Management of Genetic Characteristics

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Abstract

Within the last years several research groups showed that there are different haplotypes which may cause embryo loss in the homozygote state. Ongoing research will identify more of them in the next years. Therefore there is a clear demand to develop a genetic index to combine recessive fertility defects (HH1-HH5 and Brachyspina) with positive traits (polled) for publication and mating decisions. The genetic index depends on the allele frequencies of the recessive fertility defects in the population and the economic value of the genetic characteristic. Non-Return-Rate was used to determine the economic value per lost embryo. A genomic breeding program was simulated to study the impact of changing the selection criteria from assortative mating to selecting the females due to the genetic index. In conclusion the results demonstrate that selection for a genetic index on the female path is a method to control the allele frequencies by reducing undesirable alleles and simultaneously increasing positive traits maintaining most of the genetic gain in other traits. However further instigation is needed to determine the correct time of embryo loss and the economic value. For breeding decisions the index should be used for the female path and bulls should be selected due to breeding values to maintain the genetic gain in the quantitative traits. Mating recommendations should be derived using mating programs taking all genetic characteristics of mating partners into account.

Key words: genetic index, recessive diseases, genomics, fertility, embryo loss

1. Introduction

Routine genotyping of thousands of animals per year for genomic evaluation provides the possibility to discover recessive fertility defects. VanRaden *et al.* (2011) showed that there are three different haplotypes for Holstein (HH1, HH2, HH3) which may cause embryo loss in the homozygote state. Other research groups from France (Fritz *et al.*, 2013), Denmark (Sahana *et al.*, 2013) and America (Cooper *et al.*, 2013) confirm these haplotypes and identified additional haplotypes and mutations which are associated with a fertility decrease. But there are also positive traits like polled and casein, which should be expanded in our populations. In future due to increased genotyping and next generation sequence analyses it is foreseeable that there will be a lot of new lethal recessive fertility defects detected which have to be combined with positive characteristics for publications and mating decisions.

The aim of this study was to develop an index of genetic properties which summarize the genetic characteristics considering their economic values.

2. Materials and Methods

Table 1 illustrates the effect of a genetic recessive fertility defect on the population. The effect depends on the genotype of the sire, the allele frequency (p and q) of the population and the economic value (α). The genetic index is the sum over the different considered genetic characteristics.
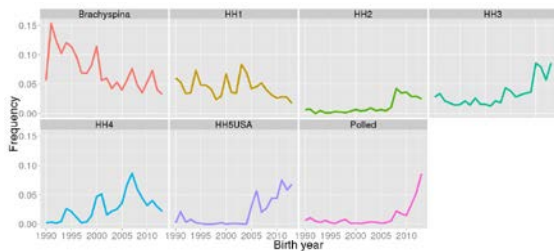
Table 1. Effect of a recessive fertility defect on the population.

Genotype sire	Average effect population
AA	$2q\,\alpha$
AB	$(q-p)\,\alpha$
BB	$-2p\,\alpha$

Carrier frequencies and economic values

Six recessive fertility defects (Brachyspina, HH1 - HH5) and one positive trait (polled) were chosen for the study. Figure 1 shows the development of the carrier frequency over the birth years for the seven traits. Brachyspina, HH1, HH2 and HH4 are decreasing at the moment, but especially Brachyspina had a high carrier frequency in the German population in the past. In contrast HH3 and HH5 are still increasing because the popular sires PICSTON SHOTTLE and O-BEE MANFRED JUSTICE-ET, which have a high impact on the German population carrying these haplotypes. Polled is also increasing at the moment because of a social policy force to avoid dehorning.

Figure 1. Carrier frequencies of the analysed recessive fertility defects.

To determine the economic value for each recessive fertility defect Non-Return-Rate (NRR) 56 and 90 for heifers as well as stillbirth were analysed to approximate the time of embryo lost (table 2). For Brachyspina, HH1 and HH2 a significant effect on NRR90 could be determined whereas for NRR56 only a slight effect was found. This implicates that the embryo dies between day 56 and 90. Compared to that a main effect on NRR56 for HH3 and HH4 is reported, which implies that the embryo dies before day 56.

Because of different times of embryo loss two different economic values of 95 and 52 euros per lost embryo were considered. For polled the economic value was set to seven euro per calf, because an average farmer saves five euro salary and two euro for drugs if the calve is polled. The social policy value was not considered. No other positive traits were included because these traits have no economic benefit for an average German farmer.

Table 2. Impact of recessive fertility defects on fertility traits.

	NRR56	NRR90	Still-birth	Economic value per embryo
BY	-0.2	-1.6	1.8	95
HH1	-0.5	-2.1	1.3	95
HH2	-0.6	-2.8	2.7	95
HH3	-3.5	-4.4	-0.3	52
HH4	-4.0	-4.2	-0.7	52
HH5	-3.0	-1.0	2.1	95

Simulation of a genomic breeding program

To investigate the influence of a genetic index on breeding values and allele frequencies a genomic breeding program was simulated as reported by Täubert *et al.* (2012) and Segelke *et al.* (2013).

The breeding program assumes a size of 250,000 dairy cows under milk recording, from which the best 1% will be selected as bull dams based on their breeding values. From these dams 1,250 male selection candidates are born. 500 bull calves will be genotyped from the 1,250 candidates. 29 of these 500 bull calves will be selected on genomics and used as service sires as soon as they produce semen. One bull will be for second crop service. To realise as much genetic gain as possible, 95% of sire of sons are young genomic tested bulls. Only 5 % of all sires of sons are also daughter proven. Cow sires are 94% genomic proven and 6% daughter proven bulls.

The cow base population had a mean of 100 and a variation of 20. The reliability of the estimated breeding values was 50%. Because the AI bulls are superior compared to the cows, 500 bulls were simulated in the first generation with a mean of 130 and the best 30 animals were selected as sires. The reliability for the estimated breeding values was 67% for the genomic bulls and 99% for the daughter proven bulls. There was no mating of close related animals. 20 generations were investigated and the simulation was 100 times repeated.

Two different breeding scenarios for the females were analysed:

1) Scenario A: All animals were selected due to breeding values. The genetic index was not considered.
2) Scenario I: Animals on the dam-dam path were selected due to the genetic index.

In both scenarios the AI bulls were selected due to the estimated breeding values to maintain the genetic gain for the quantitative traits.

3. Results

Figure 2 shows for both scenarios the development of the breeding values over 20 generations for bulls and dams. Over the time a great increase of the breeding values can be found. Changing the mating strategy of the female side from assortative mating to selection on genetic index results in little loss of genetic gain compared to scenario A.

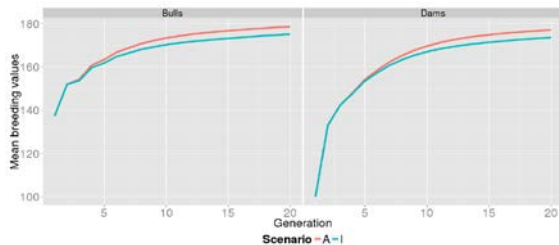**Figure 2.** Development of the breeding values over 20 generations.

Figure 3 shows the development of the genetic index over 20 generation for both scenarios. In both scenarios there is an increase of the mean genetic index over time. Because homozygote animals are not able to survive, there is a natural selection against recessive alleles resulting in a increase of the genetic index. Additionally polled is a dominant trait which also results in an increase of the genetic index. However selecting the females due to scenario I instead of selecting them due to the breeding values results in a higher increase of the genetic index.

Figure 3. Development of the genetic index over 20 generations.
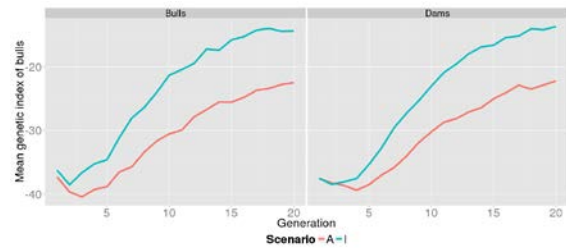
Figure 4 illustrates the change of the allele frequencies for the seven analyzed traits. As already mentioned recessive fertility defects are decreasing over time because homozygote embryos do not survive. Polled increase a bit in scenario A because of the dominant inheritance. In scenario I there is a higher increase of the polled allele frequency because the positive economic value results in a slight additional selection for polled. In comparison the recessive fertility defects have a negative economic value which results in an additional selection against these traits. In conclusion the figures demonstrate that selection for a genetic index is an efficient method to control the allele frequencies by reducing undesirable alleles and simultaneously increasing positive traits.

Figure 4. Development of the mean allele frequencies over 20 generations.
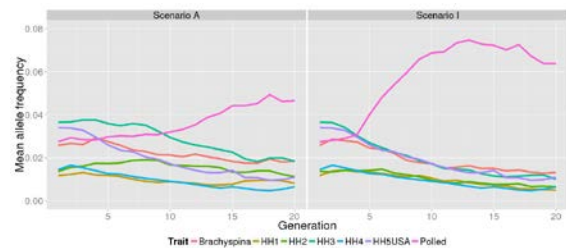
4. Discussion

Non Return Rates as well as stillbirth were used to determine the time of embryo loss. Estimated effects of HH3 and time of embryo loss are in agreement with VanRaden *et al.* (2011a). However for Brachyspina and HH2 the estimated effects deferred. VanRaden *et al.*

(2011a) concluded that for Brachyspina and HH2 the embryo loss is mainly before 60 days, whether our results suggest that the time of embryo loss is between day 56 and 90. For HH1 VanRaden *et al*. (2011a) concluded that the embryo dies throughout the gestation. The difference between the two studies shows that the measures are approximately and new traits and measurements are needed to determine the correct time of embryo loss. Additionally more research is needed to determine whether the effects of the receive alleles are already considered in the fertility breeding values and how the genetic index can be integrated in the total merit indices.

5. Conclusion

A genetic index is a method to combine different genetic characteristics with different economic values. Because of ongoing detection of recessive fertility defects there is a clear demand to consider the genetic characteristics due to their economic value and combine them to an index for publication. However further investigation is needed to determine the correct time of embryo loss and the economic value. For breeding decisions the index should be used for the female path and bulls should be selected due to breeding values of production and functional traits to maintain the genetic gain. Mating recommendations should be calculated using mating programs taking all genetic characteristics of mating partners into account.

6. Acknowledgments

7. References

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