TROTTER BREEDING – PERSPECTIVES FROM AN ANIMAL BREEDING SPECIALIST

"21 World trotting Conference

Oslo Norway May 20 2009

Theme " Sport and breeding"

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Past: **Chairman of the breeding advisory Board, Norwegian Horse Center.**

Chairman of the board, Norwegian Warmblood (riding horses)

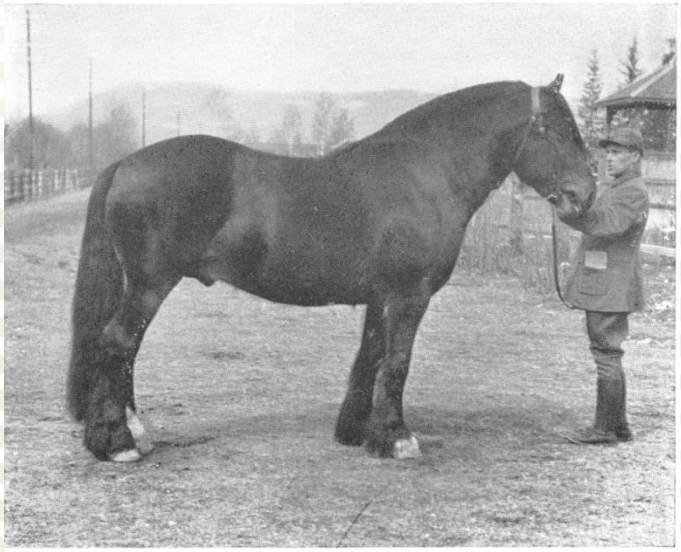
Project leader "New breeding plans for Norwegian horse breeding.

Present: **Teaching horse breeding at University level.**

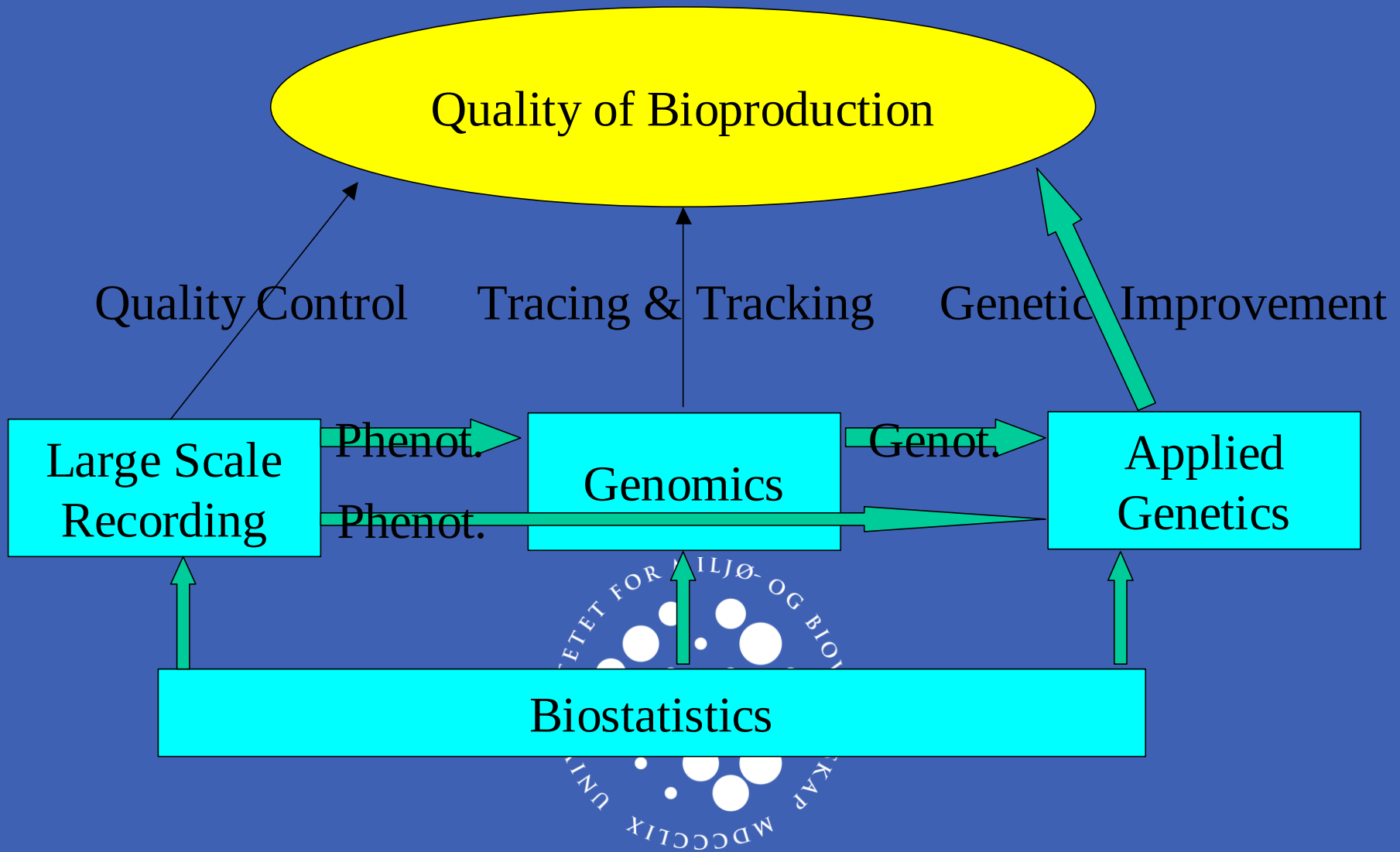
Author of several books on horse production and breeding.

Veikle Balder D.4, den første matador i kaldblodsavlen. Hingsten finnes i stammen på alle av dagens kjente kaldblodstravere. Tegnet av H. W. Smith i 1897 etter foto tatt av statsagronom Johan Lindeqvist.

Norwegian Horse Breeding-from a light horse (Veikle Balder), to a draft horse (Gjestar) to a modern coldblooded trotter (Elding) – Breeding is constantly changing our horse- within and across breeds- directly or indirectly



Gjestar 1185. Fot. 1923. J. B.-J.

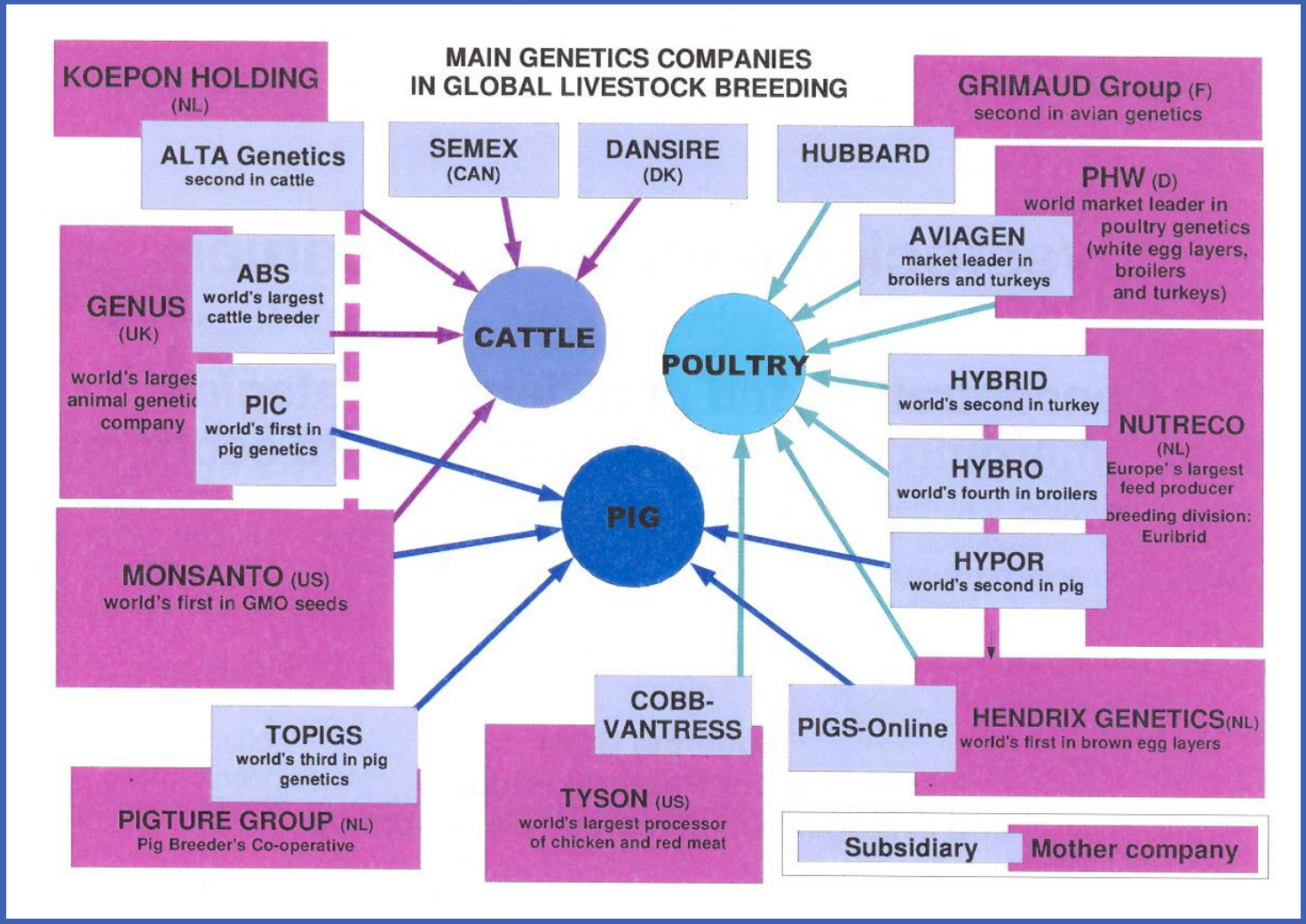

Quality of Bioproduction
Quality Control
Tracing & Tracking
Genetic Improvement
Large Scale Recording
Phenot.
Phenot.
Genomics
Genot.
Applied Genetics
Biostatistics

The animal breeding/genetics industry

Big business internationally- competition between international companies- more and more genetics on fewer hands

- **Animal breeding theory more and more utilized by the horse industry**
- **Databases with recording of traits (production), pedigree (relationship matrices) of higher economic value than before ("investments in genetics").**
- **Breeding value estimation**
- **Programs for optimizing the balance between selection and maintaining genetic variation within and across breeds.**
- **Breeding plans for genetic progress AND sustainable use of genetics (a short term conflict)**

Concentration of ownership to Animal Genetic Resources (The animal breeding industry of the world)



IS THE TROTTER BREEDING DIFFERENT FROM FARM ANIMAL BREEDING?:

YES:

Because the sport is not necessarily chasing genetic progress?

Because it does not matter if the time or earnings are improved genetically as long as there is variation and possibilities for competition?

NO:

Because the trotter breeding is dependant on genetic variation

Because the sport want improvements, both genetically and environmentwise.

AND

Because there are breeding plans for most trotter breeds where speed, earnings, start frequencies etc are the main traits. GENETIC IMPROVEMENTS ARE EXPECTED THROUGH BREEDING.

The internationalization of horse breeding-1

- **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 sucessfully adapted. WEB-page:**

- **World*Fengur* 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, colours, 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.**

The internationalization of horse breeding-2

INTERSTALLION- cooperation between breeding organisations for riding horses.

2. Pilot projects

The aim of the two Interstallion pilot projects has been to improve the comparison of breeding values for stallions across countries. The first pilot project based on young horse's tests in different breeding populations (DWB, Han, Holst, KWPN and SWB). The other is working on a comparable pilot project based on results in jumping competition in 7 countries (BEL, DNK, FRA, GER, IRL, NLD and SWE). Both projects constitute parts of PhD studies primarily financed by Swedish and French sources.

The first phase of both studies has been to see how connected the different warmblood riding horse populations are, i.e. to what extent the same stallions are represented as sires or grandsires of the tested or competing horses in each country. The first pilot project shows that the genetic connectedness between the five studied breeding organisations is at such a level that it should be possible to estimate genetic correlations between similar performance traits of young horses tested within them. The genetic connectedness became better over time and it is currently better than connectedness in dairy cattle populations (which are already included in the international genetic evaluation for dairy bulls). Also the second pilot project reported a high genetic connectedness for a number of populations.

The second phase of both projects is dealing with the estimation of genetic correlations. These studies will be less extensive than inititially planned as the KWPN and German studbooks decided not to participate in this second phase. The estimation of genetic correlations between young-horse performance traits (pilot project 1) will include Danish and Swedish data. The estimation of genetic correlations between competition data (pilot project 2) will include 10,091 national breeding values for 926, 563, 5290, 1159 and 2153 stallions in Belgium, Denmark, France, Ireland and Sweden, respectively.

The example of INTERBULL-1

A cooperation between breeding companies in dairy cattle breeding. A balance between cooperation and competition:

- **Interbull Centre** is the operational unit of Interbull. The Interbull Centre provides a number of user-paid services to member countries. In 2007, Interbull had 42 member countries and more countries are likely to join in the future.

  In 1999 Interbull finalised an agreement with a North American Consortium consisting of Holstein Association USA, National Association of Animal Breeders, Holstein Canada and Canadian Dairy Network to subcontract part of the computations for the international genetic evaluation for conformation traits.

  Benefits. Interbull currently provides four major benefits to its member countries:

- **International Communication**
  A major benefit of Interbull membership is the exchange of information with other member countries. Interbull co-ordinates this international communication through the use of meetings, workshops, surveys, presentations, publications and its Internet site www.interbull.org. Interbull annually organizes an international seminar for exchange of research results and experiences among industry representatives and scientists in the area of genetic evaluation of dairy cattle. Proceedings of these meetings are published in the Interbull Bulletin series.

- **International Research & Development**
  The Interbull Centre provides international leadership in researching and developing methods for generating international genetic evaluations. It achieves this through co-ordinating and reviewing research done in member countries, as well as running it's own research program.

- **International Genetic Evaluation Service**
  The International Genetic Evaluation Service provided by the Interbull Centre calculates international genetic evaluations for most of the economically important traits in dairy cattle. Over 25 countries currently subscribe to this service.

- **International Technical Support**
  Interbull provides member countries with advice and assistance on all matters relating to the genetic evaluation of cattle. This includes guidance for countries developing joint evaluation or recording schemes, and recommended codes of practice for national evaluation systems.

The example of INTERBULL-2

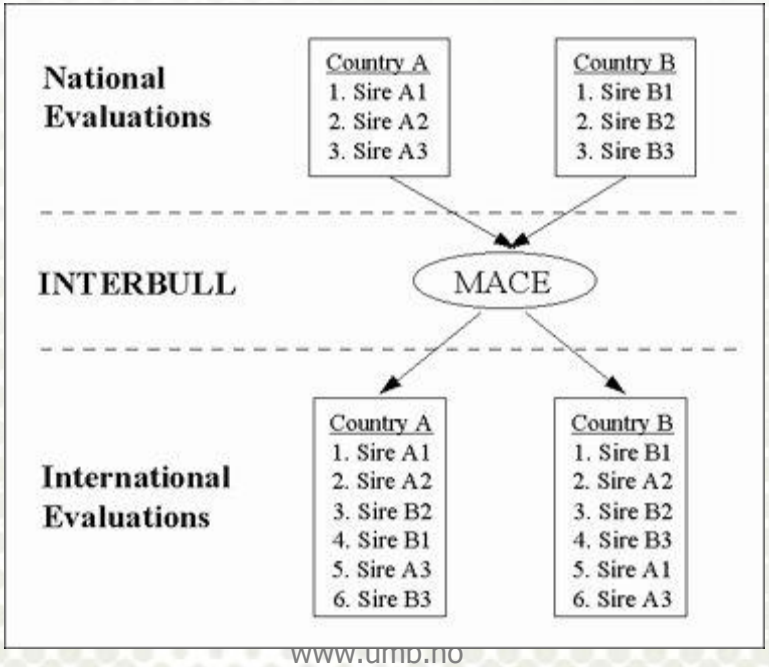
- **International Genetic Evaluation Service**

  International Genetic Evaluations are across-country measures of genetic merit of dairy for individual traits. In 2007, the International Genetic Evaluation Service provided by Interbull evaluates sires of 6 breeds and 6 trait groups (milk production, udder health, conformation, longevity, calving and female fertility traits). Other traits will be included in the future.

  Interbull uses a scientifically advanced method known as Multiple Across Country Evaluation (MACE) to calculate International Genetic Evaluations. MACE has two major advantages over other methods:

- **Use of all known relationships between animals**
  MACE combines information from each country using all known relationships between animals, both within and across populations.

- **Genotype by environment interactions**
  MACE accounts for the possibility of animals re-ranking between certain countries. This occurs when animals perform better in certain environments than they do in others or when genetic evaluation methods differ between countries. For this reason, a separate set of results is calculated for every participating country. This process is demonstrated in the figure demonstrated in the figure below:



What can the trotter breeding learn from these examples??

- **Possibilities for international cooperation within breeding organisations (what is the optimal balance between competition and cooperation in trotter breeding?)**
- **Presentation of comparable breeding values ("sire proofs", "EBV-values", "BLUP-values" etc)**
- **Better management of the world population of standardbred trotters**

  (controlling inbreeding developments, overuse of the best stallions - lisencing rules etc etc).

Horse breeding can be "controlled" to different degrees- however ,higher genetic progress is achieved IF more breeders are "marching together" with a joint platform of knowledge and understanding:

AN EXAMPLE:

The "leading stars" for Norwegian Breeding Organizations were formulated around 1960 and were expressed as such:

- **Genetic progress for the many** (***the farmers, heavily involved in recordings for the breeding organisation, have the right to shear a part of the outcome of genetic progress)***
- **The farmer's right to be consulted**

  (involvement, ownership)
- **Utilizing the scientific improvements**

  (utilizing new knowledge, bridge between theory and practice)

AND TODAY THIS HAS PRODUCED GENETIC PROGRESS IN DEMAND AROUND THE WORLD- ANIMAL GENETICS HAS BECOME AN EXPORT ARTICLE! FROM NORWAY!

The success of a breeding organisation is dependant on the genetic improvement created, and this genetic improvement is dependant on scientific inputs. Here are some important factors:

- Strongly organised
- High AI percentage (high selection intensities and efficient use of males)
- High health status
- Short distance theory-practice
- Interested and motivated breeders
- Openness of breeding system
- Documentation of genetic level

WHICH OF THESE FACTORS ARE THE EASIEST AND/OR MOST DIFFICULT TO ADOPT TO THE TROTTER BREEDING INDUSTRY??????

Criteria for sustainable breeding

The main breeding organisations in Norway have all documentet- in their yearly reports- that their breeding is sustainablee accoring to the following factors;

- Documentation of inbreeding development
- Genetic progress for other traits than production efficiency (health, fertility etc)

MEANING: The socieety is following our breeding practices- we should strive for high acceptance in the society!

Criteria for sustainable animal breeding (Vangen 2006)

At the breed level:

- **Breeding for more traits than production efficiency- crucial for a balanced biology of the animals**
- **Breeding in a long term perspective is important for a balanced biology of the animal**
- **Recording of traits in the natural environments (="field", "on-farm") ensures adaptation to the production environments**
- **Be aware of the biologial limitations and non- linear relationships between traits**
- **Maintain an large enough effective population size**
- **Balance breeding values with the animal's genetic uniqueness value.**

The challenges for international horse breeding will be the same as for the dairy cattle challenges:

Main challenge for sustainable breeding in Norwegian Red Cattle (NRF):

- Maintaining genetic variance
- Minimum inbreeding
- Genetic gain

GENETIC GAIN IS NOT THE ONLY ISSUE FOR A BREEDING ORGANIZATION

Other dairy cattle populations

	Population	Effective size	ΔF
Weigel 2001	US Holstein	39	1,28
	US Ayrshire	161	0,31
	US Brown Swiss	61	0,82
	US Guernsey	65	0,77
	US Jersey	30	1,67
Sørensen et al 2004	Danish Holstein	70	0,71
	Danish Jersey	98	0,51
	RDM	274	0,18
Sehested 2005	NRF	167	0,30

Solutions

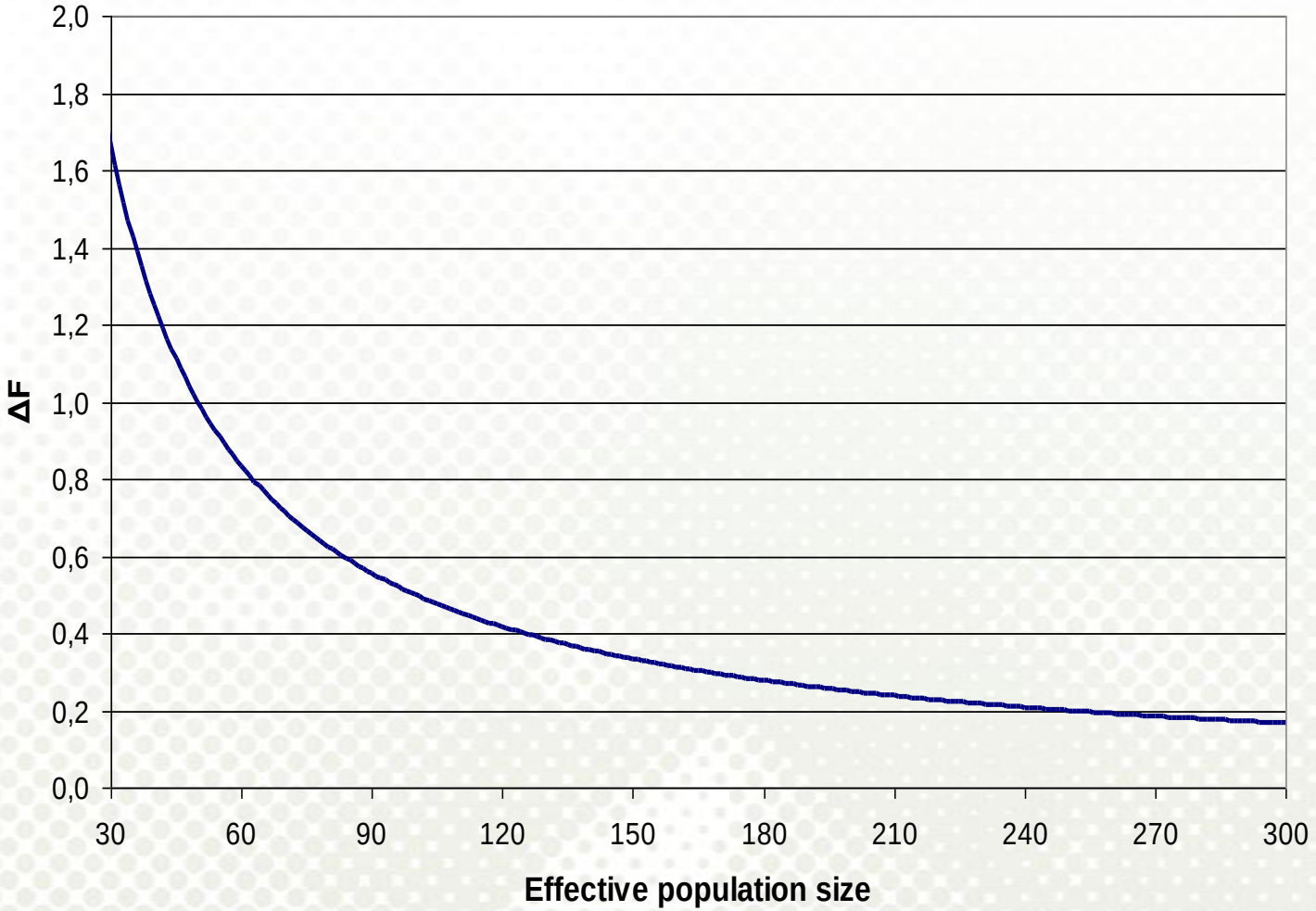
- Optimal selection of elite stallions
- Optimal use of elite stallions

Optimal: Taking both total merit and the stallions' relationship with the mares of the population into account

Different tools available (computer programs):

- ″Optimal contribution″
- ″GENCONT″
- ″EVA″
- ″other programs??″

Inbreeding and effective population size



The danger of intensive selection of relatives:

ARNASON:

Eks. Nordic trotter poulation (coldblooded):

2000 brood mares, 160 approved stallions:

HOWEVER:

Effective population size: 30 animals

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

- Because we dont 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 dont WANT too heavy restrictions on breeding practices within the trotter 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 horse breeding- overuse of popular stallions

- There are licensing rules for stallions
- There are national breeding programs, AI programs etc.
- What about the size of quotas (if quotas) on use of popular stallions?
- What about the problem of licensing TOO many sons from the popular sires, or the sires with the highest breeding values (BLUP breeding values will lead to family selection).
- Example from Norwegian coldblooded trotters: Licencing 18 sons from the top ranked sire- far too many to maintain a high effective population size .

Genetic gain is determined by:

- Breeding goal: $T = a_1G_1+a_2G_2+.....a_nG_n$(one or more traits)
- Genetic parameters (h^2, correlations, variances)
- Population structure/breeding plan

The simple formulae for genetic progress:

GENETIC GAIN IS:

SELECTION INTENSITY x ACCURACY(heritability)x VARIATION)
GENERATION INTERVAL

minus INBREEDING DEPRESSION

Sustainable breeding programs depend on how we handle these parameters

Heritabilities of performence traits in standardbred trotters:

Ojala (1987):

Percentage of first placings:	**0.16**
Earnings, totally (3-5yrs):	**0.17**
Earnings/start:	**0.25**
Best racing time:	**0.26**
Average all traits:	**0.20**

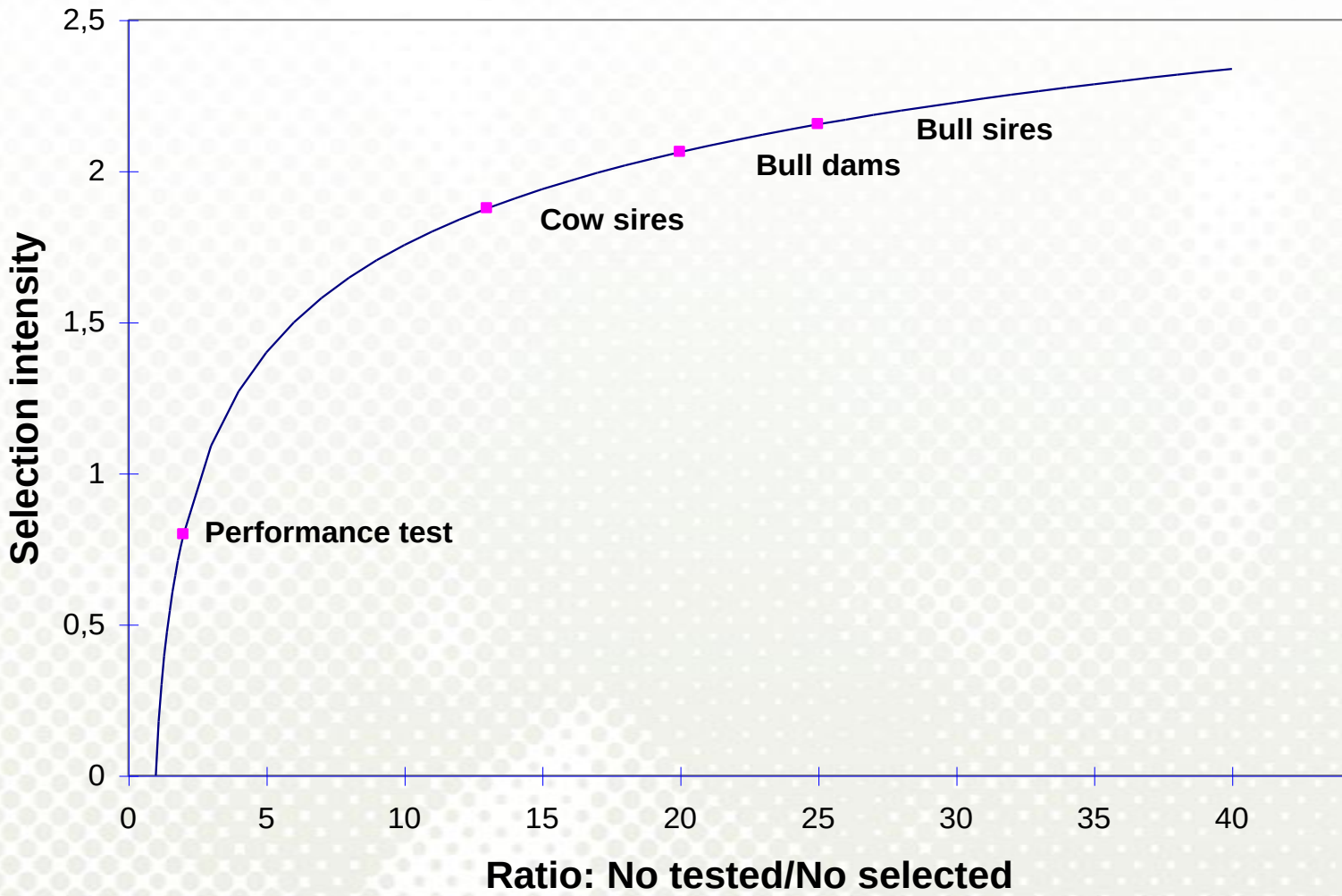
Arnason (2000):

No. Races	**0.16**
Racing status	**0.31**
Percentage placings	**0.33**
Earnings/races	**0.23**
Earnings	**0.36**
Best racing time	**0.32**

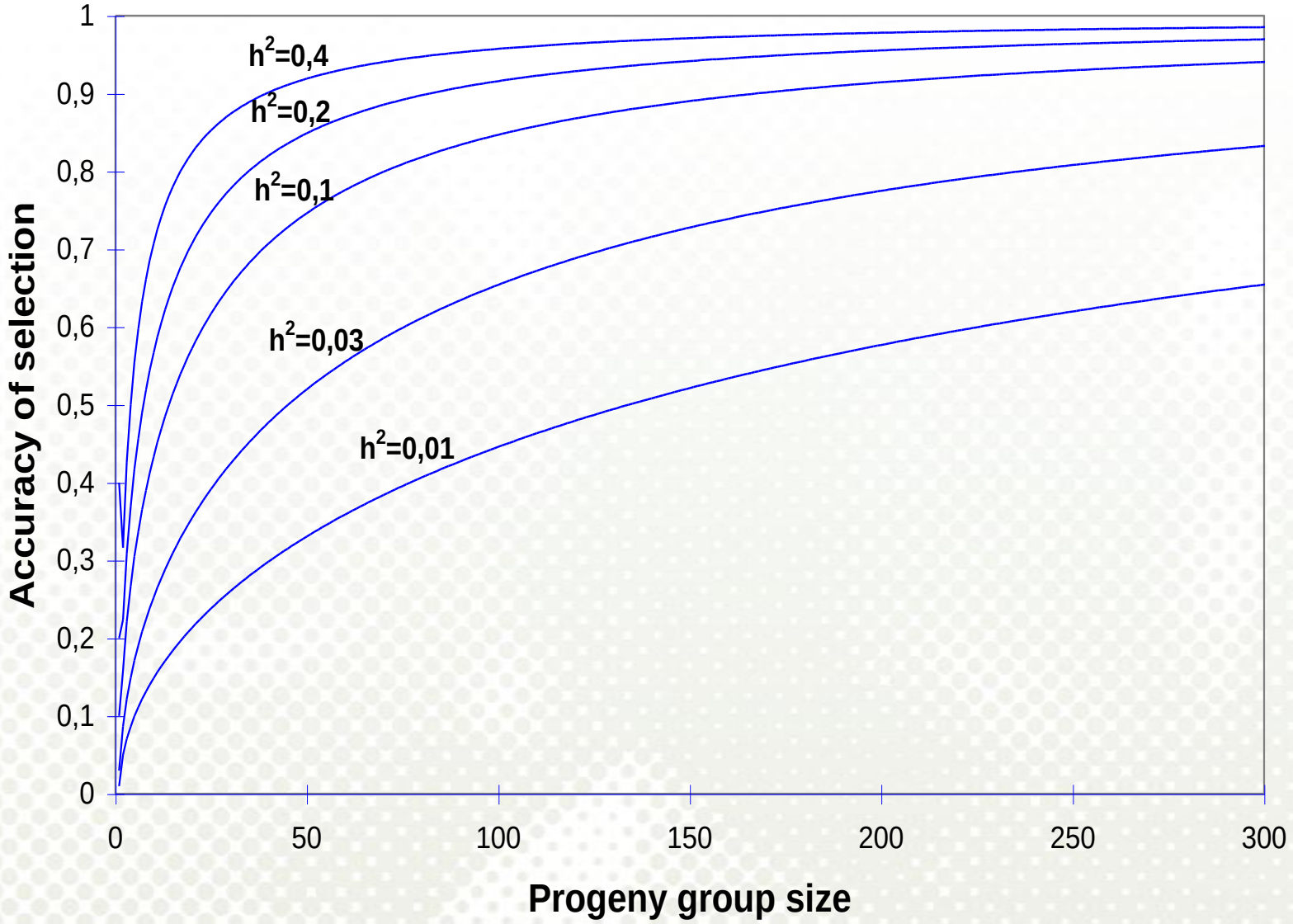
Sikkerhet på slektskapsinformasjon

Type slektskapsinformasjon	Arvbarhet 0,1	0,3	0,5
Dyret selv	10 %	30 %	50 %
Far + mor	5 %	15 %	25 %
Alle aner	8 %	20 %	29 %
Helsøsken			
4 søsken	8 %	20 %	28 %
Halvsøsken			
20 søsken	8 %	15 %	19 %
Avkom			
5 avkom	12 %	28 %	42 %
10 avkom	20 %	49 %	59 %
20 avkom	32 %	60 %	76 %
40 avkom	50 %	76 %	85 %
120 avkom	76 %	90 %	94 %

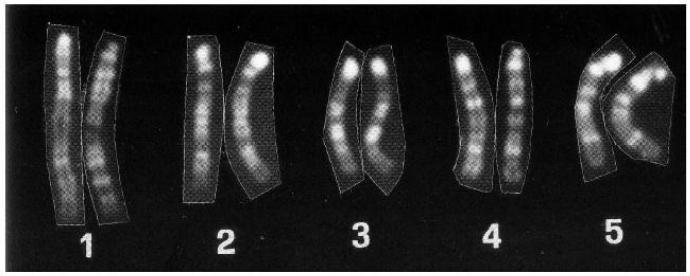
High selection intensity-few selected- BUT low ratio no. tested/no. selected because the population size is normally constant (balance selection and accuracy)



Accuracy


Accuracy of selection
1
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
h^2=0,4
h^2=0,2
h^2=0,1
h^2=0,03
h^2=0,01
0
50
100
150
200
250
300
Progeny group size

Genotype



Phenotype

Selection

Traditional breeding- new technologies?

- The modern animal breeding dates back to the 1950's when computers and statistical methods made breeding value estimation possible based on phenotypic recordings and registration of environmental factors.
- The traits to be improved (according to the breeding plan) are recorded on the individual and/or relatives. Potential breeding animals are ranked according to their breeding values. Computers are continuously recalculating breeding values along with new information (siblings, offspring etc).
- Selection is done based on these breeding values. Selection decisions on males are in production animals mainly done by the breeding organisation while the breeders' are performing the selection decisions on the female side.
- **New technologies- molecular genetics:**

  DNA-technologies makes it possible to study the genetic makeup directly – through blood samples – and select on that basis without phenotypic infromation?????????????

Summary of molecular techniques

- Marker selection. Finding genes associated with traits, but has not found ”the gene for”. QTLs Info on genetic defects, colour, some health traits.
- Genomic selection- does not need to know ”the gene”. Scanning of the whole genome. Analysing technique with 54000 markers (SNPs), is now down to 280 dollar/animal.
- Proteomics. Studies of protein functions- and expressions.
- Transgenics, transgene animals, only medical use (?) So far transgenic animals have many defects. First transgenic mice in 1982.

Overview of reproduction techniques:

- Artifical insemination. High selection intensities obtained, however often overuse of the best or most popular sires.
- Semen sexing. Flowcytometri, different techniques, patenting issues and legal rights. Of main interest in cattle and horses?
- Cloning Dolly from 1997. What was the importance? For animal breeding- almost nothing. Only of interest for the harmacy industry. **You cannot produce animals with identical traits- or properties- unless the heritability is one.!!**

Genom-prosjects- knowledge of the whole genome:

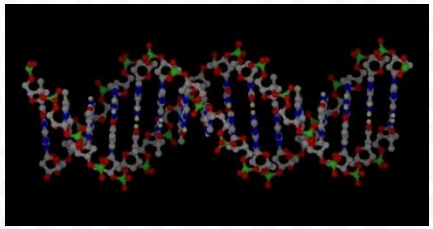
- Dog (7.6X, Juli 2004)
- Chicken (6.6X, Mars 2004)
- Cattle (7.15X, August 2006)
- Horse (6.8X, November 2008)
- Pigs (ongoing)
- Salmon? (Canada, Chile, Norge)

http://www.ncbi.nlm.nih.gov/Genomes/

What will it mean to animal breeding? Little- at least on the short horizon!

IMPLEMENTATION OF GENOMIC INFORMATION-1

- Selection without genomic information
  - Phenotypic records and relationship information
  - Assumes infinitesimal model



- Genotype

Environment

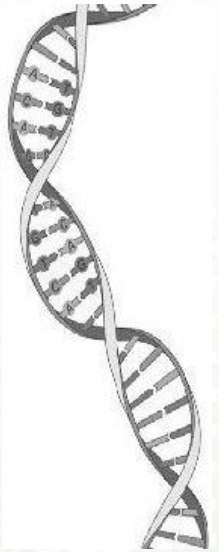
Phenotype

- Expected genetic gain

$$\Delta G = \text{intensity} * \text{accuracy} * \text{additive genetic variance} / \text{generation interval}$$

IMPLEMENTATION OF GENOMIC INFORMATION-2

- Advantages
  - Control of inbreeding on molecular level
  - Quick fixation of favourable alleles
  - Break up unfavourable correlations
  - Estimate effective population size
  - ➢ Maintain genetic variation in population



– ΔG = intensity * accuracy * additive genetic variance / generation interval

- intensity: screening more candidates
- interval: early performance testing
- accuracy: measures directly on candidates

(Andersson & Georges 2004, Daetwyler et al. 2007)

GENOMIC SELECTION

- Effect of GS tested in North American Dairy bulls
  - Bovine 53K Illumina array
  - 27 traits
  - ~2600 bulls

  - Average for all traits showed 18% increased ”reliability of prediction” compared to parental average
  - Increase was larger for low heritability traits
  - Lower than shown in simulation studies
    - Compensated by reduction in generation interval

(Chesnais et al. 2008, van Raden et al. 2008)

GENOMIC SELECTION

- Some breeding companies have started using genomic selection

ThePigSite Latest News

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Use the above box to search this section or the whole site

Thursday, December 14, 2006

First use of commercial genomic selection

THE NETHERLANDS - Euribrid announces the first large-sca Selection" technology in poultry. This is also the first time has been used in commercial animal breeding. The anima on November 22, 2006. Although the basics of this technolo of this application is still rare.

No published data on their experience

Westfalia | Stackyard News | Mar 08

Avoncroft Adopts Genomic Selection to Speed Up Genetic Progress

13/03/08

CRV, the major supplier of Dutch genetics to British cattle breeding company Avoncroft Genetics, will be fully using genomic selection in its bull proving scheme by the second half of 2008. The Dutch company CRV, also known as Holland Genetics - is the forerunner in the application of this advanced selection technique.

Genomic selection - the selection of animals through breeding values based on DNA-profiles – provides reliable information, at a young age, on potential breeding animals. This enables 'sharper' and more accurate selection of animals and leads to faster genetic progress. CRV will implement significant changes in its breeding programme in order to maximise the benefits of genomic selection. These include:

- A doubling of the selection pool. Annually, CRV selects 500 young Holstein and red Holstein bulls. With the additional information provided by using genomic selection, this number will increase to 1,000. This will be the result of more intensive use of bull dams within the CRV Delta breeding programme and from contracting more young bulls, out of bull dams from private breeders.

BIG DEBATE IF/HOW MUCH MOLECULAR GENETICS WILL IMPROVE THE GENTIC PROGRESS OF BREEDING PROGRAMS:

- Wil it give us a sheaper breeding program without all the recording?
- Will it give additional information on genotype that our ”quantitative genetics” does not give?
- Is it neglecting the genes x environment interactions?
- Is it neglecting the interactions among genes?

ANYWAY:

The trotter industry will get the records on performance from the races for all other purposes all the same. Genomic selection therefore only of interest for other traits like fertility, health etc??

Some examples on where the trotter industry is in relation to breeding plans and traits for selection-1

US Trotting Association:

Presents statistics on sires (the offspring's results);

- **Earnings, totally**
- **Earnings per offspring**
- **No. offspring started (% started)**
- **+ other statistics.**
- **WHAT IS THE BREEDING GOAL? UP TO THE BREEDER TO SELECT SIRE ON DESIRED TRAITS?**
- **MORE???**

Some examples on where the trotter industry is in relation to breeding plans and traits for selection-2

US Trotting Association:

Ranking of sires according to the different traits (based on results presented on internet)

- The sire, among the top 20, highest ranked for Earnings per foal in 2009, is ranked no. 20 based on total earnings (all age progeny), and he will be ranked no. 5 based on Percent starters among progeny.

- There are on average 60 foals per sire (born in 2006, started in 2009) with results, giving an average start frequency of 45 (varying from 67 to 30 between sires). No. Started progeny is on average 27.3 per sire per year.

Some examples on where the trotter industry is in relation to breeding plans and traits for selection-3

The Norwegian breeding plan/breeding organisation for standardbred trotter:

- **Presents statistics on sires (the offspring's results);**
- **Presents the breeding goal:**

  Performance, longevity: 80percent

  Conformation, temperament: 20 percent

  Fertility and disorders- independant culling
- **Has quotas on use of each stallion (150 matings/yr).**
- **Generally the national breeds have more detailed breeding plans than the international breeds??**

Some examples on where the trotter industry is in relation to breeding plans and traits for selection-4

The UET organization- Europe:

- **67 000 racing horses (9 000 ”foreign”)**
- **2408 stallions (2007)**
- **37 783 mares, 26 574 foals**
- **16 mares/yr/stallion, 11 foals/yr/stallion**

- **Presents statistics on most winning horses and offspring winnings (money)**
- **Presents statistics on time?, osires (the offspring’s results);**

Intentions of more joint breeding efforts???

Some conclusions

The animal breeding theory is there to be used by the horse industry.

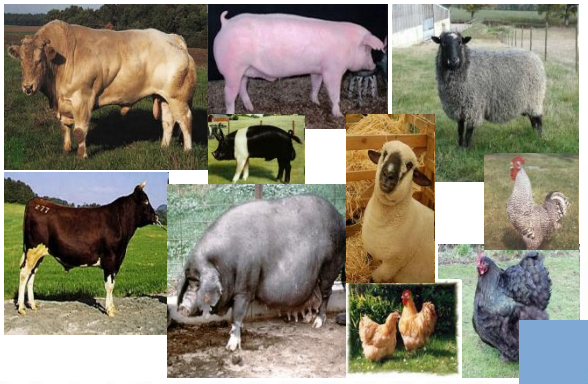
The Icelandic horse and the Riding Horses, internationally, and the coldblooded trotter, nationally, has utilized the theory for genetic improvements to the largest extent.

Very few estimates of genetic progress in horse breeding are produced in the world. (should we hope for half a percent/generation if the cattle industry is getting above 1 %???)

Molecular genetics is just applied in some breeding programs in cattle and pigs- still with no realized improved genetic progress.

Little quantitative genetics work is published on standardbred trotters. On international conferences we hear mostly about riding horse breeding and breeding of small national breeds.

DO WE FEEL THIS AS A CHALLENGE???????????????



Thank you for this opportunity to takk about the most exiting topic I know about- animal breeding!