Investigations on genetic variability in Holstein Horse breed using pedigree data

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Holstein Horses are expressive sport horses with preferential aptitude for show jumping, originated in Schleswig-Holstein, Germany

Breeding organisation founded in 1935

Formation of the breed influenced by Yorkshire Coach and Thoroughbred horses

Due to agricultural mechanisation, breeding goal shifted from medium weight draft horse to large framed riding horse

Refinement driven by Anglo Normans and Thoroughbreds

Studbook for mares strictly closed, use of foreign stallions is minimized
Aims of the Study

• Point out updated levels of inbreeding (incl. “age” of inbreeding) and effective population size

• Determine proportion of foreign blood in population

• Specify genetic contributions of outstanding ancestors to current structure of breeding stock
Material and Methods

Pedigree data:

- Breeding stock: 7,693 mares, 225 licensed stallions (2012)
- Total pedigree: 131,272 animals (until 2010)
- After revision: 129,923 animals analysed
- First recorded ancestor born in 1869
- Reference population: horses born 1990 until 2010 (n = 78,677)
- Essential metrics of population structure calculated for reference population
  
  software: PEDIG (Boichard, 2002)
Material and Methods

Inbreeding:


- Method of Kalinowski et al. (2000) used to determine “age of inbreeding”:
  
  'Classical inbreeding (Wright, 1922) divided into two parts: ancestral inbreeding (homozygous alleles, met in the past) new inbreeding (alleles which are homozygous first time)

Effective population size ($N_e$):

- Computed with classical approach (Sölkner et al. 1998):

$$N_e = 1/(2^F)$$
## Results

### Population structure:

#### Metrics of pedigree analysis for reference population

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedigree Completeness</td>
<td>%</td>
<td>88</td>
</tr>
<tr>
<td>average Generation equivalent</td>
<td>generations</td>
<td>5.62</td>
</tr>
<tr>
<td>Generation Interval</td>
<td>years</td>
<td>10.3</td>
</tr>
<tr>
<td>$F_{\text{reference population (all horses)}}$</td>
<td>%</td>
<td>2.27</td>
</tr>
<tr>
<td>$F_{\text{anc}}$ (Kalinowski, 2000)</td>
<td>%</td>
<td>0.08</td>
</tr>
<tr>
<td>$F_{\text{new}}$ (Kalinowski, 2000)</td>
<td>%</td>
<td>1.38</td>
</tr>
<tr>
<td>Effective population size</td>
<td>n</td>
<td>55.3</td>
</tr>
<tr>
<td>Founders</td>
<td>n</td>
<td>3,194</td>
</tr>
<tr>
<td>Effective founders</td>
<td>n</td>
<td>50.2</td>
</tr>
<tr>
<td>Ancestors to explain 50% of gene pool</td>
<td>n</td>
<td>11</td>
</tr>
</tbody>
</table>
Inbreeding:

Average inbreeding per time (inbred and non-inbred horses)
Results

Effective population size:

Development of effective population size ($N_e$) per generation

<table>
<thead>
<tr>
<th>Generation</th>
<th>$N_e$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950 - 1960</td>
<td>499.7</td>
</tr>
<tr>
<td>1960 - 1970</td>
<td>416.6</td>
</tr>
<tr>
<td>1970 - 1980</td>
<td>134.7</td>
</tr>
<tr>
<td>1980 - 1990</td>
<td>108</td>
</tr>
<tr>
<td>1990 - 2000</td>
<td>49.4</td>
</tr>
<tr>
<td>2000 - 2010</td>
<td>61.1</td>
</tr>
</tbody>
</table>
Genetic contributions of foreign breeds (%):

- Holstein: 40.1%
- Engl. Thoroughbred: 25.9%
- Anglo Norman/Selle Français: 16.3%
- Arabian breeds: 3.27%
- Hanoverian: 2.75%
- Other breeds: 0.72%
Results

Most formative male ancestors:

Year of birth

Genetic contribution %

Cor de la Bryère AN
Ladykiller xx
Capitol I
Cottage son xx
Ramzes AA
Almé AN
Inbreeding:

• Reason for increase in average inbreeding could be concentration on few stallions out of certain sire lines enforced by artificial insemination

• With closed Studbooks, access of different breeds into breeding program is limited

Effective population size:

• With 55 animals, effective population size was determined on low level

• FAO (1981) constitutes critical value of 50 animals to achieve a minimum amount of genetic variability
Conclusion

• Results illustrate loss of genetic diversity related to unequal contributions caused by intensive use of particular sires

• Inbreeding mostly occurred in newer generations

• Low $N_e$ endangers preservation of genetic variability

• In recent past: stagnation in rate of inbreeding and slight increase in number of effective animals

• Rising trend in $N_e$ might caused by changes in breeding policies ’ more open access for foreign stallions
Thank you for your attention!!

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HOLSTEINER
CHARACTER. CHARISMA. KLASSE.