Analysis Of Converting A Breeding Program Under BLUP Truncation Selection To Optimum Contribution Selection

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Introduction

Today modern breeding programs are characterized by a very accurate estimation of breeding values and from the increased use of modern reproduction techniques. On the one hand, this leads to a rapid increase in genetic progress, but on the other hand this increases inbreeding by using only a few selected parents. The need to restrict the increase in the rate of inbreeding (ΔF) in genetic improvement programs has been widely recognized. Restricting ΔF allows restriction of the decrease in genetic variability and, most importantly, the reduction in fitness-related traits. Optimum contribution (OC) selection maximizes genetic gain while constraining the rate of inbreeding in the population by optimizing the contributions of the parents to the next generation (Grundy et al., 1998; Meuwissen, 1997; Meuwissen and Sonesson, 1998). These authors also showed that OC selection archives substantially more genetic gain at the same rate of inbreeding than truncation selection for BLUP breeding values.

The aim of this paper is to illustrate the changeover of a breeding program with a truncation selection for BLUP estimated breeding values to the OC selection method by Meuwissen (1997). An empirical route was followed through the use of stochastic simulations and comparisons with traditional truncation selection.

Material and methods

Simulation. Selection over multiple generations was modelled using stochastic computer simulations. The general structure is that of a nucleus scheme with discrete generations. The number of selection candidates per generation is 100 where 50 are male and 50 are female. The true breeding values for animals in the base population were obtained from a normal distribution with mean zero and variance σ_a^2 equal to the heritability ($h^2 = 0.25$) of the trait. Thus, the phenotypic variance σ_p^2 was assumed to be equal to one. Later generations are obtained by simulating offspring genotypes drawn from a normal distribution with mean $g_i = 1/2 g_s + 1/2 g_d + m_i$, where s denotes the sire and d the dam of offspring i , and m_i is the Mendelian sampling component which is sampled from $N(0,1/2[1-1/2(F_s + F_d)]h^2)$, where F_s and F_d are the inbreeding coefficients of the sire and dam. The phenotypic value was obtained by adding to the true breeding value an environmental component sampled from a normal distribution with mean zero and variance $1-h^2$. To create next generation

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offspring mating pairs were chosen randomly from the selection candidates. In the case of truncation selection each selection candidate had the same probability to be chosen as parent for the next generation. For OC selection the probability was set equal to the estimated contribution in vector c_t. A BLUP Animal model was used to estimate breeding values. Populations were evaluated over 20 generations of selection. A total of 100 replicates were performed.

Converting selection (CS). The breeding scheme for the first ten generations was that of a standard truncation selection, were a fixed number of sires and dams with the highest EBVs were selected. After these 10 generations of truncation selection the selection method is changed to an OC selection as described by Meuwissen (1997). In the OC selection ΔF was constrained to 0.005, 0.01 or 0.025 for each generation. The number of selected sires and dams in the truncation selection were chosen by trail and error for two different goals. First there should be the same ΔF in all 20 generations. Therefore n_s and n_d were found to be 50, 36 or 18. Second there should be the same genetic gain in every generation achieved by setting n_s and n_d to 25, 10 or 5. For comparison a standard truncation selection over 20 generations with the same number of selected parents as described before were sampled.

Results and discussion

Fixed rate of inbreeding. Figure.1 shows genetic gain for the CS and TS with ΔF constrained to 0.005, 0.01 or 0.05, respectively. The choice of selection candidates for TS was successful to yield the same ΔF in each generation as the predefined constraint ΔF in OC selection. As expected, the highest genetic gain could be achieved with the most relaxed ΔF (ΔF = 0.025) followed by ΔF = 0.01 and 0.005. After ten generations of TS the selection method switched to an optimized selection.

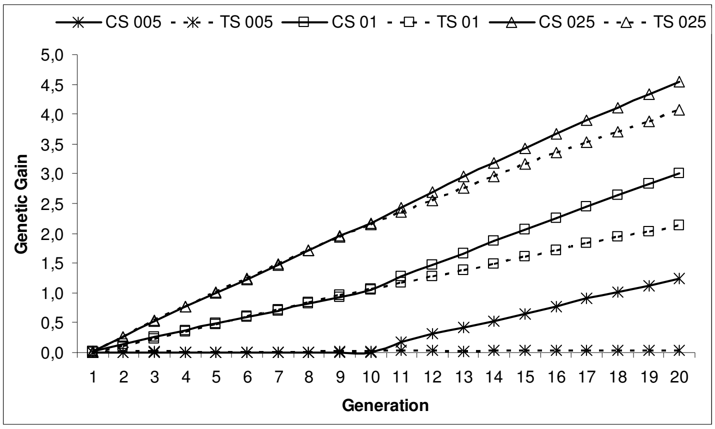

Figure 1: Average genetic gain over 20 generation of selection for truncation selection (TS) and converting selection (CS) for an expected ΔF = 0.005, 0.01 or 0.025

Therefore, with the same ΔF in each generation, the genetic gain increased more than in the comparable TS. The most benefit of the OC selection was yielded for the tightest ΔF, were

after 20 generations (ten generations of OC selection) the genetic gain increase up to 1.24 units in contrast to the comparable TS, witch was a random selection with no increase of genetic gain. Further relaxation of ΔF decreased the benefit of OC selection (ΔF = 0.01 1.4-fold and ΔF = 0.025 1.1-fold genetic gain after 20 generation).
For TS the number of selection candidates was higher than for OC selection yielded the same ΔF in all generations. For the most severe ΔF the number of selection candidates was 100 for the ten generation of TS (50 males and 50 females) witch is similar to a random selection. After converting the breeding program the number of selection candidates dropped down to average 84 (42 males and 42 females) for OC selection. The relaxation of ΔF led to a decreased number of selection candidates, as expected. For an expected ΔF = 0.01 the number of selection candidates dropped down to 72 for TS and average 56 (28 males and 28 females) in OC selection and for ΔF = 0.025 the number of selection candidates was 36 for TS and average 30 (15 males and 15 females) for OC selection.

Fixed genetic gain. Figure 2 shows the inbreeding coefficient for the TS and CS when both had the same genetic gain. Inbreeding was highest when only 10 animals (5 males and 5 females) were selected for the TS. Therefore the average ΔF for the first ten generation of TS was 0.109 and the inbreeding coefficient raise up to 0.603. After changing to the OC selection the same genetic gain as in the comparable TS could yield by restricting ΔF to 0.025 so that the inbreeding coefficient after 20 generations increased to 0.703 which was 26% lower than in the comparable TS.

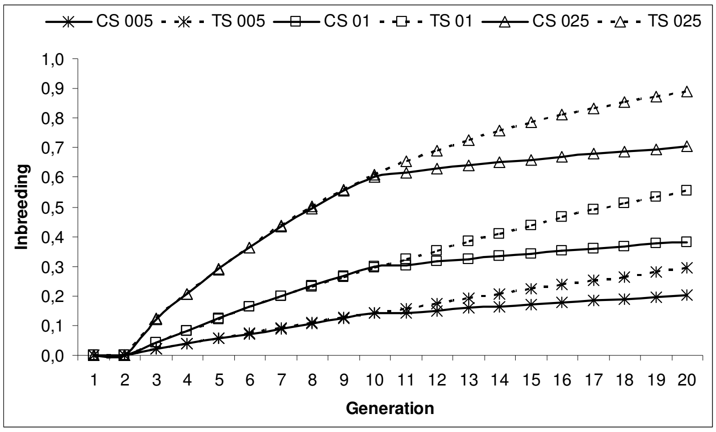

Figure 2: Average coefficient of inbreeding for truncation selection (TS) and converting selection (CS) over 20 generations when both yielded the same genetic gain and ΔF was constraint to 0.005, 0.01 or 0.025 for CS.

When increasing the number of selection candidates for TS the inbreeding coefficients and the genetic gain decrease. Nearly the same difference in the inbreeding coefficient after 20 generation was obtained when selecting 26 (13 males and 13 females) in the TS and constrained ΔF to 0.01 in the following OC selection. In this case, the average ΔF for the ten generation of TS was 0.176. When selecting 50 animals (25 males and 25 females) with the

TS and a constraint ΔF to 0.005 the difference of inbreeding coefficients in generation 20 was highest with 31%.

Conclusion

This work showed the change of an existing breeding scheme with TS for BLUP EBV to an OC selection scheme. The change to an OC selection can increase genetic gain for a given rate of inbreeding or attain similar genetic gains at much lower rates of inbreeding compared to previous TS. Compared with TS over the same selection horizon the change to a breeding program to an OC selection can lead to a decrease of rates of inbreeding or increase of genetic gain for a long term. In this work the chance of a breeding program with discrete generations was shown, but the OC algorithm can extend to overlapping generations (Grundy et al., 2000; Meuwissen and Sonesson, 1998).

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