Genetics as a tool towards more sustainable and agro--ecological animal production systems

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Genetics as a tool towards more sustainable and agro-ecological animal production systems*

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Livestock production : major challenges

Growing world demand on animal products

Major concerns about :

- **Health issues (antibioresistance, zoonoses, sanitary and nutritional qualities of animal products,…)**
- **Societal issues (animal welfare, ethical issues, societal acceptance, …)**
- **Competition for land use and with human food consumption**
- **In a context of climate change**

How can we cope with these challenges ?

French bill on the future of agriculture, food and forestry : produce differently by :

- Combining economic, social & environmental performance,
- Developing agro-ecology
- Protecting agricultural land
- Reducing the use of pesticides and antibiotics
- Maintaining biodiversity
- …

How can we cope with these challenges ?

5 main objectives for agro-ecological livestock production systems (Dumont et al, 2013):

- Improve animal health through integrated management practices
- Decrease the inputs required for production
- Decrease pollution by optimizing the functioning of farming systems
- Strengthen the resilience of LP systems by enhancing their diversity
- Maintaining biodiversity by adapting management practices

Adaptation of livestock populations to :

- Changes in biotic and abiotic environmental conditions
- Changes in agricultural production systems

Some characteristics of animal breeding

"Adapting" means "changing" livestock populations

1) Replacing population by "better" (more productive or more adapted, …) populations
2) Use of crossbreeding
3) Selection within population (1/2)
   - A slow (1-3% of mean perf/ year) but cumulative effect
   - Requires different steps
     a) Define breeding goals,
     b) Get necessary information to evaluate candidates
     c) Compute breeding values
     d) Select the best animals
     e) Disseminate the "best genes" in the whole population

Some characteristics of animal breeding

“Adapting” means “changing” livestock populations

3) Selection within populations (2/2)

- Positive relationship between population size and selection efficiency (negative relationship between the diversity of populations and selection efficiency
- Some recent increasingly used technological advances
  - High throughput genomics
  - Semen sexing,
  - …
- Other unused technological advances (GMO, cloning)

Sustainable livestock breeding goals

Breeding goal :

- technically = the set of traits to be improved and their relative (economic) weight;
- a larger number of traits in the breeding goal generally means a lower progress for each trait

Breeding goals have largely evolved over last decades

	Dairy cattle	Pigs
- 1960's – 1970's	milk quantity	Growth, carcass, FE
- 1980's	+ milk quality	+ meat quality
- 1990's	+ fertility	+ Prolificacy
- 2000's	+ longevity, SCC	+ Maternal traits
- 2010's	+ udder health	+ Survivability

Sustainable livestock breeding goals

Use of animals that are less sensitive to pathogens (and require less antibiotics / drugs) by either :

- **select on functional traits (longevity, reproduction, udder morphology & health ,…)**
- **Better control of pathogens cycles (strongyles, salmonella, …)**
- **Improved immune competence**

- **Define these new breeding goals in the frame of integrated animal health management stragegies**

An example of intergrated management of animal health : resistance to strongyles in small ruminants

Combined use of :

- Selection of resistant (low excretion) animals
- Reduction of host contact with infective larvae through flock management
  - Reduced stocking rates
  - Grazing animals with different sensitivity status
  - Compromise between grass quality and infection risk
  - Use of targeted, parsimonious treatments

Sustainable livestock breeding goals

Decrease the inputs necessary for production

Decrease the use of antibiotics and drugs (see above)

Improve the efficiency of feed use

- **Considering feed efficiency over whole life cycles**
- **Including feed efficiency in ruminants breeding goals, particularly at grazing**
- **Feed efficiency largely considered in pigs and poultry, but only using highly digestible diets; additional variation exists for lower quality diets in poultry and pigs**
- **Carnivorous fish can successfully be selecting for adaptation to plant based diets**
- **Feed consumption has been shown to be an indicator of adaptation to hot climates**

Sustainable livestock breeding goals

Decrease pollution by optimizing the functioning of farming systems

- Manure, green house gaz (ruminants, particularly beef cattle)
- At the animal level, importance of the efficiency of feed use
- Additional traits (behaviour,…) have to be considered in multi-species farming systems
- Evaluation at the system level largely remains to be developed

Sustainable livestock breeding goals

Strengthen the resilience of livestock production systems by increasing the diversity

- Improved adaptation to increasingly diverse production systems
- some competition/antagonism between the number of selected populations, population size and selection efficiency
- A higher flexibility offered by crossbreeding systems (increased number of breed combinations)
- Potential impact of genomic selection through across breed genomic evaluation
- This topic largely remains to be investigated

Sustainable livestock breeding goals

Maintaining biodiversity

- Agricultural environment biodiversity

  Impact of genetics in combination with approaches at the farming system level

- Livestock population diversity

  Diversity within- and between populations

  Tools available within-population

  Across populations, preservation (sheep) or development of alternative production systems

  Interest of advances in genomics and reproductive physiology to preserve genetic diversity

Advances in methods and tools

The “genomics” revolution

- **High throughput genomic tools offer exciting new opportunities to build more sustainable & agro-ecological production systems**

  Genomic selection strongly improves the efficiency of selection in most livestock species

  It can be used to increase genetic gains on standard production traits …

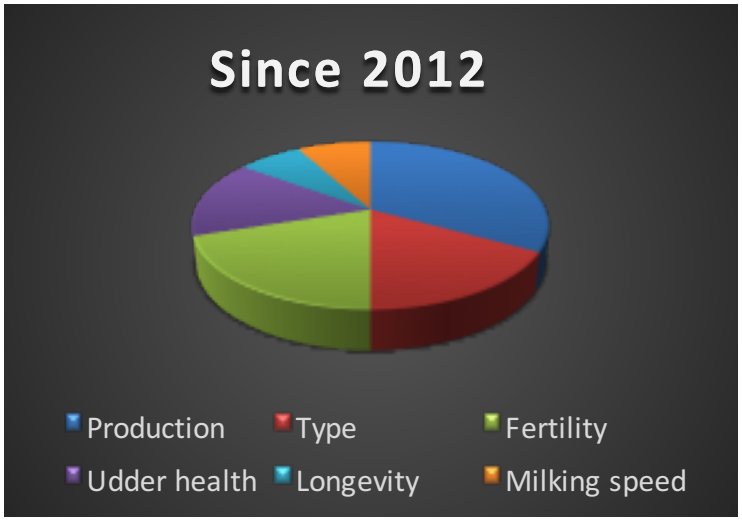
  …. or preferably to maintain some selection pressure on production traits and select at the same time for additional traits related to health, behaviour,… and to better manage genetic diversity

Advances in methods and tools

The “genomics” revolution

- **This is already the case in cattle in France : the increased efficiency allowed by genomic selection has to a large extent been used to improve additional functional traits**

Breeding goal in French Holstein population (Boichard et al, 2015)

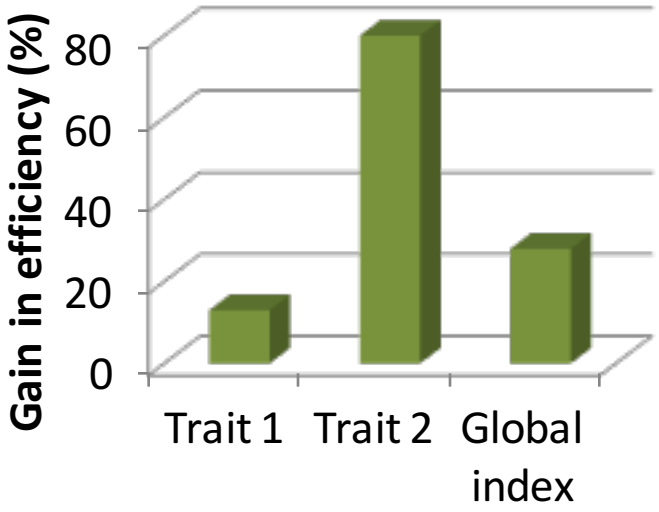


Advances in methods and tools

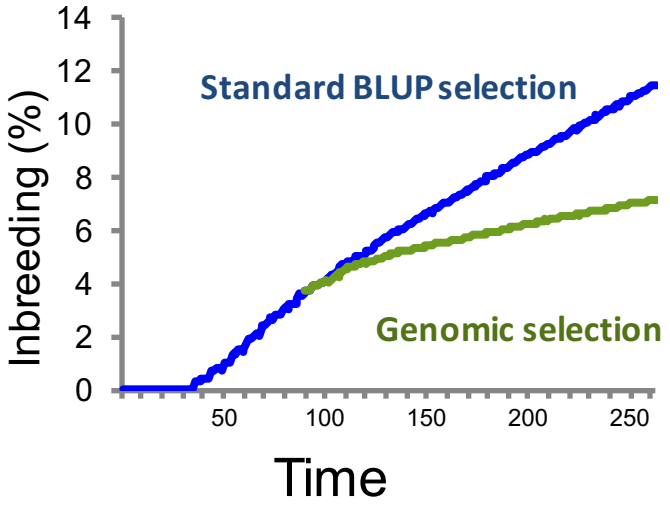
The "genomics" revolution

- **Potential interest in pigs (Tribout et al, 2012; 2013)**

Response to selection



Evolution of inbreeding



Advances in methods and tools

Precision livestock farming systems

- **High throughput phenotyping**
- **Modelling of biological functions and of the farming systems**

- **=> Improved management and detection of the most efficient / the most robust (ability to maintain performance under a large range of environmental conditions**
  - **e.g. early detection of sanitary problems through high throughput feed and/or temperature recording systems**
  - **Early detection of oestrus**
  - **…**

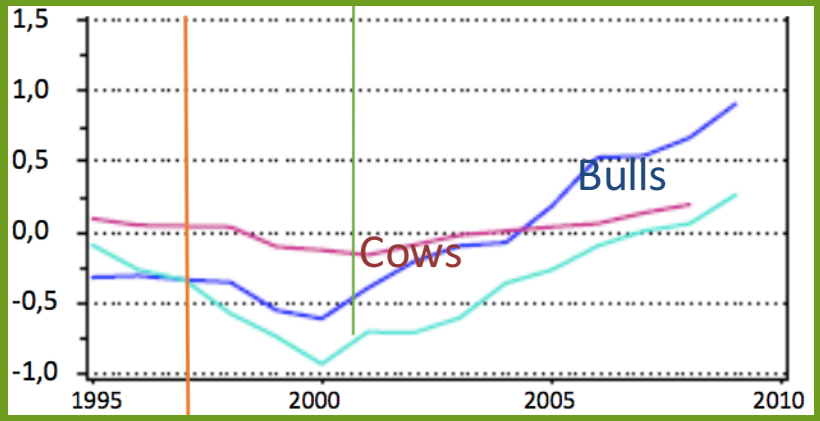
Conclusion (1/2)

Large changes are necessary in future agricultural and livestock systems

Major importance of agro-ecological principles to reach this goal

Some changes in the right direction have already been made

Genetic trend for udder health in French Holstein breed (Idele, INRA)



Most of the work still remains to be done

Conclusion (2/2)

Strong opportunities offered by scientific advances in genomics, phenotyping, …

However, threats could also result from a “wrong” use of these scientific advances (short term gains on production traits, loss in genetic diversity,…), particularly in strongly competitive markets

Incentives to go in the right direction ?

- Societal concern
- Market regulation
- Industry self-regulation
- Public control / management
  - long term challenges (biodiversity)
  - GHG