

A WHFF VIEW ON INBREEDING IN HOLSTEIN CATTLE

Inbreeding is a current topic in Holstein breeding since breeding programmes worldwide are focussing on a limited number of Holstein bulls to become sires of sons. An analysis completed in 2010 by the Holstein Association of Japan, under the auspices of the World Holstein Friesian Federation (WHFF), showed that in some of the leading Holstein countries a level of the inbreeding coefficient of around 4% to almost 6% was present. Besides that the trend in most Holstein populations shows an ongoing increase of the inbreeding coefficient.

Due to the widespread use of popular AI sires across the Holstein breed in recent years there is the potential risk for continuous increase of inbreeding, unless breeders and their breeding organisations actively avoid the mating of closely related animals.

Breeding

In general, breeding is focused on the improvement of the genetic ability of the animals, with the aim that future generations will produce the required products, milk and beef, in a more efficient way. Breeding is to 'improve' instead of just to 'reproduce'. Improvement of the genetic ability will be realised by selecting the best individuals in the current population and subsequently use these animals as parents for the next generation. When selecting animals in a population, according to a particular breeding goal, those animals which resemble this breeding goal occur to be more related to each other than the average relationship between animals in the whole population.

Cattle breeding is based on two important pillars:

- The estimation of genetic ability of animals (breeding value estimation), and
- The breeding programme or the structure in which the genetic improvement or selection takes place.

In the past decades, both the methods of breeding value estimations, as well as the breeding programmes have been significantly improved. This has resulted in strong genetic improvement. At the same time it has also led to a decrease of genetic diversity within populations. This decrease of genetic diversity is measured with the increase of inbreeding. (Piter Bijma).

Inbreeding

Inbreeding is the mating of related animals. This simply means they have one or more ancestor in common; the closer the relationship between two animals, the greater the amount of inbreeding in the resulting progeny. (Bob Guest). In a broad sense, all members of a breed are related. As a result, any breeder is practicing some degree of inbreeding. Therefore, we generally reserve the term inbreeding for the mating of animals that are more closely related than the average of the breed. (Sally Northcutt).

Related animals have more genes (alleles) in common than unrelated animals. As well as having more favourable genes in common, related animals also have more undesirable genes in common. Most animals carry undesirable genes that remain hidden and are not expressed in the phenotype. These genes are referred to as being recessive genes. There are many recessive genes which cause genetic disorders, or adversely affect reproduction, survival or overall functional fitness. Recessive genes only cause problems in animals that carry two copies of the gene - Homozygous recessive animals. (Bob Guest).

Disorders as defined by WHFF are caused by homozygous recessive genes.

The genetic disorders found in the Holstein breed and recognised by the World Holstein Friesian Federation are published on the WHFF website:

www.whff.info/info/geneticrecessives.php

Normally animals that express an undesirable trait are culled and therefore removed from the population. This causes the gene frequency for that trait (gene) in the breed to be decreased. Across a breed as a whole, there may be very few animals which are homozygous for a particular gene, but the genes are still there, undetected, in heterozygous or "carrier" animals.

As inbreeding results in an increase in the level of *homozygosity*, it will increase the risk of the appearance of undesirable effects in the phenotype. These undesirable effects (known as inbreeding depression) are generally associated with fertility and survival, and of lesser importance in production, growth and carcass traits. Where the rate of inbreeding increases slowly, culling and strict selection criteria can be used to eliminate undesirable types and poor producers (Bob Guest).

Line-breeding

Line-breeding is a form of inbreeding where the mating of closely related animals takes place in an attempt to concentrate desirable characteristics in the progeny. This is sometimes done with outstanding animals trying to fix or concentrate the genes of that superior animal in its progeny.

Out-breeding (or outcross)

Out-breeding is the opposite of inbreeding: it's the mating of animals that are less related than the average degree of relationship within the population. Out-breeding increases the number of *heterozygous* (i.e. different) gene pairs. An important aspect of out-breeding is the use of non-related animals within the breed. Two animals with a certain inbreeding coefficient (i.e. 6.25%) can be considered an outcross when the pedigrees of these animals are totally not related. Amongst each other, the animals are not related at all (outcross) and can be considered as a preferred combination to avoid inbreeding.

Calculating the Inbreeding Percentage

The amount of inbreeding for a particular animal is measured by its inbreeding coefficient, which is the probability that any pair of specific genes have been inherited from a common ancestor. The inbreeding coefficient measures the percent increase in homozygous gene pairs in an individual relative to the average of the population from which the individual came.

Computer programs can rapidly calculate inbreeding coefficients for individual animals from their pedigree information. Table 1 shows the inbreeding coefficients in progeny resulting from particular types of mating. (Bob Guest)

Table 1: Level of inbreeding in the progeny arising from mating of related animals (in all these examples it is assumed that the parents are not already inbred).

Full brother-sister mating	25%
Half brother sister mating	12.5%
Father-daughter	25%
Grand dam-grandson	12.5%
Common grandparents (cousins)	6.25%

The effects inbreeding

Breeding per definition, is selecting for the better genes in the population. It automatically means that inbreeding is a result of that selection. There's nothing wrong with that, but we should realise that it's important to manage the increase of inbreeding. The level of inbreeding itself is not that important; it's the increase of inbreeding per generation that might cause inbreeding depression.

Basically inbreeding has three different negative aspects (Piter Bijma):

- It causes a decrease of genetic diversity and reduces the potential future genetic progress:
- It causes a decrease of fitness and reproduction traits of animals, i.e. lower fertility rates:
- After all it causes an increase of the occurrence of genetic defects.

Inbreeding does not create undesirable recessive genes, but it does tend to bring to light these unfavourable genetics. This leads to a decline in average phenotypic performance called inbreeding depression.

Inbreeding depression has the greatest effect on reproductive traits, such as fertility, followed by productive traits, growth and milk production, with little or no effect on carcass traits. This pattern is the reverse of the magnitude of heritability for these classes of traits. Inbreeding depression is essentially the opposite effect of heterosis (hybrid vigour), which is the advantage gained from crossing lines or breeds. (Bob Guest).

Genomic Selection

In the near future the technique of genomic selection can play an important role in avoiding the negative aspects of inbreeding. The role of genomic selection will differ:

- a. It can give more genetic improvement at the same level of inbreeding, compared with more traditional selection;
- b. It offers tools to find the recessive defects earlier and to determine for every animal whether he or she is a carrier; information that can be used in possible matings;
- c. Last but not least genomics makes it possible to calculate the inbreeding coefficient at DNA-level and the degree of relationship between animals.

In these ways genomic selection might contribute to avoid the negative aspects of inbreeding.

How to manage Inbreeding

As the aim of most Holstein breeders is to increase the average performance of the herd, inbreeding should be managed by both the Holstein breeder and its organisations:

Holstein breeders can manage the (increase of) inbreeding in their herd, by:

- Taking care of the pedigree of cows and bulls when mating the animal - herdbook registration is of great importance for this task.
- Making use of professional and computerised mating programmes that check the pedigrees and avoid inbreeding to a certain percentage;

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Holstein Herdbooks and AI-organisations worldwide should monitor the inbreeding coefficient in the population and develop policies to control the level of inbreeding at any acceptable level:

- Taking care of the relationship between the selected bulls and the population;
- Manage the relationship between the selected bulls within the group considered.

Conclusions

- Inbreeding is the result of mating related animals and it occurs in any population which is under selection;
- As well as having more favourable genes (alleles) in common, related animals also have more undesirable genes in common;
- The decline in average phenotypic performance is called inbreeding depression;
- Inbreeding depression has the greatest effect on reproductive traits (like fertility), followed by productive traits, growth, milk production, with little or no effect on carcass traits;
- The inbreeding coefficient in some of the leading Holstein countries varies between 4% and 6%, whereas in some countries 5% is considered as a maximum acceptable level;
- Managing the increase of inbreeding per year or generation is of more importance than managing the absolute level of inbreeding;
- Since inbreeding reduces genetic variation it can reduce the potential future genetic progress;
- In future genomic selection might help to manage the increase of inbreeding;

- Holstein Herdbooks and AI-organisations world wide should monitor the inbreeding coefficient in the population and develop policies to control the level of inbreeding at any acceptable level;
- Holstein Breeders worldwide should manage the increase of inbreeding in their herd, by pedigree checks and or the use of mating programmes, avoiding inbreeding.

WHFF

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References

- Piter Bijma, Long term Genetic Contributions, Wageningen University, the Netherlands
- Bob Guest – Angus Australia: Inbreeding in cattle, what you need to know.
- Sally L. Northcutt, David S. Buchanan and Archie C. Clutter of Oklahoma Co-operative Extension Service, USA
- Jos Buiting and Gerben de Jong, CRV-Herdbook, Arnhem, the Netherlands.