Comparison of Ten Friesian Strains in Poland for Yield Traits from First Three Parities[1]

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ABSTRACT

Milk yield, fat yield, and fat percentage for the first three parities were compared for crosses of Friesian strains from Canada, Denmark, Israel, The Netherlands, New Zealand, Sweden, the United Kingdom, the US, and West Germany with Polish black-and-white cattle. Mixed model multitrait BLUP solutions for milk yield ranked Holstein strains (US, Canada, and Israel) and New Zealand Friesians higher than European Friesian strains for all three parities. Largest difference for milk yield between highest ranking US strain and lowest ranking Polish strain was 1002 kg for first lactation. Rankings for fat yield were similar to those for milk yield. For all three parities, the New Zealand strain ranked highest for fat percentage and the US strain lowest. Although rankings were consistent across parities for all yield traits, differences between Holstein and Friesian strains decreased as parity increased. Holstein strains maintained their superiority for milk and fat yields for all three parities despite difficult environmental conditions and a feeding regimen worse than in their country of origin.
(Key words: yield, Friesian, Poland)

Abbreviation key: FAO = Food and Agriculture Organization, HYS = herd-year-season, UK = United Kingdom.

INTRODUCTION

Large-scale importation of North American Holstein-Friesians to Europe began in the early 1970s. First reports, particularly from West Germany and The Netherlands, indicated these Holsteins to be superior to European Friesians in dairy performance (9). The growing exchange of semen among dairy populations prompted the United Nations Food and Agriculture Organization (FAO) to begin an international comparison of several Friesian strains (7). The project was designed to compare genetic merit of the progeny of bulls from 10 Friesian strains for growth traits and first lactation milk production on Polish state commercial farms. Only first lactation records were used for ranking of strains in the FAO-coordinated research analysis.

After first lactation, surviving daughters continued to produce in Poland, usually in the same herds. The purpose of this study was to compare the Friesian strains for yield traits based on the first three parities of daughters from the FAO trial.

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MATERIALS AND METHODS

Design of the FAO trial and experimental procedures were described in detail by Stolzman et al. (7, 8). Semen from 388 young, unproven bulls from 10 cooperating countries [Canada, Denmark, Israel, The Netherlands, New Zealand, Poland, Sweden, United Kingdom (UK), US, and West Germany] was used to inseminate 33,699 Polish black-and-white mature cows on 70 state dairy farms. Bulls were born from 1970 to 1973. Although most bulls were representative of average breeding value in their country of origin, Israeli bulls were slightly below and Canadian bulls slightly above average (3). Inseminations started in March 1974 and were completed by the end of 1976. Data for resulting daughters were identified by strain according to origin of sire. For the FAO trial, 305-d lactation records for these daughters were calculated directly from farm files with results of monthly milk samplings. However, for this study, 305-d records from the state dairy recording system were used, which resulted in first lactation records from 7892 cows. Lactation minimums of 200 d in milk and 1800 kg of milk were imposed and resulted in loss of 680 records because of short lactation length and 216 records because of low yield. After formal edits and requirement of at least five daughters per bull and two records per herd-year-season (HYS) of calving for first lactation, 15,099 lactation records (6597 first, 4902 second, and 3600 third lactations) of 6597 cows sired by 365 bulls were available for analysis. Number of first lactation records available for analysis was greater than the 6504 records reported by Jasiorowski et al. (3) for the FAO trial because of the extended time period for completion of first lactation records and the use of state rather than farm records. Calving seasons were April through September and October through March. Number of HYS subclasses were 348 for first, 377 for second, and 375 for third lactations.

A single-trait fixed model was used to estimate linear regression within strains on age at calving. The model applied to each yield trait within parity was

$$\mathbf{y} = \mathbf{X}\mathbf{b} + \mathbf{X}_a\mathbf{b}_a + \mathbf{e}$$

where $\mathbf{y}$ is the vector of observations for a single yield trait (milk yield, fat yield, or fat percentage) in a given parity, $\mathbf{b}$ is the vector of strain and HYS effects, $\mathbf{b}_a$ is the vector of within-strain linear regression coefficients on age at calving, $\mathbf{X}$ is an appropriate incidence matrix, $\mathbf{X}_a$ is an animal × strain matrix of ages, and $\mathbf{e}$ is the residual effects with variance of $\mathbf{I}\sigma_e^2$ where $\mathbf{I}$ is an identity matrix.

Usually some culling of cows occurs based on yield in previous parities; therefore, multitrait BLUP was applied to minimize bias due to selection (2). Multitrait estimates of strain effects in first, second, and third lactation were calculated using the following mixed model:

$$\mathbf{y}_i = \mathbf{X}_i\mathbf{b}_i + \mathbf{Z}_i\mathbf{s}_i + \mathbf{e}_i$$

where $\mathbf{y}_i$ is the vector of observations for a single trait (milk yield, fat yield, or fat percentage) for parity i corrected for age at calving using estimated regression coefficients from the within-parity model, $\mathbf{b}_i$ is the vector of fixed strain and HYS effects, $\mathbf{s}_i$ is the vector of random sire within-strain effects, $\mathbf{X}_i$ and $\mathbf{Z}_i$ represent incidence matrices, and $\mathbf{e}_i$ is the residual vector. Although age correction factors may have been biased because they were estimated within parity without accounting for selection, simultaneous estimation in the multitrait analysis was not done because of the complexity of constructing the equations. Expectations and variance or covariance structure for random effects in the model were

$$E\begin{bmatrix}\mathbf{b}_i\\ \mathbf{s}_i\\ \mathbf{e}_i\end{bmatrix} = \begin{bmatrix}\mathbf{b}_i\\ 0\\ 0\end{bmatrix}$$

$$\mathrm{Var}\begin{bmatrix}\mathbf{s}_1\\ \mathbf{s}_2\\ \mathbf{s}_3\end{bmatrix} = \begin{bmatrix}\mathbf{I}\sigma_1^2 & \mathbf{I}\sigma_{12} & \mathbf{I}\sigma_{13}\\ & \mathbf{I}\sigma_2^2 & \mathbf{I}\sigma_{23}\\ \text{Symmetric} & & \mathbf{I}\sigma_3^2\end{bmatrix}$$

$$\mathrm{Var}\begin{bmatrix}\mathbf{e}_1\\ \mathbf{e}_2\\ \mathbf{e}_3\end{bmatrix} = \begin{bmatrix}\mathbf{I}_{11}\sigma_{e_1}^2 & \mathbf{I}_{12}\sigma_{e_{12}} & \mathbf{I}_{13}\sigma_{e_{13}}\\ & \mathbf{I}_{22}\sigma_{e_2}^2 & \mathbf{I}_{23}\sigma_{e_{23}}\\ \text{Symmetric} & & \mathbf{I}_{33}\sigma_{e_3}^2\end{bmatrix}.$$

Parameters assumed for each trait for each parity are in Table 1. Variance and covariance

TABLE 1. Parameters assumed for dairy traits by parity (heritabilities on diagonals, genetic correlations above diagonals, and phenotypic correlations below diagonals).

		Parity		
Trait	Parity	1	2	3
Milk and fat yields	1	.250	.900	.850
	2	.500	.225	.950
	3	.500	.500	.200
Fat percentage	1	.400	.900	.900
	2	.500	.400	.900
	3	.500	.500	.400

components for sire and error effects were based on estimates for Polish black-and-white cattle (10); phenotypic variances and covariances were estimated from the data. Solutions for strains were forced to sum to 0 within each parity. Although sires of different strains were found to be related in the FAO trial (3, 8), the FAO Technical Advisory Committee recommended not including the relationship matrix in the model because it could lead to confounding of strain differences, thus distorting interpretation of results. Therefore, sires (strains) were assumed to be unrelated in this study. If a trait was missing for parity i ($i \leq 3$), traits were present for parities 1 to $i - 1$ and missing for parities $\geq i$.

A Cholesky decomposition of the residual covariance matrix (6) was used to simplify constructing the mixed model equations. Solutions for fixed and random effects on the original scale were derived by multiplying by the inverse of the Cholesky decomposition matrix times the solutions based on the transformed scale. Significance of differences among strains for each trait within parity were tested by the following approximate *F* test:

$$F = [(\mathbf{H}'\mathbf{b}^0)' (\mathbf{H}'\mathbf{M}\mathbf{H})^{-1}\mathbf{H}'\mathbf{b}^0]/\hat{\sigma}_e^2$$

where $\mathbf{H}$ is the known matrix defining the hypotheses tested, $\mathbf{b}^0$ is the vector of mixed model solutions of the strain effects, $\mathbf{M}$ is the part of the inverse of the mixed model equations pertaining to the strain effect, and $\hat{\sigma}_e^2$ is the estimated residual variance.

RESULTS AND DISCUSSION

Means and SD for age at calving and yield traits are in Table 2 for the 10 Friesian strains by parity. Because first lactation data used in this study were primarily the same as those for the FAO trial, means were similar to those reported by Jasiorowski et al. (3). For each parity, no appreciable differences in mean calving age were found among countries. Mean milk and fat yields for second lactation were slightly larger than for first lactation except for milk yield of the UK strain. Increases in means for milk and fat yields from second to third lactation were somewhat larger than those from first to second lactation except for Netherlands milk and fat means and US fat means, which decreased slightly. Increases of 600 to 700 kg of milk from first to second lactation and 500 to 600 kg from second to third lactation have been found in high producing populations (4, 5). The small increases in yield in successive parities found for the 10 Friesian strains in Poland almost certainly were due to an adverse Polish environment. Feeding and climatic conditions in Poland deteriorated between first and later parities because of the economic crisis and extremely severe winters.

Fat percentage generally increased slightly from first to second and from second to third lactation (Table 2). For the Swedish strain, fat percentage increased slightly in second lactation but then decreased. No change in fat percentage was found for the Danish strain in later lactations or for the Polish strain in third lactation.

Strain solutions of mixed model equations with appropriate SE are in Table 3. Although strain effects are not estimable under the model assumed, mixed model solutions for strain effects can be used to rank strains within parity. Differences among strain solutions estimate strain differences within parity. Differences among strains within parity were significant ($P < .01$) for all traits with the lowest calculated F value equal to 130 for milk yield in first lactation.

The US, Canadian, and Israeli Holstein strains ranked highest for first lactation milk yield followed by the New Zealand Friesian strain. These strains were followed by European Friesians. The difference between the US and Polish strains for first lactation milk yield was 1002 kg. Rankings for first lactation fat yield were similar except that the New Zealand strain ranked second behind the US while West Germany and Denmark switched orders. Difference between US and Polish strains for first lactation fat yield was 32.9 kg. Fat percentage for Holstein strains was lower than for Friesian strains. The New Zealand Friesian strain ranked highest for first lactation fat percentage followed by the European Friesians. The Canadian, Israeli, and US Holstein strains had the lowest rankings with a difference of .21% between the New Zealand and US strains.

Ranking of the 10 strains for second lactation milk yield was almost identical to that for first lactation. Difference between US and Polish strains was 905 kg, slightly less than for first lactation. Rankings for second lactation fat yield also were the same as for first lactation except that the New Zealand and Canadian strains reversed positions. Difference between US and Polish strains was 31.2 kg, again slightly less than for first lactation. New Zealand and The Netherlands ranked highest, and Canada, Israel, and the US lowest for

TABLE 2. Means and SD for age at calving and yield traits for 10 Friesian strains in Poland by parity.

Strain[1]	Parity	Number of records	Age at calving		Milk yield		Fat yield		Fat percentage	
			— (mo) —		— (kg) —					
			$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD
Canada	1	632	28.8	3.5	3821	876	148.9	36.5	3.90	.35
	2	519	41.9	4.3	3823	997	150.8	45.1	3.93	.35
	3	396	54.5	4.9	4007	1081	159.2	47.3	3.96	.35
Denmark	1	604	29.1	3.5	3556	810	141.0	35.2	3.96	.33
	2	420	42.2	4.5	3591	879	142.0	40.2	3.96	.32
	3	290	55.0	5.4	3716	1018	146.6	42.6	3.96	.38
Israel	1	649	29.0	3.6	3882	902	151.5	37.7	3.90	.36
	2	498	42.3	4.6	3909	1145	153.0	46.4	3.92	.35
	3	383	54.8	5.3	4052	1218	159.6	49.5	3.94	.35
The Netherlands	1	567	29.2	3.5	3461	746	139.0	44.2	3.98	.32
	2	398	42.0	4.3	3607	923	144.3	39.0	4.00	.36
	3	272	54.8	5.4	3681	949	148.5	41.1	4.02	.36
New Zealand	1	682	29.2	3.5	3705	856	149.6	36.8	4.04	.37
	2	518	42.5	4.5	3708	946	149.8	40.9	4.05	.38
	3	394	55.4	5.4	3870	1064	158.7	47.4	4.09	.43
Poland	1	1020	29.8	3.7	3464	765	137.4	32.8	3.96	.31
	2	711	42.7	4.4	3529	889	139.6	38.0	3.96	.34
	3	477	55.2	5.1	3753	961	149.6	42.2	3.98	.36
Sweden	1	646	29.4	3.7	3610	817	142.7	35.5	3.95	.33
	2	489	42.1	4.2	3640	949	144.0	39.1	3.96	.31
	3	362	54.8	5.2	3910	1007	154.6	43.6	3.95	.37
United Kingdom	1	622	29.2	3.3	3586	829	140.3	33.5	3.93	.37
	2	464	42.3	4.3	3581	928	141.6	38.4	3.96	.31
	3	343	54.6	5.2	3703	940	147.1	39.1	3.97	.33
US	1	543	29.0	3.4	3955	945	152.6	39.6	3.86	.39
	2	433	42.4	4.4	4011	1151	156.6	48.1	3.89	.34
	3	342	55.4	5.2	4104	1167	160.3	48.7	3.90	.39
West Germany	1	632	28.8	3.3	3523	828	138.0	33.7	3.92	.32
	2	452	41.7	4.0	3596	908	141.5	37.7	3.94	.34
	3	341	54.5	4.9	3778	1034	149.9	43.7	3.96	.37

[1]Based on sire's country of origin.

TABLE 3. Mixed model solutions[1] and SE for yield traits for 10 Friesian strains in Poland by parity.

Strain[2]	Parity	Milk yield Solution	Milk yield SE	Fat yield Solution	Fat yield SE	Fat percentage Solution	Fat percentage SE
		(kg)					
Canada	1	386	47	12.1	2.1	–.06	.03
	2	314	47	10.7	2.0	–.06	.03
	3	358	54	12.1	2.3	–.05	.03
Denmark	1	–202	47	–7.0	2.0	.00	.03
	2	–168	48	–5.9	2.0	.02	.03
	3	–235	57	–11.6	2.4	–.03	.03
Israel	1	346	47	10.6	2.0	–.08	.03
	2	260	47	7.5	2.0	–.06	.03
	3	294	54	9.3	2.3	–.04	.03
The Netherlands	1	–345	46	–8.5	2.0	.09	.03
	2	–260	48	–7.8	2.0	.04	.03
	3	–390	57	–10.0	2.4	.09	.03
New Zealand	1	215	45	13.5	2.0	.12	.03
	2	131	46	10.2	1.9	.14	.03
	3	90	53	9.6	2.2	.16	.03
Poland	1	–481	44	–16.9	1.9	.04	.03
	2	–405	45	–15.0	1.9	.02	.03
	3	–385	52	–13.0	2.2	.03	.03
Sweden	1	–103	46	–4.9	2.0	–.02	.03
	2	–118	47	–3.5	2.0	.02	.03
	3	–2	54	–.4	2.2	.00	.03
United Kingdom	1	–151	46	–7.0	2.0	.02	.03
	2	–106	47	–5.4	2.0	.00	.03
	3	–151	54	–7.3	2.3	–.02	.03
US	1	521	48	16.0	2.1	–.09	.03
	2	500	49	16.2	2.1	–.10	.03
	3	462	56	14.0	2.3	–.10	.03
West Germany	1	–186	46	–8.1	2.0	–.03	.03
	2	–149	47	–7.0	2.0	–.03	.03
	3	–41	55	–2.7	2.3	–.03	.03

[1]Sum to zero within parity.

[2]Based on sire's country of origin.

second lactation fat percentage, the same ranking as for first lactation. The difference between New Zealand and US strains for second lactation fat percentage was .24%.

Rankings for third lactation milk yield were similar to those for other parities, but rankings among European Friesian strains changed slightly. Differences between Holsteins and European strains continued to decrease; difference between US and The Netherlands strain for third lactation milk yield was 852 kg. Rankings for third lactation fat yield also were similar to those for other parities. Difference between US and Polish strains for third lactation fat yield was 27 kg. Rankings for fat percentage were similar to those for other parities. Difference between New Zealand and US strains continued to increase and was .26% for third lactation fat percentage.

Rankings of strains for first lactation yield traits from the multitrait model were the same as found for the FAO trial, but strain differences (measured by differences among mixed model solutions within parity) were larger than results of Jasiorowski et al. (3). The difference between US and Polish strains in the FAO trial was 622 kg for milk yield, 21.7 kg for fat yield, and .09% for fat percentage as compared with 1002 kg milk, 32.9 kg fat, and .13% fat in this study. Other strain differences between single-trait and multitrait solutions for first lactation production were smaller, but estimates from multitrait analysis were higher for all traits and strains. The larger differences are related at least partly to differences in higher culling intensities after first and second lactations. Between first and third lactations, 53% of Polish and 52% of Netherlands crosses were culled; only 37% of Canadian and US daughters were culled. Consequently, differences between Polish or Netherlands and US strains were much larger in the multitrait than in the single-trait analysis. Differences between US and Canadian strains were of similar magnitude in both analyses. Larger differences among extreme strains may have resulted from biases in age correction factors and in the genetic parameters assumed.

An Israeli study (1) prompted by results of the FAO trial evaluated the five Friesian strains ranked highest in Poland. However, semen from some of the top proven bulls was used rather than semen from young, unproven sires as in Poland. In addition, the Israeli trial was conducted in herds with average milk yield exceeding 8000 kg. Based on first lactation milk yield, ranking of strains was Israel, US, and Canada followed by Sweden. Although the New Zealand strain ranked lowest for milk yield in this Israeli trial (difference of 1551 kg from Israeli strain), it ranked highest for fat percentage.

Spearman's rank correlation coefficients calculated for ranking based on milk yield were .988 between first and second lactations, .976 between first and third, and .952 between second and third ($P < .01$). Correlations for ranking based on fat yield were .985 between first and second lactation, .918 between first and third, and .939 between second and third ($P < .01$). Correlations for fat percentage were lower but significant ($P < .01$): .888 between first and second lactation, .927 between first and third, and .900 between second and third.

Rankings of strains for yield traits based on each of the first three parities were similar as shown by the magnitudes of Spearman's correlation coefficients. Despite low production levels and difficult environmental conditions, the top strains maintained their superiority for all three parities.

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REFERENCES

1 Bar-Anan, R., M. Heiman, M. Ron, and J. I. Weller. 1987. Comparison of proven sires from five Holstein-Friesian strains in high-yield Israeli dairy herds. Livest. Prod. Sci. 17:305.

2 Henderson, C. R. 1976. Multiple trait sire evaluation using the relationship matrix. J. Dairy Sci. 59:769.

3 Jasiorowski, H. A., M. Stolzman, and Z. Reklewski. 1988. The international Friesian strain comparison trial. A world perspective. Food Agric. Org., United Nations, Rome, Italy.

4 Meyer, K. 1984. Estimates of genetic parameters for milk and fat yield for the first three lactations in British Friesian cows. Anim. Prod. 38:313.

5 Norman, H. D., P. D. Miller, B. T. McDaniel, F. N. Dickinson, and C. R. Henderson. 1974. USDA-DHIA factors for standardizing 305-day lactation records for age and month of calving. USDA, ARS-NE-40, Washington, DC.

6 Schaeffer, L. R. 1986. Estimation of variances and covariances within the allowable parameter space. J. Dairy Sci. 69:187.

7 Stolzman, M., H. Jasiorowski, Z. Reklewski, A. Zarnecki, and G. Kalinowska. 1981. Friesian cattle in Poland—preliminary results of testing different strains. World Anim. Rev. 38:9.

8 Stolzman, M., H. Jasiorowski, Z. Reklewski, A. Zarnecki, and G. Kalinowska. 1988. Comparison of ten Friesian strains in Poland under field conditions. I. Strain comparison for growth rate. Livest. Prod. Sci. 18:217.

9 Turton, J. D. 1981. Crossbreeding of dairy cattle—a selective review. Anim. Breed. Abstr. 49:293.

10 Zarnecki, A. 1979. Estimation of genetic parameters of milk and meat traits in dual purpose cattle. Final Rep., Project No. PL-ARS-26, Acad. Agric., Krakow, Poland.