Effect of Imported Young Bulls with Higher Genetic Merit on Genetic Progress of Japanese Holstein Population

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ABSTRACT : The effect of imported young bulls on the genetic progress was examined in the Holstein dairy cattle population in Japan. The effect of the difference of mean genetic merit between imported and domestic young bulls ("genetic difference") was recognized on the genetic progress of the domestic animals in the early stage of selection. On the other hand, the genetic progress of domestic animals were remarkably influenced by the genetic trend of imported young bulls ("genetic trend") in the later stage. Import of young bulls originated from high genetic level population improved the genetic progress of domestic population. But, the increase of the immigration ratio of imported young bulls ("immigration ratio") did not influence linearly on the progress of the genetic merit of domestic animals. Even if "immigration ratio" was 100%, the genetic merit of domestic animals could not overcome the one of imported young bulls. In the later stage of selection, the genetic merit of domestic animals ran parallel to those of imported young bulls.
(**Key Words**: Imported Young Bull, Genetic Progress, Japanese Holstein)

INTRODUCTION

Young bulls have been imported in Japanese Holstein cattle population for many years. It is important to recognize the effects of imported young bulls on genetic progress of the Japanese Holstein cattle population in order to develop an efficient breeding program. However, there is no study which clarifies the effect of imported young bulls on genetic progress of the Japanese Holstein cattle population. Moreover, no work describes the method which estimates the effect of migrated young bulls on genetic progress of the native cattle population.

Gene flow method (Brascamp, 1978; Hill, 1974; McClintock and Cunningham, 1974) can trace the flow of gene originating from the certain animals. Therefore, the method can be used to clarify the effect of migrated young bulls on the genetic progress of the cattle population. However, the superiority of selected animals has to be determined before simulation begins, when gene flow method are used. In practice, it is predicted that the difference of genetic level between the two population varied and/or decreased. Therefore, a method that can estimate the difference of genetic level between the two population each year is needed.

The objectives of this study are a) to propose the method which estimates the difference of genetic level between the two population each year and b) to examine the effect of imported young bulls on genetic improvement of Japanese Holstein cattle population. Especially, this study focused on the immigration ratio of imported young bulls ("immigration ratio"), the difference of the mean genetic merits butween imported and domestic young bulls when selection started ("genetic difference") and the genetic trend of imported young bulls ("genetic trend").

MATERIALS AND METHODS

The population structure used in this deterministic simulation is presented in figrue 1. The population is divided into two sub-populations, namely recorded cows, including cows to bulls, and unrecorded cows. The details of the population structure were described by Terawaki et al. (1996). Imported young bulls are immigrated into young-bull in figure 1. Young-bull consists of imported young bulls and domestic young bulls. Conditions of the simulation are shown in table 1. "Immigration ratio" varied from 0 to 100% by 25%. "Genetic trend" was assumed to be 60 or 80 kg per year (Cassel et at., 1986; Van Vleck et al., 1986; Lee et al., 1985).

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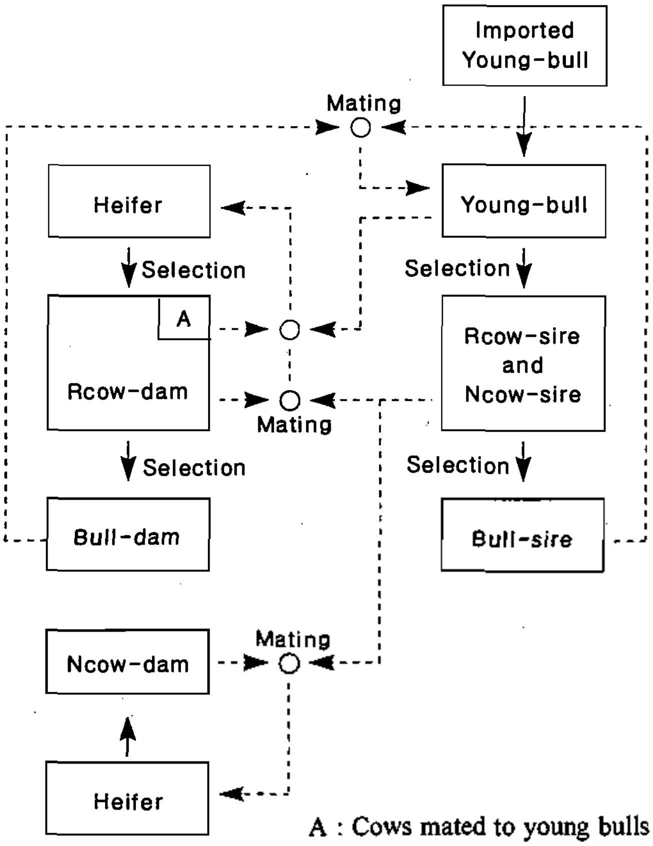

A : Cows mated to young bulls

Figure 1. Structure of dairy cattle population.

Table 1. Conditions of the simulation

Tobal number of cows	2,000,000
Proportion of recorded cows	40%
Proportion of recorded cows inseminated with young bulls	10%
Breeding length of Rcow- and Ncow-slre	5 years
Selected trait	Milk yield
Immigration ratio of imported young bulls ("immigration ratio")	0, 25, 50, 75 or 100%
Difference of the mean genetic merits between imported and domestic young bulls when selection started ("genetic difference")	400, 600 or 800 kg
Genetic trend of imported young bulls ("genetic trend").	60 or 80 kg per year

The superiority of selected animals were estimated by using Ducrocq and Quaas's method (1988) which assumed truncation selection across generations. In this study, two generations correspond to imported young bulls and domestic young bulls. The estimation of genetic merits of imported and domestic young bulls enable us to estimate the superiority of selected animals every year. The genetic merits of domestic young bulls were estimated as follows.

When the selection was performed only on Rcow-sire, the ratio of gene originated from Rcow-sire born in j-th year on the domestic young bulls produced in i-th year, M(i,j), were estimated by gene flow method. When only Rcow-sire was considered as selected animals, genetic merit of domestic young bulls produced in j-th year is estimated as follows:

$$GI(j) = \sum_{k=1}^{j-1} M(j,k) \cdot \triangle D(k)$$

where,

GI(j) : genetic merit of domestic young bulls produced in j-th year.

$\triangle D(k)$: genetic superiority of Rcow-sires which were born and imported in k-th year

When selections were carried out in several paths, genetic merit of domestic young bulls produced in j-th year was estimated by following equation:

$$GI(j) = \sum_{k=1}^{j-1} (j,k) \cdot \triangle D(k) + \sum_{k=1}^{j-1} N(j,k) \cdot \triangle H(k) + \sum_{k=1}^{j-1} O(j,k) \cdot \triangle I(k)$$

where,

M(j,k), N(j,k) and O(j,k) : the ratio of gene originated from Rcow-sire, Bull-sire and young bulls born in k-th year on the domestic young bulls produced in j-th year.

$\triangle D(k)$, $\triangle H(k)$, $\triangle I(k)$: genetic superiority of Rcow-sire, Bull-sire and young-bull born and imported in k-th year.

$\triangle I(k)$ was estimated by multiplying the genetic differece between domestic and imported young bull by "immigration ratio".

RESULTS

Figure 2 shows the effects of "genetic difference" on genetic progress of the population. Also, the genetic

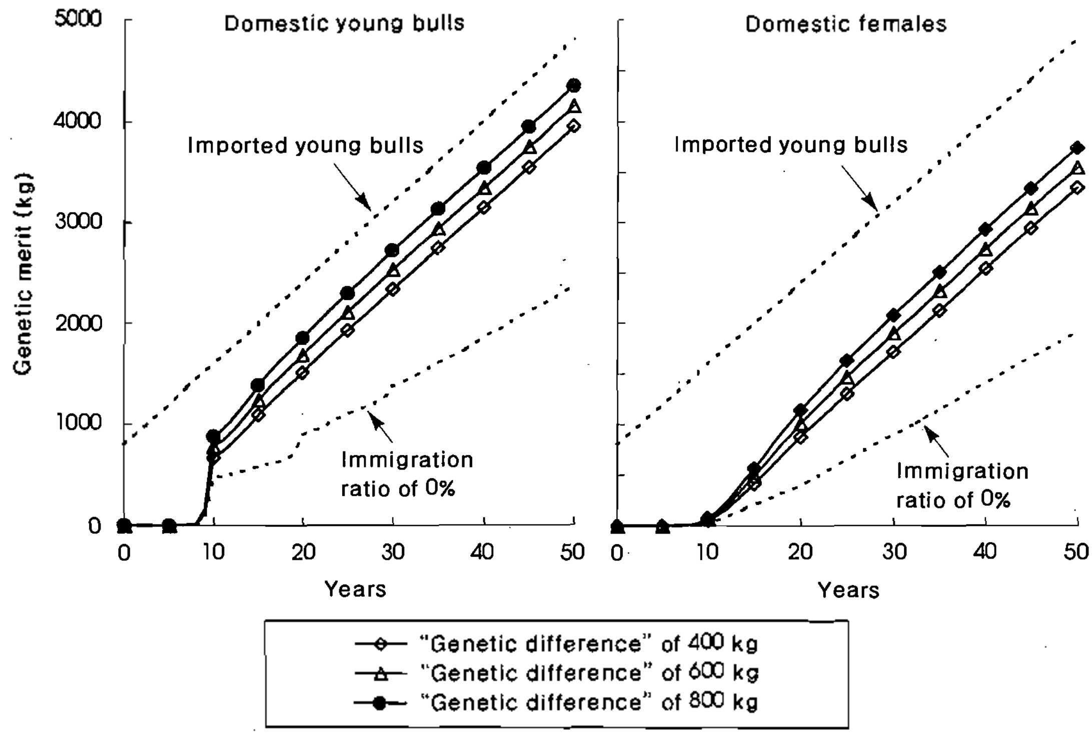

Figure 2. Effect of "genetic difference" on the genetic merits of the domestic young bulls and females. ("Immigration ratio" and "genetic trend" were 75% and 80 kg).

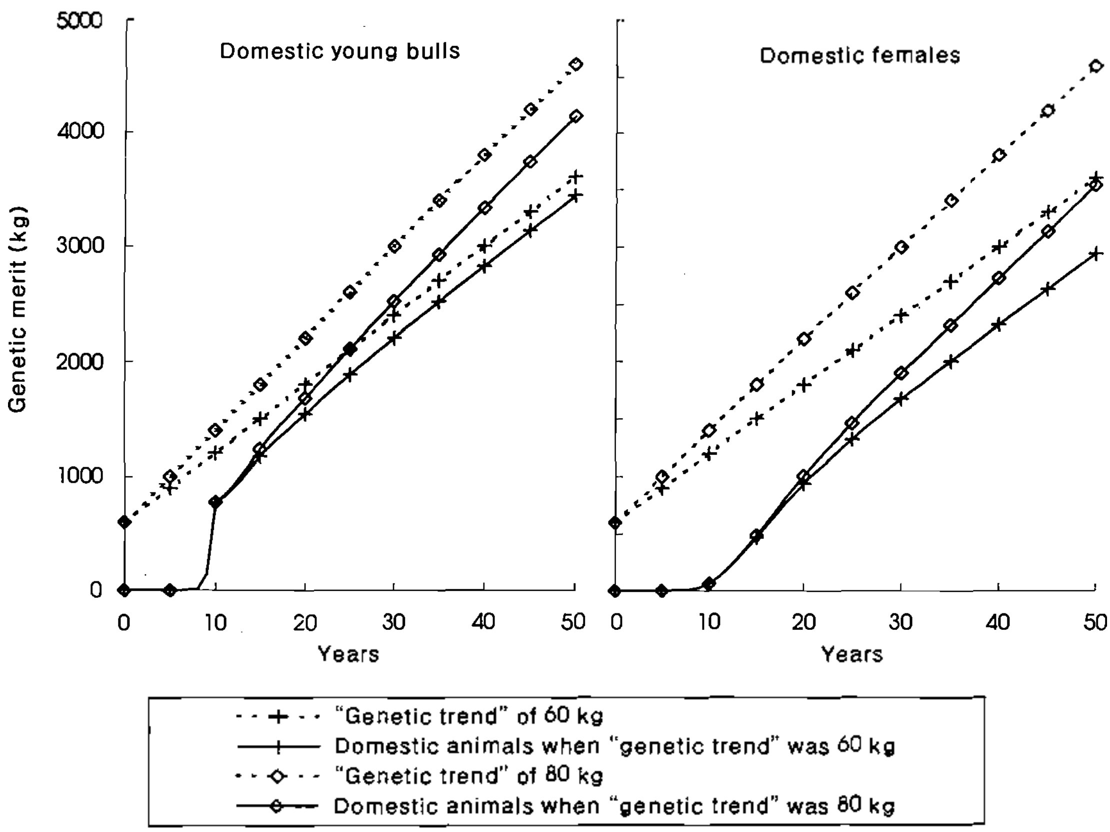

Figure 3. Effect of "genetic trend" on the genetic merits of the domestic young bulls and females ("Immigration ratio" and "genetic difference" were 75% and 600 kg).

progress of the scheme without imported young bulls are shown. The scheme without importation of young bulls had smaller genetic gain per year than one of the schemes importing young bulls. Therefore, the difference of genetic merits between the schemes with and without imported young bulls increased as selection proceeded. The effect of "genetic difference" was recognized on the mean genetic merits of domestic young bulls after 10 years at first. Thereafter, the difference of the genetic merit among the three schemes increased, but the lines of the genetic merit paralleled each other in the later stage. The mean genetic merits of domestic young bulls after 20 years were about 1,850, 1,680 and 1,510 kg respectively, when "genetic difference" were 800, 600 and 400 kg. The difference of the mean genetic merit among schemes were about 200 kg after 50 years. The genetic gain per year of domestic population converged to "genetic trend".

The mean genetic merit of domestic young bulls and females are shown in figure 3. No influence of "genetic trend" were recognized on the mean genetic merits of domestic young bulls and females until 10 years. The distance between the lines of two schemes increased, and after 50 years the difference of the two lines were about 700 and 600 kg for domestic young bulls and females, respectively. The genetic gain per year of domestic young bulls and females converged to "genetic trend".

The scheme with higher "immigration ratio" had higher mean genetic merits (figure 4). The mean genetic merits of the population approached to one of imported

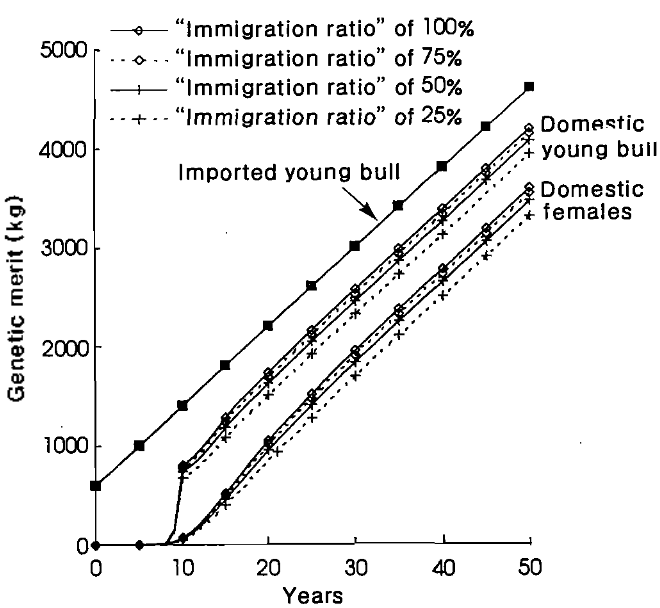

Figure 4. Effect of "immigration ratio" on the genetic merits of the domestic young bulls and females ("Genetic difference" and "genetic trend" were 600 kg and 80 kg).

young bulls as selection proceeded. But, no scheme had genetic merit over imported young bulls.

In general, the genetic superiority of selected animals is a main cause which influenced the genetic gain per year of the population. Figure 5 indicates the effect of the three factors considered in this study, "genetic difference", "genetic trend" and "immigration ratio", on the superiority of selected animals. Two schemes with 100% "immigration ratio" had the superiority of selected animals which moved on the same line irrespectively to "genetic trend". Also, the schemes with 25% "immigration ratio" indicated the same aspect.

DISCUSSION

"Genetic difference" resulted in the difference among the genetic merits of domestic young bulls in three schemes. The differences among the genetic merits of domestic young bulls in three schemes were about 170 and 200 kg after 20 and 50 years, respectively. Also the differences among the genetic merits of domestic females in three schemes were about 130 and 200 kg after 20 and 50years, respectively. The genetic merit of domestic young bulls in the scheme with 80 kg "genetic trend" was about 140 and 700 kg over than one with 60 kg "genetic trend" after 20 and 50 years, respectively. For domestic females, the superiority of scheme with 80 kg "genetic trend" over 60 kg "genetic trend" was 70 and 600 kg after 20 and 50 years. The influence of "genetic trend" on the genetic merits of the population became more remarkable with aggression of selection compared with "genetic difference". In a short term program, "genetic difference" was an important factor, and "genetic tend" was a factor which should be considered in a long term breeding program.

The scheme with low "immigration ratio" (25%) had about 600 kg or 1,600 kg higher genetic merit than one without imported young bulls after 20 and 50 years, respectively. On the other hand, the difference between the genetic merits of schemes with 75% and 100% "immigration ratio" was small (about 40 kg). The difference of genetic merit among the three schemes slightly increased as selection proceeded. Compared with "genetic difference", "immigration ratio" had a large effect on the genetic merit of domestic population even if the scheme had low "immigration ratio" (25%). It was clear that immigration of young bulls originating from higher level population was very useful strategy in order to rapidly improve the genetic merit of domestic population.

Figure 5 indicated that "genetic trend" had no direct

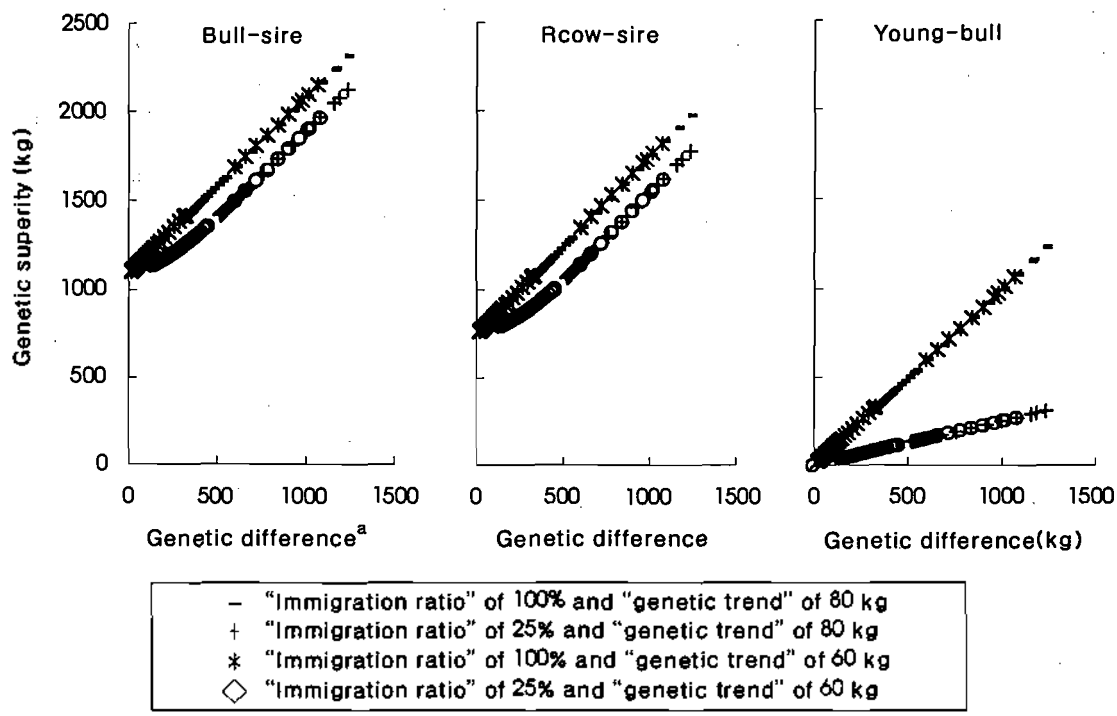

Figure 5. Regression of genetic superiority of selected animals on genetic difference. ([a] ; Difference of the mean genetic merits between imported and domestic young bulls each year. "Genetic difference" was 600 kg).

effect on the superiority of selected animals. Moreover, it was clear that the genetic superiority of selected animals linearly regress on the difference of the mean genetic merit between imported and domestic young bulls by "immigration ratio".

Therefore,

$$A = a_0 + a \cdot x$$
$$B = b_0 + b \cdot x \quad \cdots\cdots (1)$$
$$C = c \cdot x$$

where,

A, B, C : the genetic superiority of Bull-sire, Rcow-sire, and young bull, respectively,

a, b, c : linear regression coefficient of the gennetic superiority of selected animals on the difference of the mean gencetic merit between imported and domestic young bulls,

a_0, b_0 : intercept (the genetic superiority of selected animals without imported young bulls and/or with zero difference of the mean genetic merit between imported and domestic young bulls),

x : the difference of the mean genetic merit between imported and domestic young bulls.

According to Skjerrold and Laugholz (1964), genetic gain per year is described by the following equation:

$$\triangle G = (A + (1-y) \cdot B + y \cdot C) / (L_A + (1-y) \cdot L_B + y \cdot L_C) \quad \cdots\cdots (2)$$

Absorbing equation (1) into equation (2),

$$\triangle G = (a_0 + (1-y) \cdot b_0 / L) + (a + (1-y) \cdot b + y \cdot C / L) \cdot x \quad \cdots\cdots (3)$$

where, $L = L_A + (1-y) \cdot L_B + y \cdot L_C$,

L_A, L_B, L_C : genetic interval of Bull-sire, Rcow-sire and young-bull respectively,

y : ratio of the cows mated with young-bull.

The first term of right hand member in equation (3) is the genetic gain per year without imported young bulls and the second term is the genetic gain per year with imported young bulls. The genetic gain per year of domestic young bulls was very large in the earlier stage. The difference of the mean genetic merit betweein imported and domestic young bulls (x in equation (3)) was very large at the starting of selection, so that this phenomena occurred.

With the progress of selection, the difference of the genetic merit between imported and domestic young bulls gradually decreased. Afterward, the genetic gain per year of domestic population became small, and the genetic merits of imported young bulls and domestic population paralleled in the later stage of selection. In equation (3), as x became small, $\triangle G$ decreased. Finally, $\triangle G$ (equation (3)) was the same as "genetic trend". Consequently, x had not changed, and also $\triangle G$ became constant.

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