Effects of inbreeding on semen quality of Friesian stallions

Colloquium summary

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Introduction

The Friesian Horse Studbook has been registering Friesian horses since 1879. There have been two serious bottlenecks in the pedigree in 1913 and in the 1960's, when the breeding population was very small (Sevinga *et al.,* 2004). After the 1960's, the population size increased and nowadays consists of more than 40,000 animals. Currently, there are 88 active breeding stallions and about 6,000 foals are born each year (www.kfps.nl). The effective population size, however, is limited. There is continuing concern that the narrow genetic base and high inbreeding rates in the Friesian horse population may limit genetic progress and increase the frequency of heritable disorders.

Because a stallion usually mates many mares, stallion fertility is an important factor of the overall success of a breeding program (van Buiten *et al*., 2003). Before Friesian stallions can be registered for breeding, they must pass a breeding evaluation test. It is clear that semen quality of Friesians is low, compared to e.g. Dutch Warmbloods (Parlevliet *et al.,* 1994). Almost 50% of the submitted Friesian stallions are rejected from breeding because of insufficient semen quality. Inbreeding is widely believed to have detrimental effects on reproduction. First aim of the current study was to investigate if inbreeding level affects semen quality traits of Friesian stallions. Furthermore, it was hypothesized that inbreeding on particular ancestors of the Friesian horse population is responsible for certain positive or negative effects with respect to semen quality. Therefore, the second aim was to investigate if a higher degree of inbreeding of stallions on particular ancestors can have influence on their semen quality traits. Third aim was to estimate genetic parameters for semen quality, because those were not yet available for Friesian stallions.

Material and methods

Semen evaluation took place at the Department of Equine Sciences of Utrecht University during the years 1987-2002. Stallion age ranged from 24 to 47 months and was assigned to two age classes of ±2.5 or ±3.5 years old. Ejaculates were collected in September, October and November. Semen quality of one ejaculate was analyzed for 1146 stallions. Six semen characteristics were investigated: ejaculate volume, sperm cell concentration, % progressively motile sperm and % morphologically normal sperm; TNM value, which is a multiplication of these four traits; and % abnormal acrosomes, which is part of morphology. The possible effects of year, month and age at time of semen evaluation were investigated with SAS (SAS, 1985), using the GLM procedure. The inbreeding coefficient over the entire pedigree of each animal was estimated with PEDIG (Boichard *et al.,* 1997) and included in the linear models. ASReml (Gilmour *et al*., 2002) was used to estimate heritabilities and breeding values. CFC (Sargolzaei *et al.,* 2006), was used to calculate the ancestral decomposition of inbreeding for each analyzed stallion. To investigate ancestral effects, inbreeding coefficients on 26 ancestors were included in the linear model as a separate factor.

Results

Mean values and heritability estimates of the analyzed traits are shown in table 1. Semen quantity and quality was lower for younger stallions, % abnormal acrosomes increased over the years and morphological quality was lowest in November. No effect of inbreeding on semen characteristics was found, except that volume increased when inbreeding level was higher. Twelve of the 26 analyzed ancestors were found to have a significant effect on one or more semen quality traits. Most ancestral effects were found for % abnormal acrosomes.

Table 1: Mean values and heritability estimates of semen quality parameters and mean values of inbreeding percentage.

Variable	*Mean*	*Std. dev.*	*Minimum*	*Maximum*	*h^2 (± SE)*
TNM value	1815.94	1716.50	0.10	17028.10	0.21 ± 0.07
Ejaculate volume (ml)	53.49	24.59	10.00	210.00	0.20 ± 0.07
Sperm cell concentration ($x10^6$/ml)	109.33	115.99	1.00	1128.00	0.22 ± 0.07
Progressively motile sperm(%)	66.83	12.60	1.00	90.00	0.26 ± 0.08
Morphologically normal sperm (%)	52.93	15.62	1.00	88.60	0.45 ± 0.10
Abnormal acrosomes (%)	32.99	19.67	0.00	97.00	0.62 ± 0.11
Inbreeding over entire pedigree (%)	15.17	1.75	10.13	22.06	

Discussion

There was a limited range in inbreeding percentage and the lowest percentage was already 10.13%, which could be reasons that, except from the small effect on ejaculate volume, no effect of inbreeding on semen quality was found. Populations seem to differ in sensitivity to inbreeding depression (reviewed by Oliehoek, 1999). This might be a reason that inbreeding was found to have a detrimental effect on semen quality traits in Shetland ponies (Van Eldik *et al*., 2006), but that these effects are not seen in Friesian horses.

The moderate to high heritability estimates, combined with the large phenotypic variation present for semen quality parameters, indicate that selection could be a promising tool to improve semen quality in Friesians. However, it is yet unknown if there is sufficient genetic variance to make genetic progress possible. At the moment, almost half of the submitted Friesian stallions fail to meet the minimum requirements for semen quality. When the percentage that passes semen quality examination would increase, there are more possibilities to select stallions on other phenotypic traits, e.g. conformation and gaits.

Analysis based on pedigree information alone, suggests that it is the passage of genes underlying semen quality which explains the ancestral effects. Inbreeding increases homozygosity and thereby attends fixation of recessive deleterious alleles. This is a potential mechanism by which inbreeding on a particular ancestor might affect semen quality in stallions. In the current study, only 26 ancestors were analyzed for effects on semen quality. These results indicate that further research, with respect to other influential ancestors as well as to other traits, could provide interesting information about the way in which inbreeding can spread certain abnormalities through a population.

Foaling rate might be a more representative index of stallion fertility than semen quality, but those numbers are retrospective and largely influenced by factors like mare reproductive status and breeding management (Colenbrander *et al*., 2003). Stallions with really poor semen quality will fail to produce many offspring, but good semen quality is not always a guarantee for adequate reproductive performance. The true relationship between semen quality and pregnancy and foaling rates has not been determined yet.

Conclusions

- Except for ejaculate volume, higher inbreeding levels did not affect semen quality of Friesian stallions.
- The moderate to high heritability estimates suggest that semen quality is determined substantially by the genotype of a stallion. If stricter selection on semen quality can improve fertility of Friesians, depends on the amount of genetic variance and on the effect of improved semen quality on pregnancy and foaling rates.
- Twelve of the 26 analyzed ancestors were found to have a significant influence on one or more semen traits. It indicates that further research, with respect to other ancestors and other traits, could provide interesting information about the way in which inbreeding can spread certain abnormalities through a population.

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