

Breeding in small populations



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Odd Vangen

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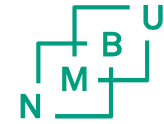
dr.agric. dr. scient.

Professor of animal breeding and genetics

Foto: Katrine Haugaard

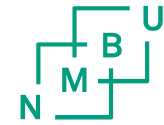


ABOUT ME



- **Project «Digitalizing the herdsbooks for the 3 national horse breeds 1981-1983. Horses born 1850 – 1976.**
- **Published «Inbreeding level and developments of Norwegian horse breeds» in 1983.** Vangen, O. 1983. The use of relationship matrices to avoid inbreeding in small horse populations. *Z. Tierzüchtg. Züchtgsbiol*, 100, 48-54.
- **Chairman of the project «Breeding plans for Norwegian horse breeds».** Breeding plan documents for 18 breeds. 1995-1997.
- **Chairman of the breeding advisory board at The Norwegian Equine Center 1993-95 (member 91-93).**
- **Chairman and member of the Norwegian Gene Resource Committee for farm animals from 1990 to 2015.**
- **At present member of the National Working Group on «Actions for the national breeds in Norway» (2015-2016)**
- **Teaching horse breeding at University level in 40 years. Written text books on horse breeding. Chairing «Nordic Interstallion»; «Joint Nordic breeding values for warmblood riding horses» in cooperation with the 4 breeding organisations.**
- **Relevant hobbies: Stallion licencing committee in the 90's. Horse riding. Former president of «Norwegian Warmblood»**

What will I talk abouton



- Definitions, «small populations»
- How do we «protect» Farm Animal Genetic Resources?
 - general FAO recommendations
 - what do we act or recommend to do in Norway
- How to maintain genetic variation in a population
- The dilemma between selection and maintenance of variation
- Tools to optimize the breeding work («Optimal contribution»)
- Challenges for national breeds (=Fjord horse)
 - breeding objectives
 - databases
 - inbreeding
- Future Fjord Horse Breeding



Animal breeding theory

Animal breeding theory

The basis for genetic change:

- Selection intensity (percent selected)
- Accuracy (heritability plus info from relatives , BLUP-breeding values)
 - Genetic variation
 - Generation interval

AND the rest of the theory:

Avoiding selection of relatives

Inbreeding

Loosing genetic variation

IN A LONG TERM PERSPECTIVE THE BREED HAS TO BE SUSTAINABLE

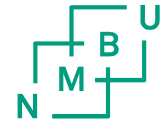
Definitions

Status of breeds, according to FAO

	High reproductive capacity			Low reproductive capacity		
	Critical	At risk	Vulnerable	Critical	At risk	Vulnerable
Number of breeding females	< 100	< 1 000	< 2 000	< 300	< 3 000	< 6 000



What is influencing Genetic Variation in a population?

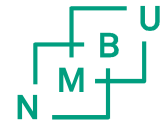


1. **The base population. Number of founder animals. How much relationship was there between the founders?**
2. **Genetic drift. Alleles are accidentally lost or fixated. Faster in small populations (by chance!). Higher if little variation between parental animals.**
3. **Selection. All selection reduces genetic variation, faster the fewer genes behind. Modern BLUP-selection reduces variation faster, because selection of relatives. However BLUP-values make the selection more accurate.**
4. **Migration. New breeding animals into the population. From sister populations, or from other breeds (crossbreeding). IMPORTANT IN MANY SMALL POPULATIONS. Don't be too "register-conservative".**
5. **Mutations. Rapid changes in genetic material. New alleles. Most mutants are lethal or semi-lethal, others may have played a positive role in developing breeds. Mutations have survived.**

What is giving a large effective population size?

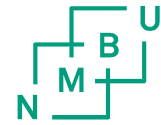
1. Random mating
2. Same number of offspring from each sex
3. Equal no. offspring per parent
4. Separate generations

Common practice (according to theory) in a breeding population



1. Assortative matings
2. Males are allowed more offspring
3. Variation in family size, the best animals are allowed more progeny
4. Overlapping generations

Breeding populations will, if just thinking genetic change, very often have small effective population sizes.



Minimum effective population size

- N_e (effective number) = 50-100 is regarded as a minimum to prevent too rapid increase in inbreeding.
- Is there a problem to obtain N_e of 50-100????

Effective population size, N_e

How it is calculated:

$$N_e = \frac{4 N_m N_f}{N_m + N_f}$$

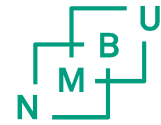
N_m = no stallions

N_f = no mares

N_e = effective
population
size

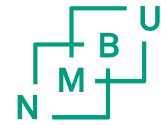
Males N_m	Females N_f	N_e
100	100	200
60	140	168
20	180	72
10	190	38
1	199	4
30	50 000 000	120
10	50 000 000	40

Sustainable horse breeding, aim:



- Sustainable – functionality over time
- Maintain genetic variation
 - Inbreeding increase less than 0.5 - 1 % pr generation
 - Effective breeding population of more than 50 - 100
- Functional animals with the right breed characteristics
- Optimal health and fertility

Examples from international cattle breeding



<i>Breed</i>	<i>Year</i>	<i>Ne</i>	ΔF
US Holstein	2001	39	1,28
US Ayrshire	2001	161	0,31
US Jersey	2001	30	1,67
Dansk holstein	2004	70	0,71
Dansk jersey	2004	98	0,51
Rødt dansk melkefe	2004	274	0,18
NRF	2005	167	0,30
NRF	2007	208	0,24

$$\Delta F = \frac{1}{2N_e}$$

The danger of intensive selection

of relatives:

Eks. Nordic coldblooded trotter population:
(one joint breeding population between Norway and Sweden)

ARNASON (2007?):

2000 brood mares, 160 approved stallions:

HOWEVER:

Effective population size: 30 animals

(mainly due to overuse of same stallions AND THEIR SONS; the most used stallion had 20 licenced sons in the herdbook)

Why is the danger of too low effective population size bigger in horse breeding than in cattle breeding.



- Because we don't have the same control with the use of sires as in production animals -the individual breeders/syndicates- not the breeding organisation- are the owners of the stallions.
- Because we don't WANT too heavy restrictions on breeding practices within the horse industry.

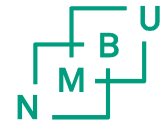
MY WORRIES: Parts of the horse breeding industry have adopted parts of the breeding theory- but does not want the other elements of control- the elements important for sustainable breeding

Sustainable breeding in small populations



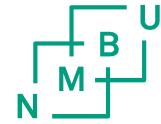
1. Breeding plans with realistic goals.
 - Relationship matrices
 - Registration of relevant performance traits
 - Registration of relevant conformation traits
2. Follow the development of relationships in the breed
 - Many breeding animals, especially increase number of stallions.
 - Actions to reduce inbreeding developments (programs like Gencont, Eva etc).
3. Overlook genetic developments in traits (Development of BLUP-values)
4. Introduce OPTIMAL CONTRIBUTION for the total management of the population

Genomic relationship



- Relationship matrix based on genetic SNPs (fragments of genes) (analysed by blood, hair etc) (G) can be different from the relationship based on the traditional additive relationship-matrix (A), because it also includes the effect of mendelian sampling (we are just ON AVERAGE 50% in relation to our full siblings and just ON AVERAGE 25 % in relation to half siblings).
- Genomic relationship has proved to be somewhat different from A-relationship (cattle, pigs), and is regarded as more correct.
- When selection within families this is even more obvious, as all individuals then has the same parents (selection among siblings), and as such the same A – relationship, but varying G-relationship.

The internationalization of horse breeding

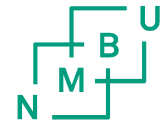


- Herdbooks and breeding regulations are international (for some breeds) Thoroughbred, Standardbred , Arabians...
- Competition and/or cooperation is typical for most international horse breeds

Examples-1:

- **World Fengur- international database for Icelandic horses. One international organisation-more or less controlled by the country of origin, Iceland. THE horse breed in the world where the animal breeding theory is most successfully adapted. WEB-page:**
- *WorldFengur* is the studbook of origin for the Icelandic horse. WorldFengur is a web database program, which opens access to a database containing information on Icelandic horses in the membership countries of the FEIF (International Federation of Icelandic Horse Associations). WorldFengur is a joint effort by the Farmers Association of Iceland (FAIC) and FEIF to construct an official and central database on horses of Icelandic origin located all over the world. In WorldFengur you can find comprehensive information on around 300.000 Icelandic horses all around the world e.g. pedigree, offspring, assessments, owners, breeders, BLUP, colors, microchips and more. Also you can find about 5.000 pictures of breeding horses. These numbers are increasing every day. You are just one step away from accessing WorldFengur. Buy a 12 months subscription with 150 visits for 50 EUR (only 4.17 EUR per month). If you need more visits you can buy a 12 months subscription with 300 visits for 69 EUR.

What can the Fjord Horse co-operation learn from these examples??



- **Possibilities for international cooperation within breeding organisations** (what is the optimal balance between competition and cooperation between countries?)
- **Presentation of comparable breeding values** (“sire proofs”, “EBV-values”, “BLUP-values” etc)
- **Better management of the world population of Fjord Horses**
(controlling inbreeding developments, overuse of the best stallions - lisencing rules etc etc).
- ***Agree on important traits and how to record them.***

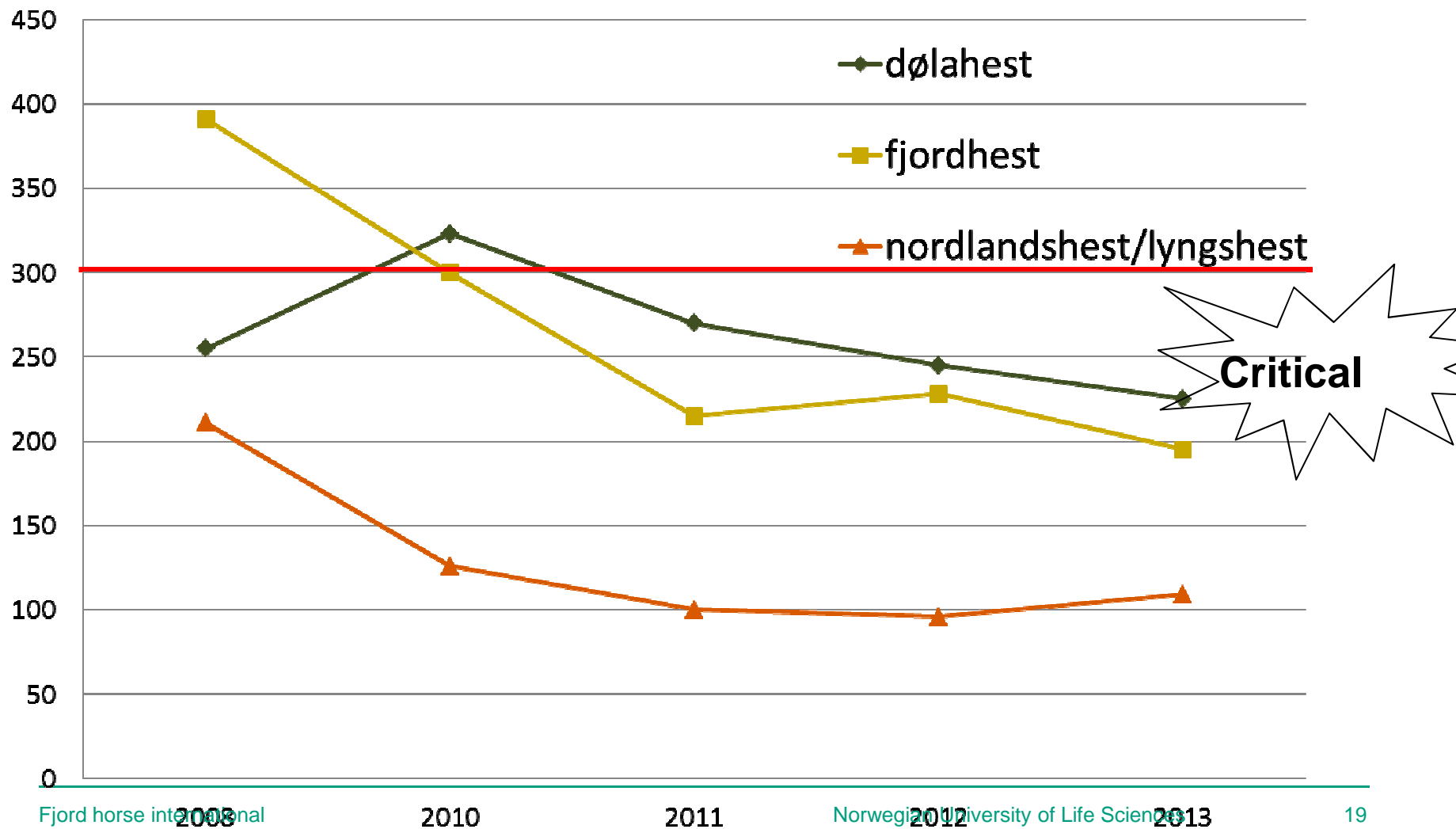
Marginal contributions, Fjord Horse (N)



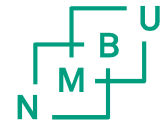
Seilen 2009: Many sires contribute to the Fjord horse of today!

Rang	Fødd	ID	Namn	Marginalt bidrag
1	1891	166FH	Njål	0,1339
2	1946	1417FH	Torbjørn	0,098913
3	1923	819FH	Øyarblakken	0,089166
4	1955	1569FH	Valebu	0,080347
5	1913	635FH	Bergfast	0,058812
.....
20	1999	FJH 721 DK	Frederik Skovå	0,009881792
21	1981	1920FH	Reiulf	0,009734131
.....
28	1994	N-94-2681	Fjølestaen	0,005796845
29	1985	EFJH 643 DK	Knast Halsnæs	0,005590067
30	1994	N-94-2789	Lunnar	0,00555363
31	1979	2011FH	Aser	0,005505828
.....
41	1999	N-99-2625	Lunner gråen	0,002823751
.....
48	1985	7992 DK	Lene Tyler	0,001907437
49	1980	7353 DK	Stine Fj 7353	0,001785372
50	1991	N-91-2869	Bjørktind	0,001768652
Totalt				0,511485505

Covered mares Norway



Effective number in the Norwegian Fjord Horse population



Seilen and Johnsen (2009): Effective population size: 107

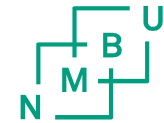
Fure (2015): Effective population size : 67

Meaning; Alarming decrease in effective population size!

WHY: Rapid decrease in number of foals

Overuse of some stallions? (see next slide)

Fjord Horse in Norway



Fjord Horse (N=5500)

	2000	2013	2014	2015
Covered mares:	575		210	150	242
No. stallions used:				32*	35**
Born foales (registered):	380		125	120	80

* 4 of them covered 41 % of mares (21,17,14,10 mares each).

** 4 of them covered 46 % of mares (48,22,21,21 mares each).

No. of covered mares halved from 2000 to 2015

A slight increase last year (a trend?)

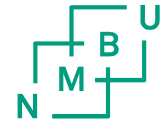
Situation is CRITICAL

Fortunately, there are sister populations!!!!!!!

(the most used stallion 2015 was “foreign”. An important contribution to reduce increase in inbreeding)

Expect to increase effective population size in years to come IF NOT
~~OVERUSE OF SONS.~~

What about traits to improve---- we want to do selection as well??



Conformation traits are moderate heritable

Gaits are moderate heritable

Temperament is moderate heritable

(conclusions from next slide)

ARE WE MEASURING THE RIGHT TRAITS?

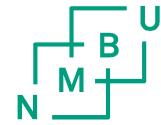
IN SHOWS??

IN LICENCING TESTS??

IN COMPETITIONS??

Develop further cooperation between populations!!!!!!

Heritabilities of traits in the Fjord Horse, from horse shows and licencing events (Selle 2010)



Conformation	Heritability
Breed type	0.23
Body, muscularity	0.23
Legs, quality and correctness	0.04
Gaits	0.20
Performance traits	
“For-/fraspenning”	0.08
Gaits in test	0.12
Driving	0.04
Working spirit	0.16
Temperament	
By performance test judges	0.19
By conformation judges:	0.16
By inspecting vets:	0.19

WHAT DO WE NEED IN FUTURE FJORD HORSE BREEDING



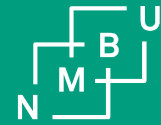
NATIONALLY:

- Relationship matrices, continuously updated
- Databases for conformation traits
- Databases for performance traits
- Databases for mentality/behaviour/temperament
- Optimize selection vs. genetic uniqueness.
- More cooperation with the riding-societies (databases)
- Further development of OWN competition concepts

INTERNATIONALLY:

- Relationship matrices
- Plan for optimizing genetic variation
- Standardizing conformation traits?
- Standardizing performance traits?
- Joint breeding values?

GENERALLY: OPERATIONALIZE BREEDING PLANS



FUTURE POTENTIAL

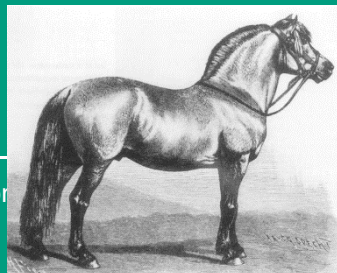
Many interested and motivated breeds, both nationally and internationally

Increasing understanding of horse breeding as not only hobby, but a professional occupation.

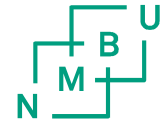
Much theoretical developments in animal breeding to be adopted in horse breeding. Horse breeding is becoming more and more professional.

Many challenges ahead of us in order to improve our Fjord horse breeding.

Good luck.



FROM THE DISCUSSION AFTER THE TALK; POINTS FOR FUTURE COOPERATION (as Odd Vangen sees it) :



- **AI: Which countries are offering AI? Could there be an overview from FHI on which countries/companies/single persons who are offering frozen AI for the international market? Which stallions are available?**
- **Conference for inspectors/judges: Even if we don't need or don't have to totally agree on conformation traits in different countries, judges' conferences would be important for both exchanging experiences, learn from each other and discuss new scoring methods like "linear scoring" etc. etc. These type of conferences you see in most other international breeds.**
- **Use of unique identification numbers. Countries are supposed to use the UELN-number, as a unique ID for all horses of all breeds. All documents should be of the same type and contain the same information, so there should not be any doubt of ID when transferring between countries or stud books. Breeding across countries and stud books are then much easier! Including the possibilities of including offspring from different stud books when calculating breeding values for stallions.**
- **Together you have a large population size in your breed!**