Preliminary Study of Genetic Evaluation for Female Fertility in Japan

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Introduction

There are several measures for fertility traits. Calving interval seem to be widely reported across countries. Among countries surveyed*, Japanese Holstein cows have the longest calving interval, the longest lactation length, and produce the greatest milk yield per lactation (ICAR, 2004).

Genetically, a decline in fertility of cows, especially Holstein-Friesians, has been reported in recent publications (Pryce *et al.,* 2004; Ponsart *et al.,* 2004; Roth, 2004; VanRaden *et al.,* 2004). Considering the close relationship of Holstein genetics across countries, this could be a world wide phenomenon. The growing size of Japanese dairy herds (MAFF, 2004) should be noticed. Management of larger herds with more production per cow is one of the challenges faced by Japanese dairy farmers. Under such a changing environment, fertility traits would be worthwhile to monitor. Insemination date, pregnancy verification, and service sire have been recorded in Japanese milk recording scheme, and historical days open (DO) records are available at NLBC.

The objectives of this study are:
1. To estimate genetic parameters,
2. To study genetic and environmental effects on DO, and
3. To examine the feasibility of genetic evaluation for female fertility from accumulated records in Japan.

* Among countries reporting calving interval, lactation length and milk yields of Holstein-Friesians all together. Countries with lactation length = 360 days were excluded.

Materials and Methods

DO records since 1980 were obtained from Japanese national milk recording scheme. These records were edited as follows:

1. Holstein cows whose sire were identified,
2. 1^{st} to 5^{th} calving,
3. DO between 21 and 293 days, assuming records out of range were reporting error,
4. first calving information must be available,
5. at least one contemporary record must exist in the herd-year subclass.

Total of 2,903,883 records were extracted, and three variables (DO, $\log_e$(DO), Daughter Pregnancy Rate (DPR, VanRaden *et al.,* 2004)) were tested for normality applying univariate procedure (SAS, 1999) before estimating genetic parameters.

Following animal model was assumed to estimate genetic parameters and calculate breeding values:

$$y_{ijkl} = HY_i + BMY_j + AGE_k + u_l + pe_l + e_{ijkl}$$

where:

- y_{ijkl}: DO observations in days
- HY_i : fixed effect of herd-calving year to account for the management effect on the records,
- BMY_j: fixed effect of calving month-year-regional block (Hokkaido, which is located in sub-arctic zone, and others mostly located in temperate zone),
- AGE_k: fixed effect of calving age, 47 levels,
- u_l: random additive genetic effect of the animals,
- pe_l: random permanent environmental effect (PE) of the animal,
- e_{ijkl}: random residual effect.

For genetic parameter estimation, records from every 6th herd were chosen to give 483,756 records due to hardware restriction. Genetic parameters were computed using MTC program (Misztal *et al.,* 1992).

Pedigrees were identified at least two generations back on each recorded cow. Unknown parents were assigned to genetic groups by national origin, birth year of the animal, and pathway of selection. Small genetic groups (i.e. less than 10 animals) were combined to adjacent birth year groups.

Results and Discussion

Basic statistics of DO, $\log_e$(DO), DPR are shown in Table 1. Figure 1 shows the distribution of DO records used in this analysis. Normality assumption was rejected in all 3 variables. From the D value and skewness statistics, the variable $\log_e$(DO) was closest to a normal distribution, whereas kurtosis showed that DO was the closest. Because of easy application to the dairy industries, DO was selected for this analysis.

Estimated genetic parameters are shown in Table 2. Estimated heritability was 0.05, and similar to heritabilities of fertility traits reported to INTERBULL (INTERBULL, 2005).

Estimated seasonal effects are shown in Figure 2. Due to conception difficulties in summer, cows that calved in April-May tended to have longer DO, especially in the southern region of the country. In the northern part of Japan summers are cooler.

Chronological changes of HY effects and herd size (number of records in a herd) are shown in Figure 3. The relationship between herd size and DO is suspected. Table 3 shows basic statistics of HY effects in 2003 by herd size. Heat detection might be more difficult in bigger herd than smaller ones, however, mean values shows bigger farms tend to have shorter DO. Smaller farms are often multiple farms running dairy and rice farming together, whereas bigger farm are specialized in dairy farming and often equipped useful tools such as pedometers to detect heat. Such a difference in management could affect the results and detailed study of general farm environment and HY estimate would be required to clarify the reason.

Fixed effect of calving age is shown in Figure 4. The older the calving age, the longer the DO become as expected. However, the estimates were unstable around 35, 47, 58, and 71 month where records from 2 different parities were mixed. Age effect should be separated by parity.

Genetic trend of DO is shown in Figure 5. Similar to HY effects, the trends are in an undesirable direction in terms of calf production, however, longer DO could be caused by longer lactation length due to higher production, which is preferable. As indicated by Weigel (2004), the optimum balance of fertility and production should be closely examined.

DO records shorter than 21 days and longer than 293 days were excluded in this study. Alternative solution would be to replace outliers with a certain limiting value (VanRaden *et al.,* 2004). Records from lactations without pregnancy within the range could also be applied; however, further sensitivity study is required.

Stability of genetic evaluation results should also be examined for reliable routine evaluation. Short daughter DO records are always reported earlier than long DO for pregnancy tested young bulls, breeding values of young bulls might start low, but increase as daughters complete their first lactation. A Solution might be to put a threshold on days in milk, or make some adjustment for DO records from early lactation (Kuhn *et al.,* 2004).

Through re-processing of all the past insemination records, other fertility traits that would be less directly related to lactation length and milk yields (such as Non-Return-Rate (NRR), number of services per conception, interval from calving to first service, and gestation length) would be available, and give further details of female fertility in Japan.

Conclusions

Genetic evaluation of DO is possible in Japan; however, further study is required to provide a reliable routine genetic evaluation. Further study applying other fertility trait definitions would also be useful for best possible solution for fertility.

Acknowledgements

Thanks go to Dr. Larry Schaeffer and Dr. C.Y Lin (CGIL, University of Guelph) for useful comments and English writing, Dr. Ignacy Misztal (University of Georgia) for computer program, and Mr. Mitsuo Aihara (Livestock Improvement Assoc. of Japan Inc.) and Miss Yuko Kawamura (The Holstein Cattle Assoc. of Japan Inc.) for providing data.

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Table 1 Basic statistics of observations

	DO	$\log_e$(DO)	DPR
mean	121.7	4.689	0.808
standard deviation	58.67	0.478	1.894
Skewness	0.878	0.009	7.652
Kurtosis	0.055	-0.681	71.276
Kolmogorov-Smirnov D	0.102	0.032	0.351
Pr > D	<0.010	<0.010	<0.010

Table 2 Estimated genetic parameters

variance	PE	181.8
	additive genetic	171.1
	residual	2850.6
heritability		0.053
repeatability		0.110

Table 3 Herd effects by size (2003)

records in a herd	number of herds	mean	s.d.
-19	5802	3.091	28.504
20-39	2960	-6.008	15.919
40-59	496	-9.600	13.812
60-79	169	-10.839	10.928
80-99	62	-11.823	11.600
100-	61	-12.927	9.091

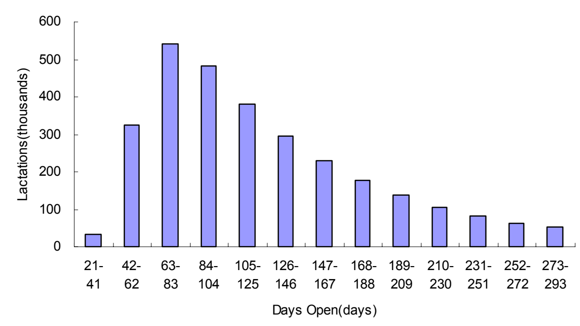

Figure 1 Distribution of days open(DO)

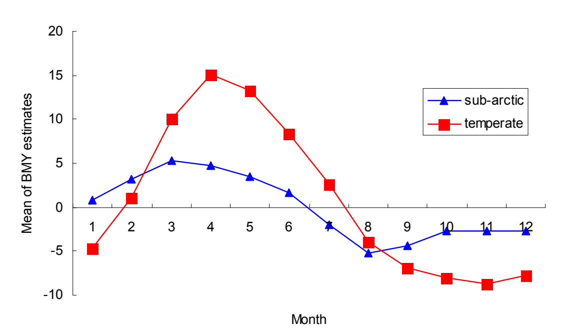

Figure 2 Seasonal effects on DO

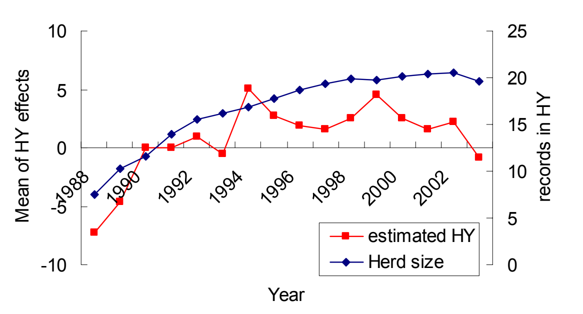

Figure 3 Chronological change of HY effects and herd size

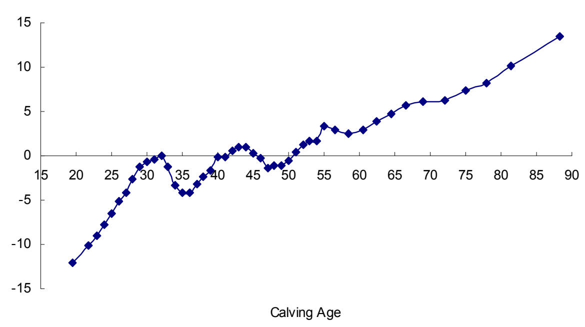

Figure 4 Calving Age effect on DO

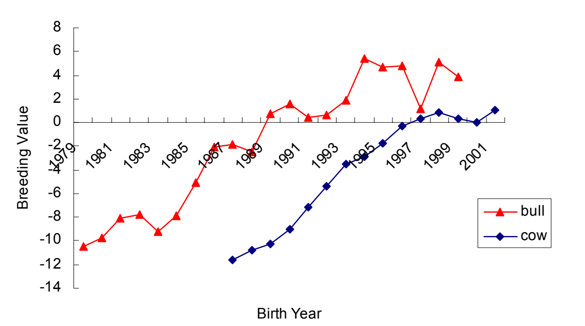

Figure 5 Genetic trend of DO