Maximising genetic gain in pigs while controlling inbreeding

Sustainable breeding strikes a balance between realising genetic gain and reducing the harmful effects of inbreeding.

DanBred uses the state-of-the-art method of selection – optimum-contribution selection – to maximise genetic gain while controlling the rates of inbreeding.

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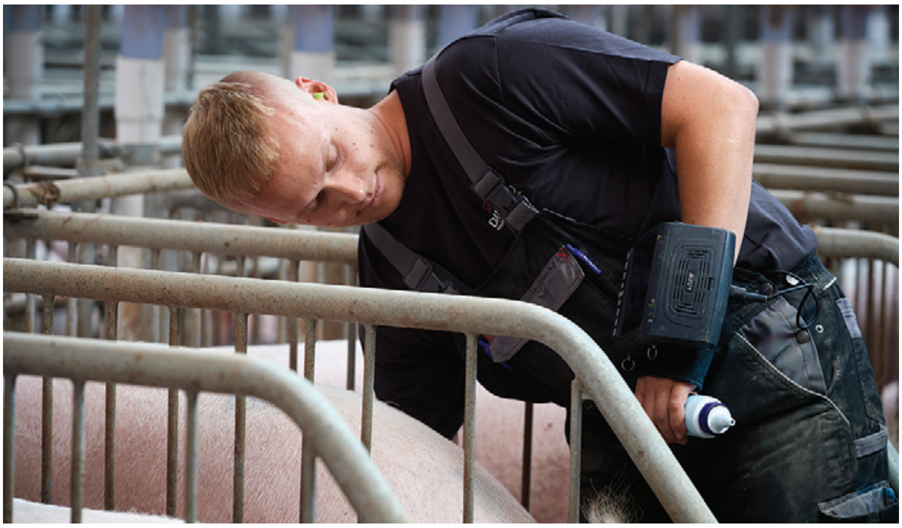

DanBred's breeding programme – like other advanced animal breeding programmes – has become highly effective at using selection to realise genetic gain and increase the genetic potential of its pigs to deliver high performance results in production.

Breeders can reliably identify the best animals for breeding thanks to rapid advances in genetic and statistical technologies.

While selection is a powerful tool that has increased the genetic potential of animals, these gains come with a cost: inbreeding.

As selection becomes more intense, and only the very best animals are selected as parents to the next generation, animals in a breeding population become more related and more inbred.

Clearly, breeders face a dilemma between realising genetic gain and controlling inbreeding. The lure of genetic gains driven by global competition between breeding companies can make it tempting for breeders to ignore the harmful effects of inbreeding and select only the very best animals as parents.

This temptation is only amplified by the fact that genetic gain from selection is often seen already in the first generation, whereas the harmful effects of inbreeding take time to accumulate and become a problem in future generations.

Consequently, breeding programmes that are responsible, sustainable, and profitable in the long-term strike the right balance between realising genetic gains and reducing the harmful effects of inbreeding.

Rate of inbreeding

Inbreeding occurs when the two versions of a gene inherited by an offspring from its parents are copies of the same gene from an ancestor. These offspring are identical-by-descent (IBD) for that specific gene. The inbreeding coefficient of an individual animal is the proportion of its genes that are IBD.

However, the inbreeding coefficient of an individual animal is not the critical inbreeding parameter for an animal population. What is important is the rate at which the inbreeding coefficients of individuals in a population increase over generations. This is known as the rate of inbreeding for a population, and it is directly related to the harmful effects of inbreeding. Consequently, controlling the rate of inbreeding is key to reducing the harmful effects of inbreeding.

Continued on page 8

FACT BOX:
Inbreeding and its consequences

Inbreeding is a natural and inevitable phenomenon of animal populations. Inbreeding occurs when offspring are produced by mating related individuals; meaning individuals that have a common ancestor(s). The more related the individuals, the more inbreeding. Inbreeding is harmful to a breeding programme because:

- It causes inbreeding depression, which reduces an animal's production performance, health, and welfare.
- It causes losses in genetic variation in a population, which reduces the potential to realise future genetic gains.
- In its most extreme form, inbreeding can lead to the demise of animal breeds.

Continued from page 7

Accurate estimates of rate of inbreeding

If it were possible to observe all the genes along the DNA of animals in a population, we would know each animal's true inbreeding coefficient and the rate of true inbreeding in the population.

Unfortunately, this is not possible. This makes observable and accurate estimators of rates of true inbreeding central to breeding programmes.

Rates of true inbreeding can be estimated by using pedigree or genomic information. However, pedigree information always underestimates rates of true inbreeding, whereas genomic relationships tend to overestimate them.

Without accurate estimators for rates of true inbreeding, it is challenging to control rates of true inbreeding. Therefore, DanBred is working on developing observable and accurate estimators of rates of true inbreeding.

Inbreeding control at DanBred

DanBred controls rates of inbreeding in its purebred populations: Duroc, Landrace, and Yorkshire. Each of these breeds is a closed population, so selection makes each breed susceptible to the harmful effects of inbreeding. Genetically improved pigs from DanBred's purebred populations are used to produce crossbred slaughter pigs in a three-way crossing system; DanBred Duroc is used as a sire line and crossed with DanBred Landrace x DanBred Yorkshire sows (DanBred Hybrids). Inbreeding does not need to be managed in the crossbred animals. Crossbreed animals are not inbred because their parents are unrelated as they come from different populations.

Striking the right balance

DanBred uses optimum-contribution selection (OCS) to select boars in its breeding programme for Duroc. OCS is the state-of-the-art method of selection because it maximises genetic gain at acceptable rates of inbreeding.

OCS optimises the genetic contribution – number of matings – of each selection candidate to the next generation. In doing so, OCS not only determines which animals should be selected to contribute to the next generation, it also calculates how much each selected animal contributes.

DanBred uses EVA – a computer package developed by Peer Berg at Aarhus University, Denmark – to carry out OCS for Duroc.

Danbred is also working to implement EVA in Landrace and Yorkshire.

Pedigree control of inbreeding

One of the benefits of OCS is that it can optimise genetic contributions when different sources of information are used to predict genetic gain and control rates of inbreeding. Genetic gain is predicted using breeding values based on genomic information, also referred to as genomic selection. Rates of inbreeding can be controlled using OCS with pedigree or genomic information (POCS or GOCS). DanBred uses POCS to control inbreeding in its breeding programme for Duroc.

When POCS and GOCS are compared at the same rate of true inbreeding in simulated data, POCS always realises more genetic gain than GOCS. This may seem counterintuitive at first, as genomic information is more accurate than pedigree information. But POCS realises more genetic gain than GOCS because it allows selection to increase the number of favourable genes in a population more than GOCS.

There is clearly more incentive to use POCS in DanBred's breeding programme, but that does not rule out the possibility of using GOCS in the future.

There is much to learn before we can use genomic information to control rates of inbreeding. DanBred is working towards methods that improve GOCS so that it realises more genetic gain than POCS at acceptable rates of inbreeding. ■