Pig genetics in France

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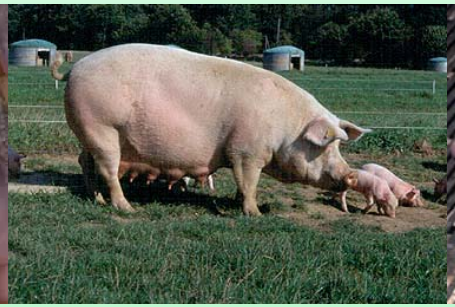

FOOD & NUTRITION
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INRA overview

http://www.international.inra.fr/

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INRA
National Institute for Agricultural Research

INRA carries out mission-oriented research for
-high-quality and healthy foods,
-competitive and sustainable agriculture,
-a preserved and valorised environment.

Research area

Research is guided by developments in scientific fields and focuses on worldwide challenges related to :

food and nutrition,

the environment and land use facing the world of agriculture and agronomics today.

Challenges are :

climate change,

human nutrition,

competition between food and non-food crops,

the exhaustion of fossil resources and appropriate land

INRA

INRA produces knowledge, innovation and know-how for society

INRA assists the development of industries and regions of France: it actively participates in a transfer partnership while seeking the public good

INRA lends its expertise to public decision-making.

Some figures

8500 staff :

1,839 researchers and 1,891 doctoral students

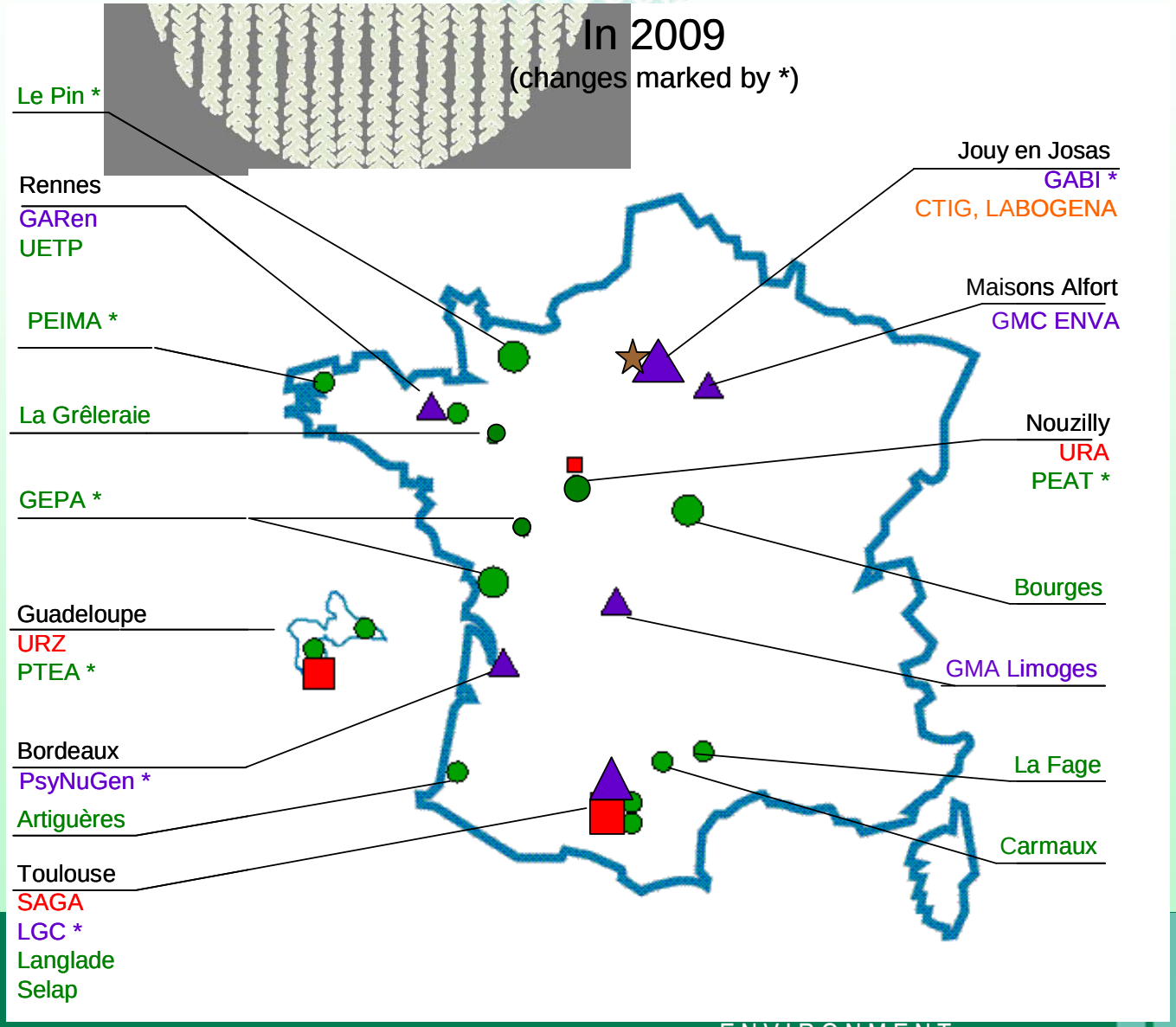
1,500 foreign researchers and students come every year.

14 research divisions, 19 regional centres, strong scientific partnerships.

49 experimental units with a total surface area of 10,000 ha and 94,000 animals.

INRA is ranked 2nd in the world and 1st in Europe in agricultural sciences, and plant and animal sciences.

Animal Genetic Division



Pig genetics

Les races locales

Local breeds

Ces races locales bénéficient d'un programme national de conservation pour le maintien de la variabilité génétique

A national program insures the preservation of the genetic variability of those local breeds

Pie Noir du Pays Basque

Gascon

Cul Noir Limousin

Porc de Bayeux

Porc Blanc de l'Ouest

Nustrale

Crédits photos : IFIP, ADN, GENE+, NUCLEUS, PEN A

ifip institut du porc

Avec le soutien financier de FranceAgriMer.

MINISTÈRE DE L'ALIMENTATION DE L'AGRICULTURE ET DE LA PÊCHE

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Characterisation

Size of the populations

	Basque	Bayeux	Gascon	Limousin	Nustrale	Blanc de l'ouest
Sows	136	51	796	148	109	153
Boars	24	15	102	40	12	28
Breeders	29	26	75	39	29	69

Prolificacy : 8 – 11 piglets

http://www.agroparistech.fr/svs/genere/especes/porcins.htm

Use of local breeds

Very localised production

Low intensive production systems

Outdoor production systems

Heavy weight slaughtering

High quality products

- -fresh meat
- -dry cured ham/sausage

Conservation

In charge

- -breeder associations (LIGERAL)
- -IFIP (Pig technical Institute)

Genealogy recording and management

- -mating plan on a family base
- -limit inbreeding rate
- -no selection breeding scheme

Cryopreservation of boar semen

- national cryobank

Les races porcines en France

Pig breeds in France

Les races sélectionnées

Selected breeds

Type femelle
Dam lines

Axes de sélection :
- Prolificité
- Qualités maternelles
- Rusticité et facilités d'adaptation
- *Prolificacy*
- *Maternal abilities*
- *Hardy and easy to adapt*

Lignées Large White femelle
Large White dam lines

Lignées Landrace Français
Landrace French lines

Lignées sino-européennes
Chinese-european lines

Lignées Duroc femelle
Duroc dam lines

Type mâle
Sire lines

Axes de sélection :
- Croissance
- Indice de consommation
- Composition des carcasses
- Qualité de viande
- *Growth rate*
- *Feed conversion ratio*
- *Carcass muscle content*
- *Meat quality*

Lignées Piétrain
Pietrain sire lines

Lignées Large White mâle
Large White sire lines

Lignées synthétiques
Composite lines

Lignées Duroc mâle
Duroc sire lines

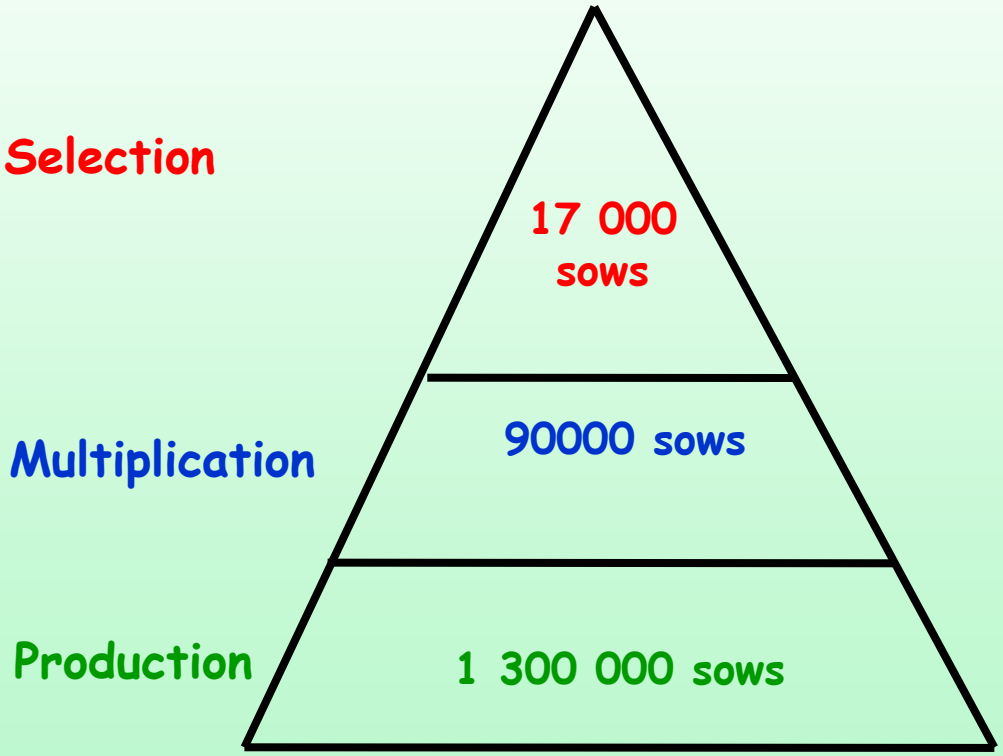
Outline

- Genetic improvement of pigs
  - General principles
  - Selection goals/production characteristics
  - Controlling the efficiency of pig breeding plans
  - Pig genetics INRA Research activities

Pig breeding schemes – general principles

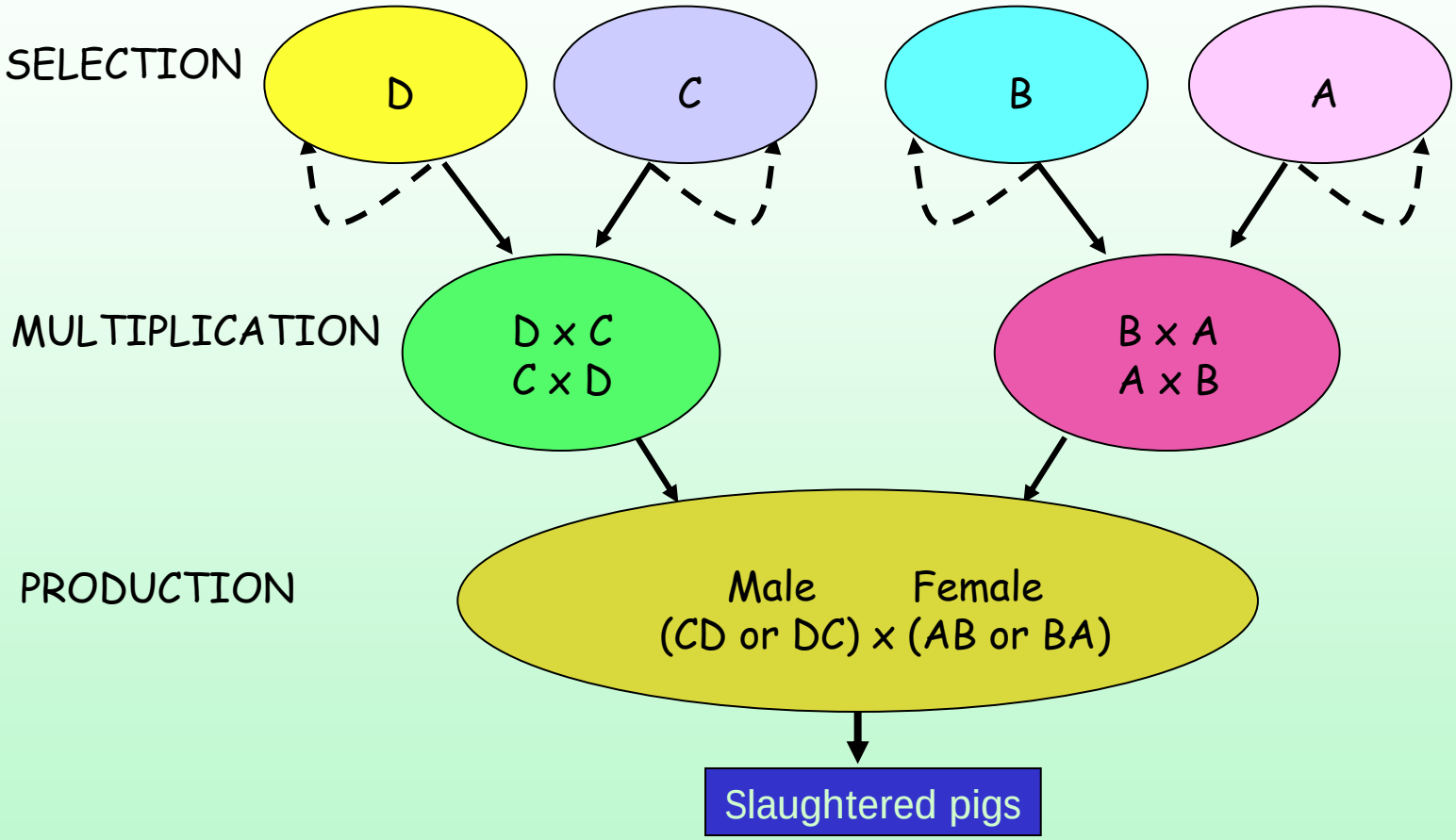
Pyramidal structure

The example of France



25 millions slaughtered pigs / year

Pig breeding schemes – general principles



The French national pig breeding scheme

- Four populations

2 female populations

Female
Large White

4500 sows

French
Landrace

2500 sows

2 male populations

Male
Large White

450 sows

Piétrain

1100 sows

Main characteristics of pig production

Homogeneity of production conditions

- **A dominant production system**
- Objective : production of (reasonable) quality meat at the lowest price
  - ✓ Standardised housing, feed & management conditions
- **Some exceptions**
  - ✓ Example of local pigs production systems

Homogeneity of the pig produced

- **Slaughtered at a given target weight**
  - ✓ 110 kg on average
  - ✓ Some "heavy pig" chains (local pigs)

Conversely, pig meat is consumed in many different ways

- **Fresh meat**
- **Many processed products**
  - ✓ « cooked » or « dry » ham & sausages, "ready to use" dishes,…

Components of the economic efficiency of pig production

Production costs

2 main groups of traits

1. Production cost of piglets (up to 25 kg)
   - Is mainly a function of herd numerical productivity
2. Cost of the growth period
   - Is a function of:
     - Growth rate (cost of housing)
     - Feed conversion ratio (amount of feed consumed)
     - Mortality

Usage value of the slaughter pig

1. Quantitative aspect = dressing percentage
2. Qualitative aspects
   - Carcass composition (lean meat content)
   - Meat and fat quality (not paid to farmers except boar taint)

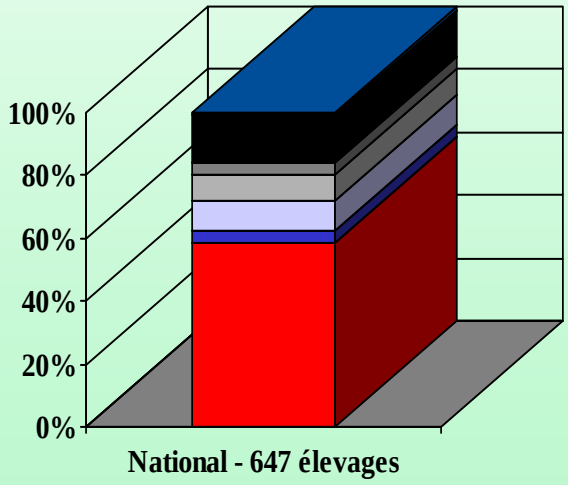
Traits of economic interest

FEED EFFICIENCY

Food conversion ratio = amount of feed (kg) necessary for 1 kg live weight gain

Considerable economic impact

Production costs
In weaning – fattening herds



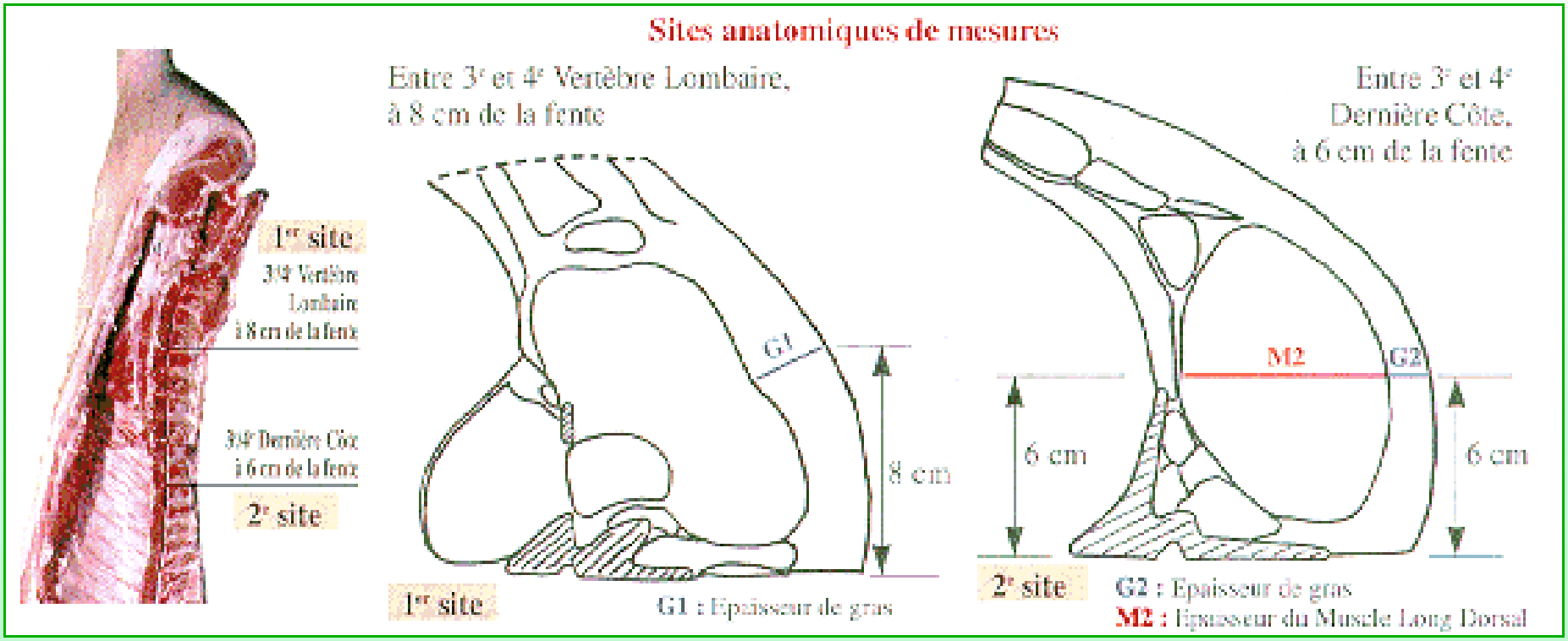
Others

Feed

Individual measurement :
Automatic feeders

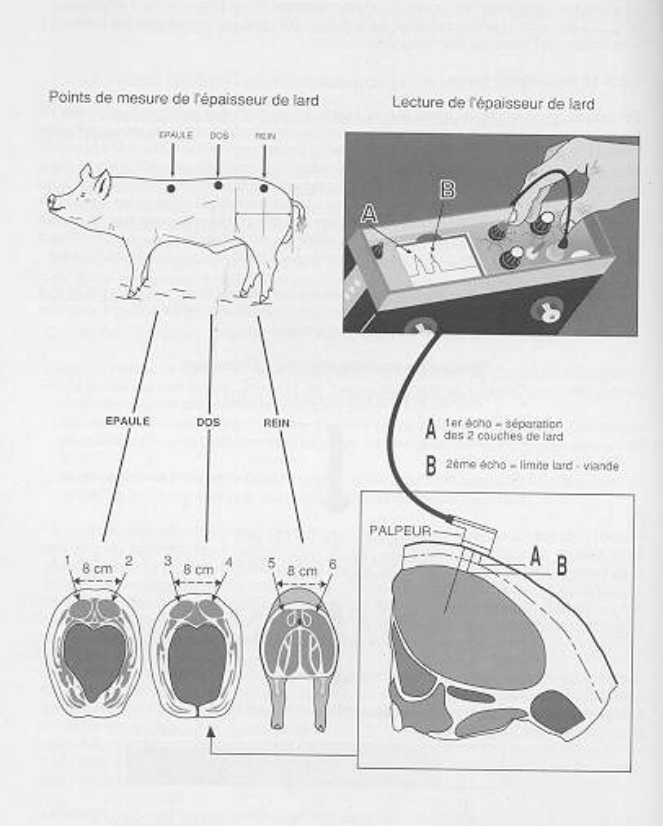
Traits of economic interest

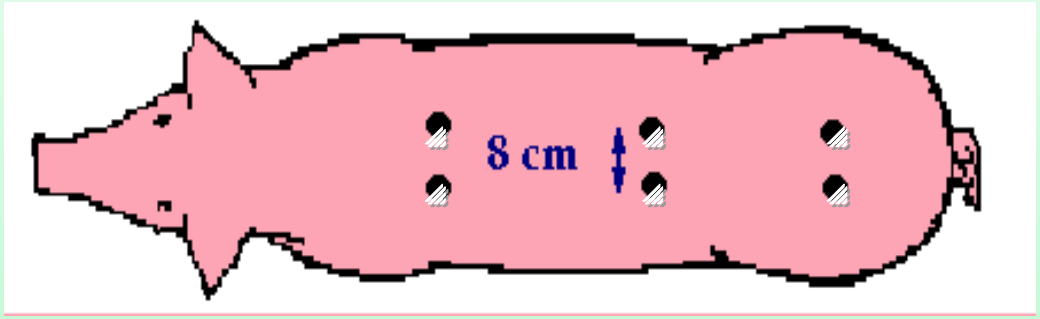
Carcass traits



Traits of economic interest

Carcass traits
Estimation of carcass composition
Through ultrasonic backfat depth





Economic consequences of product quality

For farmers :

no payment for meat quality

Some meat defaults can be forbidden

For slaughterhouses :

Weight losses through exudation (1 - 3%)

For distributors :

Weight losses through exudation (1 - 3%)

Selling difficulties

For processing units

Weight losses at cooking (1 - 10%)

Losses when making slides (0 – 50%)

Losses when conservation is poor

For consumers:

Weight losses at cooking (1 - 10%)

Meat technological quality criteria

Post mortem evolution of pH

Imbibition time	Water Holding Capacity
Exudation losses	
Cooking losses	
Glycolytic potential (GP)	Chemical composition
% water	
% proteins	

… measured on different muscles

Technological yields (Napole, cooking or drying %)
Fibre characteristics

Fat technological quality criteria

Firmness
Caractère rance
% water, % lipids
Fatty acid composition (polyunsaturated/saturated)

… Also characterize dietetic and organoleptic qualities

Boar taint (androstenone, skatole)

Meat organoleptic quality criteria

Intramuscular fat content (% IMF)
Shear force

… usually measured on the loin

Tenderness
Juiciness
Flavour

} Consumer panel tests

Outline

Genetic improvement of pigs

- General principles
- Selection goals/production characteristics
- Controlling the efficiency of pig breeding plans
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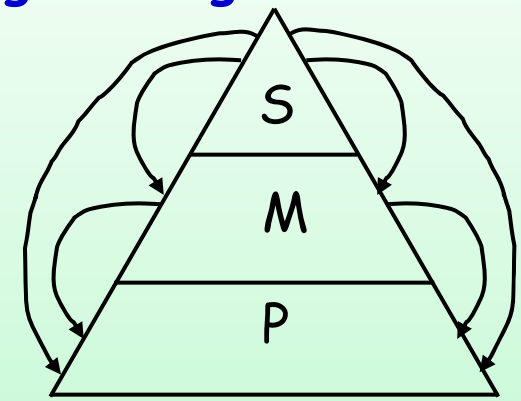
Definition of breeding goals

What time interval should we consider ?

Minimum interval

- **Depends on the genetic gain diffusion structure**

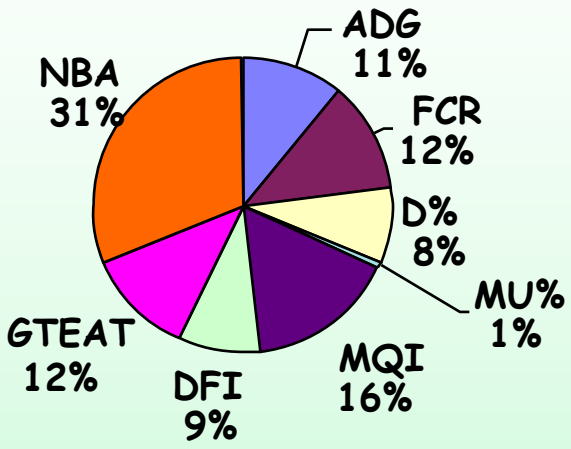


- **In general, 3 to 5 years = genetic lag**

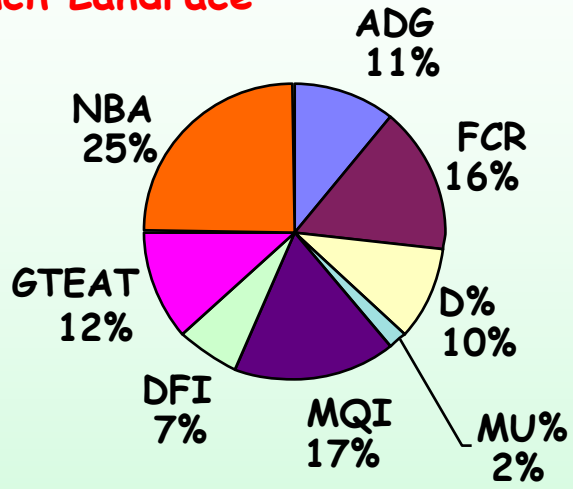
+ "economic" lag in a competitive situation
  - = temps necessary for buyers to perceive changes

The French national pig breeding scheme
Breeding goal: relative weights

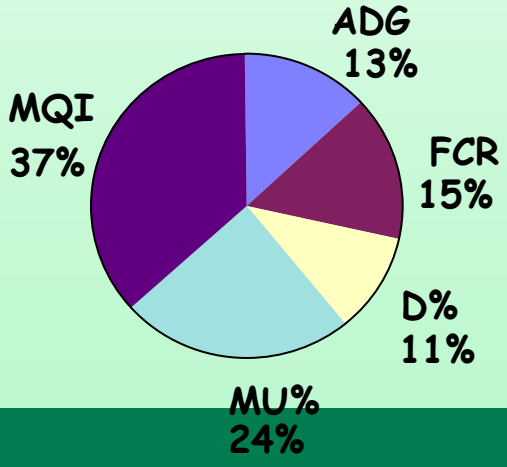
Large White – maternal line



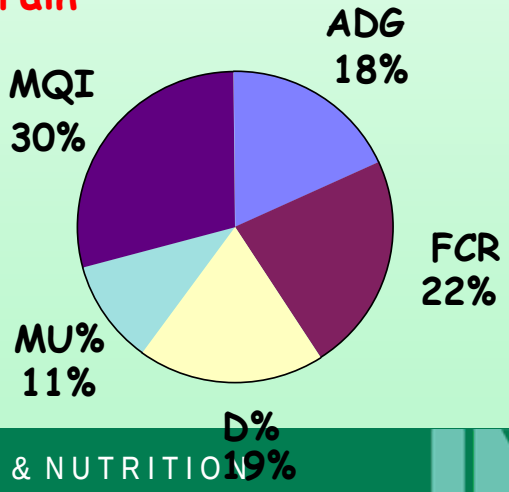
French Landrace



Large White – sire line



Piétrain



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Future breeding goals

How to integrate :

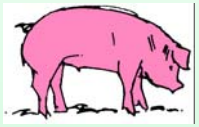
- Behavioural traits
- Environmental effects of animal production (including contribution to global warming)
- Robustness / resistance to diseases
- Environmental sensitivity
- …

The French national pig breeding scheme

on-farm performance test

production traits

Young male and female candidates



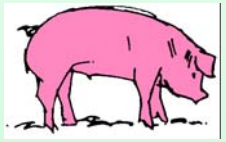
- age at 100 Kg
- backfat thickness at 100 Kg
- Loin depth (male lines)
- (Meat quality)

« reproduction » traits

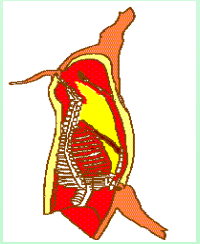
- numbers of live born piglets
- number of functional teats

station performance test

slaughtered sibs from young candidate males



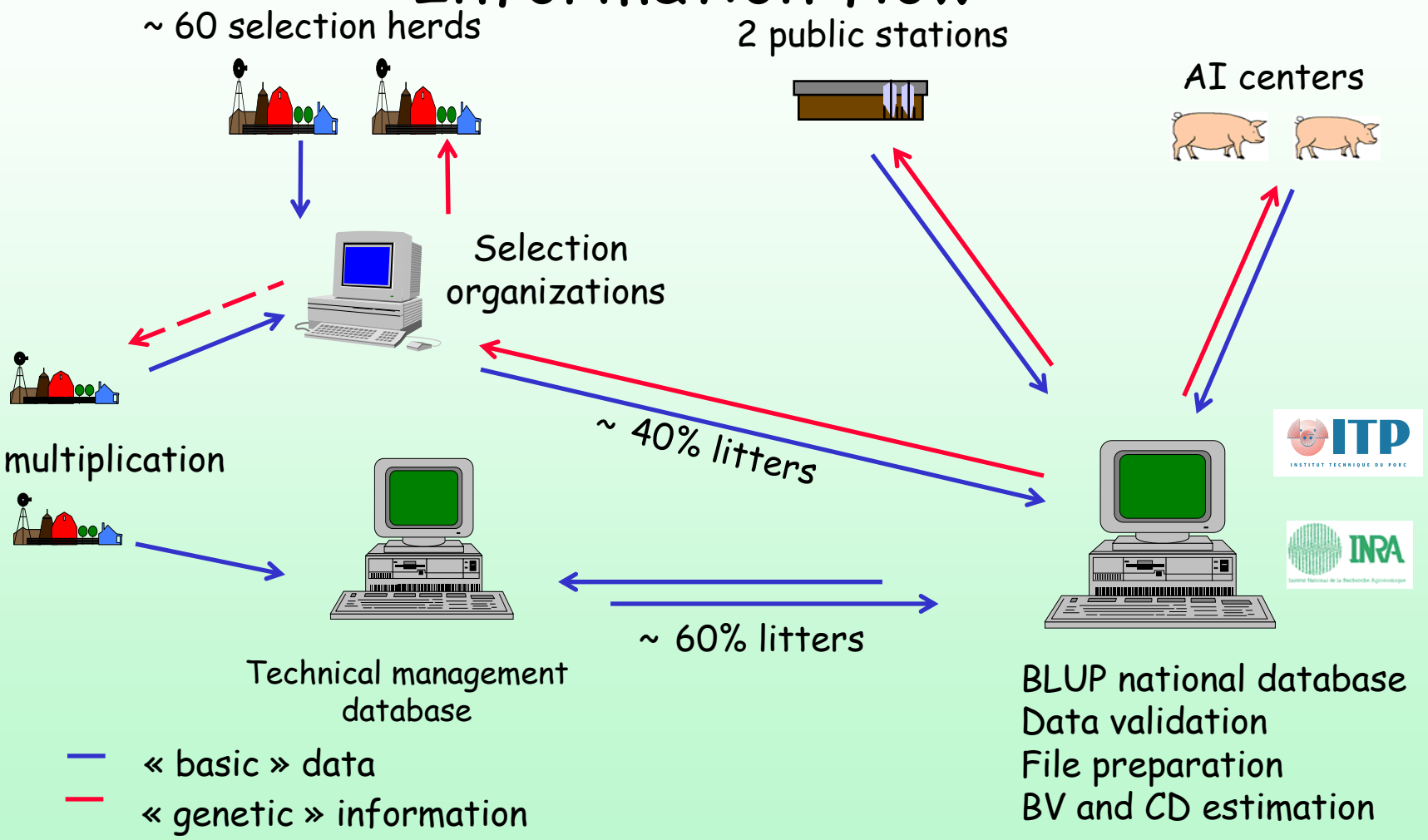
- average daily gain
- daily feed intake
- feed conversion ratio



- dressing percentage
- carcass lean content
- meat quality index

The French national pig breeding scheme

Information flow



Genetic evaluation of pigs
Production traits

- Combined on farm – station evaluation since 1996

- Multiple trait (10 / 11 traits) evaluation

- Monthly evaluation, independently for each breed

- Collaboration between INRA - IFIP

- Use of PEST software

-Breeds concerned : Large White, French Landrace, Piétrain
(Large White male and female lines are jointly evaluated)

Outline

- Genetic improvement of pigs
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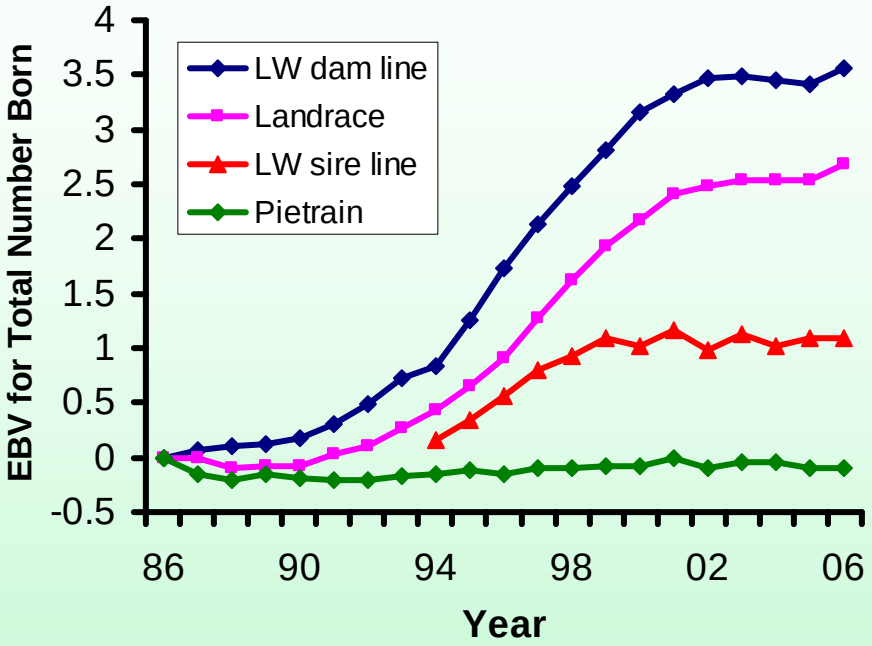
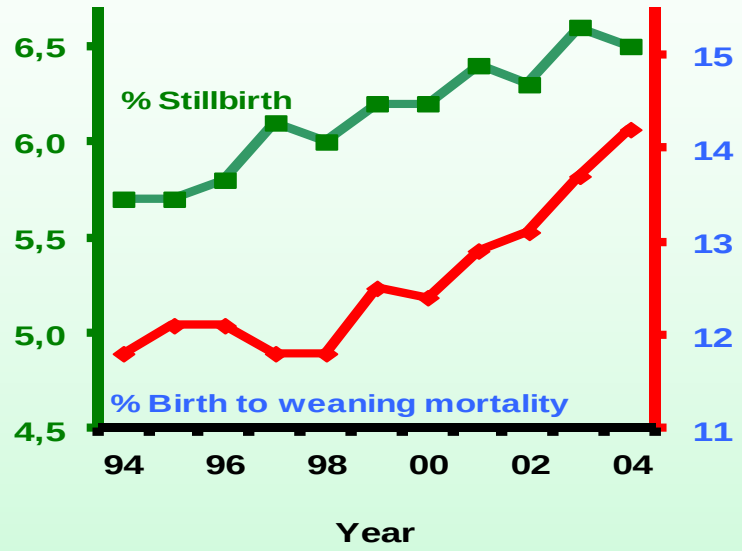
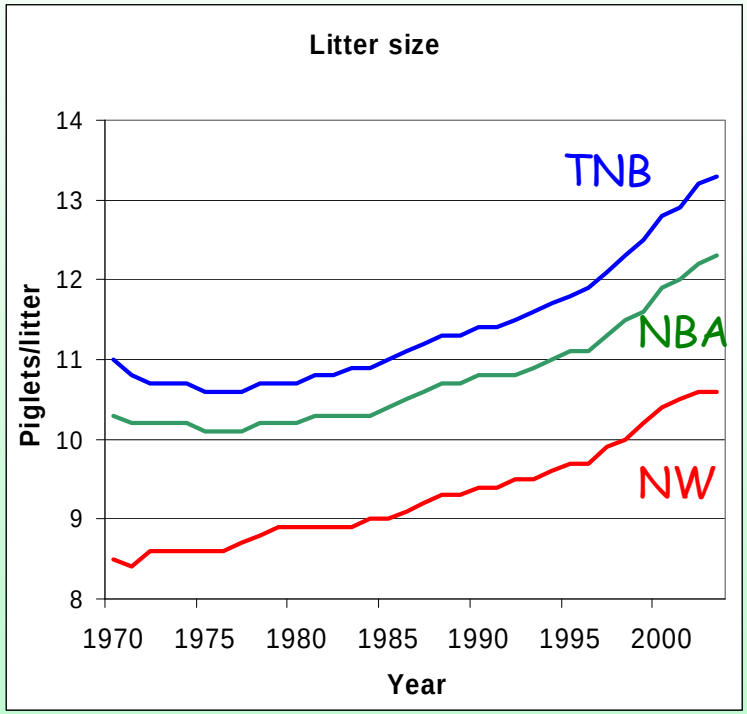
Checking the efficiency of breeding schemes
Trends for litter size at the selection level

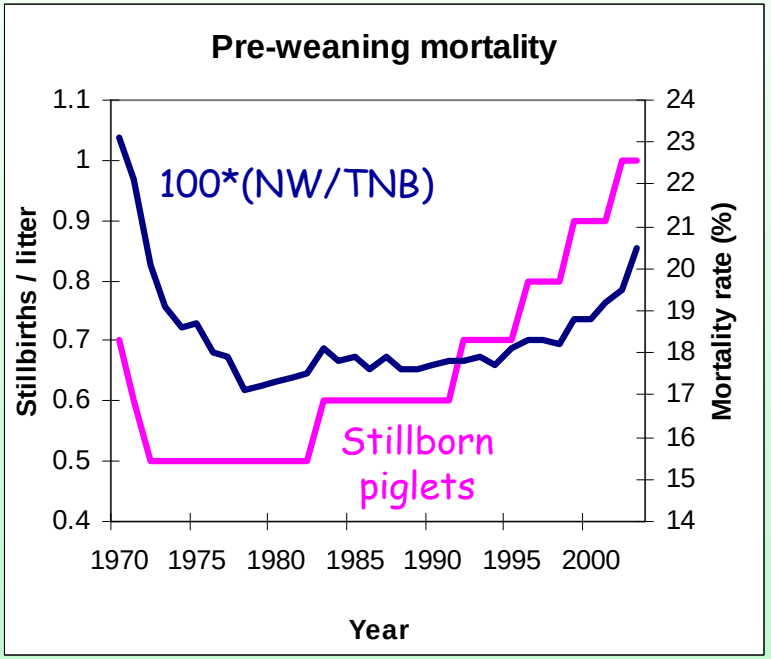




- Selection dans in female lines
  - Increase of litter size
  - Increase of stillbirth and post partum mortality

Checking the efficiency of breeding schemes
Trends for litter size at the production level





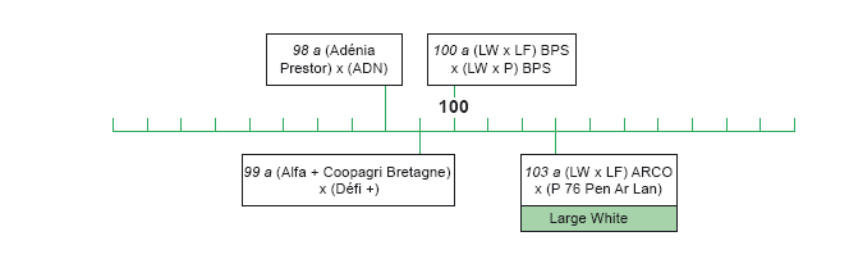
Checking the efficiency of breeding schemes
Control of terminal products

- Sample of slaughter pigs from different breeding organisations compared in an official test station

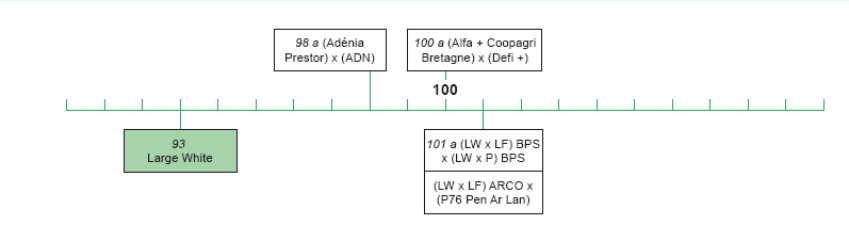
- Results officially published by the ministry of Agriculture

Ex : 24rd TP test

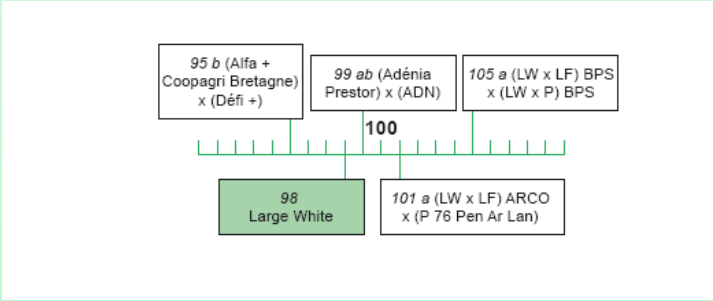
Growth index; 10 points = 2.30 euros



Carcass index; 10 points = 3.08 euros



Meat quality index; 10 points = 1.16 euros



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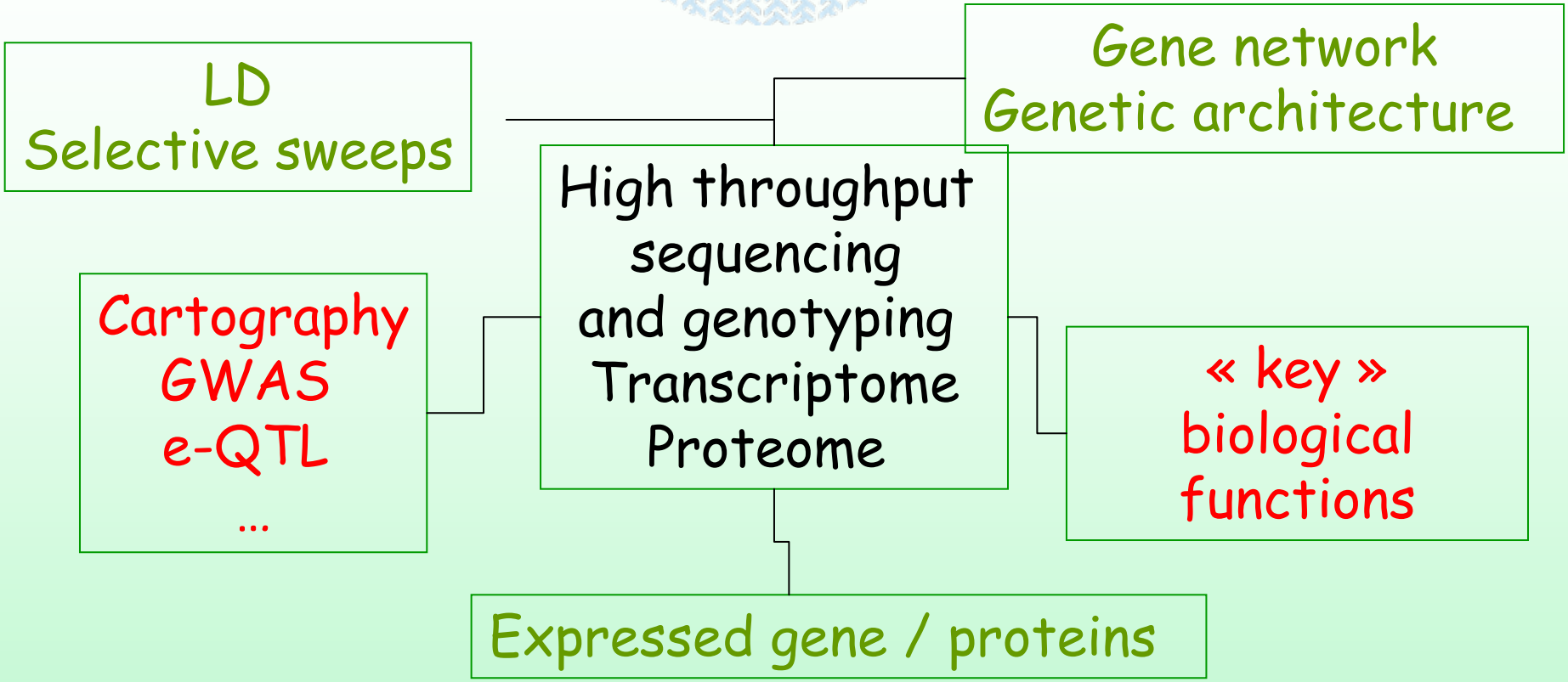
Variability of genome structure and functionning



Research activities

- 2 thematic field:
  - Genetic determinism of traits of interest
  - Population gestion

- Activities
  - Experimentation
  - Methodology
  - Breeding scheme for french national breeds

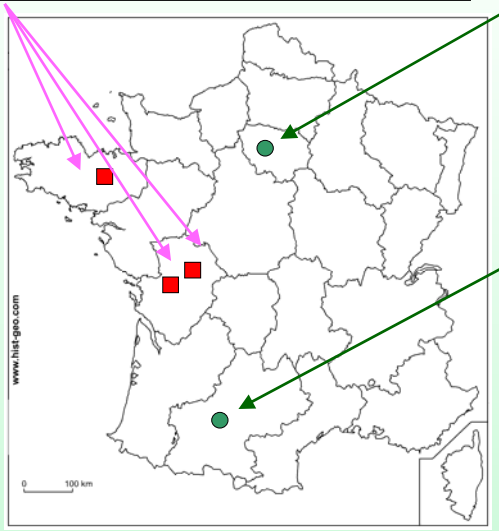
- Breeds
  - Large White, Landrace, Piétrain, Duroc
  - Synthetic lines (sino-european)
  - Meishan, local breeds

Pig research facilities

GABI

LGC

3 experimental units



340 Sows,
5000 pigs/year

Scientific
Collaborations
Other research labs

Technical and professionnal partners

CTIG (computing center)

Labogéna
Toulouse Genopole

Computing facilities

National genetic databases

DNA banks

Geno-types

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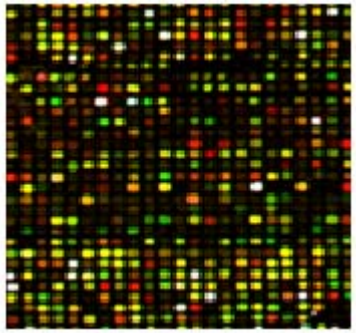
Animal Ressources

- Experimental unit
  - National breeds
  - Selection experiments
  - Crossbreeding
  - Fine phenotyping

- Commercial breeds (IFIP / OSP)
  - Central control station
  - Farm control

Genetic variability

- Polygenic variability
  - New traits
  - Data integration
- QTL Cartography (fine)
  - High throughput genotyping
- Gene study
  - Comparison of genotypes
  - Functional genomic



Genetic determinism studies

- Traits of interest
  - Efficiency: growth rate, feed efficiency (cost, manure)
  - Meat quality: homogeneity, prediction, castration
  - Adaptation : maternal abilities, piglet survival, heat tolerance, robustness
  - Health/Biomedical : immune response, melanoma

- Methodology
  - Modelisation / Polygenic variability+ QTL / Consequences of sélection / relations between traits
  - QTL / comparaison of genotype

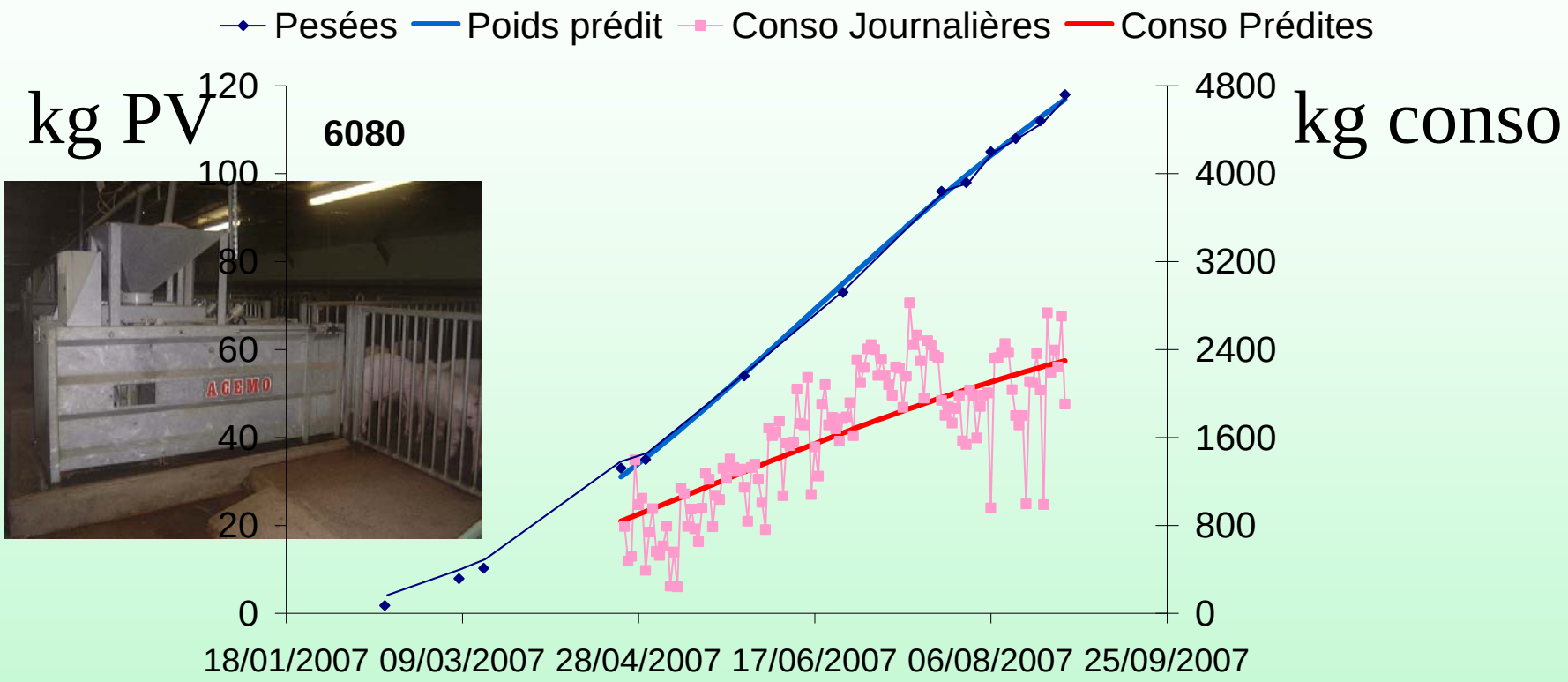
Feed efficiency

- Divergent selection experiment for residual daily feed intake
  - Direct and indirect responses
- QTL location for feed efficiency and feed behaviour

Response to selection

- Low line vs high line
  - ↘ RFID(2 écarts-types génétiques) ☺
  - ↘ growth rate
  - ↘ fatness☺
  - ↘ ultimate pH (meat quality)
  - ↘ intramuscular fat

Growth and ingestion modelisation



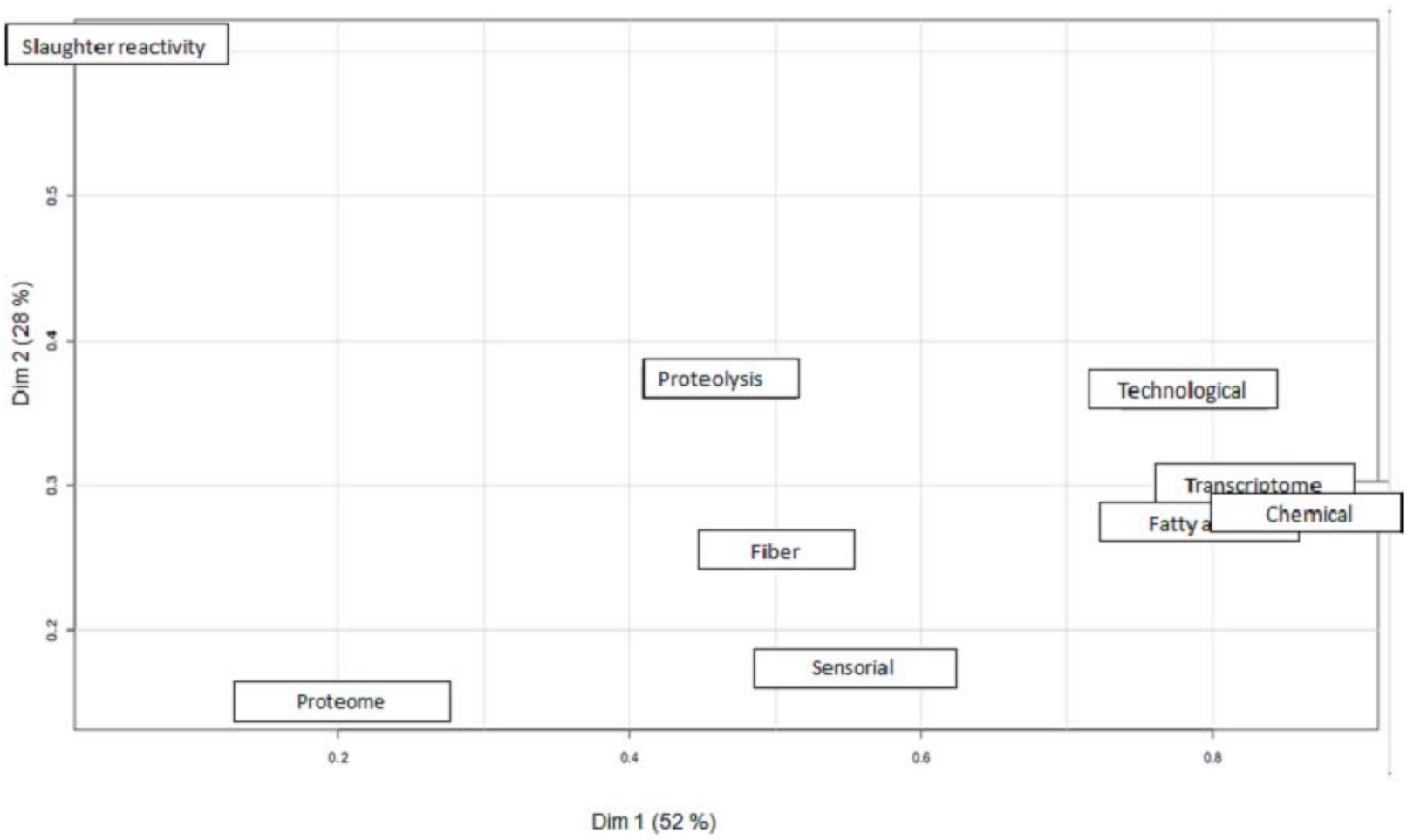
BW=f(**age**; $B_{Gompertz}$; age_{110kg};PV_{65j}) **CMJ** = a_{conso} × **BW**^{bcons}

Meat quality predictors

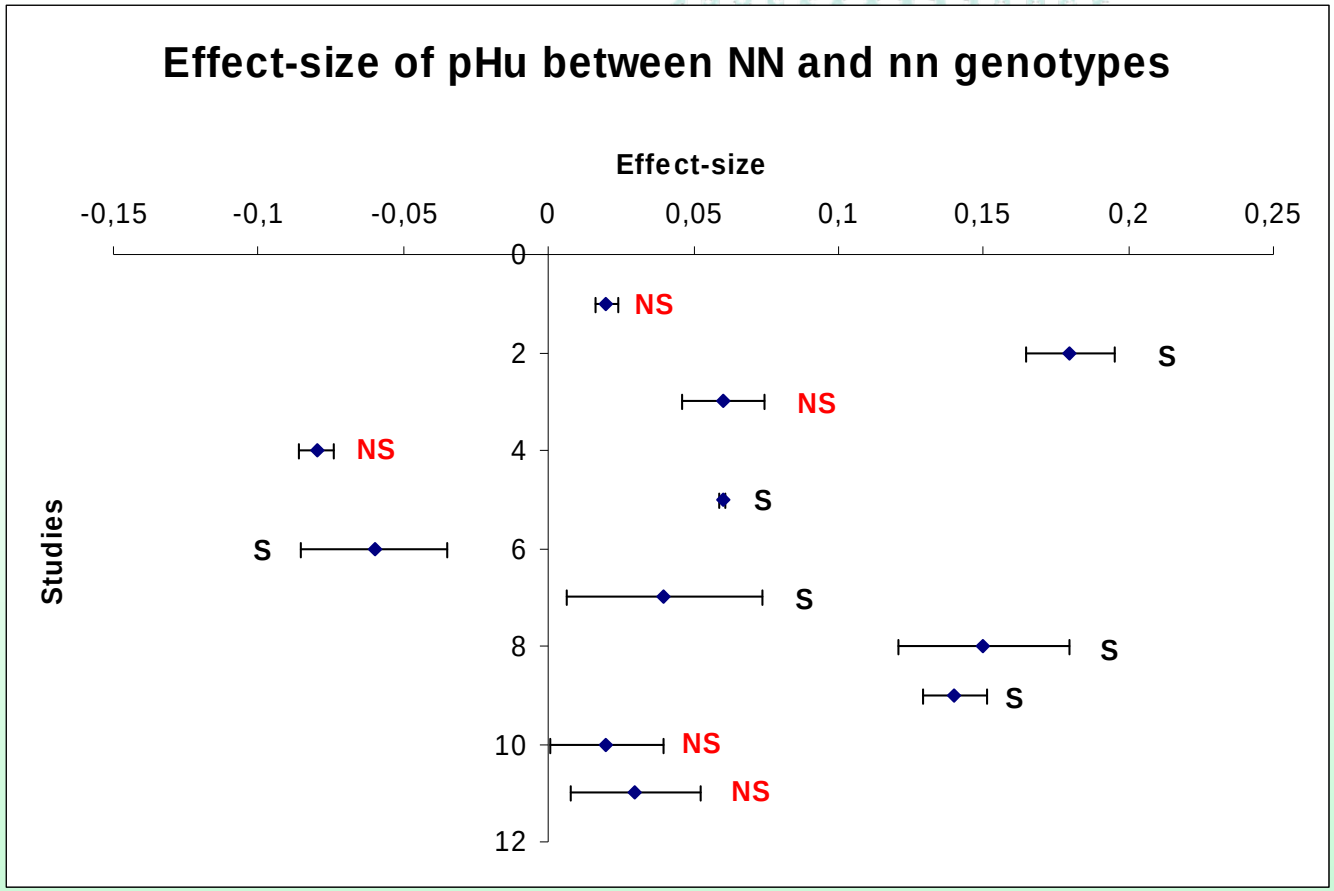
- Expression data (transcriptomic)
  - Relationship with meat quality(sensory, WHC, IMF)
  - Carcass choice

- Hyerarchisation of différents factors
  - Meta-analytis
  - Gene Hal, preslaughter conditions

Relationship between traits



MA: Halothane gene effect on pHu

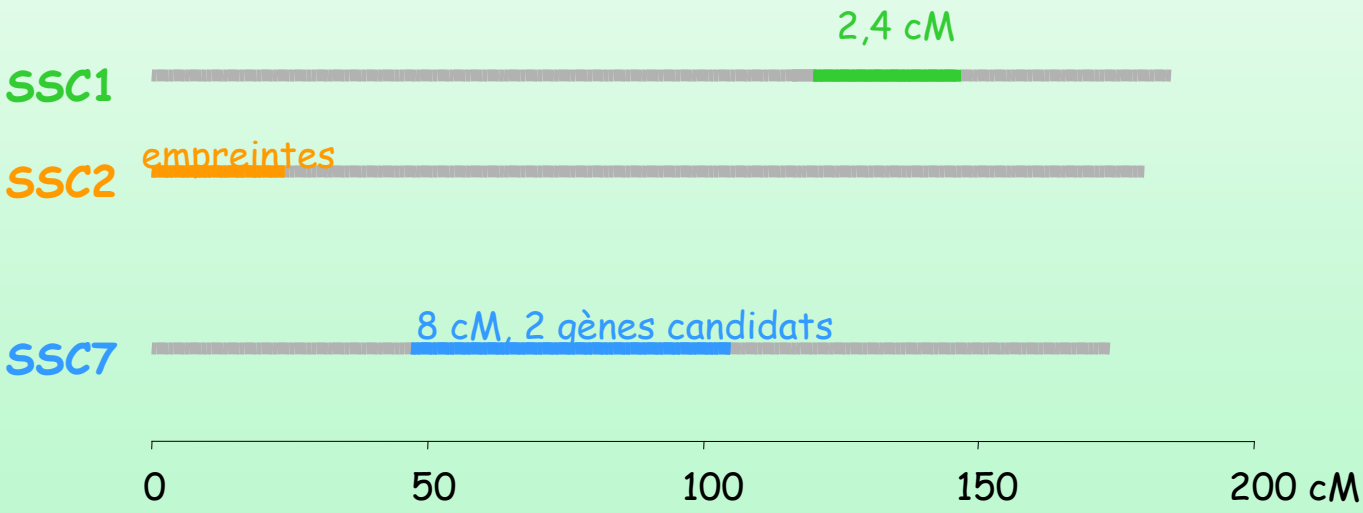


Effect-size = pHu(NN) - pHu(nn)

- 2 studies among the 11 combined studies concluded that pHu (nn) is higher than pHu (NN).
- 5 studies among the 11 combined studies found a non-significant effect of the halothane gene on the pHu.

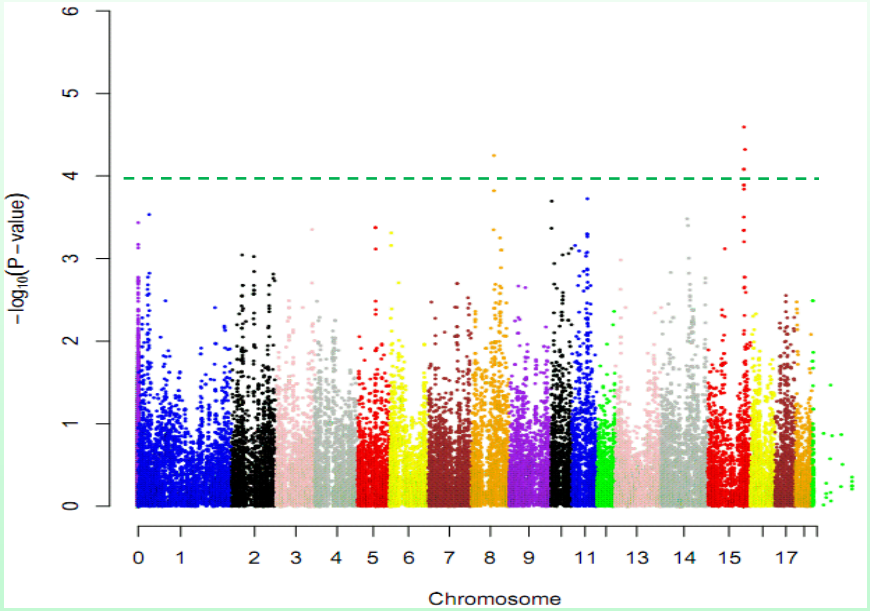
Fatness QTL mapping

- Foundating study: PorQTL
  - F2 (MS x LW)
  - Lots of QTL > rough location
- Following studies
  - refine QTL location (growth, carcass composition)
  - Confirm 4 QTL locations in commercial populations



Meat quality QTL: Example of GWAS

- 2 QTL, 1 on SSC15



Trait	SSC	SNP	Position (Mbp)
WHC	15	DRGA0015508	113.726097
	15	ALGA0087340	116.735371
	8	ASGA0039159	71.443924
	15	ALGA0087116	113.451557
	15	ALGA0087118	113.464523

Maternal abilities

- Genetic variability/ Relation with piglet survival and growth
  - Variability of farrowing cinetic
  - Production and Composition of colostrum
  - Sow and piglet behaviour
  - Litter characteritics

- Selection criteria
  - Piglet weight (homogeneity)
  - Piglet maturity (comparison Ms / LW)

How to improve animal robustness ?

- Selection on functional traits
  - Morphology
  - Disease resistance, immune response
  - Survival, longevity

- Environmental sensitivity
  - G x E
  - Reaction norm

- Stress reactivity

Cortisol and robustness

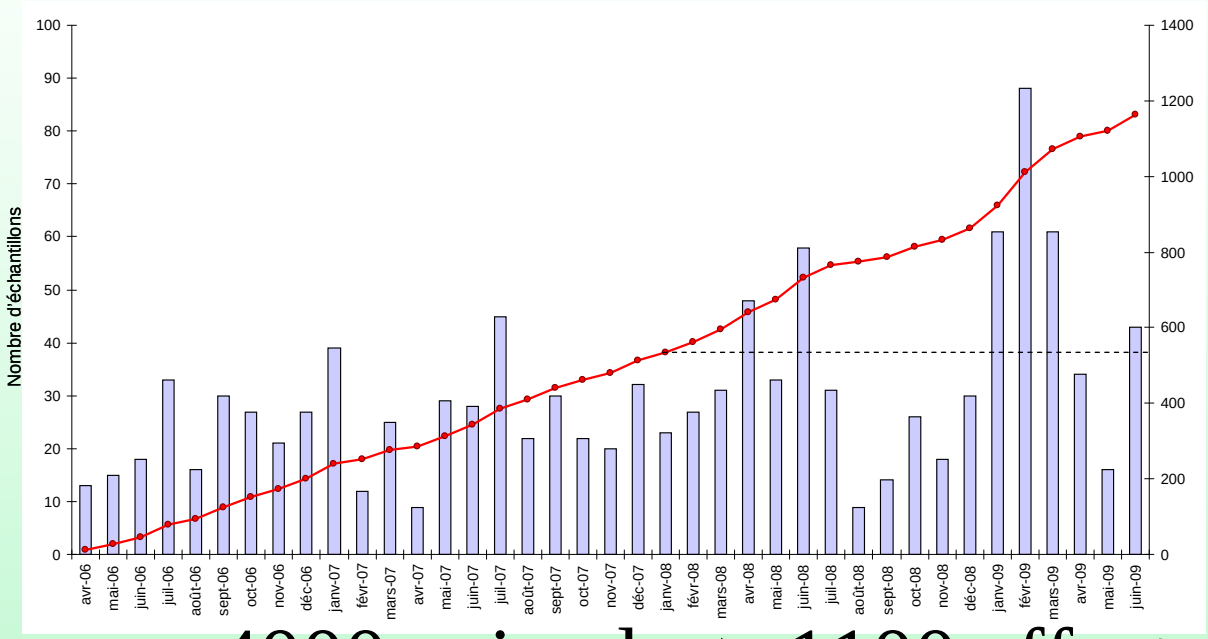
- Higher cortisol levels
  - ↘ Growth rate, feed efficiency, ↗ fat/lean ratio
  - ↗ Newborn survival, tolerance to heat stress
- Improve robustness = higher HPA axis activity

Estimate genetic determinism of ACTH response in pigs, and associated traits

Health, immune response program

- Objective
  - Estimate genetic variation of immune response
- Program
  1. Estimate genetic parameters of a large number of immune response traits (innate and acquired)
  2. Selection experiment on the most pertinent traits
  3. Genomic studies
  4. Metagenomic studies and relation with immunity

Congenital disorders: DNA bank



~4000 animals, > 1100 affected

600 + 800 genotyped

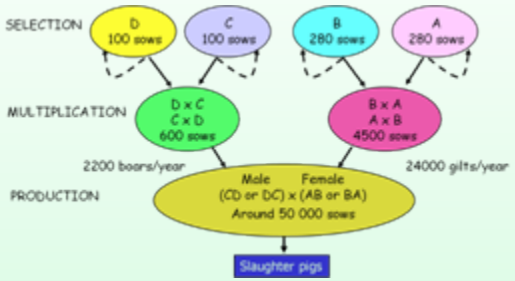
Minipig line > human nutrition studies

3 breeds:

- Vietnamese (Mong Caï, I, crossbred?),
- Pitman-Moore,
- Yucatan

Genomic selection

- Genomic selection for pyramidal breeding scheme
  - Crossbred animals
  - Selection / production environment



- Phenotypes
  - Wellfare
  - Health
  - Quality (boar taint)