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Lifetime yield and herd life for crosses of Friesian strains in Poland*

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ABSTRACT

Lifetime yield performance and herd life through nine lactations were examined for 7353 F_1 cows that resulted from crosses of 374 Holstein or Friesian bulls from Canada, Denmark, Israel, New Zealand, Sweden, The Netherlands, the United Kingdom, the US, and West Germany with Polish Black and White cows. Lifetime traits included number of calvings, days in milk (DIM), days of productive life (DPL), age at last calving, age at disposal, lifetime milk and fat yields, and mean milk and fat yields per DIM. Mean number of calvings was 3.8. Ranking of strains based on means and mixed model solutions demonstrated the superiority of US, Canadian, New Zealand, and Israeli strains for measures of longevity and lifetime performance. For all lifetime traits Polish, Netherlands, and Danish strains ranked lowest. Sire and error components of variance were estimated with a REML procedure. Heritabilities of lifetime milk and fat yields and measures of herd life were low (0.03 to 0.07); heritabilities for mean yield per DIM were 0.22 for milk and 0.19 for fat.

KEY WORDS: lifetime performance, herd life, Friesian, crossbreeding

INTRODUCTION

Lifetime performance of dairy cows is an important characteristic affecting breeding and economic decisions. The capacity for long herd life increases selection possibilities and influences profitability. Lifetime performance and

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other related measures have been studied extensively for dairy cattle (Honnette et al., 1980; Hoque and Hodges, 1980; Norman et al., 1981; VanDoormaal et al., 1985, 1986; Ducrocq 1987; Nieuwhof et al., 1989; Żarnecki et al., 1990).

Estimates of heritability for lifetime performance vary with the specific trait that is being measured. For lifetime milk and fat yields, heritability estimates ranged from 0.10 to 0.28 (Hoque and Hodges, 1980; Jairath et al., 1994). Heritability estimates for longevity traits were usually lower and ranged from 0.05 to 0.20 (Hoque and Hodges, 1980). Stayability, the measure of cow survival to a certain age, also had low heritability: 0.02 to 0.05 (Hudson and Van Vleck, 1981).

The Polish experiment, coordinated by the Food and Agriculture Organization of the United Nations, compared 10 Friesian strains. The experiment was designed to rank F_1 crosses and backcrosses according to body weight, growth rate, and milk yield during first lactation (Jasiorowski et al., 1988). Most of the attention in this experiment focused on yield during first lactation. However, records from later lactations (through parity 9) of the crossbred cows were collected through the milk recording program. Żarnecki et al. (1991) used multitrait analysis to study records from the first three parities. All F_1 cows from this trial have had sufficient time to produce for as long as they remained in the herd.

The purpose of this study was to compare the lifetime performance and herd life of F_1 cows that resulted from crosses of Polish Black and White cows with bulls from 10 Friesian strains.

MATERIAL AND METHODS

The design of the trial and the experimental procedures were described in detail by Stolzman et al. (1981, 1988). Semen from 388 young, unproven bulls from 10 cooperating countries (Canada, Denmark, Israel, New Zealand, Poland, Sweden, The Netherlands, the United Kingdom, the US, and West Germany) was used to inseminate 33.699 Polish Black and White mature cows on 70 state dairy farms. Inseminations started during March 1974 and were completed by December 1978.

Data for F_1 cows were extracted from files of the state dairy recording system. These data included cow, sire, and strain identification; 305-d milk and fat yields; and calving and disposal dates for all lactations through ninth. A recommendation was made to herd managers who were cooperating in the trial to milk all cows for one complete lactation even if yield was low. Nevertheless, records for cows with first lactations of 150 d were excluded. Other record edits included a check for consistency of calving date, length of calving interval, and identification of parents. Calving dates were grouped into two seasons: October through March and April through September. After edits, records were available for 7353 cows (daughters of 374 bulls) with first calvings in 379 herd-year-seasons.

Lifetime variables that were examined included: 1. number of calvings, 2. age at last calving, 3.age at disposal, 4. days of productive life (DPL; the number of days from first calving to disposal), 5. lifetime days in milk (DIM); sum of DIM across lactations with a maximum of 305 d per lactation), 6. lifetime milk yield (sum of yield across lactations with a maximum of 305 d per lactation), 7. lifetime fat yield, 8.mean milk yield per DIM, and 9. mean fat yield per DIM. Unlike age at disposal DPL accounts for differences in age at first calving. Number of calvings is a similarly useful (although coarser) lifetime variable, although number of calvings does not account for the length of calving intervals. Lifetime DIM provides more information on the length of lactations. Age at last calving may be useful when age at disposal is not known and when cows are being retained in the herd despite low yield.

All variables were analyzed with a single-trait model:

$$y_{ijkl} = \mu + h_i + g_j + s_{jk} + e_{ijkl}$$

where y_{ijkl} is the lifetime variable for a cow that first calved during herd-year--season i and that was sired by bull k from strain j, μ is the population mean, h is the fixed effect of herd-year-season of first calving, g is the fixed effect of sire strain, s is the random effect of sire within strain, and e is a random residual effect.

Effects of sire and residual were assumed to be uncorrelated and normally distributed with means of 0. Variance components were estimated for sire and residual effects with a REML procedure. The computational strategies of VanRaden (1986) were used except that solutions were required to sum to 0 for strain effects.

RESULTS AND DISCUSSION

Means for lifetime yield and herd life traits are given in Table 1; standard deviations are in Table 2. Mean number of calvings across strains was 3.8. The largest mean number of calvings was 4.2 for US and Canadian strains, followed by 4.0 for Israeli and New Zealand strains; lowest means were 3.5 for Danish and Netherlands strains and 3.3 for the Polish strain. Lifetime DIM was closely related to the number of lactations. Strain rankings for four other measures of herd longevity (ages at last calving and disposal, DPL, and lifetime DIM) were similar to the ranking for number of calvings: North American Holstein strains remained in the herds the longest, followed by New Zealand and Israeli strains; the Polish, Netherlands, and Danish Friesian strains had the shortest herd life.

TABLE 1

Means for lifetime yield and herd life traits of Friesian strain

Strain	Cows	Calvings	Age		Productive	Lifetime	Lifetime yield		Lifetime yield per DIM	
			last calving	disposal	life[1]	DIM	milk	fat	milk	fat
	no.		mo		d		kg		kg/d	
Canada	687	4.2	69.5	78.0	1495	1160	15.909	624	13.2	0.52
Denmark	686	3.5	61.9	70.2	1248	967	11.879	470	11.8	0.47
Israel	716	4.0	67.7	76.4	1440	1117	15.626	614	13.3	0.52
New Zealand	737	4.0	68.7	77.4	1465	1120	14.646	596	12.6	0.51
Poland	1146	3.3	59.6	68.0	1162	906	11.162	443	11.8	0.46
Sweden	712	3.9	66.0	74.3	1365	1059	13.554	535	12.2	0.48
The Netherlands	652	3.5	60.6	68.8	1204	931	11.288	452	11.6	0.46
United Kingdom	689	3.9	65.9	74.3	1372	1058	13.379	529	12.2	0.48
US	623	4.2	70.8	79.4	1532	1171	16.538	646	13.5	0.53
West Germany	705	3.8	64.4	72.8	1335	1030	12.923	508	12.1	0.47
All strains	7353	3.8	65.1	73.6	1349	1043	13.533	535	12.4	0.49

[1]interval from first calving to disposal

TABLE 2

Standard deviations for lifetime yield and herd life traits of Friesian strain

Strain	Cows	Calvings	Age		Productive	Lifetime	Lifetime yield		Lifetime yield per DIM	
			last calving	disposal	life[1]	DIM	milk	fat	milk	fat
	no.		mo		d		kg		kg/d	
Canada	687	2.3	28.5	28.7	872	647	10.653	422	3.2	0.13
Denmark	686	2.0	25.9	26.1	792	579	8718	350	3.1	0.13
Israel	716	2.3	28.7	28.8	875	652	11.120	440	3.4	0.14
New Zealand	737	2.3	28.9	29.0	890	644	9922	408	3.0	0.13
Poland	1146	2.0	24.9	25.1	768	564	8500	346	2.9	0.12
Sweden	712	2.1	26.2	26.4	810	598	9221	371	2.9	0.12
The Netherlands	652	2.0	25.1	25.3	766	562	8274	340	2.8	0.13
United Kingdom	689	2.2	27.3	27.3	830	609	9221	371	2.9	0.12
US	623	2.3	29.0	29.2	893	661	11.159	442	3.5	0.14
West Germany	705	2.1	27.1	27.3	831	607	9180	364	3.1	0.12
All strains	7353	2.2	27.3	27.5	839	617	9765	391	3.1	0.13

[1]interval from first calving to disposal

Nieuwhof et al. (1989) reported that the mean productive herd life was 3.4 calvings for US Holsteins as well as for registered Holsteins. For Canadian Holsteins, means of 28 (Jairath et al., 1994) and 43 mo (Hoque and Hodges, 1980) have been reported for productive life and 2.6 (Jairath et al., 1994) and 3.3 calvings. The large differences among means from previous studies and those for F_1 cows from the Polish trial clearly demonstrate that these measures of herd life are greatly influenced by feeding and management systems as well as by culling practices.

Strain rankings for lifetime yields of milk and fat also were similar to rankings for longevity traits. Lifetime milk and fat yields were highest for the US strain, followed by the Canadian, Israeli, and New Zealand strains; the yields were lowest for the Polish, Netherlands, and Danish strains. For mean yield per DIM, strain rankings varied slightly among the highest and lowest rankings. Daily yields for milk and fat were highest for the US strain; followed by the Israeli, Canadian, and New Zealand strains; and the lowest for the Netherlands, Polish, and Danish strains.

Strain rankings based on mixed model solutions for lifetime traits (Table 3) were similar to those based on means. The US strain was the highest, followed by the Canadian or New Zealand strains. The Israeli strain was fourth, and the Polish, Netherlands, and Danish strains were the lowest. Differences in DPL among the highest and among the lowest strains were small: 51 d between US and Canadian strains, 8 d between Canadian and New Zealand strains, 24 d between New Zealand and Israeli strains, 41d between Danish and Netherlands strains, and 23 d between Netherlands and Polish strains. The largest difference was between the US and Polish strains for all traits. Compared with the Polish strain, the US strain had 0.7 more calvings, was 9.5 mo older at last calving and 9.8 mo older at disposal, and had 326 d longer productive life and 234 d more in milk. For lifetime yield, the US strain outproduced the Polish strain by 5481 kg of milk and 207 kg of fat; mean daily yield per DIM was 2.2 kg/d for milk and 0.09 kg/d for fat. Differences in lifetime milk yield and mean daily milk yield per DIM among the highest strains and among the lowest strains were 730 kg and 0.3 kg/d between US and Canadian strains, 519 kg and 0.2 kg/d between Canadian and Israeli strains, and 430 kg and 0.3 kg/d between Israeli and New Zealand strains, 588 kg and 0.3 kg/d between Danish and Netherlands strains, and 540 kg and 0.3 kg/d between Netherlands and Polish strains. The New Zealand strain was slightly higher than the Israeli strain for lifetime fat yield (4 kg) and mean daily fat yield per DIM (0.01 kg/d). This ranking and grouping of strains are similar to that reported by Żarnecki et al. (1991) based on dairy performance for the first three parities (White et al., 1965) except for the ranking of the Danish strain. For the first two parities, for fat yield, the Danish strain ranked the same as the United Kingdom and higher than the West German strain; however, rank of the

TABLE 3

Mixed model solutions for lifetime yield and herd life traits of Friesian strain

Strain	Calvings	Age		Productive life[1]	Lifetime DIM	Lifetime yield		Lifetime yield per DIM	
		last calving	disposal			milk	fat	milk	fat
	no.	mo		d		kg		kg/d	
Canada	0.27	3.04	3.17	108	88	2042	76	0.83	0.03
Denmark	−0.25	−3.03	−3.15	−103	−77	−1581	−63	−0.50	−0.02
Israel	0.16	2.20	2.39	76	59	1523	53	0.60	0.01
New Zealand	0.20	3.12	3.36	100	66	1093	57	0.32	0.02
Poland	−0.38	−4.72	−4.88	−167	−123	−2709	−105	−1.08	−0.05
Sweden	−0.04	−0.46	−0.60	−24	−16	−342	−14	−0.17	−0.01
The Netherlands	−0.34	−4.48	−4.69	−144	−108	−2169	−81	−0.77	−0.03
United Kingdom	0.03	0.18	0.11	4	3	−310	−11	−0.18	−0.01
US	0.33	4.74	4.90	159	111	2772	102	1.12	0.04
West Germany	0.00	−0.58	−0.57	−9	−3	−320	−16	−0.17	−0.01

[1]interval from first calving to disposal

TABLE 4

Standard errors of mixed model solutions for lifetime yield and herd life traits of Friesian strain

Strain	Calvings	Age		Productive life[1]	Lifetime DIM	Lifetime yield		Lifetime yield per DIM	
		last calving	disposal			milk	fat	milk	fat
	no.	mo		d		kg		kg/d	
Canada	0.12	1.48	1.49	45	34	518	21	0.14	0.01
Denmark	0.12	1.47	1.48	45	34	515	20	0.14	0.01
Israel	0.12	1.48	1.49	45	34	519	21	0.14	0.01
New Zealand	0.12	1.48	1.49	45	34	519	21	0.14	0.01
Poland	0.11	1.37	1.38	42	31	484	19	0.14	0.01
Sweden	0.12	1.46	1.47	45	33	510	20	0.14	0.01
The Netherlands	0.12	1.50	1.51	46	34	524	21	0.14	0.01
United Kingdom	0.12	1.48	1.49	45	34	517	20	0.14	0.01
US	0.12	1.52	1.53	47	34	530	21	0.14	0.01
West Germany	0.12	1.47	1.48	45	33	514	20	0.14	0.01

[1]interval from first calving to disposal

TABLE 5

Estimated heritabilities and standard errors for lifetime yield and herd life traits

Trait	Heritability	SE
Number of calvings	0.04	0.02
Age at last calving	0.03	0.02
Age at disposal	0.04	0.02
Days of productive life[1]	0.03	0.02
Lifetime DIM	0.05	0.02
Lifetime milk yield	0.07	0.02
Lifetime fat yield	0.06	0.02
Milk yield per DIM	0.22	0.03
Fat yield per DIM	0.19	0.03

[1]interval from first calving to disposal

Danish strain fell below that for other European strains (except for the Polish strain) during third lactation due to a decrease in fat percentage for Danish crosses during third lactation (Żarnecki et al., 1991). Standard errors for mixed model solutions for lifetime traits are given in Table 4.

Heritability estimates for longevity traits (number of calvings, ages at last calving and disposal, DPL, and lifetime DIM) were low, ranging from 0.03 to 0.05 (Table 5). Several researchers (Hoque and Hodges, 1980; Jairath et al., 1994) have reported low to moderate heritabilities for longevity.

Lifetime yield can also be considered to be a partial measure of stayability because lifetime yield is highly correlated with age at disposal and number of calvings (Norman et al., 1981; Jairath et al., 1994). Heritabilities reported for lifetime yields have been low to moderate and ranged from 0.11 to 0.26 (Hargrove et al., 1980; Hoque and Hodges, 1980; Jairath et al., 1994). Although estimates in Table 5 were higher (0.07 for milk and 0.06 for fat), they were similar to the heritability estimates from 0.04 to 0.06 reported by Van Doormaal et al. (1985) for stayability to total life. Heritability estimates in Table 5 were highest for milk yield per DIM (0.22) and fat yield per DIM (0.19). However, heritabilities reported by other researchers generally were higher and ranged from 0.21 to 0.40 (Evans et al., 1964; Hargrove et al., 1980; Hoque and Hodges, 1980; Jairath et al., 1994).

CONCLUSIONS

The Polish trial was conducted during the early stages of Holstein importation to Europe in the 1970s. Initially the strain crosses in the experiment were ranked according to first lactation milk and fat yields. A follow-up study ranked strains based on yields during the first three lactations. The results of the Polish trial contributed to the increased importation of Holstein semen in Europe, and more than 20 years of intensive crossing have resulted in much higher genetic merit for yield traits for current European Friesians.

The superiority of Holstein crosses for yield during first lactation was demonstrated under poor feeding regimens. Consequently, yields were low, which could reflect on lifetime yields and herd life. However, similar to findings for first lactation alone and for the first three lactations, lifetime yield was greater, and herd life was longer, for Holstein crosses than for crosses from other strains. The largest number of calvings was found for US and Canadian strains, followed by Israeli and New Zealand strains; the smallest was for the Polish strain. Heritability estimates for measures of longevity were low; estimates for lifetime yield performance were moderate.

Because data for this study of lifetime performance concern cows which had been given the opportunity to complete their herd lives, the results reflect strain rankings for the previous generation rather than today's breeding populations. However, a strong relationship was found between strain rankings for yield and herd life. Genetic trend for yield in these countries is different from when the cows in the Polish trial calved; therefore, genetic trend for herd life is likely different also. Great genetic improvement for yield has been made throughout the world, and ranking of strains for both yield and lifetime performance would not be expected to be the same if the Polish crossbreeding trial were repeated today.

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STRESZCZENIE

Wydajność życiowa i długość życia mieszańców odmian bydła fryzyjskiego w Polsce

Zbadano wydajność życiową i długość życia (do dziewiątej laktacji włącznie) 7353 krów mieszańców, córek 374 buhajów odmian fryzyjskich i holsztyńsko-fryzyjskich i matek rasy polskiej czarno-białej. Nasienie buhajów, w ramach tzw. doświadczenia FAO nad porównaniem różnych odmian bydła fryzyjskiego, zostało dostarczone z następujących krajów: Kanada, Dania, Izrael, Nowa Zelandia, Szwecja, Holandia, Wk. Brytania, USA, Federalna Republika Niemiec. Cechami charakteryzującymi długość życia krów były: liczba ocieleń, liczba dni doju, liczba dni życia produkcyjnego, wiek przy ostatnim ocieleniu, wiek w dniu wybrakowania, życiowa wydajność mleka i tłuszczu, średnia dzienna całożyciowa wydajność mleka i tłuszczu.

Średnia liczba ocieleń wynosiła 3,8. Uszeregowanie odmian na podstawie średnich i rozwiązania modelu mieszanego wykazały, że najlepsze wyniki osiągnęły córki buhajów odmian Holstein z USA, Kanady oraz odmiany nowozelandzkiej i izraelskiej w zakresie cech charakteryzujących zarówno długość życia w stadzie, jak i wydajność życiową. Wartości tych cech były najniższe u odmian: polskiej, holenderskiej i duńskiej. Komponenty wariancji ojców i błędu oszacowano za pomocą procedury REML. Wskaźniki odziedziczalności życiowej wydajności mleka i tłuszczu były małe (0,03 i 0,07), odziedziczalność średniej dziennej wydajności życiowej wynosiła 0,22 – mleka i 0,19 – tłuszczu.