

# Swine breeding programmes in the Nordic countries

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## **Nordic pig breeding in short**

National, cooperative breeding organisations dominate the genetic improvement in the Nordic countries: Quality Genetics in Sweden, Norsvin in Norway, National Committee for Pig Production (Danbred) in Denmark and the Finnish Animal Breeding Association (FABA) in Finland. Pig production has increased on Iceland during the last decades, but the pig breeding is mostly a non-Icelandic activity. Icelandic production is based on regular imports, mainly from Norway and Finland.

Although four of the Nordic countries have their own breeding organisations, farmers in Norway, Sweden and Finland partly share the same genetic material. In Sweden, the 35 % of the pig producers that prefer private slaughter plants (instead of the cooperative slaughter organisation), buy genetic material from Norsvin for many years. Norsvin buys Yorkshire semen from FABA in Finland. In Norway, the terminal sire is a Landrace x Duroc cross. Quality Genetics uses Hampshire and Danbred uses both Hampshire and Duroc as terminal sire breeds. Traditionally, Finnish pigs raised for slaughter are two breed crosses (Finnish Landrace x Yorkshire), but today a large proportion of the Finnish farmers use either Swedish Hampshire or Norwegian Landrace x Duroc as terminal sire.

The breeding structure in the Nordic breeding organisations is, like in other countries, hierarchical, with nucleus, multiplier and production herds. A large part of the F1 gilts (Landrace x Yorkshire) are, however, produced in the nucleus herds in Sweden, Denmark and Finland, but not in Norway. Sow and piglet traits for the litter recording scheme are recorded in nucleus and multiplier herds. Performance testing of young boars and gilts is done in nucleus herds and in Finland also in multiplier and production herds. In addition to field testing, testing stations are used for young boars in all four countries. The best animals are used for artificial insemination (AI). Non AI boars are dissected to record lean content and other traits. In Norway, siblings raised in two large production herds are used for carcass dissection and all AI boars are recruited from the testing station. In Finland, the testing station is also used for sib testing of gilts and castrates. Since the Swedish testing station was rebuilt a few years ago data from the station has not been fully used, but now records from the station is included in the genetic evaluation again.

Although the breeding goal seems to be almost the same for all breeding organisations according to their annual reports, the traits selected (Table 1) differ. The models used for genetic evaluation also vary. Some examples: Litter size is analysed as a repeated trait within Danbred and Quality Genetics, while Norsvin handles litter size from first, second and third parity as different traits in a multivariate analyse. FABA handles litter size in first parity and litter size in the following parities (repeated measurements) in a multivariate analyse. Norsvin includes number of teats in

the genetic evaluation, whereas the breeders in the other organisations perform a threshold selection for teat number (at least 14 teats).

Table 1. Selection traits used by Nordic breeding organisations

Type of trait	Organisation	Selection trait
Reproduction	Norsvin	Age at 1st service; Litter size, born alive; Number of teats; Litter weight at 3 wk; Weaning to service interval
	Danbred	Litter size, alive at 5 days
	FABA	Age at 1st farrowing; Litter size, total born; Stillborn; Mortality of liveborn; Farrowing interval
	Quality Genetics	Litter size, born alive; Farrowing interval
Production	Norsvin	Growth rate (age at 100 kg); Carcass leanness; Feed efficiency (25-100 kg); Dressing percentage; Bacon side quality
	Danbred	Growth rate (0-30 kg); Growth rate (30-100 kg); Carcass leanness; Feed efficiency (30-100 kg); Dressing percentage
	FABA	Growth rate (30-100 kg); Carcass leanness; Feed efficiency (30-100 kg)
	Quality Genetics	Growth rate (birth-100 kg); Carcass leanness; Feed efficiency (30-100 kg)
Health	Norsvin	Conformation score; Osteochondrosis
	Danbred	Conformation scores; E.coli (MAS)
	Quality Genetics	Conformation scores; Osteochondrosis
Meat quality	Norsvin	Ultimate pH; Reflection; Intramuscular fat (Duroc)
	FABA	Ultimate pH; Reflection
	Quality Genetics	RN allele (Hampshire)

Some years ago, a cooperation between Quality Genetics and Danbred was discussed. The breeding programmes are very much alike in the two organisations but the production is much larger in Denmark (23 million pigs versus 3 million pigs produced per year) and the breeding facilities, the number of nucleus herds and purebred sows are of course much larger in Denmark. However, the health status in Danish pig production differs from the Swedish, regarding PRRS and Salmonella. The freedom of these diseases in Sweden made it impossible to transfer semen or live pigs from Denmark to Sweden and in the end there was no agreement between these breeding organisations.

Danish pig production is larger than the sum of the production in all the other Nordic countries. Thus, cooperation between countries is more urgent for Sweden-Norway-Finland than for Denmark. The same high health status in Sweden, Norway and Finland also facilitates cooperation. In March 2005, a three-year agreement concerning the maternal lines was signed by Norsvin and Quality Genetics. According to this agreement, Landrace will be produced in Norway and Yorkshire in Sweden. Thus, the Swedish Landrace nucleus herds are closing down and next year there will be no Swedish Landrace boars at the AI stations. In Norway, they will continue to produce Duroc and use Landrace x Duroc as terminal sires, and Quality Genetics will

continue to produce and use Hampshire as a sire breed in Sweden. A group of Finnish farmers has recently decided to buy Yorkshire material from Quality Genetics and Landrace material from Norsvin. At the same time, FABA has started to build a new testing station for the Finnish national breeding programme.

### **Pork consumption and meat quality**

Pork is the most consumed meat in four of the five Nordic countries: Denmark, Sweden, Finland and Norway. On Iceland, where the pig production is of less importance, mutton and lamb is the most consumed meat. A large part of the pork is bought as fresh meat by the consumer and eaten in stews, in meat balls, as baked ham, grilled entrecote, roasted fillet and cutlets. Thus, meat quality should be more important in our countries than in e.g. France, where more pork is bought and consumed as cooked ham (jambon de Paris) and other charcuteries. Consequently, Quality Genetics has decided to increase the RN<sup>-</sup> allele frequency in Hampshire. This allele improves taste and juiciness. French breeding organisations, on the contrary, have selected against the RN<sup>-</sup> allele, since it gives higher cooking loss and thus is unfavourable for the processing industry. In spite of our food traditions, meat quality is not included in the genetic evaluation in Sweden and Denmark. In Norway and Finland, ultimate pH and meat colour (reflectance) are recorded in sibling tests and included in the genetic evaluation. Serenius et al (2004) recently estimated genetic parameters for these traits. The heritabilities were estimated at 0.15 for Finnish Landrace and at 0.16-0.35 for Yorkshire.

Norwegian Duroc is selected for high intramuscular fat (IMF). Norsvin and the Norwegian University of Life Sciences have an ongoing research project where they try to map an IMF gene on chromosome 6. Likewise, Danbred and the Danish Institute of Agricultural Sciences at Research Centre Foulum cooperate in a genome project where QTL studies of drip loss are included. An important genetic fact with regard to meat quality is that all breeds used in the Nordic countries are free from the porcine stress syndrome allele, which causes extreme stress sensitivity and low meat quality (pale, soft and exudative meat). Based on research at the Swedish University of Agriculture, a Swedish eradication programme was started already in the beginning of the 1980'ies. The selection against carriers of the recessive allele was performed with marker assisted selection, using blood groups as markers. The strategic decision to get rid of the so called halothane gene, in spite of its favourable effect on leanness, also led to an improved animal welfare.

For most consumers, boar taint is indeed judged as very low meat quality. All male pigs raised for slaughter in the Nordic countries are castrated. But castration is painful and this practice is questioned for welfare reasons. In Norway, castration will be prohibited by law from 2009. Until then, castration should be performed by veterinarians, using anaesthesia. Androstenone is a sexual pheromone and breeding for reduced sexual function carries risks. An alternative would be to select animals with certain alleles important for androstenone synthesis. Androstenone and testosterone are the products of two parallel chains in the testis which have a common precursor. If a QTL that affects the choice between these two synthesis chains could be identified, animals producing testosterone rather than androstenone could be selected. Such selection would

probably not influence female reproduction traits. Molecular genetic studies of boar taint are performed in several Nordic countries.

### **Breeding for vital piglets**

In 1992, total number of piglets born per litter was included as the only reproduction trait in the Danish genetic evaluation of Landrace and Yorkshire. The genetic change in total born has been large (+3.0 Yorkshire piglets and +3.8 Landrace piglets per litter) , but piglet mortality has also increased. According to Danish data, there are 10 % stillborn in litters of 10 born and 20% stillborn in litters of 20 born. The mortality of liveborn increases as well, it is around 16 % in production herds in Denmark today. In Sweden, where number of liveborn piglets is the selection trait and where the genetic change in litter size has been slower than in Denmark, the mortality of liveborn is below 15 %. Average number of weaned piglets per litter from sows in nucleus and multiplier herds in Sweden is 9.7 and in production herds it is 10.3.

According to preliminary results from a longevity project, low maternal ability accounts for 17% of the culling of Danish sows. The increased piglet mortality led to a change of selection traits last year, from total born to number of piglets alive at day five. Of piglets not reaching weaning, 90 % are stillborn or dying before day 5. Thus, Danbred takes the main part of piglet mortality into account with this selection trait.

FABA continues to select for total born, but also for low number of stillborn and low mortality of live born piglets. Norsvin does not select for piglet survival yet, but litter weight (adjusted for litter size) at 3 weeks is included in the genetic evaluation since 2004. According to results from Holm et al (2005) and Grandinson et al (2005), there are both direct and maternal genetic effects on piglet growth. Furthermore, the correlation between these effects is negative and therefore both components ought to be included in the genetic evaluation in the long run. Some of the breeders in Norway also record birth weight, which could be an alternative selection trait. Grandinson et al (2002) showed that the genetic correlation between birth weight and crushing is negative (high weight - low mortality). The corresponding correlation between birth weight and stillbirth is, however positive (high weight - high mortality).

Geneticists and ethologists from the Nordic agricultural universities and research institutes have collaborated in a project on the maternal behaviour of sows (Rydhmer et al, 2003). The project included genetic studies of sow behaviour, such as sow's carefulness, reaction to piglet handling, aggression and fear of humans. Some of the behaviours are heritable and related to piglet survival (Grandinson et al, 2003; Vangen et al, 2005), but so far no behavioural traits are included in the genetic programmes. According to the Swedish animal welfare law, sows should be kept loose in the farrowing pens, but in Denmark most sows are confined in farrowing crates during the whole lactation. An ongoing EU-project will show whether there are important interactions between genotype and housing environment for maternal behaviour.

## **Breeding for strong and healthy pigs**

Several Nordic studies have focused on the genetic background of clinical leg weakness recorded at testing stations (Lundeheim, 1987; Jørgensen & Vestergaard 1990; Serenius et al, 2001).

Unfavourable genetic correlations between leg weakness and performance traits, as shown by Serenius et al (2001) and others, explain why leg weakness or conformation score is included in the genetic evaluation in Sweden, Denmark and Norway. To breed for stronger legs is of, course, also important for animal welfare reasons. In Denmark, the conformation is recorded in nucleus herds by Danbred's technicians. In Norway, conformation is recorded in nucleus herds and at the testing station, whereas only testing station data are used in Sweden.

In addition to leg weakness, Quality Genetics and Norsvin also select against osteochondrosis, a disturbance in the formation of bone from cartilage in the growing animal. In the Swedish breeding programme, the frequency and severity of osteochondrosis has been recorded on pigs slaughtered from the testing stations since 1982. From these data, osteochondrosis has been found to have a higher heritability than overall leg weakness ( $h^2=0.2-0.3$ , compared with  $0.1-0.2$ ; Lundeheim, 1987). Young pigs with osteochondrosis have higher genetic capacity for growth rate and carcass leanness and sows with genetic predisposition for osteochondrosis have a higher risk of early culling (Yazdi et al, 2000).

Using data from testing stations, Lundeheim (1979) found low heritabilities for respiratory diseases such as pneumonia and pleuritis. But data from a Danish testing station showed somewhat higher levels of heritability (Henryon et al, 2001). None of the Nordic breeding organisations have included disease resistance in the quantitative genetic evaluation yet. Danbred does, however, use marker assisted selection since 2003, to select for resistance against *E. coli* F4. The favourable allele is recessive and the genotype frequency differs between breeds. In Landrace, 1 % were homozygote for the favourable allele, versus 100 % in Hampshire, when the selection started. One year later, 8 % of the Landrace AI boars were homozygote for the favourable allele, according to 2004's annual report from the National Committee for Pig Production.

## **Who defines the breeding goal?**

Structural changes are sweeping over European agriculture. The total number of farms in EU decreased 18 % from 1995 to 2003, while the average farm size (area) increased 13 %. The decrease in farm number is largest in animal production. In Finland the number of farms with animals decreased 44 % from 1995 to 2003. The number of Swedish pig farms has decreased 88% since 1980 and the average number of sows and boars per farm has increased from 15 to 92 in these 25 years. In spite of this dramatic change, the average herd is still a rather small family enterprise. The average piglet producer has 80 sows in Sweden, 67 sows in Finland and 44 sows in Norway. The Danish herds are larger, in average 210 sows per herd.

Does the structural change influence the breeding work? Probably, at least if the nucleus herds follow the same trend. In Norway, where the average nucleus has only 40 sows, it is perhaps easier for the breeders to record traits like oestrous symptoms (which they did for three years,

until Norsvin concluded that oestrous symptoms were not heritable, see Holm, 2005), than in Denmark where the average Yorkshire nucleus has 450 sows. On the other hand, large herds can afford specialised caretakers focusing on e.g. the farrowing unit. This could increase the accuracy of maternal trait records. Furthermore, the trend towards fewer nucleus breeders that are strongly bound to their breeding organisation might facilitate the implementation of complicated recording schemes, like behaviour data.

When Denmark, Sweden and Finland joined the EU, they also became part of the EU's Common Agricultural Policy (CAP), which has a single market for agricultural products and food. There is a free exchange of goods between member states. Since Sweden entered the EU in 1995, imports of agricultural and food products have risen 70%. Around 40% of the import consists of products that can hardly be produced in Sweden, but meat imports have also increased a lot. Today, 20% of the pork is imported to Sweden (mainly from Denmark). Denmark, on the other hand, export six times more pork than they consume in the country. Most of that export goes to Germany, UK and Japan. With such an important export, consumers in the buying countries may also influence the breeding goal. A very low acceptance of boar taint in Germany put an end to the development of entire male production in Denmark in the middle of the 1990's. However in 2001, the ministers of agriculture in Denmark, Sweden and some other EU countries (probably inspired by Norway) declared that castration should be forbidden "in principal". Danbred is now involved in a European genome project on boar taint.

The new cooperation between Norsvin and Quality Genetics is an affair over the EU-border. Norway is not a member of the free market in EU and the Norwegian pig producers are paid a much higher price than the Swedish producers. Maybe that explains why Norsvin has the most broad breeding goal of the Nordic breeding organisations, including many different traits. In Sweden, the price to the producer is the second lowest of all EU countries, the production costs are high (8 % higher than in Denmark) and pork imports are increasing. Under this economic pressure, Quality Genetics has hesitated between breeding for bulk production or high quality production, while Norsvin has stated in an information brochure that "... our system distinguishes itself from most other genetic programs ... Norsvin tries to breed for the entire pig - including as many traits as possible in the breeding goal...". It will be interesting to see how these two organisations, placed in so different production environments, will define their common breeding goal and breeding programme.

### **Some Nordic PhD theses on pig genetics**

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Holm, B. 2005. Genetic analysis of sow reproduction and piglet growth - including genetic correlations to production traits. Doctor scientiarum theses 2004:47. [www.umb.no/?viewID=8591](http://www.umb.no/?viewID=8591)

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Karlskov-Mortensen, P. 2005. Mapping of quantitative trait loci in pigs with special emphasis on porcine chromosome 17. *Samfundslitteratur Grafik, Frederiksberg, Denmark*. ISBN 87 7611 103 2.

### **Nordic pig breeding organisations, universities and research institutes**

Norwegian University of Life Sciences: [www.umb.no](http://www.umb.no)

Norsvin: [www.norsvin.no](http://www.norsvin.no)

Swedish University of Agricultural Sciences: [www.slu.se](http://www.slu.se)

Quality Genetics: [www.qgenetics.com](http://www.qgenetics.com) (in Swedish)

Danish Institute of Agricultural Sciences:  
[www.agrsci.org/centre/forskningscenter\\_foulum](http://www.agrsci.org/centre/forskningscenter_foulum)

Danbred: [www.danskeslagterier.dk/smcms/LU\\_engelsk/Index.htm?ID=357](http://www.danskeslagterier.dk/smcms/LU_engelsk/Index.htm?ID=357)

AgriFood Research Finland: [www2.mtt.fi/english](http://www2.mtt.fi/english)

FABA: [www.faba.fi/english/index.html](http://www.faba.fi/english/index.html)

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