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Utilisation and conservation of farm animal genetic resources

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Curriculum vitae Kor Oldenbroek

- 1968-1973 Animal Husbandry
- Animal Breeding
- Genetics
- Disease prevention
- 1988: thesis; breeding, nutrition

- 1973-1996 IVO Schoonoord
- 1996-2005 ID-DLO (Lelystad)
- > 2005 CGN; WIAS; APS

- Comparison breeds/ crosses
- Applications of biotechnology
- Genetic diversity

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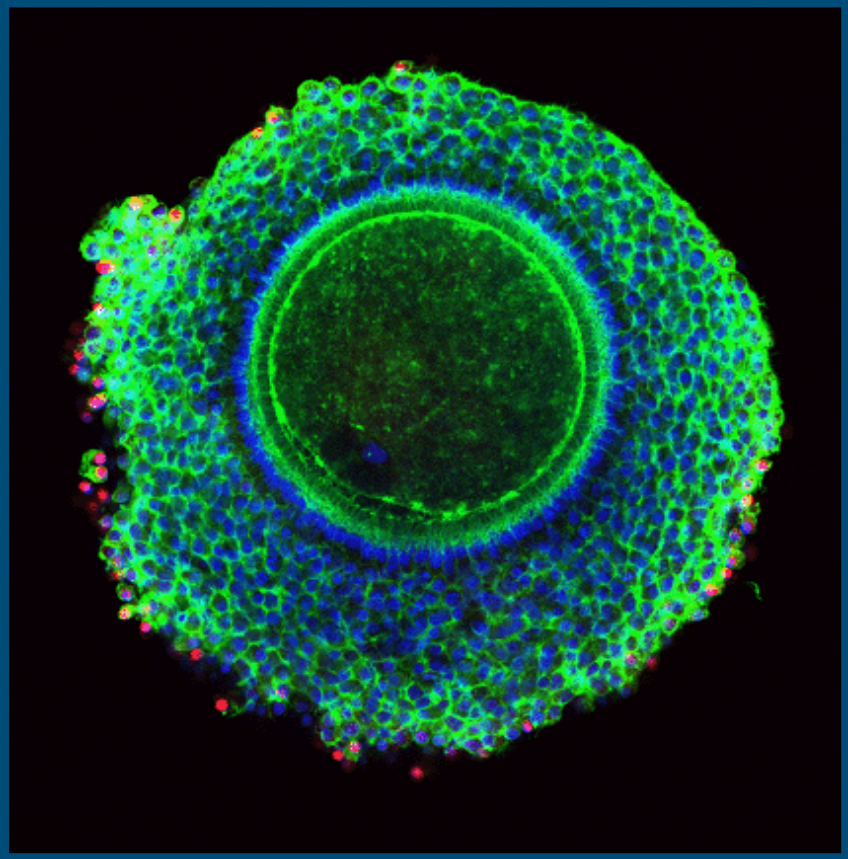
What are genetic resources?

- Genetic variation comprised in:
- Animals
- Semen
- Oocytes
- Embryos
- Somatic cells



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Farm AnGR ?

- 50.000 mammalian and avian species
- 30 species extensively used for agriculture
- 14 species account for 90% of global livestock production

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What is the problem?

- State of the World of Farm Animal Genetic Resources (FAO):

1. genetic diversity is threatened (erosion); breeds disappear without notice
2. and in globally used breeds genetic variation within the breed decreases through inbreeding

Diversity in Dutch cattle breeds

- 1975
  - > 2 million dairy cows
  - 71 % Black and White Dutch Friesian Cattle
  - 28 % Red and White Meuse Rhine Yssel cattle
  - 1 % Groningen Whiteheaded
  - Other small/rare cattle breeds

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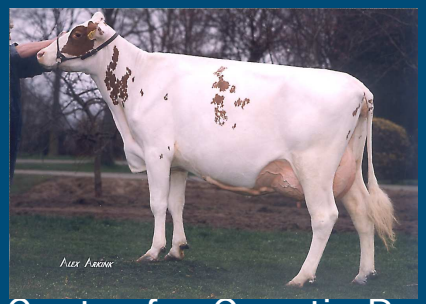
Diversity in Dutch cattle breeds

- 2002
  - Holstein Friesian > 1500000
  - MRY 30000 (decrease)
  - Dutch Friesian Black and White 6000 (decrease/stable)
  - Groningen White headed 2000 (growth)
  - Lakenvelder 1750 (growth)
  - Colour sided White back 1500 (stable)
  - Deep Red 200 (growth)
  - Dutch Friesian Red and White 200 (growth)



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What is genetic variation?

- Genetic variation ***within a species*** =

  Genetic variation ***between breeds*** +

  Genetic variation ***within breeds***

  (Varies from dependent on the trait 20 – 80 %)

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Value of genetic variation?

- Genetic ***progress =***
  accuracy*intensity* ***genetic variation***
  / generation interval

- Genetic variation within a species>>
  effect of selection between breeds
  effect of selection within breeds

The genetic diversity comprised in farm animal species and breeds is an important resource in livestock systems. For several reasons, within the different species used for food production, only a few breeds are developed towards high-output breeds fitting in high-input systems. In this process many breeds are set aside from the food producing livestock systems. These breeds will be faced with extinction unless new functions for these breeds are found. This is a real threat for the genetic diversity within species.

This book is intended to give insight into the issues of the utilisation and conservation of farm animal genetic resources towards a broad group of readers interested in these subjects. The insight is presented as applications of population, molecular and quantitative genetics that can be used to take appropriate decisions in utilisation and conservation programmes. A previous edition of this book is a key resource in courses worldwide and cited in many scientific publications.

The first two chapters discuss the decisions to be made in utilisation and conservation. Chapter 3 surveys the different ways in which the diversity we observe within a species can be characterised. Chapter 4 illustrates recent results using this theory for utilisation and conservation purposes. Chapters 5, 6 and 7 give theoretical backgrounds necessary to make decisions and chapters 8 and 9 present the operation and practical implications of selection and conservation schemes.

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Utilisation and conservation of farm animal genetic resources

Utilisation and conservation of farm animal genetic resources

edited by:
Kor Oldenbroek

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Overview (content, chapters)

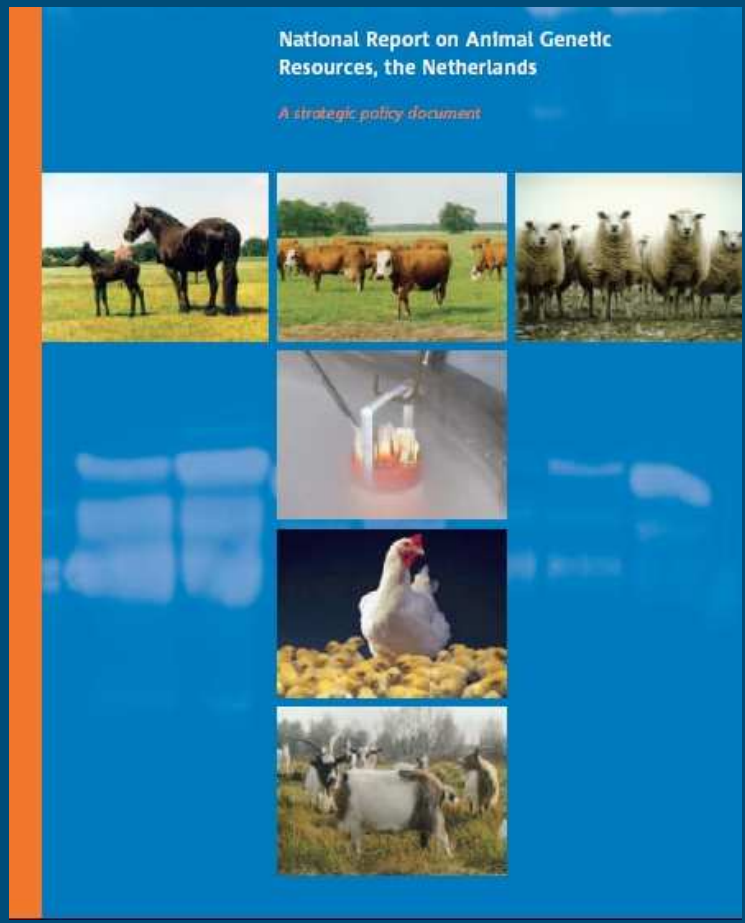
1. Livestock systems, challenges, stakeholders * * *
2. Strategies from conservation to utilisation * * *
3. Characterisation of genetic diversity *
4. Domestication and breed development *
5. Measuring genetic diversity *
6. Selection of breeds for conservation *
7. Genetic contribution and inbreeding *
8. Operation of conservation schemes * *
9. Practical implications and sustainability aspects *

FAO State of the World of Farm AnGR

- Based on 148 of 169 submitted country reports

- Content:

1. Description of livestock systems
2. Use of species and breeds
3. Changes in livestock systems to be expected
4. Conservation and required actions



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Challenges and changes (livestock systems)

- Human population from 6 > 9 billion in 2050
- Food from animals: increase of 200 % in 2050
- Intensification in developing countries (Asia)
- Drivers for change (> genetic erosion): diseases, political instability, economic growth, introduction of exotics

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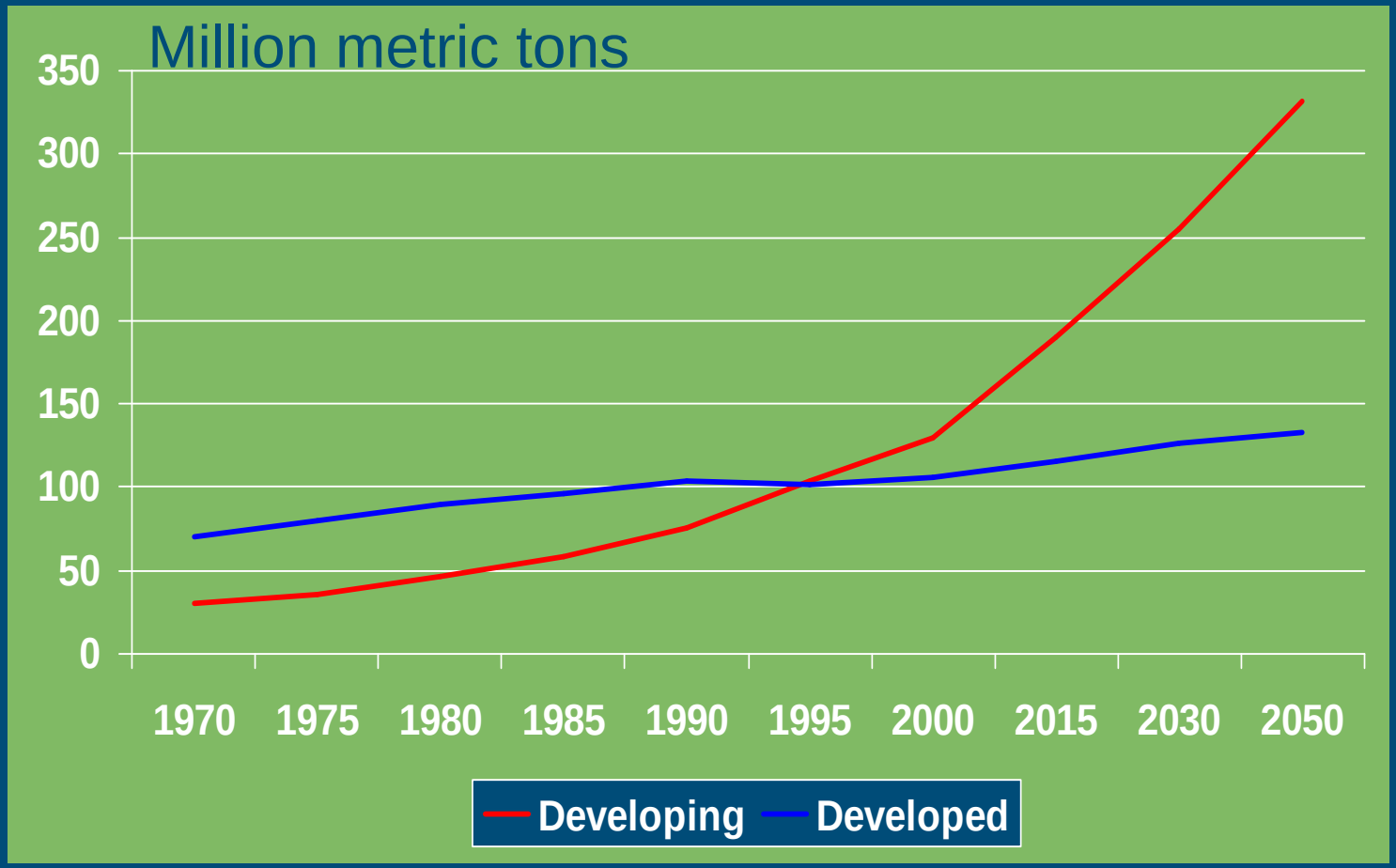
Meat production moving south



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Cattle

- Beef and dairy: intense global selection between and within breeds
- Dairy: Holstein Friesian
- Beef: French breeds

- Loss of locally developed and adapted breeds and recently developed dual purpose breeds

- Opportunities *in situ* conservation: organic farming, nature management and hobbyists

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Sheep

- Developed countries: sharp decline in numbers

  Changing goal: wool > meat > nature management = opportunity for conservation

- Developing countries: stable

  Multifunctional in small scale farming: milk, meat, wool, ceremonies = guarantee for conservation

- Breeding: only some AI and a few breeding schemes

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Goats

- Stable in numbers
- Important in small scale farming: meat and milk
- Used in variety of systems (multifunctional use)
- No breeding programmes
- No real threats (hobby animal)

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Pigs

- Developed countries: a few multinational companies
- Many breeds and lines are set aside > erosion
- No alternatives!
- Asia: many local breeds under threat (meat quality)
- Ex situ conservation: semen

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Chicken

- Numbers increase very fast
- Most specialized and industrialized species
- A few multinationals dominate
- Small scale farming: quality and taste of meat
- Kept on a large scale by hobbysists

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Horses

- Used for draught and transport in developing countries
- Developed world:

  Change in goal: draught and meat > sport and hobby
- Large variety in breeds but within breeds use of a few popular stallions

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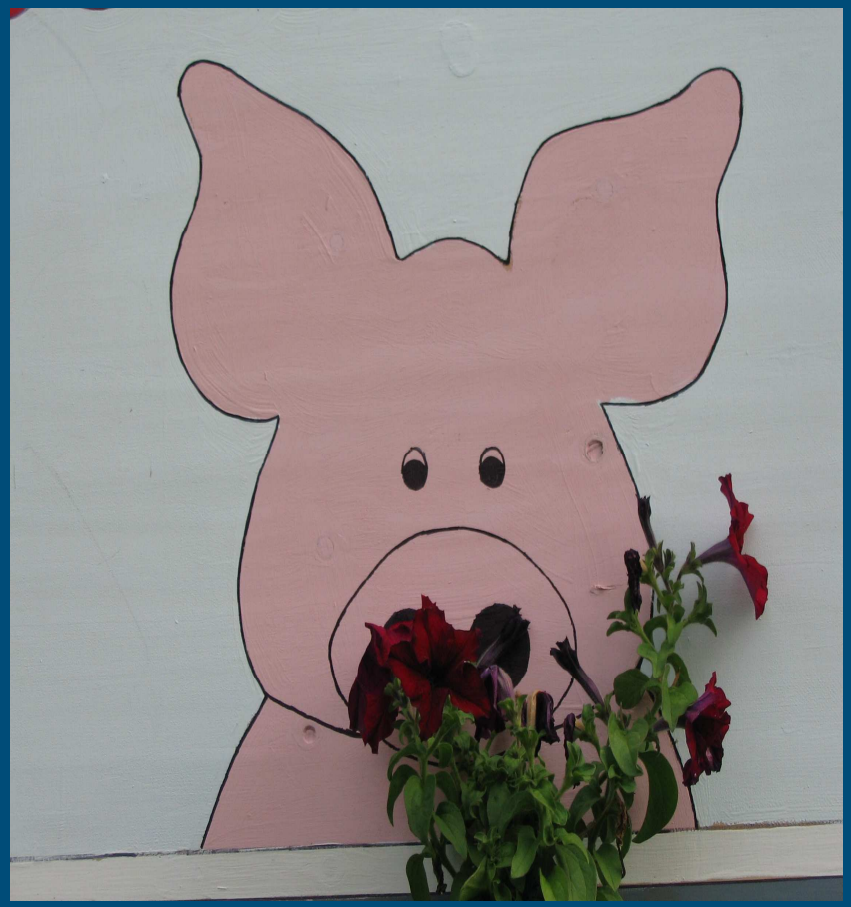
Conclusion with respect to species

- First priority: pigs
- Then: cattle, poultry, sheep, horses
- No problems with genetic erosion: goat



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Question part 1

- Who are responsible (who are the stakeholders) for the conservation of farm animal genetic resources?

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- Plants
- Trees
- Animals

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CGN's crop collections

- 20 crop collections with over 23,000 accessions
- developed from working collections
- focus on small numbers of high quality
- focus on vegetable crops and potato

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Collection management by CGN

- Acquisition
- Regeneration
- Characterisation & Evaluation
- Documentation
- Seed storage
- Distribution of seed and information service

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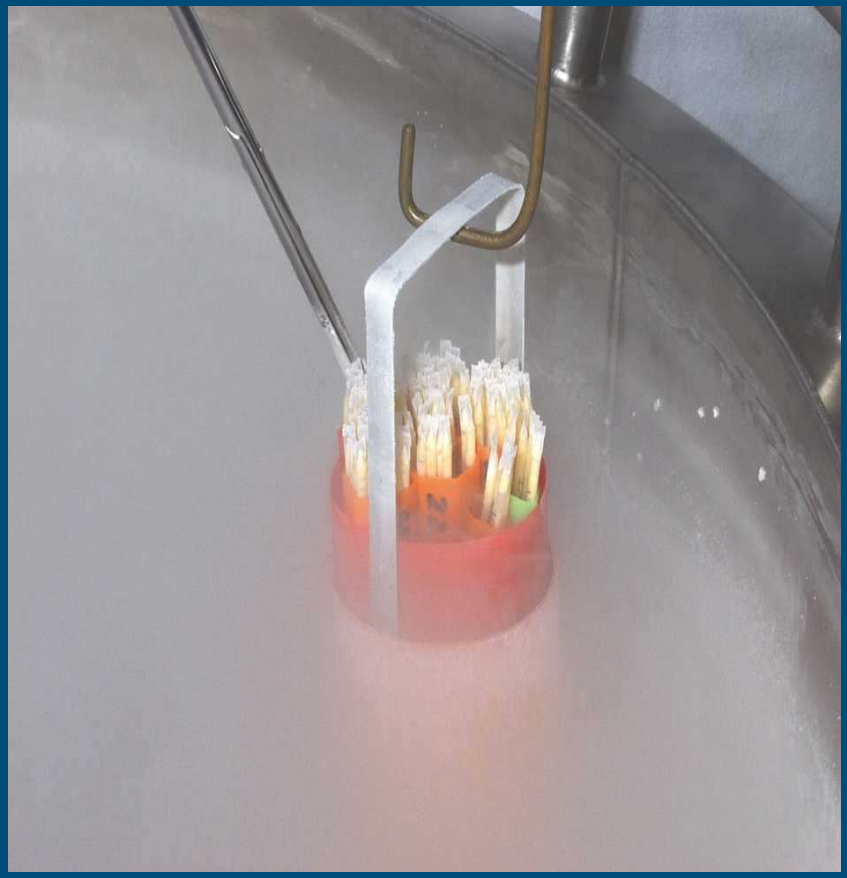
CGN's farm animal collections

- cattle (8 breeds)
- sheep (6 breeds)
- poultry (6 chicken breeds)
- horses (4 breeds)
- pigs (15 lines)

- over 100,000 insemination doses
- Stored in two locations!



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Breeding and conservation

- Animal breeding
  - selection of breeds
  - creating genetic progress (selection of parents)
  - dissemination of genetic progress
- Conservation
  - of breeds not selected and used
  - of animals not selected as parents (back-up of former generation)
  - of alleles (decreasing in frequency) not disseminated

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Objectives for conservation

- *In situ* conservation and utilisation
  - Economic function in rural communities
  - Maintenance of agro-eco-systems
  - Maintenance of cultural (historic) diversity

- *Ex situ* conservation
  - Insurance (market / environmental changes)
  - Safeguard (diseases, wars, disasters)

- *In situ* and *ex situ* are complementary

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Taking the decision

1. Which objectives apply to the breed / line?
2. Rank conservation techniques for objective
3. Rank techniques for risk of failure
4. Rank techniques for costs
5. Choose the technique

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Rare breeds ánd widely used breeds in gene bank

Cattle

- Groningen White Headed
- Deep Red
- Dutch Friesian Red & White
- Coloursided White-back
- Dutch Friesian Black and White
- Meuse Rhine-Yssel
- Holstein Friesian

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Present Dutch gene bank collections

Sheep

- Drente Heath Sheep
- Schoonebeeker Sheep
- Mergelland Sheep
- Kempen Heath Sheep
- Veluwe Heath Sheep
- Black Blazed Sheep

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Conservation techniques and objectives.

	Technique		
Objective	**cryoc on'**	***ex situ* live**	***in – situ***
Flexibility of the genetic system, as:			
•insurance for changes in production conditions	yes *	yes *	yes *
•safeguard against diseases, disasters, etc.	yes	no	no
•opportunities for research	yes	yes	yes
Sustainable utilization of rural areas:			
•opportunities for rural development	no	no	yes
•maintenance of agro-ecosystem diversity	no	poor	yes
•conservation of rural cultural diversity	no	poor	yes

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Conservation techniques and genetic factors.

	Technique		
Factors associated	**cryocon ’**	***ex situ* live**	***in –situ***
Breed evolution / genetic adaptation	no	poor	yes
Increased knowledge of breed characteristics	poor	poor	yes
Exposure to genetic drift	no	yes	yes

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State of the art of cryopreservation,

Species	Semen	Oocytes	Embryos	Somatic cells
Cattle	+	+	+	0
Sheep	+	0	+	0
Goat	+	*	+	0
Horse	+	0	0	0
Pig	+	0	0	0
Rabbit	+	?	+	0
Chicken	+	-	-	0
Fish - some species	+	*	*	*
Dog	+	?	?	0
Cat	0	0	0	0

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More cost-effective solutions for gene bank purposes?

Epididymal semen collection of rams:

- Advantages
  - Relatively cheap
  - Considerable number of doses per ram
  - Independent from character of ram
- Disadvantages
  - Collection from slaughter house: low sanitary status
- Positive results in Germany/the Netherlands
  - >100 doses per ram and positive insemination results

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Stimulating *in situ* use of native breeds

- Landscape management: Groningen White Headed
- Nature management: Dutch Belted, Heath Sheep
- Organic farming: Dutch poultry breeds
- Health care farming: young animals of all species
- Hobbyists: native poultry and sheep breeds
- Education centre

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Question part 2

- What is *ex-situ in vivo* conservation? What is its value for conservation?

Definition of a breed

1. Selection and breeding > set of heritable traits
2. Distinguished traits approved by government
3. Group within species with specific identity (area)
4. Group within a species developed by a community
5. A breed is a breed when enough people say it is

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Question part 3

- What is your definition of a breed?

History of domestication

- Livestock domestication 11,000 years ago
- Livestock forages plants > human consumption (50% of protein source)
- Central area: Fertile Crescent (Southwest Asia)
- 40 domesticated mammalian and avian species
- Widely used: buffalo, cattle, goats, horses, pigs and sheep
  chickens, ducks, geese and turkeys
- Regionally used: guinea pigs, lama's, yaks (high), camels (dry), musk, oxen, reindeer (cold)

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Domestication: ability of target species (Diamond)

- A diet easily supplied by mankind
- A high growth rate and short generation interval
- A nice character
- Adapted to captivity
- Follow the leader dominance
- No extreme panic when facing predators

- Period: 12000 – 6000 BC
- Areas: 1 -7 in Asia and Africa

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Question part 4

- Do you know populations which went trough a bottleneck?

Measuring genetic diversity

1. Weitzman diversity: based on diversity between breeds (50 % of total diversity)

2. Core set diversity: based on diversity between and within breeds (genetic distance and genetic variation within the breed)

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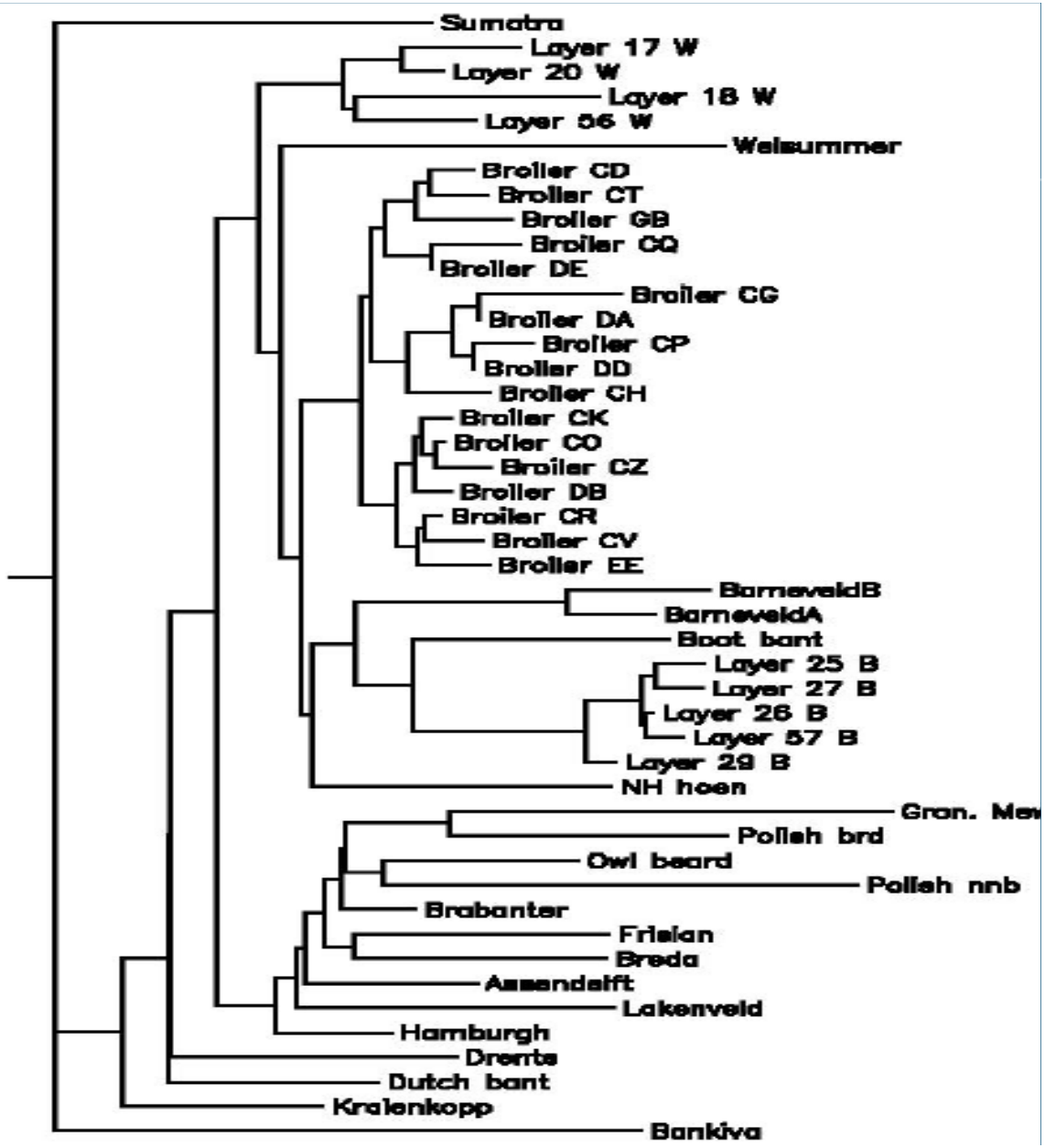
Poultry

Estimation of Marker Estimated Kinships



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Question part 5

- What is a negative point of the Weitzman diversity?

Selection of breeds for conservation

- Objectives?
- Relevant species?
- Risk strategy efficient?
- Maximum diversity strategy?
- Maximum utility strategy?
- Practical aspects

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Question part 6

- Do you go for the maximum diversity strategy or for the maximum utility strategy?

Genetic contributions and inbreeding

- Inbreeding: recognize, measure, manage (< 1 %)
- Minimising and prediction of inbreeding
- Guidelines: selection, generation interval
- Effective population size, mating schemes

Question part 7

- What causes the inbreeding problems in the global HF population?

Operation of conservation schemes

- Effective population size > 50
  Use of a related breed when Ne << 50
  Optimisation of selection and inbreeding (OC)

- Prolonging generation interval reduces drift

- Combinations of live and cryo conservation:
  - Backup of live scheme
  - Increase effective population size

Measuring genetic diversity

Rate of inbreeding

$$\Delta F = \frac{1}{2N} :$$ **in ideal population**

In livestock populations: **polygamy**
(no. ♀ >> no. ♂)

Measuring genetic diversity

Effective population size (N_e) and rate of inbreeding (ΔF) depending on number of breeding animals (n_m, n_f)

n_m	n_w	N (real)	N_e (effective)	ΔF(in%)
50	50	100	100	0,50
20	80	100	64	0,78
15	85	100	51	0,98
10	90	100	36	1,39
5	95	100	19	2,63
25	25	50	50	1,00
50	1000	1050	190,5	0,26
30	1000	1030	116,5	0,43
20	1000	1020	78,4	0,64
10	1000	1010	39,6	1,26
5	1000	1005	19,9	2,51

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Question part 8

- What might be the value of an “old” sire conserved in a gene bank?

Economic values of farm animal genetic resources

- Direct Use Value
- Indirect Use Value (ecological)
- Option value (insurance)
- Non use values (in past or future)

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Sustainability of breeding schemes

- Definition of production and breeding goal
- Sensitivity to environmental factors
- Human capacity and capabilities
- Effective population size
- Appropriate recording
- Prediction of (side)effects
- Milestones defined (evaluation)
- Profitability
- Conservation aspects

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Convention on Biological Diversity: Objectives

- Conservation
- Sustainable use of components
- Fair and equitable benefit sharing arising out of use

- Appropriate access to resources
- Appropriate transfer of technologies

- Including rights resources / technologies / funding

Convention on Biological Diversity: Principle

- States have:

Sovereign rights to exploit their own resources pursuant to their own environmental policies

and the responsibility to ensure that activities within their jurisdiction or control do not damage to the environment of other States or of areas beyond the limits of national jurisdiction

Question part 9

- What are the two most important objectives in a sustainable breeding program?

Evaluation; which part most useful?

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