INFLUENCE OF GENETIC SELECTION DIFFERENTIAL AND GENERATION INTERVAL ON ACTUAL GENETIC GAIN PER YEAR FOR MILK PRODUCTION IN HOKKAIDO HOLSTEINS IN JAPAN

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INTRODUCTION

In dairy cattle, Rendel and Robertson (1950) estimated the annual genetic gain, considering that accuracy of prediction, selection intensity, and generation interval are different for four paths of selection: sires of bulls (SB), dams of bulls (DB), sires of cows (SC), and dams of cows (DC). Objectives of this study were to examine genetic selection differential (GSD) and generation interval (GI) that affect actual genetic gain per year and to predict genetic changes in the future for milk production of Holsteins in Hokkaido, Japan.

MATERIALS AND METHODS

The data for estimation of breeding values consisted of 305-d (≥240-d) records of Holstein cows that produced milk with 2 times milking from 1976 through 2001. The data included 5,012,423 records of 1,687,142 cows for milk and fat yields, and 3,574,169 records of 1,306,174 cows for protein yield. Those records were preadjusted for heterogeneous variances among herds, calving year, parity, and herd size and level by using a simple Bayesian method proposed by Weigel and Gianola (1993). Means and standard deviations after those adjustments for milk, fat, and protein yields were 7,461±1,723 kg, 282±68 kg, and 246±52 kg, respectively. A single trait animal model with repeated records for prediction of breeding values included herd-year-parity subclass as fixed management group effects, age and month of calving within each birth year group as fixed effects, linear regression on inbreeding, random permanent environment effects of cows, random additive genetic effects of animals, and random residual effects. The inbreeding coefficients were calculated using the algorithm proposed by VanRaden (1992). The ratio of error variance to additive genetic variance was adjusted to reflect the reduced variances of Mendelian sampling that result from inbreeding. Next, the foreign bull's proofs for USDA-DHIA and Interbull downloaded from the internet homepage of AIPL (ftp://aiplarsusda.gov/ pub/bulls/031hoff.zip) were deregressed to EBV of Hokkaido Holstein by applying Wilmink's method (Wilmink *et al.*, 1986), and were blended in these animal model equations by using Henderson's method (Van Vleck, 1982). Because Japan has not participated in Interbull evaluation and high genetic correlations between EBV in Japan and in the US were estimated in range of 0.942 to 0.953 for milk production yield (Atagi *et al.*, 1999), international EBV in the US were used in this study.

The GI was calculated as the interval between the birth date of the progeny and that of its parent and was expressed in years. The GSD was estimated as the difference between EBV of parents and cows born in the same year as the parent's birth year. Then, GI and GSD were averaged on each birth year of progeny for four paths of selection. The rates of animals that obtained GI and GSD for milk and fat yields were 99.8% for both SB and DB paths in 3,093 bulls born from 1980 to 1996 and 93.0% for the SC path and 88.1% for the DC path in 1,344,054 cows born from 1980 to 1998. The rates of animals for protein yield were similar to those for milk and fat yields. Means of EBV and reliability for cows born from 1980 to 1998 were 366 kg and 56%, 14 kg and 56%, and 9 kg and 53% for milk, fat, and protein yields, respectively. Genetic standard deviations (σ_G) were estimated based on the assumption that the accuracy of selection (square root of reliability) is equal to the correlation of predicted and true breeding values, and 490 kg, 18 kg, and 13 kg were derived respectively for milk, fat, and protein yields.

RESULTS AND DISCUSSION

Milk production traits showed a steady increase of genetic trends since 1980. Table 1 contained actual genetic gains per year (σ_G/yr) for milk production by birth year groups of bulls and cows. Annual genetic gain for protein yield was the biggest change for both bulls and cows. The genetic gains of bulls in range of 1989 to 1992 were 0.09 σ_G/yr, 0.10 σ_G/yr, and 0.19 σ_G/yr, and those gains from 1993 to 1996 increased to 0.34 σ_G/yr, 0.20 σ_G/yr, and 0.39 σ_G/yr for milk, fat, and protein yields, respectively. Whereas the genetic gains of cows from 1989 to 1992 were 0.16 σ_G/yr, 0.19 σ_G/yr, and 0.20 σ_G/yr, and those gains from 1993 to 1996 decreased to 0.14 σ_G/yr, 0.14 σ_G/yr, and 0.18 σ_G/yr for milk, fat, and protein yields, respectively.

Table 1. Annual genetic changes (σ_G/yr) by regression of estimated breeding values for milk, fat and protein yields on each range of birth year.

	Bull	Cow
	1989-1992	1991-1994
Milk	0.09	0.16
Fat	0.10	0.19
Protein	0.19	0.20
	1993-1996	1995-1998
Milk	0.34	0.14
Fat	0.20	0.14
Protein	0.39	0.18

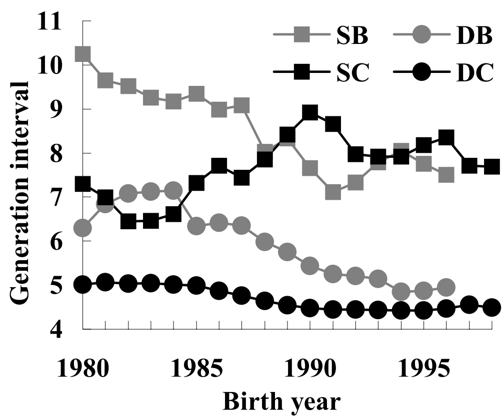
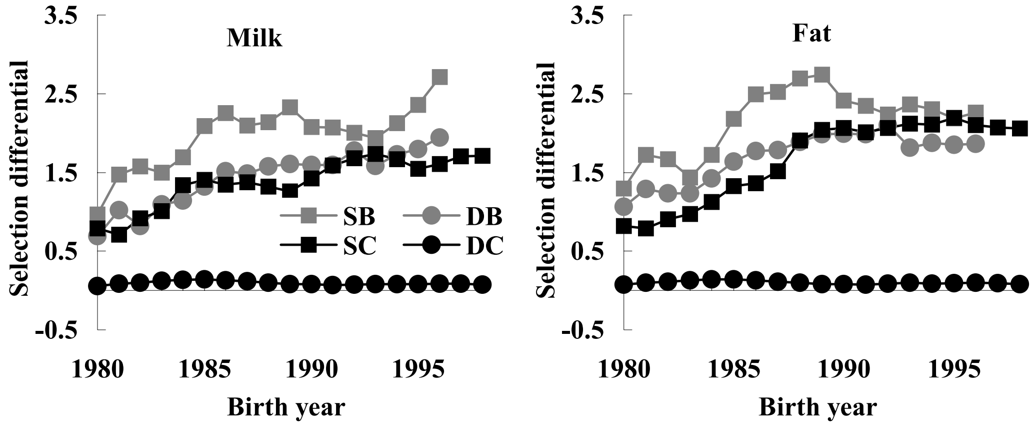


Figure 1. Means of generation intervals (yr) for four paths of selection by year of birth of bulls and cows.

In Figure 1, GI for SB and DB paths decreased steadily over the years and had dropped to 7.51 yr and 4.95 yr in the last year, respectively. Applying reproductive techniques like juvenile MOET to produce AI bulls may be needed because the interval of 4.95 yr for the DB path was longer than the 3.73 yr in Italian dairy populations (Burnside *et al.*, 1992). The GI for SC path increased slightly from 7.29 yr to 7.69 yr for cows born from 1980 to 1998, whereas the GI for dams as replacement females (DC path) decreased slightly from 5.01 yr to 4.49 yr.



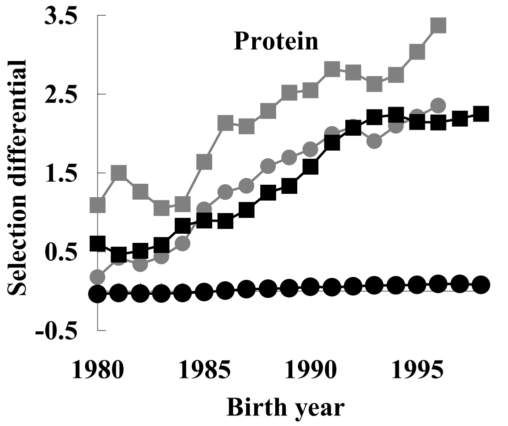


Figure 2. Means of estimated genetic selection differentials (σ_G) for four paths of selection for milk, fat and protein yields by year of birth of bulls and cows.

Estimated GSD for SB and DB paths were 2.71 σ_G/yr and 1.94 σ_G/yr for milk yield, 2.26 σ_G/yr and 1.86 σ_G/yr for fat yield, and 3.37 σ_G/yr and 2.35 σ_G/yr for protein yield, respectively (Figure 2). The GSD of milk yield for SB and DB paths tended to increase from 1993 to 1996. The GSD of fat yield stayed above 2.2 σ_G/yr for the SB path and above 1.8 σ_G/yr for the DB path in the 1990s. The GSD of protein yield for SB and DB paths increased dramatically from 1985 to 1996. The GSD for the SC path in the last year (1998) were 1.71 σ_G/yr for milk yield, 2.06 σ_G/yr for fat yield, and 2.25 σ_G/yr for protein yield. The GSD of milk yield for SC stopped increasing and maintained at about 1.5 σ_G/yr after the late 1980s. The GSD in SC path increased until 1988 for fat yield and until 1993 for protein yield. The GSD in DC path had no large changes and were below 0.10 σ_G/yr for all traits.

The annual genetic gain expected in the future for protein yield, 0.30 σ_G/yr, was greater than 0.26 σ_G/yr for fat yield and 0.23 σ_G/yr for milk yield (Table2). Those expected annual genetic gains correspond to 192%, 173%, and 188% higher genetic progress, respectively, than actual genetic changes per year in the last four years. However, several studies (Everett 1984; Van Tassell and Van Vleck, 1991; Burnside et al., 1992) suggest that actual genetic gains are less than those expected because emphasis on traits other than milk production, particularly for milk content and classification score. The increased genetic trend in Hokkaido Holstein cow population slowed down in recent years, compared accelerated genetic increase for bulls (Table1). These results indicate that selection on traits other than milk production may have been intensified in the cow population.

Table 2. Annual genetic changes (σ_G/yr) expected in the future for milk, fat and protein yields estimated from genetic selection differentials (σ_G) and generation intervals (yr) for four paths of selection.

	SB	DB	SC	DC	Total	Genetic Gain/yr
Generation interval[a)]						
	7.78	4.95	7.98	4.49	25.20	
Genetic selection differential[a)]						
Milk	2.28	1.76	1.64	0.08	5.76	0.23
Fat	2.28	1.85	2.11	0.09	6.33	0.26
Protein	2.95	2.14	2.18	0.09	7.36	0.30

a)Means for the last four years of birth

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