OPTIMAL CONTRIBUTION SELECTION IN C LINE HYCOLE: PROSPECT FOR GENETIC GAIN

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ABSTRACT

One of the consequences of breeding programs is the increase in inbreeding. The control of inbreeding avoids the occurrence of problems such as inbreeding depression or reproductive problems. Some alternatives, as mating plans, can be used to limit inbreeding progression. However, these alternatives slow down the genetic progress and do not make it possible to anticipate with precision the increase of inbreeding. The Optimum Contribution Selection (OCS) method maximizes the genetic gain while limiting the increase in inbreeding via an optimization equation. This optimization is done when selecting candidates at weaning and takes into account their degree of relationship, their contribution to the population, and their genetic value. The OCS method has been tested for routine application on the C line to measure the impact on genetic gain and livestock management. A comparison of the genetic gain was performed with the current truncation method of selection and the OCS method. A genetic gain up to 10 times higher is obtained using OCS method with a decrease of inbreeding. The implementation of this tool would not result in any significant change in livestock management, and would remove some constraints related to the management of inbreeding.

Key words: inbreeding, contribution, optimization, genetic gain

INTRODUCTION

In breeding programs, the balance between genetic gain and inbreeding is a key point. Many practices can be used to manage the evolution of the inbreeding rate (ΔF), but most of them cannot anticipate it (Woolliams *et al.*, 2015). For some selection schemes, as in rabbits, this evolution is difficult to measure because the selection is generally managed in overlapping generations. Moreover, by managing the inbreeding, genetic gain can be restrained. To respond to these constraints, Meuwissen (1997) and then Pong-Wong and Woolliams (2007), proposed a method called Optimum Contribution Selection (OCS), which optimizes the selection of candidates by maximizing the genetic merit and restricting the evolution of inbreeding to a fixed level. Nevertheless, these studies are based on simulated populations. The aim of this study was to apply the OCS method in the C line of rabbits. In this line several empirical practices have been implemented for several years to keep ΔF under an acceptable value. However, these practices do not allow a precise management and the possibility to anticipate the evolution of ΔF. The OCS application at the selection of candidates could reduce the constraints applied to manage inbreeding. The rate of inbreeding could be anticipated and genetic gain could be improved.

MATERIALS AND METHODS

Data

The different characteristics of the C line are presented in Table 1.

Table 1: Presentation of the C line

Type	Female line
Population	Closed nucleus
Type of generations	Overlapping generations
Pedigree	12 176 animals, no missing parents
Selection criteria	Maternal qualities : litter weight and litter weight range at 21 days, number of teats, fertility, number of born alive
Average number of animal per generation	1200
Number of females	210
Number of males	40
Main selection step of candidates	At weaning - 28 days old
Calculation of candidates EBV at weaning	From dam and sire EBV Multi-trait index estimated by BLUP method
Number of farms	1
Batch	Single group – Every 6 weeks
Cycles	8.7 /year

Selected females produce their first young rabbits at 24 weeks of age and are controlled, without producing future breeders, during their first three cycles to collect reproductive performances, in order to improve accuracy of maternal qualities EBV. Selected males produce their first young rabbits at 26 weeks. Each female produced an average of 10 progenies to the stage of first selection with a 50% random allocation of gender. To control the evolution of inbreeding, mating groups and limitation of siblings kept to renew the population have been set up.

Estimation of inbreeding rate of the actual generation and determination of inbreeding limit for the next generation

To fix the inbreeding limit of the next generation, the actual inbreeding of the population, Fn, must be estimated. It has been calculated with the Numerator Relationships Matrix (NRM) (Falconer and Mackay, 1996), considering all matings made in the last year:

$$\mathbf{Fn} = \frac{\sum \frac{\mathbf{a_{AX}}}{\mathbf{2}} + \sum [\![(\mathbf{a})]\!]_{\mathbf{XX}} - \mathbf{1})}{\mathbf{number\ of\ matings}}$$

where a_{AX} is the additive genetic relationship coefficient between animals A and X, and a_{XX} corresponds to the additive genetic relationship coefficient of an animal with itself. With the actual management, ΔF for the C line is estimated around 0.5% per year, where one generation represents one year.

The OCS method

Optimization used in this study is based on the OCS approach developed by Pong-Wong and Woolliams (2007) and applied to a population managed in overlapping generation. This model uses the optimization equation developed by Meuwissen (1997) to maximize genetic gain with a fix inbreeding evolution between 2 generations:

$$H = cTg - \lambda 0(cTAc\text{-}K) - (cTQ\text{-}0.5*1T)\,\lambda$$

where H is the optimization, T the transposed matrix, Q the incidence matrix, K the inbreeding constraint, λ0 and λ Lagrangian multipliers, c the contribution vectors, g the EBV and A the NRM matrix.

In order to apply it to a population with overlapping generations, population is split in several groups defined by their physiological status. First, candidates to selection and all animals younger than candidates (here 28 days of age) are defined as generation n+1 and all the older and active are generation n. In the case of C line, only animals in the generation n+1 are the candidates from the litters producing renewal. Then all animals not submitted to selection the day of optimization have a fixed contribution. All the females have a fixed contribution equivalent to one litter in generation n+1 and the males have a fixed contribution equivalent to the number of litters born from them. The other animals and the males with a fixed contribution but still active are optimized by the OCS program. This approach is dynamic. At each optimization, OCS is adapted to the physiological status and one part of the population is optimized.

Comparison between truncation method and OCS method

A comparison between the actual truncation selection method and OCS method has been done using 9 batches controlled during 2017. In each method, the global EBV is calculated on a 100 basis with a standard deviation of 30. For the truncation method, selected animals are the animals that have been selected in reality, considering their genetic value and inbreeding constraints (0.5 per year). Reproductive animals in the C line are selected depending on their EBV and mating group affiliation. The genetic gain is calculated with the selection differential between the EBV of selected animals by truncation and the EBV of all the candidates, by supposing each animal has the same contribution and a sex ratio of 0.5. OCS selected animals are chosen by the OCS method.

RESULTS AND DISCUSSION

ΔF evolution and genetic gain improvement

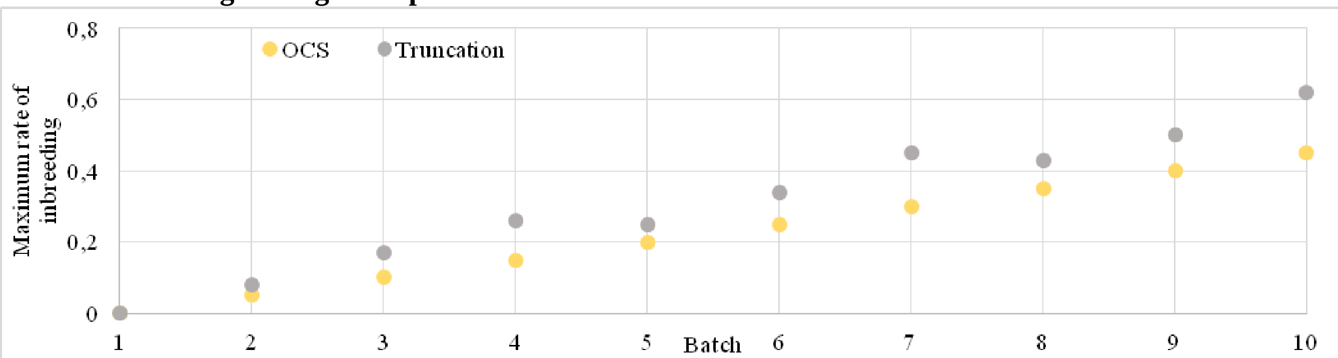

Figure 1: Evolution of the maximum rate of inbreeding for one generation of the year 2017

The evolution of the inbreeding for one generation of the year 2017 is showed in Figure 1. **ΔF** obtained with OCS method is 0.45, which is lower to the **ΔF** objective of the C line (0.5), whereas the truncation method leads to a **ΔF** of 0.62, which is higher than 0.5. This means that the C line population is responding as intended to the OCS method. Figure 2 represents the selection differential for the truncation and the OCS methods for each batch.

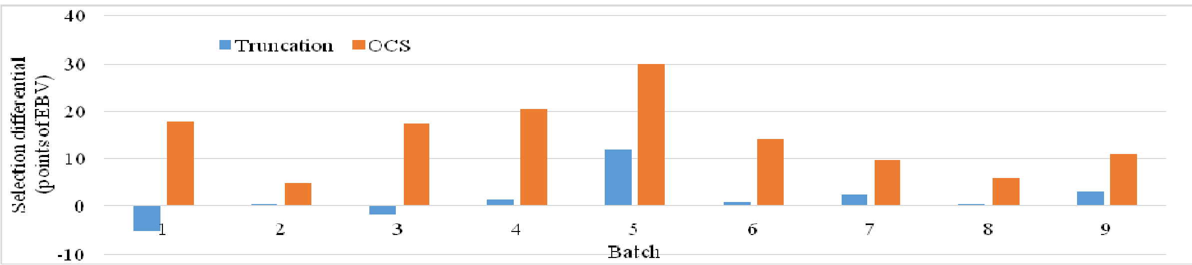

Figure 2: Selection differential (points of EBV) with truncation and OCS methods

Truncation method applied with inbreeding constraints allows an average genetic gain of 1.4 point. These constraints even lead to some batches with a negative genetic gain (batches 1 and 3). On the other hand, the OCS method allows an average genetic gain of 14.6 points, with all batches realizing progress. The maximum genetic gain is obtained on batch 5, with 30 points, whereas the truncation method obtained 12 points in the same batch.

Genetic gain with OCS method is higher than with truncation method, while keeping ΔF at its objective, whereas inbreeding constraints were not. Genetic gain obtained in this study is lower than the one obtained in the study of Avandaño *et al*. (2003), who estimated an increase of 20% to 40% of genetic gain. However, their study was based on simulated populations of Angus cows and Meatlinc sheep, with discrete generations, and with no restrictions on males use. In the present work males uses are limited to physiological and technical abilities. Moreover, the ΔF was 1% per year, which was higher than the ΔF of C line. However, applying OCS selection allows to anticipate the rate of inbreeding and to manage it to increase or decrease genetic gain.

This study has been realized with historical data and some breeding aspects were not considered, such as sanitary restriction or cross-breeding. In fact, sanitary conformity is an important factor, which increases selection pressure. In this study, every candidate was considered sanitary good for selection. To apply OCS method efficiently in routine, it will be important to adjust to the needs and to adapt to the zootechnical risks.

CONCLUSION

The OCS method is an interesting tool to maximize the genetic gain at a given inbreeding rate. Due to a precise modeling of the C population, a genetic gain up to 10 times higher is obtained while maintaining the objective inbreeding rate. It has been tested for routine application on the C line and its livestock management, and does not change too much the management of this line. In fact, the zootechnical risks were already well anticipated between selection and the first artificial insemination. OCS would even facilitate the management by removing some constraints related to the management of inbreeding, such as mating groups, and allows to anticipate the rate of inbreeding. The next step will be to see the real genetic gain obtained at the given inbreeding rates by this method in a year.

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