD and estimated transmitting ability (ETA) for the dam adjusted for days open. Regression coefficients were also similar to those of (4) with the exception of the dam's days open, adjusted ETA, having a smaller regression coefficient (4) than the coefficient for dam's CI in this study. Everett also used NEAISC PD in prediction equations, and produced slightly higher R^2 in predicting son's NEAISC PD.

Two-Variable Models

Regression coefficients of two-variable models for sire's PD and dam's CI are in Tables 7, 8, and 9. Though data sets slightly different from those in the previous tables were used, R^2 were generally 1 or 2% lower than for 3 or 4 variable models. With the exception of fat percent, D1 CI was marginally more important than D12 or D123 for predicting son's PD 1st. Correlations between D1, D12, D123 were all greater than .70, with most near .85. For fat percent when D123 CI was included, the R^2 was always the highest relative to models with D1 CI or D12

TABLE 7. Regression coefficients and standard errors for estimating son's first and all lactation Predicted Difference (PD) for milk from sire and dam information only.

Variables	PD 1st				PD all			
	b	SE	R^2 [a]	N	b	SE	R^2	N
Minimum 40% son repeatability								
Sire[b]	.401	.013	.251	3440	.448	.013	.300	3587
D1[c]	.311	.028			.330	.027		
Intercept[d]	−56.02				−25.53			
Sire	.389	.014	.243	3269	.435	.013	.290	3402
D12[e]	.278	.024			.313	.024		
Intercept	−63.55				−38.01			
Sire	.390	.014	.237	3100	.436	.014	.290	3224
D123[f]	.264	.024			.302	.023		
Intercept	−68.79				−44.86			
Minimum 70% son repeatability								
Sire	.441	.021	.244	1462	.470	.017	.303	2223
D1	.331	.046			.333	.036		
Intercept	−54.07				−31.71			
Sire	.392	.022	.240	1356	.454	.017	.302	2088
D12	.312	.040			.324	.031		
Intercept	−62.86				−41.55			
Sire	.392	.023	.236	1261	.457	.018	.304	1957
D123	.302	.038			.325	.030		
Intercept	−68.95				−51.30			

[a] R^2, multiple correlation coefficient squared.

[b] Sire, PD all.

[c] D1, dam's cow index on first available records.

[d] Kilograms.

[e] D12, dam's cow index on first and second available records.

[f] D123, dam's cow index on first three available records.

TABLE 8. Regression coefficients and standard errors for estimating son's first and all lactation Predicted Difference (PD) for fat from sire and dam information only.

	PD 1st				PD all			
Variables	b	SE	R^2 [a]	N	b	SE	R^2	N
Minimum 40% son repeatability								
Sire[b]	.325	.012	.188	3440	.363	.012	.222	3587
D1[c]	.246	.024			.257	.026		
Intercept[d]	−1.96				−1.60			
Sire	.320	.013	.182	3269	.358	.013	.220	3402
D12[e]	.210	.022			.239	.022		
Intercept	−1.80				−1.95			
Sire	.316	.013	.179	3100	.356	.013	.218	3224
D123[f]	.213	.021			.242	.021		
Intercept	−2.39				−2.21			
Minimum 70% son repeatability								
Sire	.361	.21	.189	1462	.415	.016	.238	2223
D1	.211	.041			.238	.034		
Intercept	−1.80				−1.73			
Sire	.355	.022	.186	1356	.408	.017	.238	2088
D12	.191	.036			.218	.029		
Intercept	−2.01				−2.01			
Sire	.349	.022	.185	1261	.410	.018	.241	1957
D123	.221	.034			.240	.027		
Intercept	−2.35				−2.42			

[a] R^2, multiple correlation coefficient squared.

[b] Sire, PD all.

[c] D1, dam's cow index on first available records.

[d] Kilograms.

[e] D12, dam's cow index on first and second available records.

[f] D123, dam's cow index on first three available records.

CI. The ratio of regression coefficients for sire to dam were approximately 4:3 for milk, 3:2 for fat, and 4:6 to 5:7 for fat percent. More selection emphasis on the dam would be useful for fat percent since MGS information is less important and dam's relationship with her son is high. Results were similar (1) with reference to D123 CI and MGS PD with son's PD for fat percent.

Regression coefficients for sires and MGS models are in Table 10. The R^2 were higher for sire and MGS models for milk and fat than for sire and dam models but lower for fat percent. The additional information from the dam is useful but limited for milk and fat. This is because the dam's CI includes the MGS PD. Ratios of sire to MGS were generally slightly less than the 2:1 for milk and fat, and more than the 2:1 ratio for fat percent, suggesting the greater usefulness of MGS for milk and fat.

The largest R^2 were for fat percent, while the smallest were for fat yield. These results are consistent with heritabilities for yield of fat and milk and fat percent. Since fat percent has the highest heritability (approximately .45), individual selection is more useful and the influence of the dam is more important despite her few records.

Prediction of Son's MCD

Similar work was completed with predicting son's MCD. Results were the same for relatives chosen by the stepwise procedure. This was not surprising, since average R for minimum 40% and 70% R were .70 and .84. However, R^2 were slightly lower. This may be in part from the small part-whole relationship between son's PD and sire and MGS PD when R is less than unity. Prediction equations for son's MCD are not

TABLE 9. Regression coefficients and standard errors for estimating son's first and all lactation Predicted Difference (PD) for fat percent from sire and dam information only.

	PD 1st				PD all			
Variables	b	SE	$R^{2\,a}$	N	b	SE	R^2	N
Minimum 40% son repeatability								
Sire[b]	.359	.013	.244	3440	.399	.014	.270	3587
DI[c]	.586	.030			.651	.030		
Intercept	−.011				−.025			
Sire	.354	.014	.253	3269	.393	.014	.281	3402
D12[d]	.506	.024			.566	.025		
Intercept	−.014				−.027			
Sire	.364	.014	.267	3100	.401	.014	.293	3224
D123[e]	.484	.023			.535	.023		
Intercept	−.014				−.027			
Minimum 70% son repeatability								
Sire	.462	.023	.288	1462	.462	.019	.230	2223
D1	.694	.050			.696	.040		
Intercept	−.013				−.023			
Sire	.454	.024	.310	1356	.457	.019	.307	2088
D12	.631	.042			.627	.034		
Intercept	−.015				−.025			
Sire	.473	.025	.327	1261	.470	.019	.324	1957
D123	.610	.040			.603	.032		
Intercept	−.015				−.026			

[a]R^2, multiple correlation coefficient squared.

[b]Sire, PD all.

[c]D1, dam's cow index on first available records.

[d]D12, dam's cow index on first and second available records.

[e]D123, dam's cow index on first three available records.

presented since bull studs and dairymen routinely use PD, and early prediction of a bull's PD would be more useful than prediction of his MCD.

CONCLUSIONS

Son's PD 1st and PD all for yield of milk and fat and fat percent were estimated from pedigree information, which included PD and MCD for sire, MGS, PGS and CI for D1, D12, D123 and MGD and PGD. For milk and fat, sire's and MGS's PD and dam's CI were most important whereas for fat percent sire's MCD or PD and dam's CI were most important. The addition of dam's CI after MGS's PD for milk and fat, while significant, was not large, since MGS's PD is used to estimate dam's CI. Correlations between son and sire were from .40 to .51 and were close to expectation. Correlation between son's PD and dam's CI was less than expectation, but largest for fat percent.

Prediction equations were developed and R^2 were .24 to .34, and were consistent with (1, 4, 14, 15). These equations could be useful in predicting son's merit prior to use in AI from pedigree information. Added emphasis on MGS for milk and fat and D123 CI for fat percent would aid in selection of better future sons for AI.

ACKNOWLEDGMENTS

The authors wish to thank F. N. Dickinson and W. E. Shainline, Jr., of the Animal Improvement Programs Laboratory, SEA-AR, USDA, Beltsville Agricultural Research Center, Beltsville, MD, for their help in providing the data and Sire Power, Inc., Frederick, MD for their financial assistance.

TABLE 10. Regression coefficients and standard errors for estimating son's first and all lactation Predicted Difference (PD) from sire and maternal grandsire (MGS) information only.

		PD 1st				PD all			
Traits	Variables	b	SE	R^2 [a]	N	b	SE	R^2	N
Milk –									
Minimum 40% son repeatability	Sire[b]	.376	.013	.258	3702	.427	.012	.315	3800
	MGS[b]	.194	.015			.208	.015		
	Intercept[c]	−45.90				−19.80			
Minimum 70% son repeatability	Sire	.373	.025	.250	1623	.455	.016	.316	2438
	MGS	.239	.026			.226	.019		
	Intercept	−42.80				−22.74			
Fat –									
Minimum 40% son repeatability	Sire	.310	.012	.195	3702	.350	.012	.240	3800
	MGS	.161	.014			.180	.014		
	Intercept	−1.67				−1.40			
Minimum 70% son repeatability	Sire	.332	.020	.194	1623	.395	.016	.250	2438
	MGS	.187	.024			.181	.019		
	Intercept	−1.54				−1.49			
Fat percent –									
Minimum 40% son repeatability	Sire	.363	.013	.180	3702	.409	.014	.204	3880
	MGS	.161	.015			.191	.015		
	Intercept	−.004				−.020			
Minimum 70% son repeatability	Sire	.458	.023	.215	1623	.516	.021	.211	2438
	MGS	.194	.026			.226	.024		
	Intercept	−.004				-.015			

[a] R^2, multiple correlation coefficient squared.

[b] PD all for sire and maternal grandsire.

[c] Kilograms.

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