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Cryostorage of genetic variation in Finncattle breeds

Genetic variation is a vital capital for cattle breeds because the populations' evolvability depends on available genetic variants. The changes may be a response to selection carried out by producers. Variation is also giving room for adaptation to alterations in production environment.

The amount of variation depends on the size of a population so that large groups would carry more variation than small ones. Even in a large population, the genetic variation may be lower than expected if the present population is descending from very few family lineages. The narrow genetic variation may also reflect a recent bottlenecking in population size or very unbalanced use of breeding animals.

The state of genetic variation is best described by effective population size, considering the census size and the genetic structure. The goal in the management of local breeds is to maximise the effective size and thereby to minimise the increment in kinship or coancestry. The maintenance of genetic variation requires good planning and coordinated operations.

The management of genetic variation could be backed by storing frozen material. Now often a term cryopreservation is used in this context.

Northern Finncattle bull Sorjosen Veikko PSK S 13913, born in 1989.

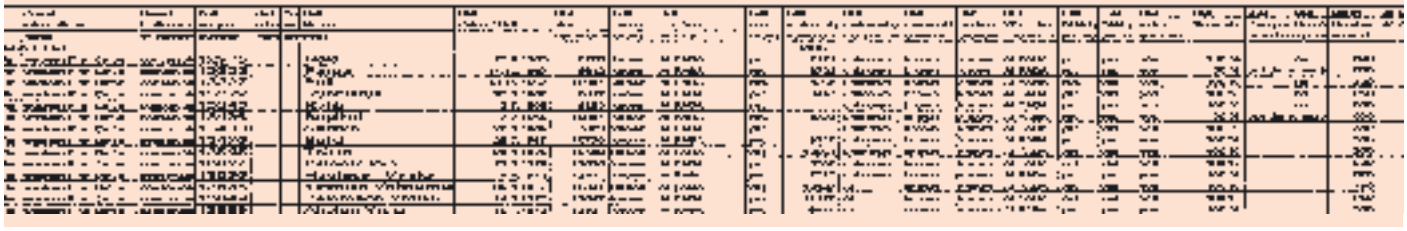
Back-up storage could be utilised to overcome the following problems: performance in fitness traits is suffering from inbreeding depression, the frequency of an inherited defect or disease has increased, an interesting feature of a breed has disappeared or most of the population has been lost due to a disease or unexpected catastrophe.

If the population is very small, one way to mitigate the effects due to genetic drift is the prolongation of generation interval with the use of frozen semen. The delayed use of bulls would, however, dilute the selection effects which should be considered before the option to slower the generation turn over is chosen.

Development of artificial insemination

Artificial insemination (AI) was first demonstrated in Finland in 1936. After the war, the interest in a wide use of AI grew very quickly and as early as the beginning

The FABA database has detailed information on all the bulls and semen doses.



Sperm doses for Finncattle breeds					
Finncattle breed	birth year	bulls	distribution of bulls by number of doses		
			< 200 doses	200 – 1000	> 1000 doses
Eastern	< 1980	6	2	4	
	1980-99	22	8	12	2
	> 2000	15			20
total		48 bulls	74 500 doses		
Western	< 1980	42	10	31	1
	1980-99	69	9	26	34
	> 2000	37		3	46
total		160 bulls	261 000 doses		
Northern	< 1980				
	1980-99	20	14	3	3
	> 2000	12		1	14
total		35 bulls	60 500 doses		

of the 1950's the organised AI covered the whole country.

The law on AI was endorsed in 1949. It stipulated the framework for keeping bulls and collecting semen. Even before Finland joined EU, the legislation on reproduction technology and breeding was harmonised with the respective EU directives. The WTO processes have given defined requirements for the health status of traded animals, semen and embryos.

The AI practices were first established for the Ayrshire breed, soon they were adopted also in the Finncattle. In 1955 about 20% of cows were inseminated, as much as 80% in 1965 and ten years later practically all cows.

The use of frozen semen has enhanced the animal breeding trade. Efficiently marketed breeds have become widely international. The Holstein-Friesian cattle entered Finland from Denmark and Sweden first time in 1962. This accelerated the decline of the Finncattle population.

Frozen semen has made the breeding trade almost unlimited. Freezing is also an efficient tool to back the maintenance of breed spectrum and the genetic variation in both the main-stream and local breeds.

The bull keeping model proposed by Skjervold and Langholz was adopted in Finland. This meant freezing a sufficient amount or 40,000 semen doses from young unproven bulls, after which the bull was slaughtered. When the progeny test results were available, the doses of less valuable bulls were thrown out from the semen storage. This was a cost-efficient way to run the bull programme.

When the collaboration and trade have increased the number of clients, there is a demand for higher number of doses. The young bulls are first producing a sufficient quantity of doses for progeny test and stay alive until the daughter records are available. After five to six years of waiting the best bulls return to semen collection. Thereby there are practically no limits in the semen sales.

The AI bulls have always been purchased and owned by the AI organisations, in some cases a bull has been jointly owned by several organisations. Over the six decades after the start, there have been several fusions among the organisations. The last few years have seen also the opening of collaboration across borders. From the beginning of 2010, the joint organisation Viking Genetics in Denmark, Finland and Sweden covers both breeding and AI within and between the countries. The Finnish co-operative FABA Service owns a quarter of the organisation.

The animal registers and unique ID's form the basis for assessing the outcome of selection and state of genetic variation. All the bovine individuals have an EU ear tag and own number, the herd-booked ones have yet another code. The genealogical analysis would require the parentage testing. The validation was first – in the 1950's – based on blood groups. From the mid-1990's they have been replaced by DNA markers.

Utilisation of frozen semen in maintaining variation

Preservation of the variation in Finncattle breeds – Eastern, Northern and Finncattle – is part of the national programme on animal genetic resources. The programme is coordinated by MTT Agrifood Research Finland, a government institute funded by the Ministry of Agriculture and Forestry. The Finncattle individuals are found across the whole country, very often in mixed herds with other breeds. There are three special gene bank herds: Pelso prison farm keeping Northern Finncattle, Kainuu Vocational College (Kajaani) having Eastern Finncattle and Ahlman Vocational College (Tampere) with Eastern and Western Finncattle. The college herds are stemming from the recently closed herd of the Sukeva prison.

The special gene bank herds are housing individuals unique over the diversity range. Over the years, these herds have offered many bulls for semen production. The semen storage is aimed to cover all the recognised family lineages avoiding a high average kinship among the bulls.

The Western Finncattle is under genetic improvement programme and has obviously the largest collection of bulls. The semen preservation of native cattle breeds was given attention in the 1980's when the threatened state of breeds was revealed. From the period

The bovine semen would keep fertilisation capabilities when stored in liquid nitrogen at -196 °C.

before 1980, there are several bulls in the Western Finncattle, very few in the Eastern one, while all the stored Northern Finncattle bulls are born after 1980.

The initial plan for preservation was prepared in 1984 and served as a useful guide line for many years. The proper action plan was written in 2004. It set the targets for the Finncattle bulls: at least 2000 doses for the Eastern and Northern ones and 3000 for the Western ones. The long-term storage should contain at least 25 Eastern and Northern Finncattle bulls with 200 doses each. Similarly all the Western Finncattle AI bulls should leave 200 doses in the long-term bank.

Every year, the FABA Service – the joint breeding and AI organisation – is purchasing all the Western Finncattle bulls and few bulls of the Eastern and Northern Finncattle. Most of the latter ones are bought and owned by the national programme. The principles followed in founding, increasing and using the cryostorage would be the same as in finding the parent candidates to maintain the variation or to minimise the average coancestry.

The bulls are taken to the bull test or directly to the FABA station of Pieksämäki for semen collection. All the semen operations are following the procedures used for the commercial AI bulls, including the semen storing and data handling. The health status requirements are also the same. Hence, the standards over the whole chain are similar and no special cost demanding arrangements are needed.

The use of the stored semen is decided jointly by the national programme and the AI organisation. The FABA breeding experts are yearly producing a detailed list of bulls recommended for all the registered Eastern and Northern Finncattle cows.

At present, the number of stored doses for each bull is well over 1000. The dose is packed in a 0.25 ml straw, previously semen pellets were used. The doses are stored at the FABA station of Pieksämäki. An alternative site is the Hollola station where the waiting bulls are housed. The FABA Service has a database for the bulls and stored semen.

Number of cows and herds (the proportion of those in milk recording scheme is in brackets), average yields in Finland in 2008.

	cows	herds	milk kg	fat %	protein %
Eastern FC	787 (32%)	289 (48%)	3706	4.28	3.51
Northern FC	970 (44%)	453 (55%)	5210	4.37	3.47
Western FC	2954 (65%)	1149 (63%)	6776	4.39	3.50
Ayrshire	181364 (84%)	11394 (73%)	8561	4.33	3.48
Holstein	91132 (80%)	9187 (72%)	9248	3.99	3.40

Source: Faba Service

Optimum policy for the preservation

The planning of semen collection and storing would start from considering the impact of each bull candidates on the genetic variation. The aim is minimise the average coancestry. When the cryobank is already established and more material is deposited, the available bulls are screened for their suitability in terms of coancestry.

Theo Meuwissen of the EURECA project used the Eastern Finncattle as an example. There was pedigree information available for 9900 individuals. The sperm bank had at the time over 60,000 doses stored. The exercise was carried out aiming to increase the number of stored doses up to 100,000. Two alternatives were considered, either re-establishing the bank from the existing storage and living bulls or just adding more doses to the present bank.

Adding doses from the chosen 70 bulls to the existing storage would result in a small increment in the average coancestry among the deposited bulls and reach 4.5%, still a fairly low level. A brand new bank would be ideal, as the overall coancestry would be kept down at 1.2%. The thorough revision of the storage would, however, require three to four times more bulls and a considerable amount of extra costs compared to a straightforward addition. In conclusion, the present cryostorage covers the available family lineages very well and the relatively inexpensive addition of doses from the present bulls would not radically increase the average coancestry among the preserved bulls.

Use of embryos

A cattle breed could be re-established with semen via systematic and slow backcrossing as semen contains only half of the genome while an embryo carries the entire genotype, even the extra-nuclear genetic material, especially mitochondria. The first embryo transfer in Finland was performed in 1979. The enhanced embryo production of elite cows was recognised in the 1980's as a powerful tool to lift the female selection closet to that of progeny tested bulls. In Finland, these thoughts motivated the foundation of Embryocentre Ltd in 1986 and later the on-set of a nucleus breeding scheme in the Ayrshire cattle.

For conservation purposes, the donators of embryos and the bulls used for fertilisation are again chosen to minimise the conancestry. The practical work is done by the flushing team of Embryocentre. In the work routines, the team is following the international standards. Often the cows at the aforementioned gene bank herds are used as donators. The stored embryos are owned by the national programme and stored at the FABA Pieksämäki premises. If there are valuable cows which cannot be flushed for one reason or another, there is also a possibility to collect oocytes from them after slaughtering. The embryos are then produced via in vitro fertilisation.

Embryos have been stored only for the Eastern Finncattle, so far there 106 embryos from 18 cows and 12 bulls. The targets set in the national programme for the Eastern and Northern Finncattle are to have embryos from 25 cows, 8 from each.

Conclusions

- The Finncattle breeds have a high priority in the national action plan for animal genetic resources: selection scheme in the Western Finncattle, maintenance of both the genetic diversity and the production performance in the Eastern and Northern Finncattle.
- The core of the schemes is the use and long-term storage of semen.
- Semen collection, storage and data management are carried out by the AI organisation.
- The semen storage for Finncattle is covering most of the available genetic diversity.
- The decisions on the use of the oldest and most valuable semen doses are made by the national programme.
- Cryostoring, especially the collection and freezing of embryos, would require more public funding.

Tuula Gargano

The Eastern Finncattle son Koivulinnan Uuno ISK S 14339 (born in 2005) ready to mount for semen collection at the bull station of Pieksämäki.

The Finncattle breeds form the indigenous cattle populations in Finland. The animals in these breeds are smaller than those of the main stream breeds Ayrshire and Holstein cattle. They are mostly polled and have high dry matter content in milk and good longevity. The three breeds – Eastern, Northern and Western Finncattle – were established over hundred years ago. In the genetic improvement programme, the breeds were merged in 1947 and soon started experiencing decline in numbers as first the Ayrshire and later the Holstein cattle gained popularity. A new attention was given to the breeds in the 1970 – 80's and ever since the number of both the Eastern and Northern breed individuals has increased from a very low level to several hundred, while the larger Western breed population – still with some 3000 cows – keeps decreasing.

The Eastern Finncattle animals are typically red colour-sided with broad winding band on the back.

The Northern Finncattle animals are virtually white to light tan in colour, with occasional red and black spots. Selection has favoured white colour and it is believed that white animals are less attractive to mosquitoes, common in the summer pastures in Lapland, where the breed earlier was most common. **n**

Elly Geverink

The Western Finncattle animals are beige-brown, with occasional white markings or spots.

The 3-year EURECA project (Towards self-sustainability of EUropean REgional CAttle breeds) started in March 2007. The project is funded from the EU AGRI GEN RES programme and is coordinated by Sipke-Joost Hiemstra of the Netherlands. It has partners from ten European countries. The purpose of the project is to learn from each other in Europe to develop better strategies to preserve the regional cattle breeds. In total, 15 cattle breeds from ten countries are being analysed in detail. For Finland, we chose the Eastern and Western Finncattle. The project included also reviews on the state of cryo preservation in different countries and on the methods and software to assess and manage the genetic variability in cattle populations.