Genetic Management

from science to practice

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Agrobiodiversity

- Why conserve old breeds?
- Valuable
  - Beautiful
  - Cultural Heritage
  - Contain unique genetic diversity
  - Convention Biological Diversity (Rio treaty)

Breeds with small population size

- Vulnerable
  - Demographic
  - Genetic
    - Inbreeding
    - Loss of diversity
- Need special attention
  - Promotion of the breed
  - Genetic management

Quantitative genetic perspective on diversity

- Relatedness is opposite of diversity
  - Gdiv = 1 – f
    - f = average kinship of population, generation
- Average relatedness of parents determines inbreeding and genetic diversity in next generation
  - r = c'Ac
    - c = contribution of parents
- Genetic management:
  - Minimise r = find minimum of c'Ac
  - Software program: Gencont

- r = Relatedness coefficient, or coancestry
- f = kinship coefficient = 0.5 * r
- F = inbreeding coefficient, r(self) = 1 + F
  - F = 0.5 * r(parents)
- A = numerator relationship matrix

Gencont Output

- G E N C O N T -

Population Average Relationship (current) = 0.6920

No of male candidates= 20
No of female cands = 12

SOLUTION :
Population Average Relationship (solution) = 0.6976

No of selected males = 11 No of selected females = 8

Animal	%_progeny	Animal	%_progeny
2708849	33.710	2848719	6.319
2708846	0.0	1730004	0.0
2733564	6.505	2821142	0.0
2700759	0.0	2821166	0.0
2606756	0.0	2740390	63.870
2595402	0.0	2735480	3.899
2874910	0.0	2829267	0.0
2689057	20.152	2810888	3.510
2821141	0.0	2878392	4.314
2677537	0.0	7986201	5.853
2781928	0.0	2832077	1.949
2740385	0.0	2894645	5.050
2841667	3.950		
2825503	3.635		
2834574	3.845		
2829263	5.800		
2878391	5.113		
2747057	5.360		
2832071	5.049		
2698121	6.882		

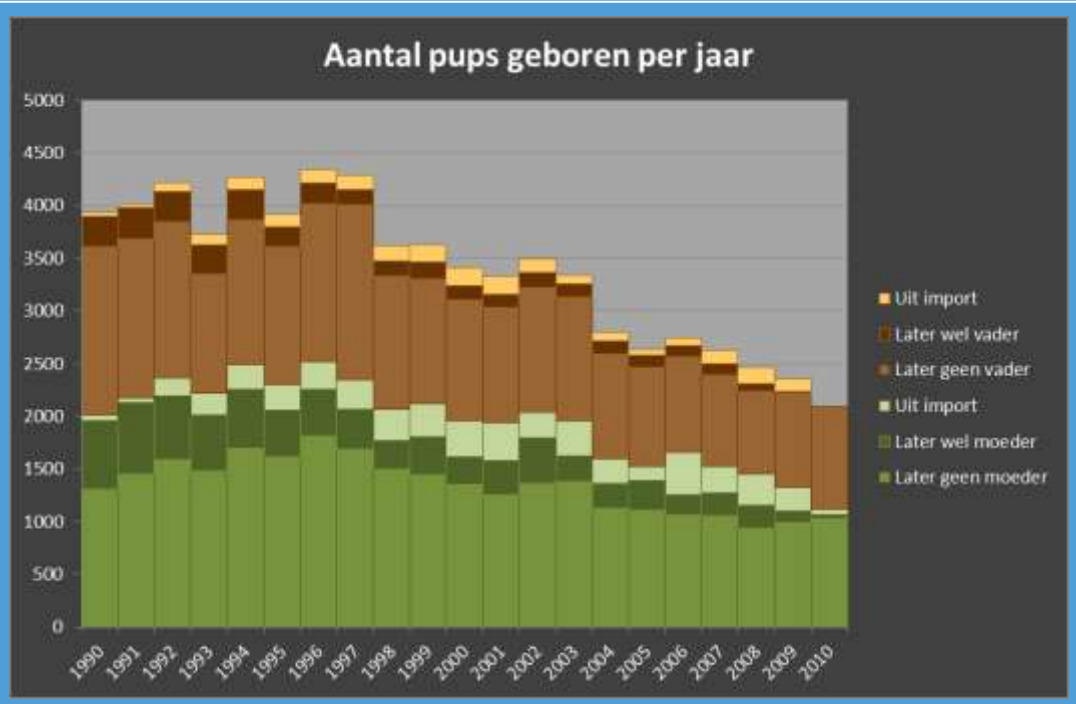
- You cannot do better than this
  - In theory
  - On paper
- But
  - Reliable pedigree?
  - Reproduction possible?
  - Breeders agreeing?

From science to practice

- Three stages

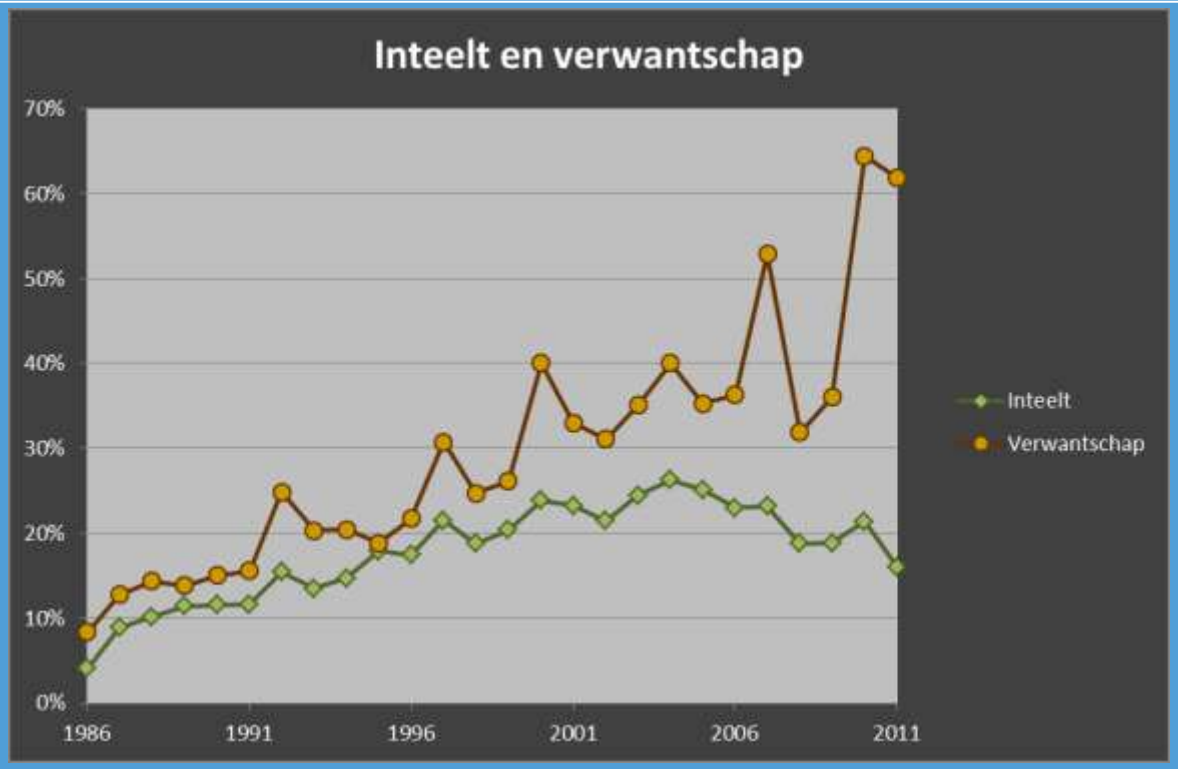
1. Monitor population
    - Determine population structure, inbreeding rate etc.
2. Manage population
    - Set rules to minimise inbreeding rate
3. Pair individuals
    - Look for combination with lowest r

Example monitoring population size



- Golden Retriever: large population decreasing numbers
- Small number used for breeding
- Substantial number of imports

Monitoring: Inbreeding and Kinship



- Relatedness increased more than inbreeding
  - Irregular pattern because of popular sires
  - Last 10 years avoidance of mating highly related pairs

Genetic management

- Only effective when approved by the breeders
- Breeders have to work together
  - "what is best depends upon the rest"
- Optimal contributions theoretically the best
  - More simple methods practically often more effective
- Different alternatives
  - Determine effectiveness
  - Determine applicability
  - Explain choices

Some alternatives for genetic management

- Restrict breeding:
  - Restrict # inseminations / sire / year
  - Restrict # inseminations / sire / life
  - Restrict # litters / dam / life
  - Restrict # sons entered in herdbook / sire
- Manage relatedness
  - Optimal contributions
  - Exclude mating parents with high r
  - Exclude animals with high average r to rest of the entire population from breeding
  - Exclude animals with high F from breeding
- Change population structure
  - Exchange animals between subpopulations
  - Breeding circle

Evaluation genetic management alternatives

- Mathematically estimations of inbreeding rate
  - Simple ones rather crude
  - Only average estimate possible
- Computer simulation
  - All different situations can be accommodated
  - Variation in outcome can be estimated
  - General simulation program made
    - User gives population parameters
    - User chooses genetic management
    - Program estimates average inbreeding, inbreeding rate and generation interval

Example: Golden Retriever

- One of the most popular dog breeds
- Dutch population
  - 600 breeding females
  - 150 breeding males
  - 300 nests / year
  - 5 top sires: 25% of the nests
- Disagreement on implementation of sire restrictions
  - Need and effectiveness
  - How strict?
  - Per year of per life?

Simulation results: Sire restrictions

Restriction	ΔF (%) per year	ΔF (%) per life	Generation interval per year	Generation interval per life
None	0.41		3.6	
20 nests	0.43	0.49	3.6	3.5
10 nests	0.27	0.42	3.8	3.5
4 nests	0.18	0.26	3.7	2.6
2 nests	0.16	0.13	3.8	2.4

- Sire restrictions more effective per year them per life
  - Males are removed when life quotum is reached
  - Generation interval decreases
  - Next generation always more related

Example 2: Managing relatedness Golden Retriever

- Options simulated
  - Minimise coancestry parents
    - Breeders seek least related mate
  - Exclude highly inbred animals from breeding
    - Reaction of some breeding organisations
    - However, highly inbred but unrelated parents do not produce inbred offspring
  - Exclude animals with a high average relatedness to the rest of the population from breeding

Golden retriever: managing relatedness

ΔF

No Restrictions
0.41%

Exclude High F
0.35%

Minimise Coancestry
0.39%

Exclude High r with population
0.14%

- Excluding animals with a high average relatedness to the rest of the population is most effective

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Example 3 Kempisch Heideschaap

- 8 herds varying from 50 to 400 sheep

50

50

200

250

300

300

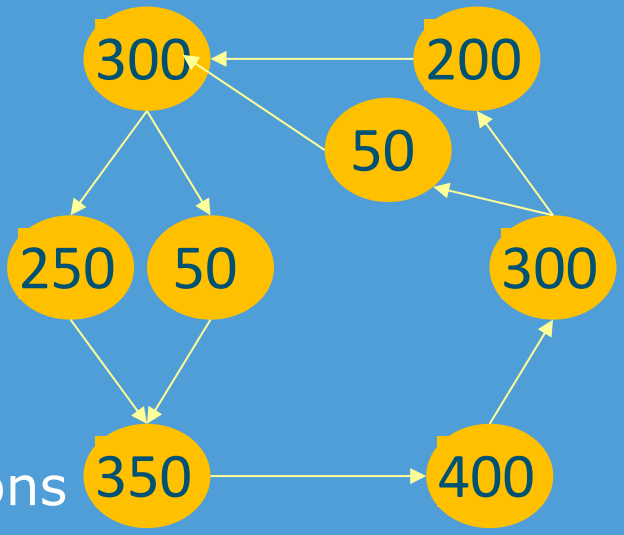
350

400

- No pedigree
- No control over mating

Simulation Kempisch Heideschaap

- Estimate F without genetic management
  - 8 herds no exchange of individuals
- Estimate F with optimal contributions
  - Fixed litter size



- Estimate F with breeding circle
  - Computer simulation: 50 generations
  - Each herd uses rams of other herd according to scheme

Result

- Inbreeding rate without measures 1.2%
- Inbreeding rate with Gencont: -3.2%
- Inbreeding rate with breeding circle: 0.16%

- Gencont results ignored
- Herd book started breeding circle with 6 of the 8 herds
- Breeding circle collapsed because of blue tongue

Veluws Heideschaap

- 3000 animals
- Ten herds of roughly equal size
- After problems with congenital defects breeding circle started 15 years ago
- Interupted by FMD

Result

- Breeding circle maintained > 18 years
- Good agreement
  - Right to pick rams from neighboring herd
  - Fixed price per ram
- Limited number of professional herds
- Congenital defects disappeared

Method to use depends on existing situation

- Commercial nucleus
  - Reliable pedigree, full control over mating and # offspring, single herd
  - Optimal Contribution no restrictions
- Heath sheep
  - Few large flocks, no pedigree, different owners
  - Breeding circle
- Other situations
  - Limited control over breeding
  - Restrict # matings per sire per year
  - Publish average relatedness with population
  - ...

Mating individuals

- Each breeder decides which sire to use for his or her dams
  - Limited to available sires
  - Availability can be restricted by breeding organisation
- Mating has only influence on
  - Single litters
  - Inbreeding in next generation

Mating decision tool developed for Dutch kennel club

BREED: Golden Retriever

FATHER

MOTHER

1090908

ID

90668

Max v.d. Kennel

Na

sy v.d. Kennel

02 – 10 - 2010

Date of birth

02 – 09 - 2009

This is a high relatedness. Consequently the use of this dog will have a negative impact on inbreeding in the long run

Relatedness with breed

0.321

0.021

generations with known ancestors

8

2

The number of known ancestors is low and estimated inb… is unreliable

Inbreeding coefficient

PUPS

0.213

The number of known ancestors is high and consequently the estimated inbreeding coefficient is reliable

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Genetic management

- Needs to be tailored to the population
- In practice
    - Monitor
    - Manage
        - Simulation
    - Mate
- Software is available