Conservation of an endangered pig breed using optimum contribution selection

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Abstract

The present study focuses on optimizing the breeding plan for an endangered Danish Landrace pigs. This original landrace pig breed (DL-1970) was until 1970 used for production of bacon, after which the breed was crossed with other landrace breeds. This study deals with the animals from DL-1970, which originates from the breed before crossing. Seven boars and 46 sows were available for selection. Optimum contribution selection (OCS) was applied to select boars and sows. Average relatedness between male candidates was 0.35, between female candidates 0.45 and between male and female candidates 0.39. Using OCS yielded lower inbreeding levels (0.141) compared to random mating (0.195). Due to the high level of relatedness between the animals and the very small population size it is recommended to use material from the gene bank to increase genetic variation in the future.

Introduction

The DL-1970 is a distinctive feature of Danish agricultural history, as the great export adventure with bacon in the first half of the last century was based on this pig breed. Around 1970, however, the breeding goal for Danish Landrace changed to having increased focus on growth, feed efficiency, fertility and meat quality (Sørensen and Nielsen, 2017). In the 1980s, crossbreeding was also performed between Danish Landrace pigs and landrace pigs from Norway and Finland. Today there are only a few individuals left of the original DL-1970 as it was in 1970 before crossing and change of the breeding goal. Therefore, the breed's existence is currently threatened. If a local breed is lost, a cultural value will be lost (Meuwissen et al., 2009). DL-1970 have a large cultural value in Denmark, since this breed founded the Danish Bacon adventure and most pigs in the current production are founded on this bred. If the breed is to survive and increase in population size, it is important that there are optimal production methods for the breed as well as possible sales opportunities for the finishers. Last but not least, it is important to maintain the genetic variation as large as possible (Meuwissen, 2009). The present study focuses on optimizing the breeding plan for DL-1970 by use of Optimum contribution selection (OCS) for selection of sires and dams.

Materials & Methods

Data. The data set included the identity (id) of the animal, id of the sire, id of the dam, sex of the animal and date of birth. There were 1179 individuals in the pedigree with the oldest animal born in 1983 and the youngest born in July 2019. Pedigree completeness (the proportion of known ancestors in each ascending generation, MacCluer et al., 1983) was calculated by tracing the pedigree 8 generations back. Potential breeding candidates were seven boars and 46 sows born from January 2018 until July 2019. Matings were assumed to occur naturally. Thus, for the optimum contribution selection it was assumed that each boar could mate a maximum of 10 sows.

Optimum contribution selection. OCS maximizes the genetic level of the next generation of animals while at the same time restricting rate of future inbreeding by restricting the increase in average co-ancestry (Meuwissen, 1997). We used the EVA software (Berg et al., 2006) to perform OCS. The function to maximize in OCS with overlapping generations was shown in Henryon et al. (2015). With full weight on average relationships and minimization of inbreeding, as applied in the current study, the function is:

$$U_t(c) = \frac{\omega}{L^2}(c + Pv)'A(c + Pv) \qquad (1)$$

Where,
c is a vector with n (total number of animals in the pedigree) genetic contributions to the new cohort,
$\omega\omega$ is a penalty applied to the average relationship of the current population,
LL is the generation interval,
PP is a matrix of size n*k with contributions to each age class of animals in the current generation,
k is the number of sex-age classes in the current generation,
vv is a vector with k expected relative contributions to future age classes,
and AA is a n*n matrix with additive genetic relationships.

Results

From 1980, pedigree completeness (Figure 1) was low, increasing to around 80 % after 2000, when tracing the pedigree back 8 generations.

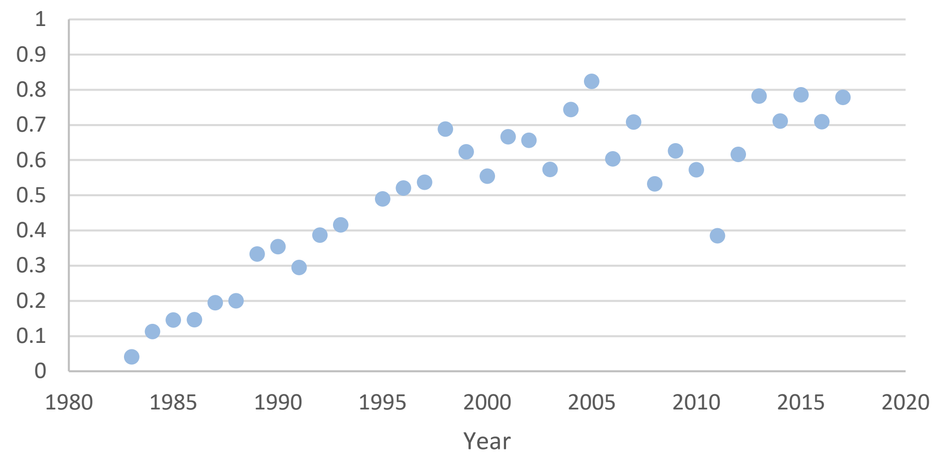

Figure 1. Pedigree completeness index (8 gen) from year 1983 to 2019.

Figure 2 shows the average inbreeding of the progeny from year 1980 to 2019. The average inbreeding was high, up to 0.33 in year 2002. During the last 5 year period, the average inbreeding was around 0.15 to 0.20.

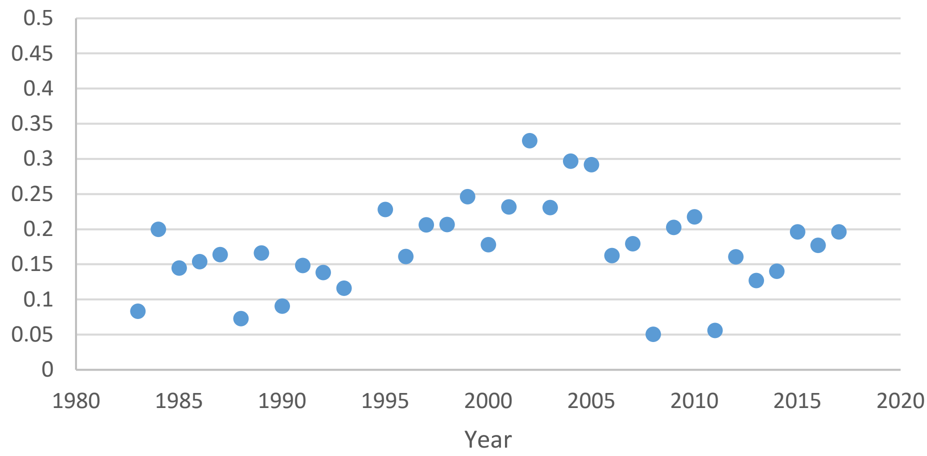

Figure 2. Average inbreeding of progeny over years

The average relatedness between male candidates were 0.35, between female candidates 0.45 and between male and female candidates 0.39. By applying OCS for selection of 20 matings, only 3 out of the 7 boars were selected (Table 1). Their contributions varied from 10 to 50%. Thus 2 sires had high contributions, which may be a problem in the future even with the use of OCS. Likewise, OCS selected 20 out of 46 available female candidates. It is clear from Table 1 that the boars selected are those with lowest relationship with the rest of the female populations.

Table 1. No of contributions (matings) for each of the sires and its relationship with the male and female population.

Boar	No of matings	Relationship with males	Relationship with females
1	0	0.405	0.386
2	10	0.424	0.260
3	2	0.439	0.281
4	0	0.484	0.447
5	0	0.507	0.548
6	8	0.424	0.266
7	0	0.530	0.543

Under random mating, expected average inbreeding was 0.195, whereas expected average inbreeding was 0.141 when applying OCS. In the last year (2017) observed with selection in the dataset, average inbreeding was 0.196. This means that by applying OCS it is possible to reduce average inbreeding in the progeny by around 0.05 compared to the previous year.

Discussion

In the present study we used OCS to optimize the breeding plan for an endangered pig breed. Using OCS yielded substantial lower inbreeding levels compared to random mating. However, the level of relatedness between the animals is very high, which means that the population is critically endangered.

In addition to using OCS, one option would be to use material from the gene bank (Hulsegge et al., 2019), which contains both semen and embryos. This stock of sperm and embryos in the gene bank was established as a safeguard that can be used if the living population is critically endangered and needs to be able to increase the genetic variation. Freezing of semen and embryos from the breed began as early as in 1996. There is semen from a total of 11 boars produced in 1996, 2001 and in 2017. Seven of the 11 boars are from a previous control line, which has shown to be only distantly related to the current population of DL-1970 (Szekeres et al., 2016). In addition, there are embryos from 16 sows and 13 boars. The living population of Danish Landrace pigs is at present at a size where use of the material in the gene bank is needed. Thus, the next step is to run OCS using semen and embryos from the gene bank.

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