Genetic improvement of robustness

Roel Veerkamp

Jan ten Napel
Piter Bijma
Mario Calus
Han Mulder
Jack Windig

SABRE
CUTTING EDGE GENOMICS FOR SUSTAINABLE ANIMAL BREEDING

ROBUSTMILK
breeding tools for improved dairy products from more robust dairy cattle

Outline

- Robustness discussions
  - What is robustness
  - Why demand for robustness?
- Genetics to improve robustness

Robustness

Robustness versus control paradigm

- Control paradigm: Avoiding disturbances to happen
  - ←"Pathogen free, ideal climate …"
  - ←"If the farmer would only do as told …"
- Robustness: Handling disturbances
  - ←"Another breed only realistic option left open to …"
  - ←"I do not want all the hassle …"

Definition of robustness

"the capacity to handle environmental disturbances in commonly accepted, economic and sustainable farming systems"

Jan ten Napel et al. 2005

Other elements of robustness discussions

- Robust system
  - ….
- Robust animal
  - Support, enabling, learning
  - Genetic ability
- Robust system within an animal
  - …

3rd SABRE Conference: Welfare and Quality Genomics, 10-11 September 2008, Foulum, Denmark.

Why demand for robustness?

Why more robust robustness (now)?

- Negative effect of selection for productivity?
- Management interaction with genetics?

→ Research + stakeholder discussion "Risk high production dairy cows (Animal Welfare Council)

Why more robust cows (now)?

- More
  - Demands: Health, welfare and food safety
  - Constraints: Antibiotics use or regulations
- Global trends in dairy production
  - Reduced margins
  - Scale enlargement
  - Less (skilled) labour available per animal
- Slight reduction in genetic ability due to single trait selection for production

Why more robustness (now)?

- Control paradigm has reached its limits
- Rely more on ability of systems and animals to deal with disturbances

→ Rather than worry about avoiding slight reduction in genetic ability, breed animals more robust to cope with future systems.

Genetics and robustness

Outline: selecting more robust animals

- Robustness at system level
  1) Biodiversity
  2) Associative effects √
- Robustness at animal level
  3) Genetic heterogeneity
  4) Multi-trait selection √
  5) Macro environmental disturbances √
  6) Micro environmental disturbances √
- Robust systems within animal
  8) SABRE: genomics examples trying to understand biological system: fertility, mastitis, immune system

3rd SABRE Conference: Welfare and Quality Genomics, 10-11 September 2008, Foulum, Denmark.

2) Robustness at system level: Associative effects

- Animal has an effect on other animals in the group, sometimes 'best at a cost for the rest'
- Examples:
  - Cannibalism in chicken
  - Competition with feeding
  - Social stress (behavior, aggression, tail biting, etc.)
  - Contagious diseases

2) Robustness at system level: Associative effects

- Consequences for breeders
  - Group selection
  - Unexpected responses to selection (cannibalism)
  - More heritable variation than currently believed
    - Mortality due to cannibalism: h^2 = ~20% instead of ~7%

→ Bill Muir; Piter Bijma & Esther Ellen

- Option to increase robustness at system level?

4) Robustness animal level: multi-trait selection

- Include health & welfare traits in breeding
- Scandinavian countries set example in dairy
- Genetic Improvement of Functional Traits (GIFT-EU)
- Since 1990's most breeding goals adapted
  (Dairy cattle: Miglior et al JDS 2005)

4) Robustness animal level: multi-trait selection

- Finish Ayrshire
- Dutch population
  - → +25d CIV
  - → -6.5% NR
- Stabilised using multi-trait selection

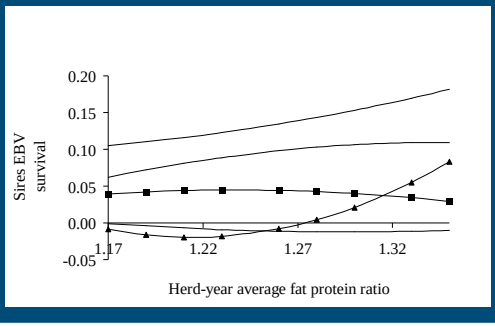
4) Robustness animal level: multi-trait selection

- How many traits do you need to consider?
  - fertility, longevity, health, feet&legs
  - energy balance, management ease
- Robustness is not multi trait selection!
  - Robustness is about capacity to handle disturbances
  - Genotype by environment interaction
  - Environmental sensitivity

5) Robustness animal level: Macro disturbances

- Does animal fit the system i.e. countries, farms or farming systems
- Environmental sensitivity and reaction norm models
  (Falconer et al, Strandberg et al; Calus et al; Windig et al; Mistzal)

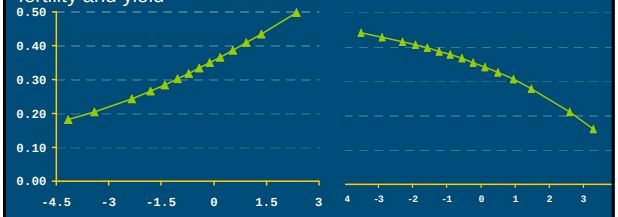
5) Robustness at animal level: Macro disturbances



Calus et al

5) Robustness at animal level: Macro disturbances

Genetic correlation fertility and yield



Fertility farm

Production level farm

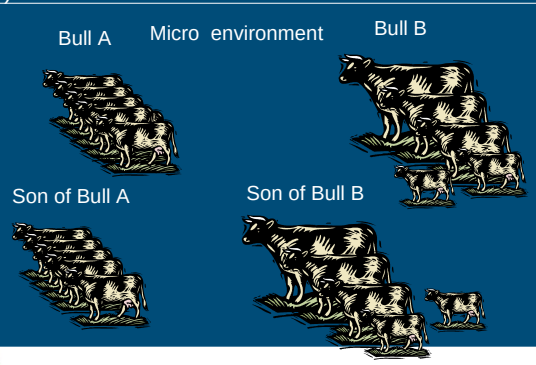
5) Robustness at animal level: Macro disturbances

- Interesting for robustness:
  - Challenges the current use of genetic parameters and prediction of selection for average environments (i.e. robustness)
  - Improving environment & selection simultaneously →make animals more sensitive, i.e. lower bandwidth to operate (e.g. Strandberg et al)

6) Robustness at animal level: Micro disturbances

- Not all environmental disturbances are known, measured or definable on a scale!
- What about unknown day to day disturbances, e.g. weather, feed, farmer.
- Is residual variation heritable?

6) Robustness at animal level: Micro disturbances



6) Robustness at animal level: Micro disturbances

- Does it exist?
- Methodology under development
  - Estimation variance components (SanCristobal 2001; Daniel Sorensen &Waagepetersen, 2003 ; Rowe et al 2006; Ye Yang&Sorenson 2008; Mulder 2008)
  - Theoretical model development and its application in livestock production (Hill&Zhang 1994; Mulder et al 2007)
- Interest
  - breed for improved uniformity of products
  - to use it as measure of robustness

Animal breeders offer lot of options to improve robustness,
with productivity and quality traits!

ANIMAL SCIENCES GROUP WAGENINGEN UR

Animal Breeding & Genomics Centre

RobustMilk

- Innovative and practical breeding tools for improved dairy products from more robust dairy cattle
  - Common data-base phenotypic records (NEB)
  - Phenotypic measurement tools, i.e. MIR
  - Statistical tools, i.e. environmental sensitivity
  - Genomic selection tools
- Netherlands, Scotland, Ireland, Sweden, Belgium
- WWW.RobustMilk.EU

ANIMAL SCIENCES GROUP WAGENINGEN UR

ROBUSTMILK

Conclusions

- Robustness: Handling disturbances at system or animal level, versus control paradigm
- Genetic selection can make major contribution
  - multi traits selection is not solving everything
  - focus on handling disturbances
  - In combination with improved productivity and product quality
- Rather than discuss the slight reduction in genetic ability from selection for production only, discuss breeding for robustness to cope with future farming systems.

ANIMAL SCIENCES GROUP WAGENINGEN UR

Animal Breeding & Genomics Centre