Better sows for better pigs : challenges and opportunities for the genetic improvement of sow reproductive efficiency

Jean Pierre Bidanel

NSIF Meeting in honor of R.K. Johnson

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Better sows for better pigs : challenges and opportunities for the genetic improvement of sow reproductive efficiency

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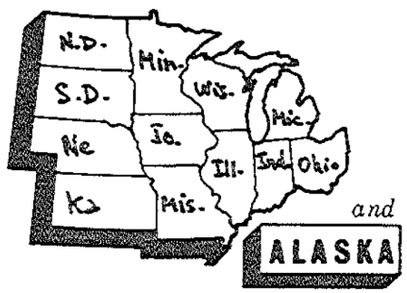
My first contacts with Dr Johnson

North Central Regional Publication No. 262

Heterosis and Breed Effects in Swine

by R. K. Johnson



Agricultural Experiment Stations of Alaska, Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, Ohio and Wisconsin cooperating

The Agricultural Experiment Station
Institute of Agriculture and Natural Resources
University of Nebraska–Lincoln
H. W. Ottoson, Director

Seminar at INRA in Jouy-en-Josas

+

ELSEVIER

Livestock Production Science 11 (1984) 541-558

LIVESTOCK PRODUCTION SCIENCE

Selection for components of reproduction in swine

R.K. Johnson, D.R. Zimmerman, R.J. Kittok

Large number of papers in pigs, rabbits, mice,…

FOOD & NUTRITION
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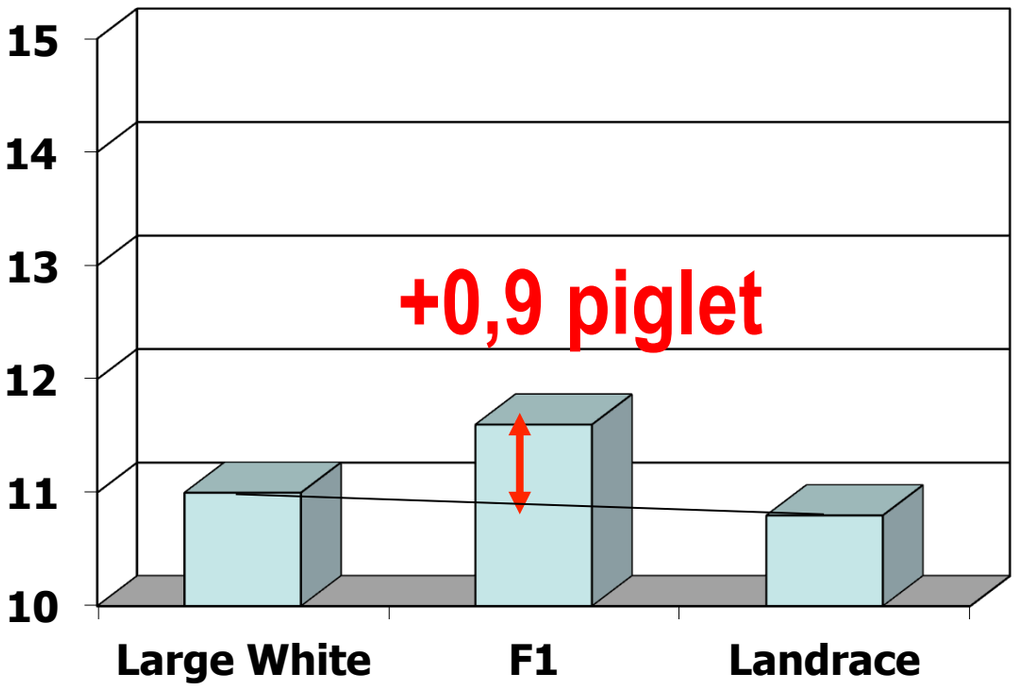
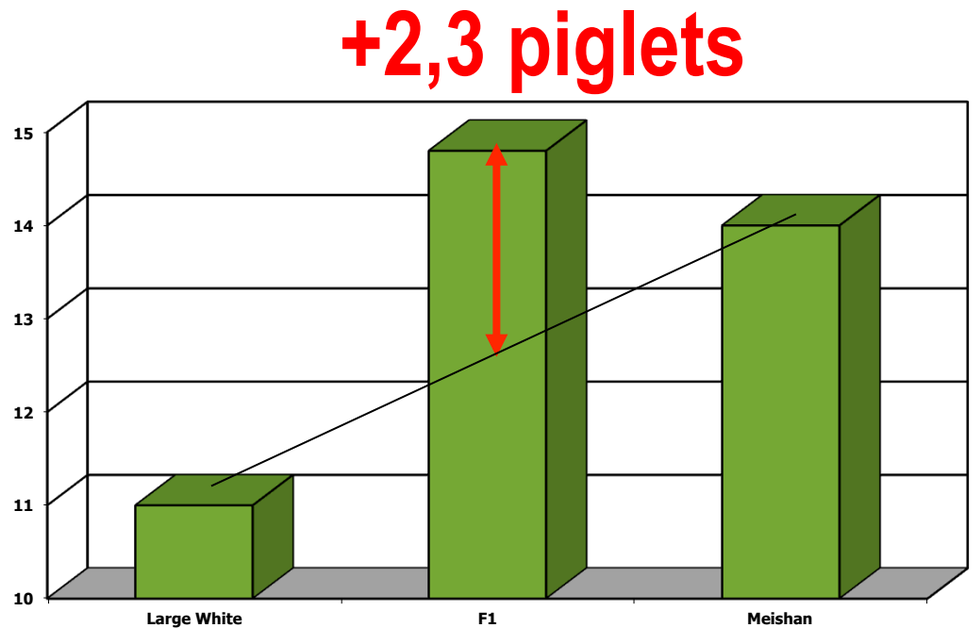
Crossbreeding parameters
HETEROSIS

Large variations according to breed combination

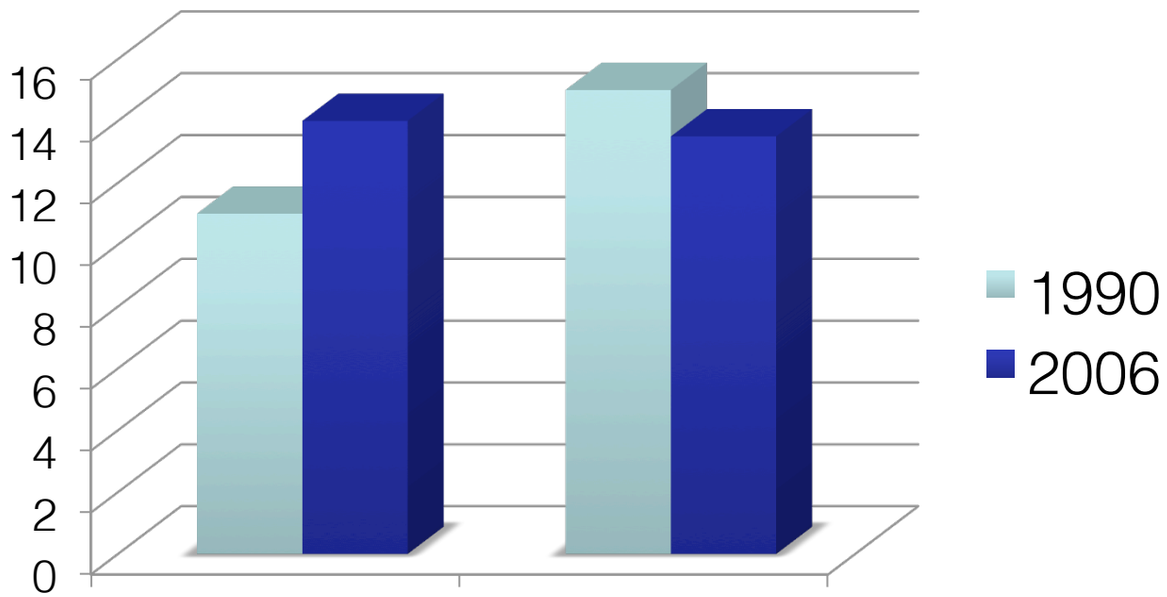




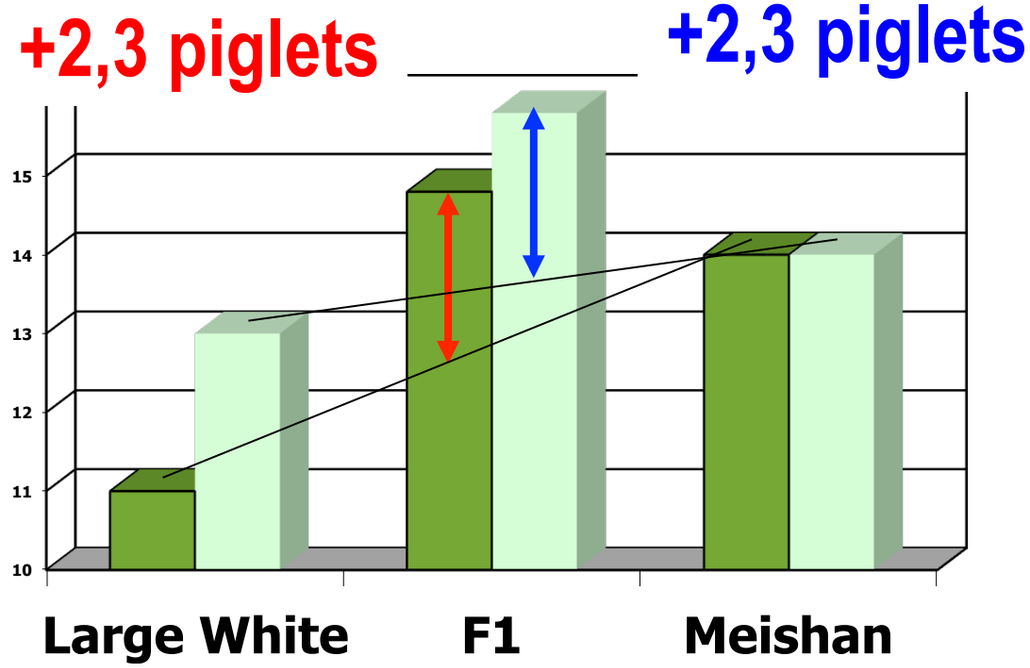
Use of heterosis :
can we move from left to right ?

Crossbreeding parameters

Recent trends



Meishan is no longer more prolific than Large White …



… but heterosis values remain very high

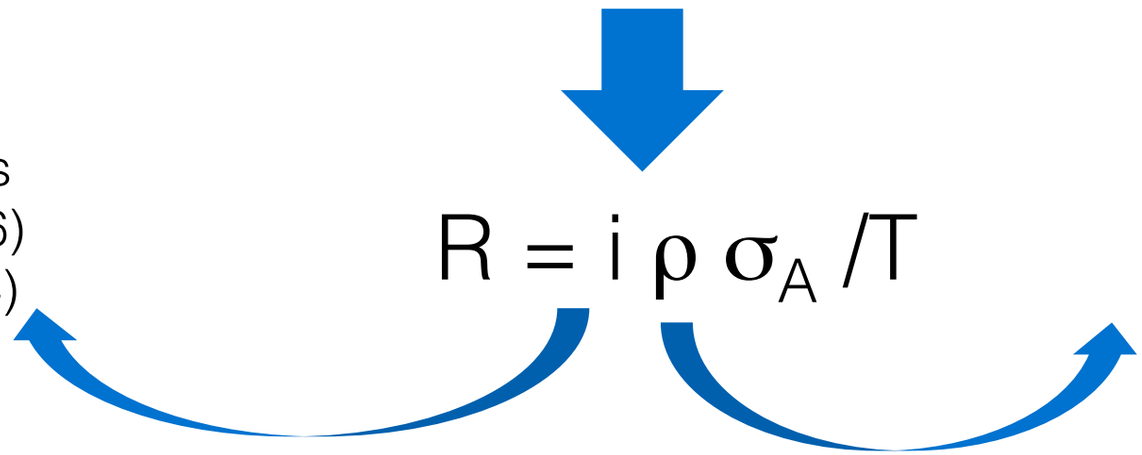
Potential interest of (HD) markers to increase heterosis Values (?)

Selection for litter size : an historical perspective

Early 80's : litter size considered as very difficult to increase through selection

- No response to selection for litter size in a French experiment (Bolet et al (1987)
- Selection for ovulation rate : significant direct response, but no correlative response on litter size (Cunningham et al (1979)

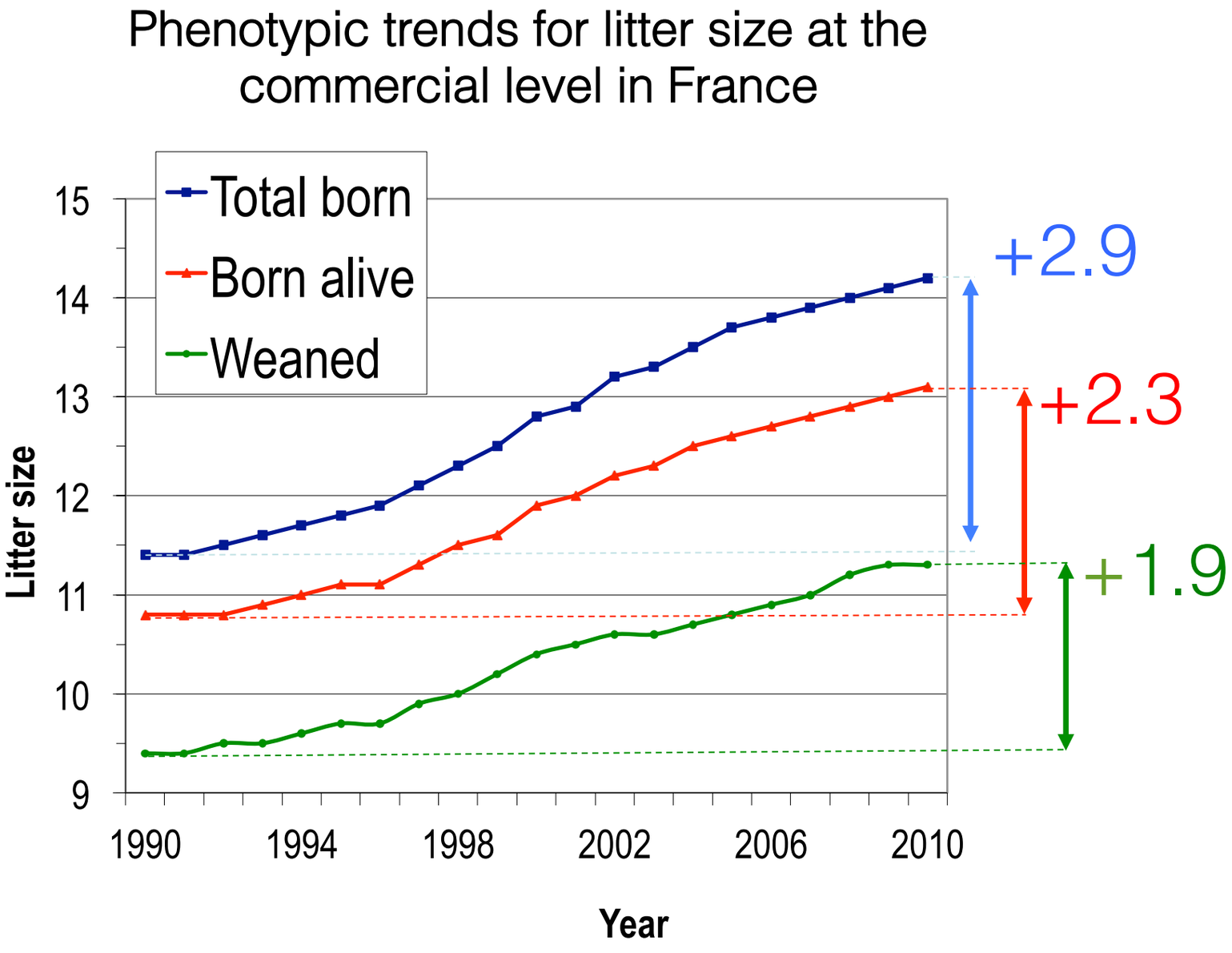
Hyperprolific
Breeding schemes
(Legault et al (1976)
Bidanel et al (1994)



Components of litter size
Uterine capacity
(Johnson et al (1984)
Bennett & Leymaster (1989)

Back in 2011

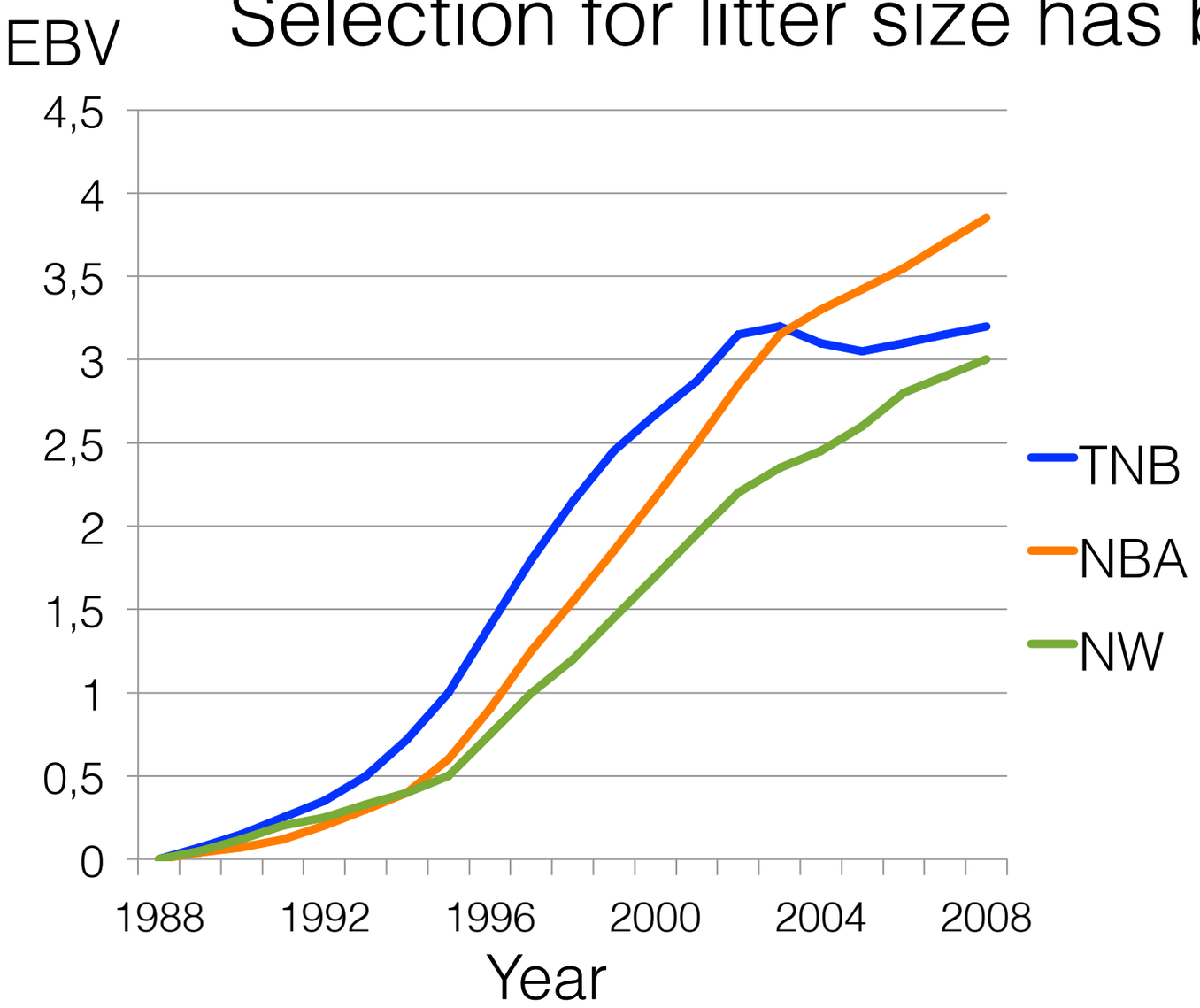
Large improvements in litter size



These trends are largely due to selection

Genetic trends for litter size

Selection for litter size has been very successful



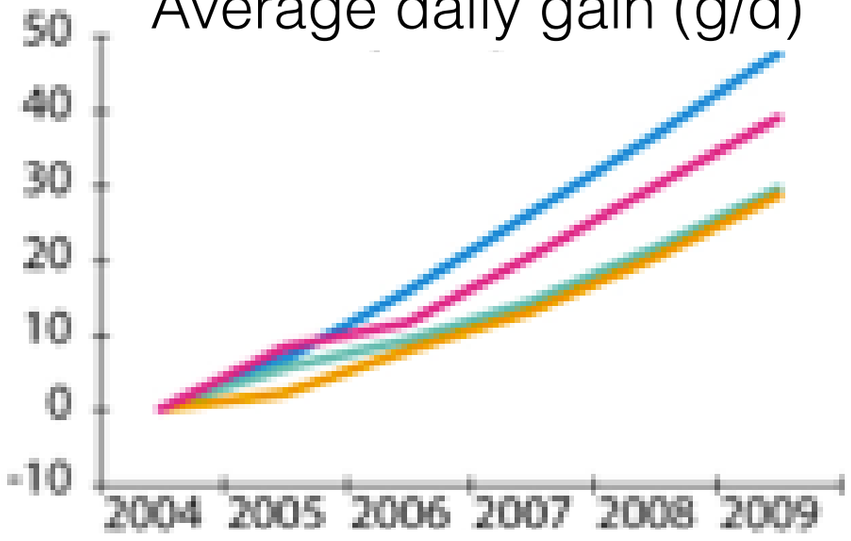
Genetic trends for litter size in
French Large White breed (Guéry et al, 2009)

as a combination of :

- The development of IA
- BLUP methodology
- Large population size

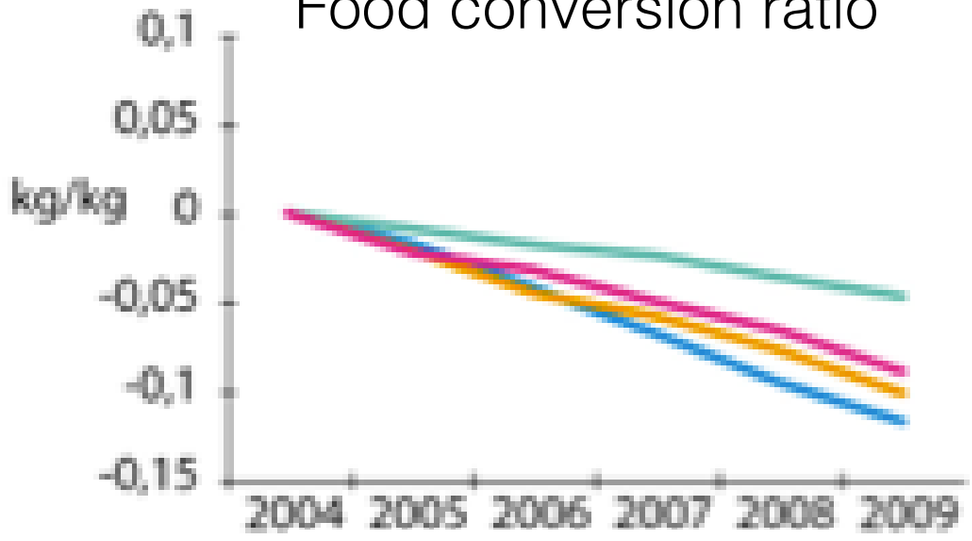
Large genetic gains for production traits

Average daily gain (g/d)



Year of birth

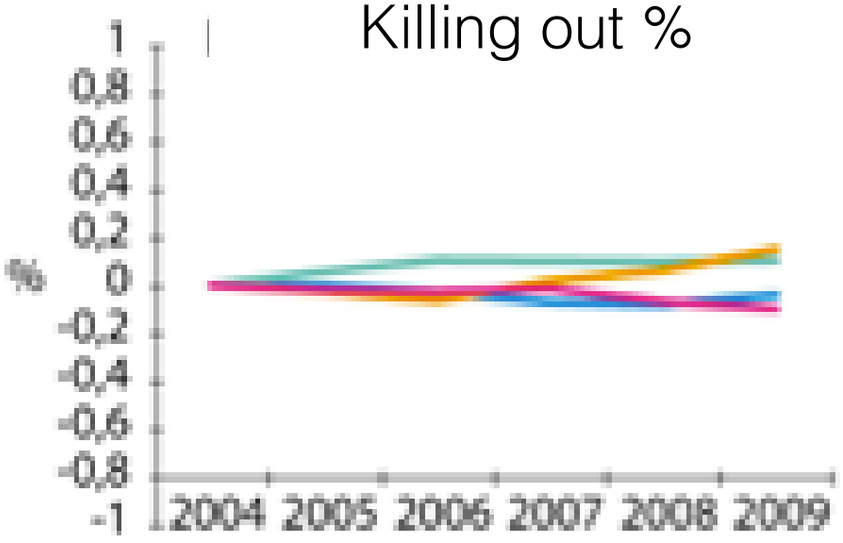
Food conversion ratio



Year of birth

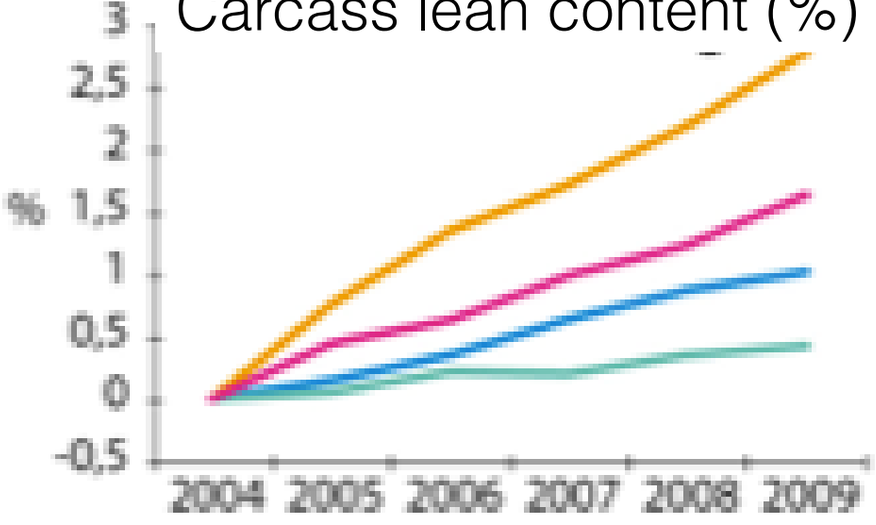
Landrace
Large White F
Large White M
Piétrain

Killing out %



Year of birth

Carcass lean content (%)



Year of birth

Source : IFIP, le porc par les chiffres 2010

➔ Everything’s working fine ?

➔ Can we expect similar gains over the next 20 years ?

Prediction of future breeding goals

Difficult question which depends of both economical, societal, regulatory as well as biological considerations, e.g.:

Ban for castration, acceptability of piglet deaths

Animal behaviour, robustness

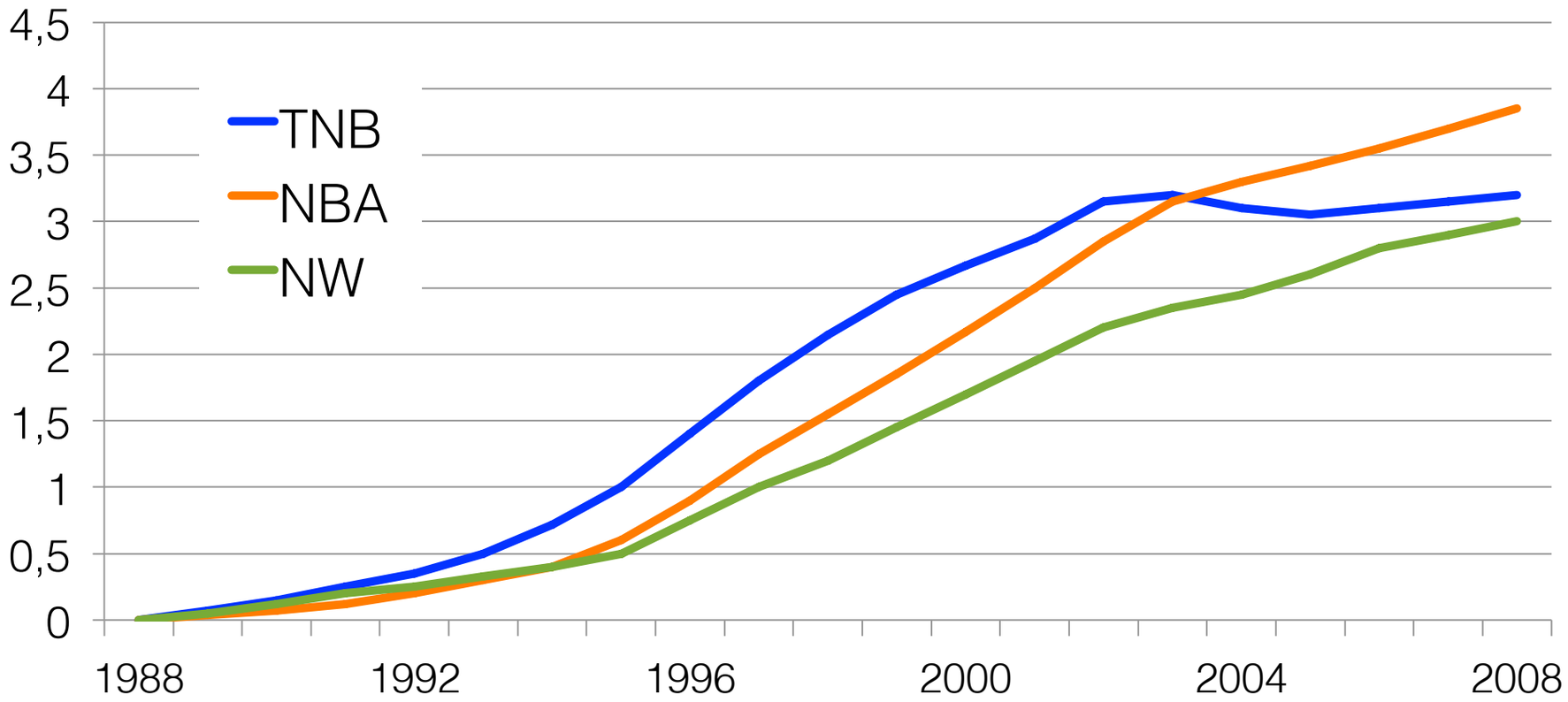
Physiological limits to selection

Unfavourable correlative responses to selection

- Useful information from :
  - Genetic parameter estimates
  - Estimated responses to selection

⇒ Example of French Large breed where this last aspect has beenThoroughly investigated

Estimation of responses to selection in French Large White breed



Production traits + TNB

Production traits +NBA + teats

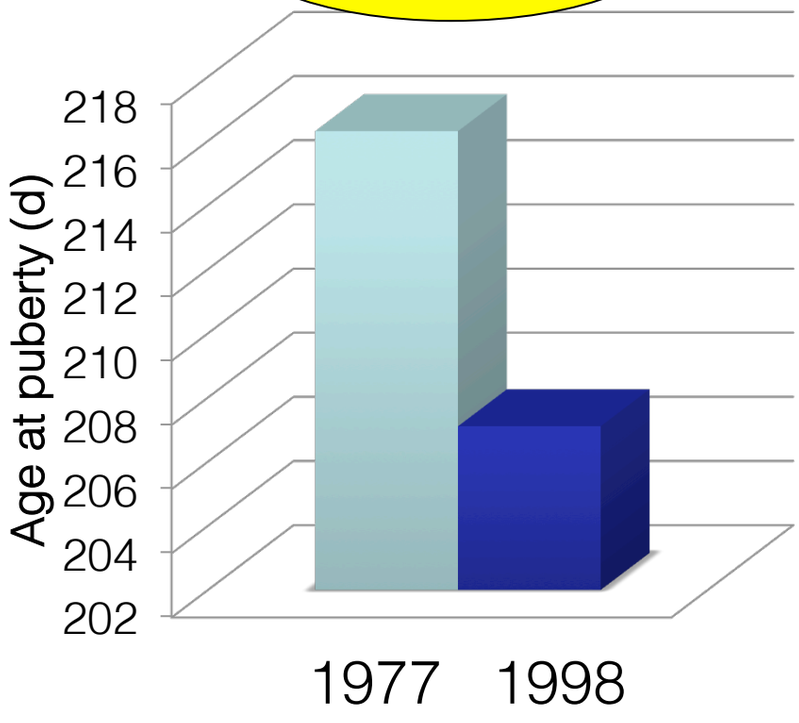
Frozen semen experiment (1977-1998)

Responses to selection in French LW

Favourable trends

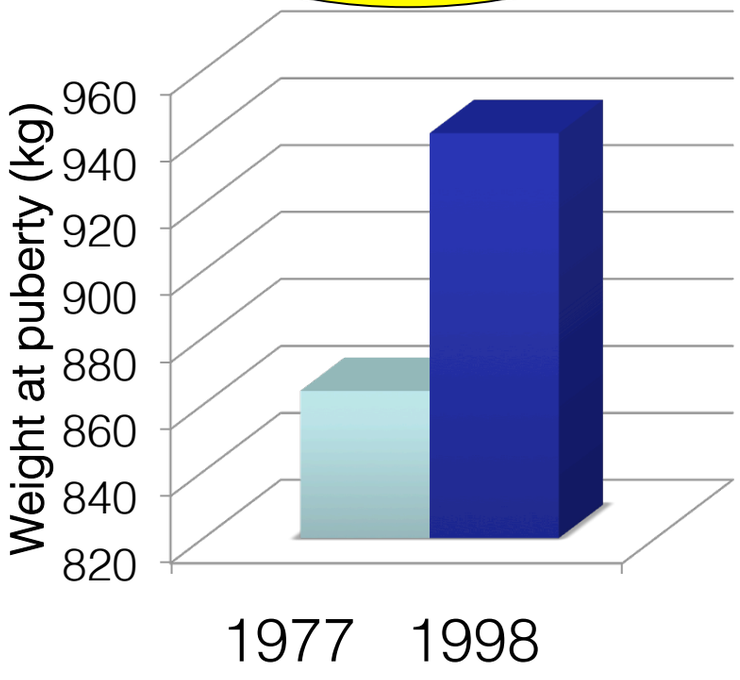
Age at puberty

-9.2 ± 9.2



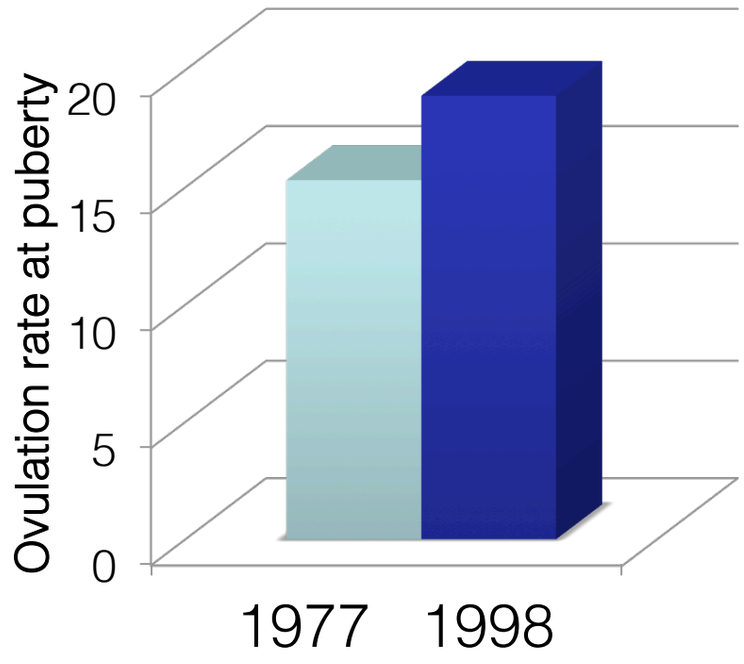
Weight at Mating (kg)

7.7 ± 5.7 +



OR at puberty

3.6 ± 1.3 ***



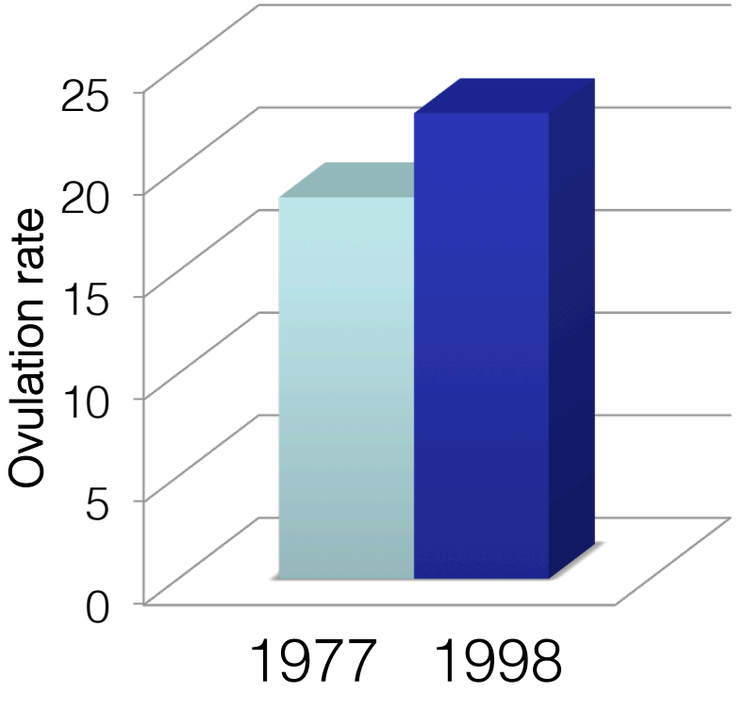
From Tribout et al, JRP, 2003

Responses to selection in French LW

Favourable trends

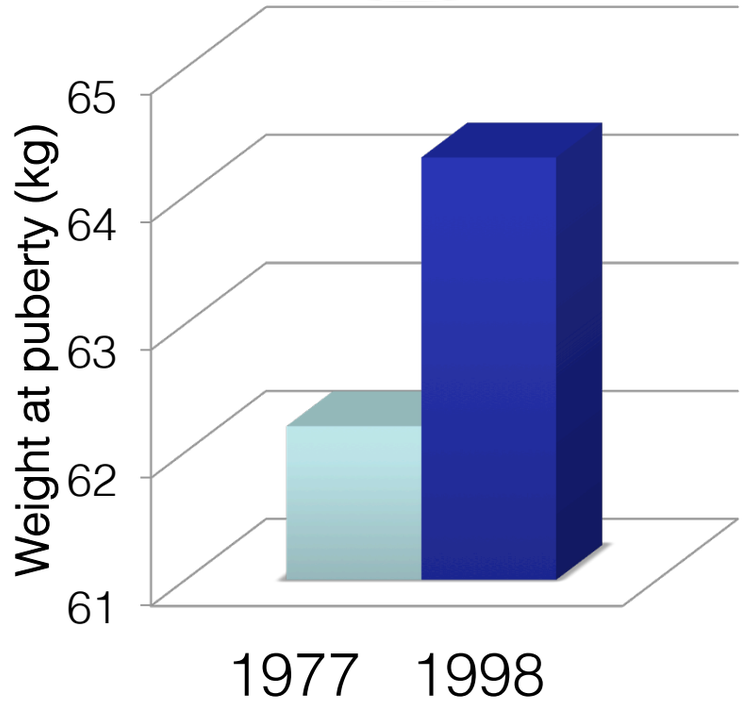
Ovulation rate at mating

4.1 ± 1.6 ***



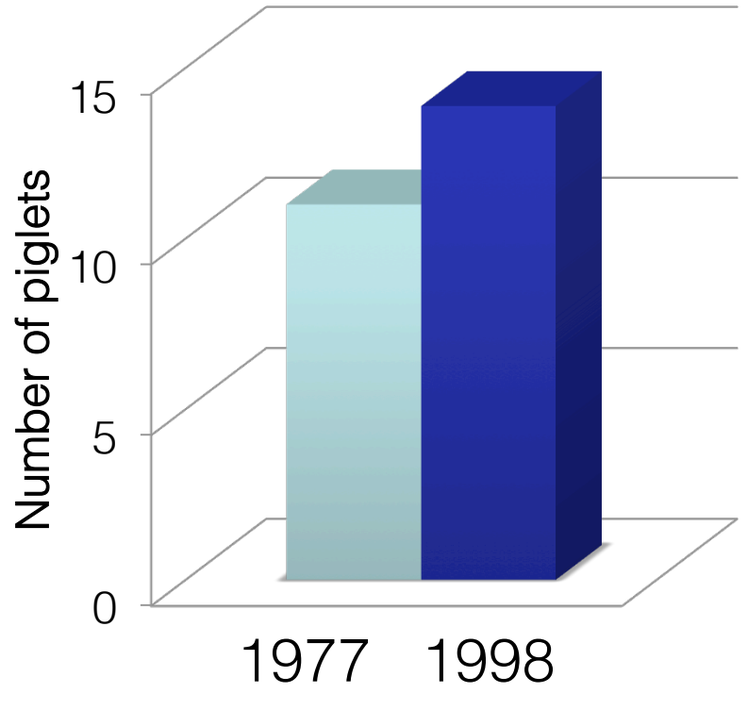
Prenatal survival (%)

2.1 ± 6.8 ns



Total number born

2,9 ± 1.3 **



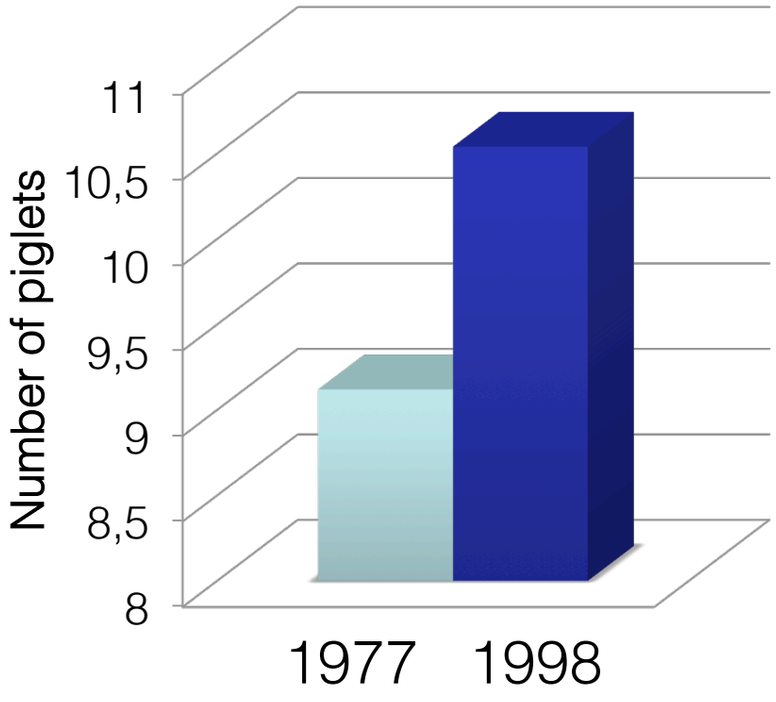
From Tribout et al, JRP, 2003

Responses to selection in French LW

Favourable trends

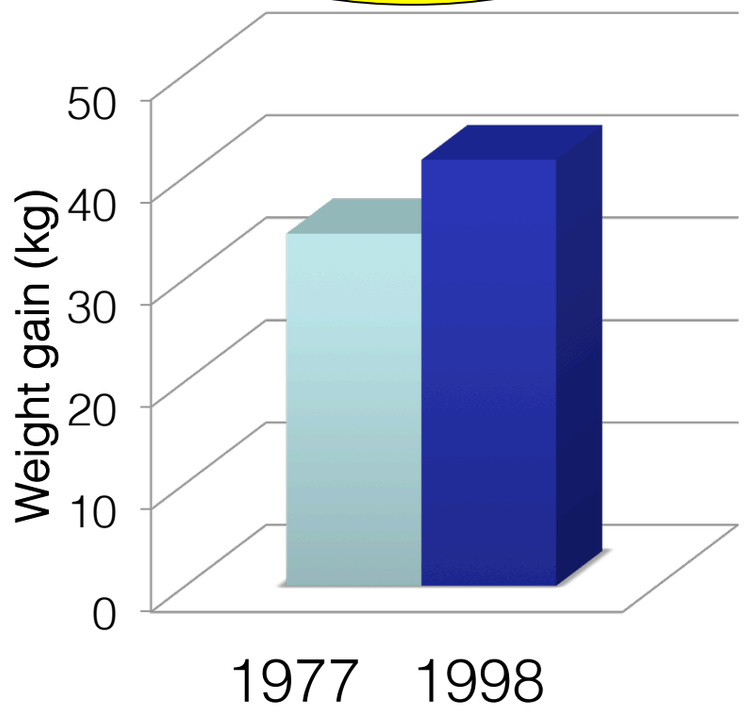
Litter size At weaning

1.4 ± 0.9 +



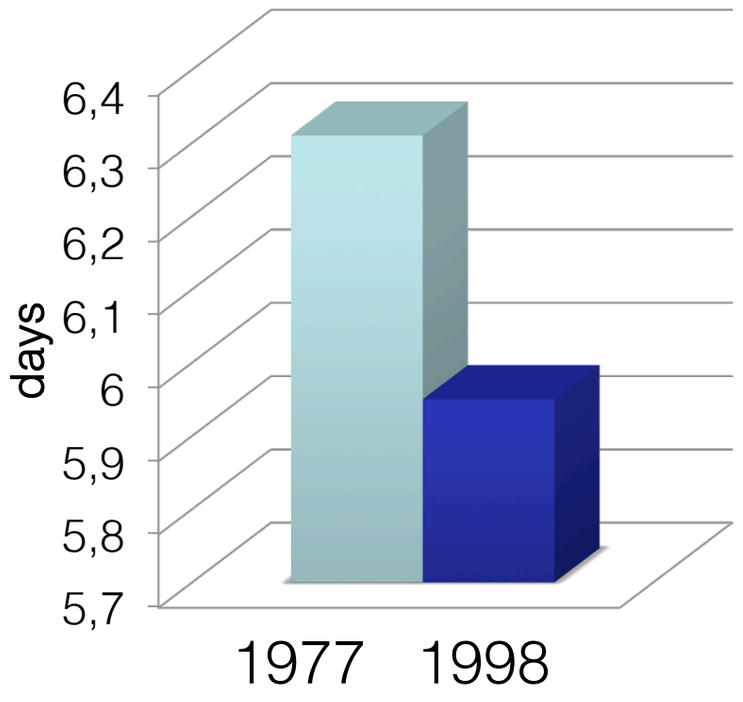
Litter weight gain 0-21d (kg)

7.4 ± 2.5 ***



Return to oestrus

-0,4 ± 0.3 ns



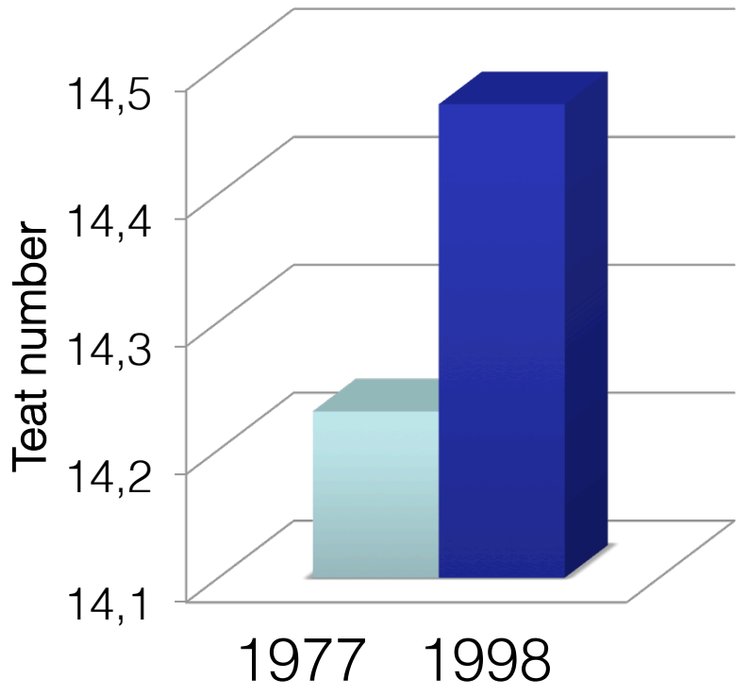
Source: Tribout et al, 2003; Canario, PhD th, 2006

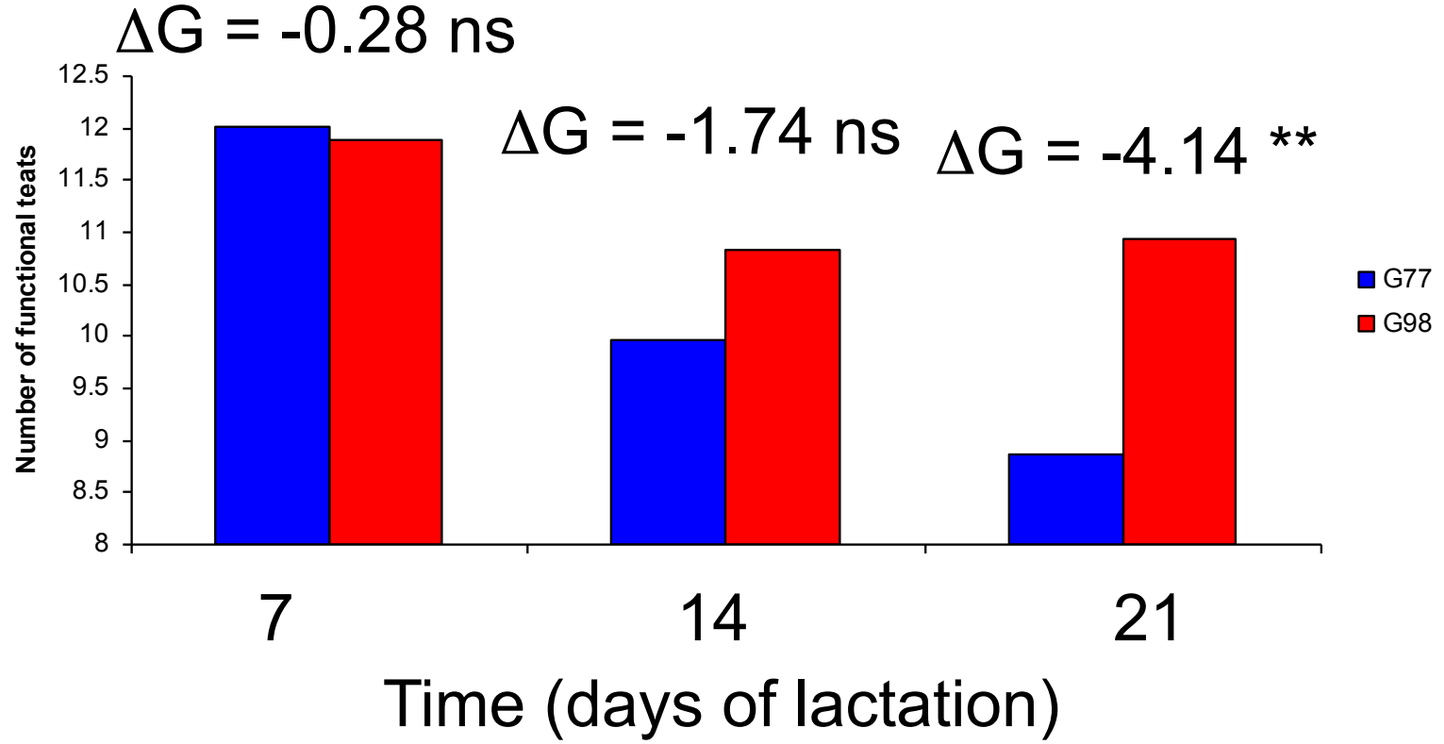
Responses to selection in French LW

Favourable trends

Teat number

0,24 ± 0.35 ns





The teats of G98 sows remain functional for a longer period of time

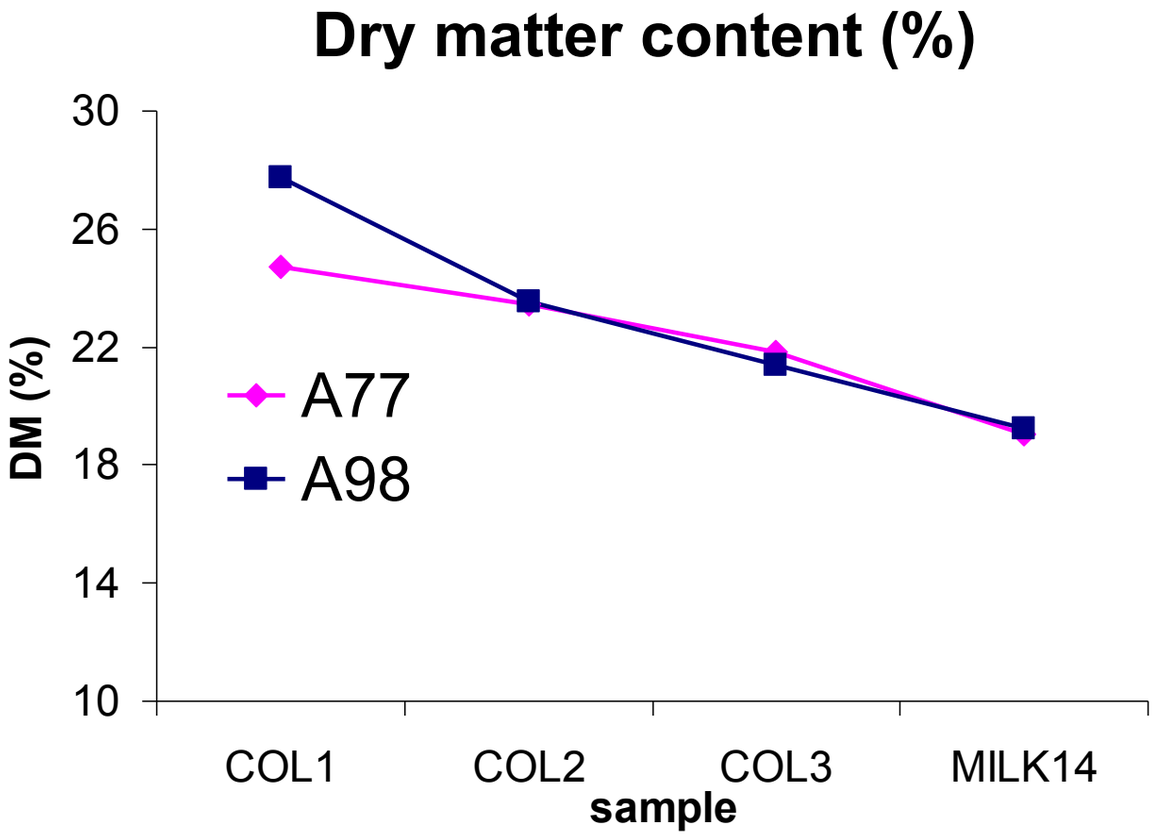
Source: Canario, PhD th, 2006

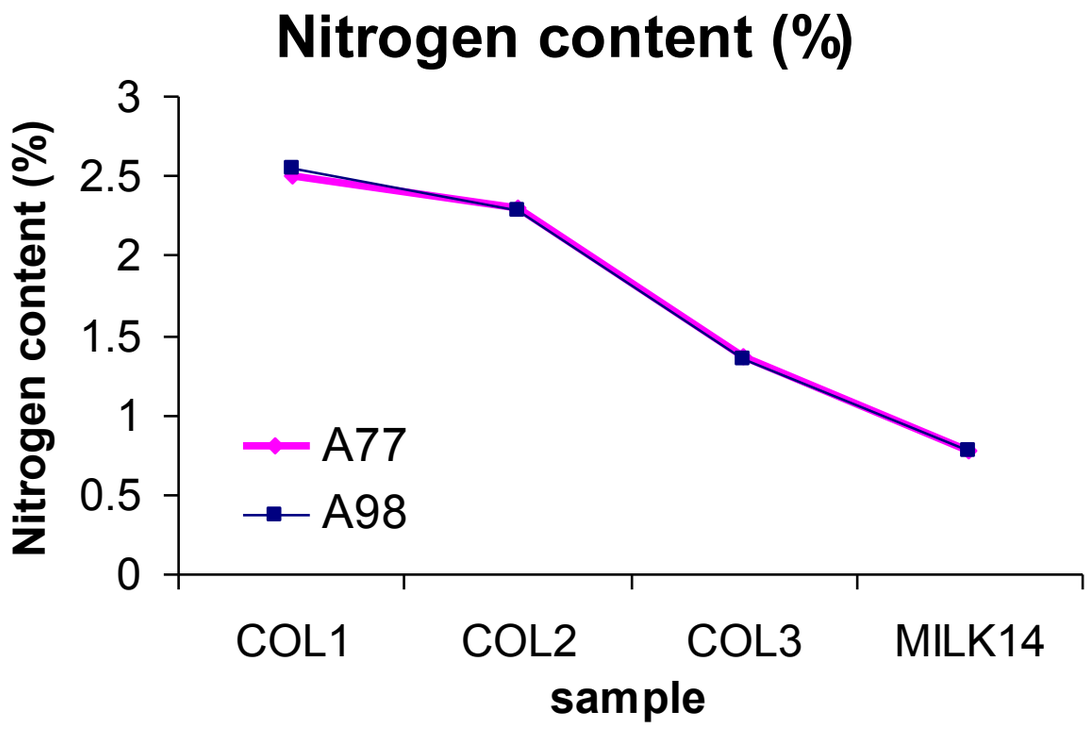
Responses to selection in French LW

Favourable trends

Colostrum and milk composition (1)

Composition of 3 colostrum samples (birth of the 1st (1) and last (2) piglet, 24h later (3) and 1 milk sample (at 14 days of age)



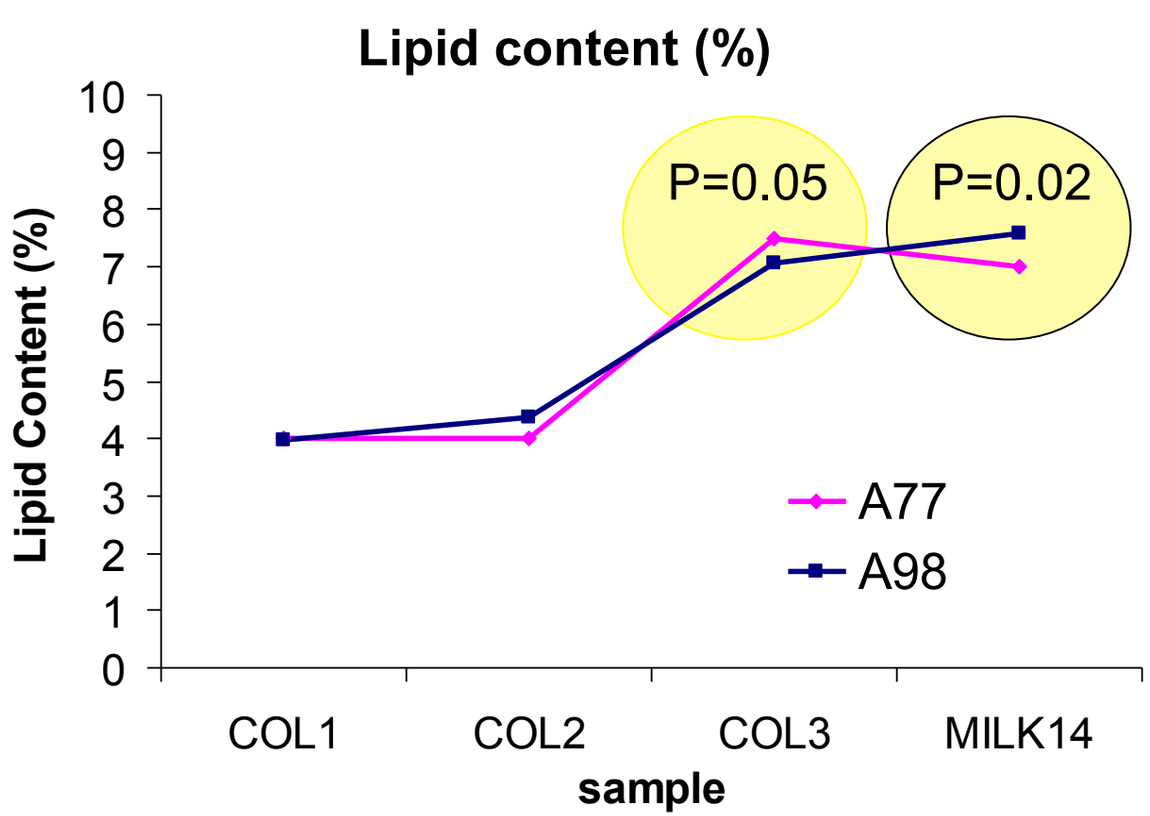


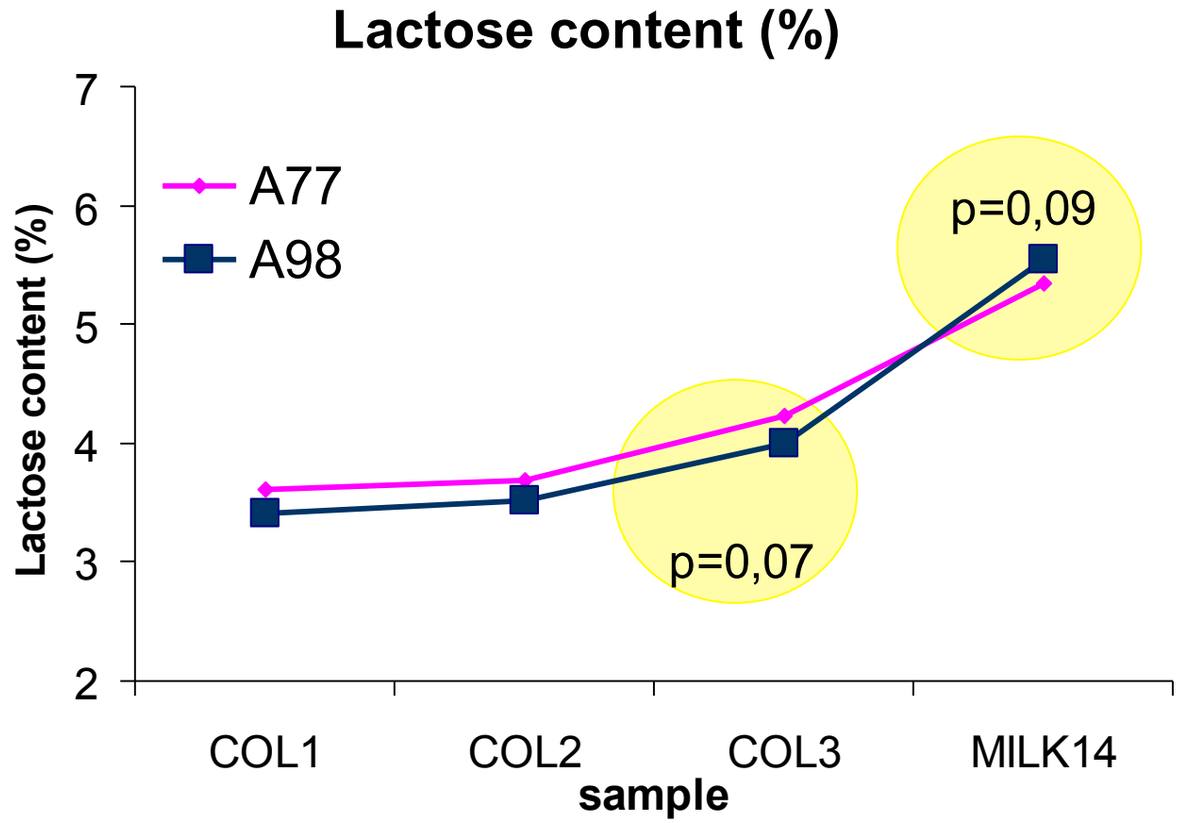
Source: Tribout et al, unpublished

Responses to selection in French LW

Favourable trends

Colostrum and milk composition (2)





- No difference in immunoglobulin (IGG) content (P > 0.15)

Limited trends on colostrum and milk composition

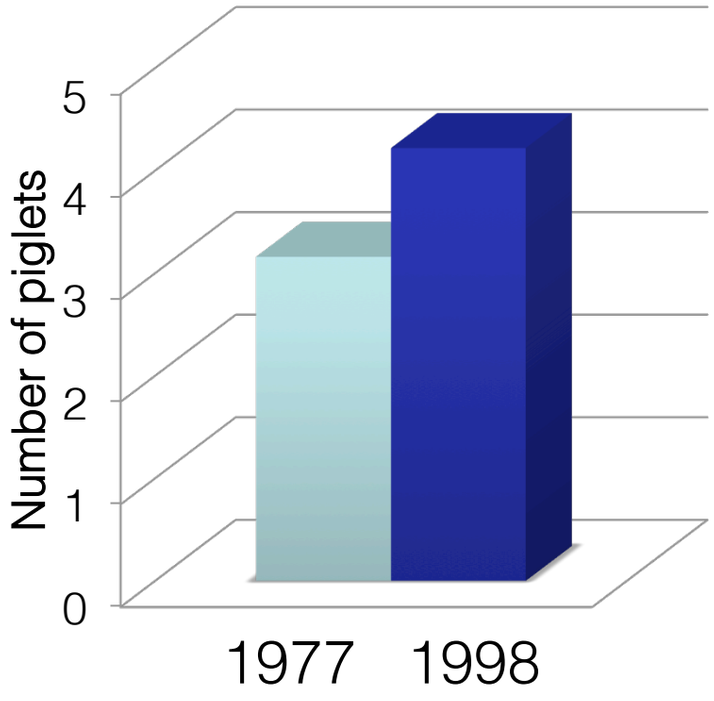
Source: Tribout et al, unpublished

Responses to selection in French LW

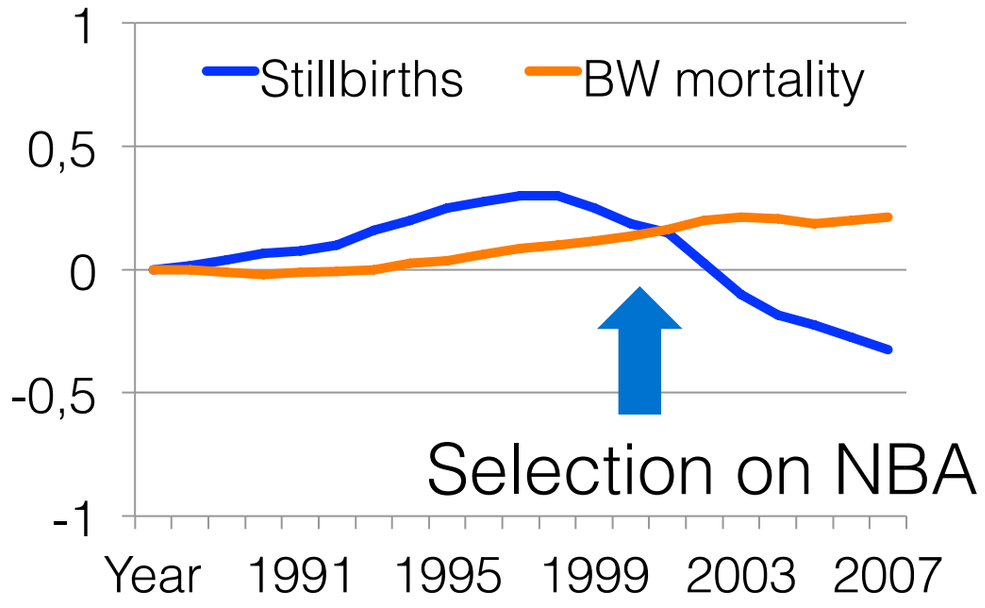
Unfavourable trends

Number of stillbirths

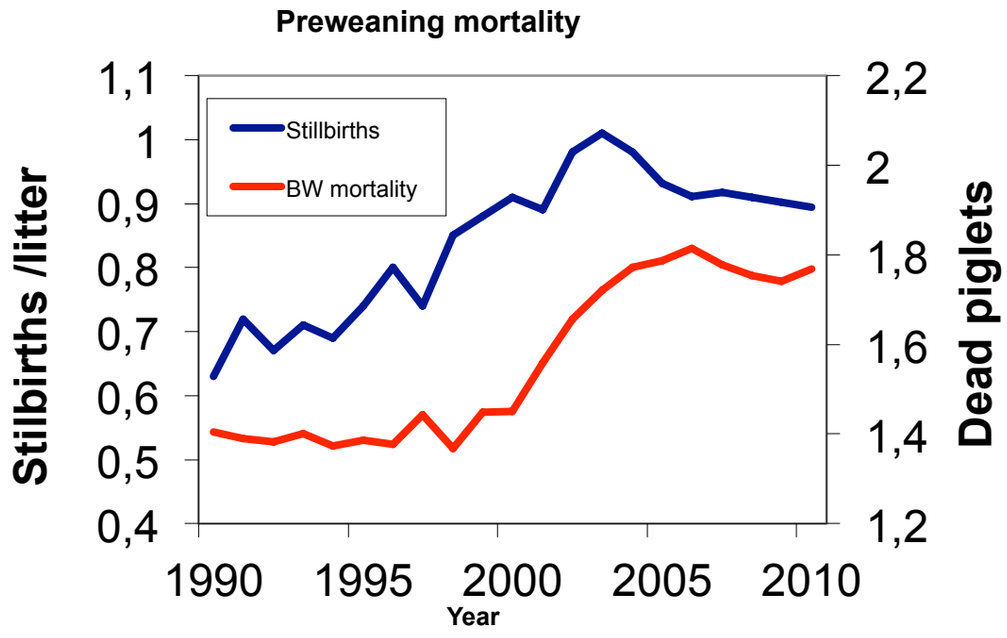
0.50 ± 0.25 *



Estimated genetic Trends in French LW population



Phenotypic trends at the production level

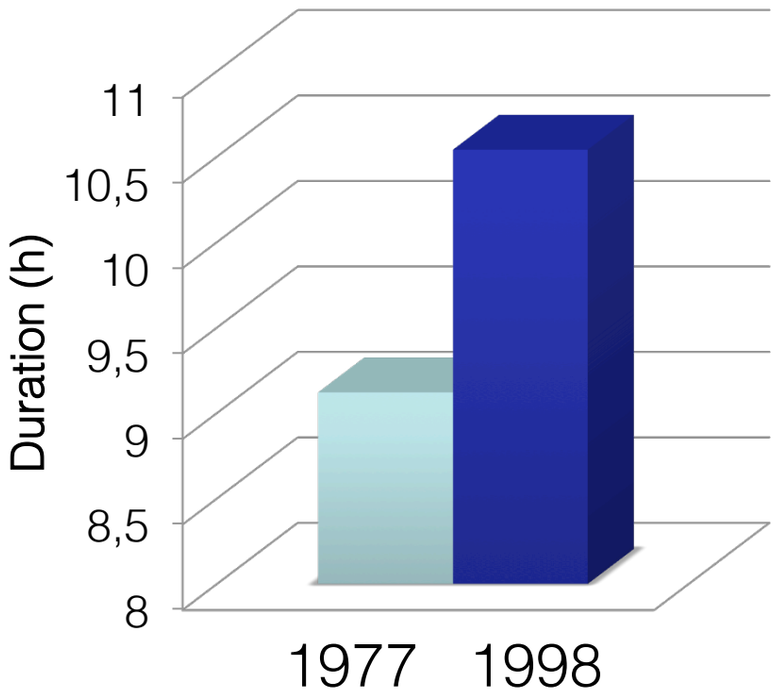


Responses to selection in French LW

Unfavourable trends

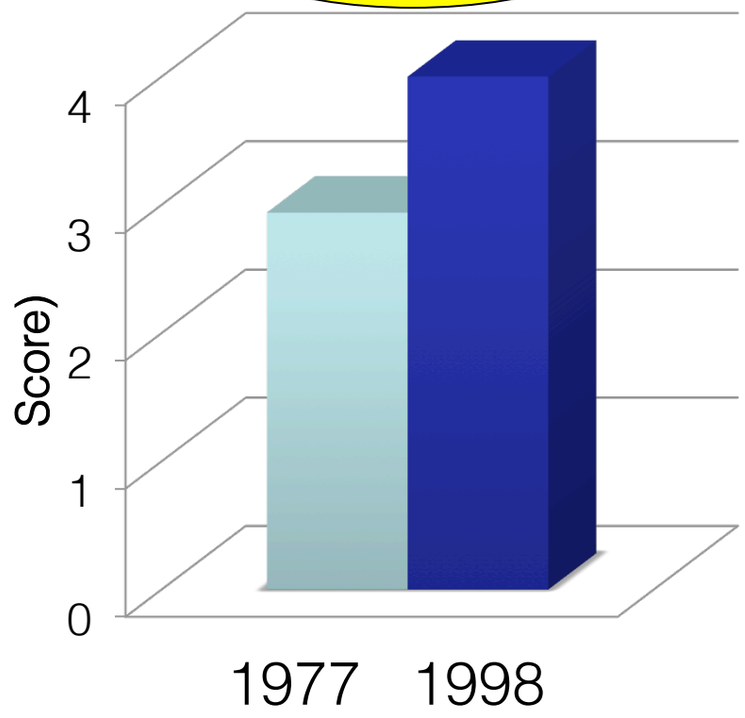
Farrowing length (h)

1.4 ± 0.9 +



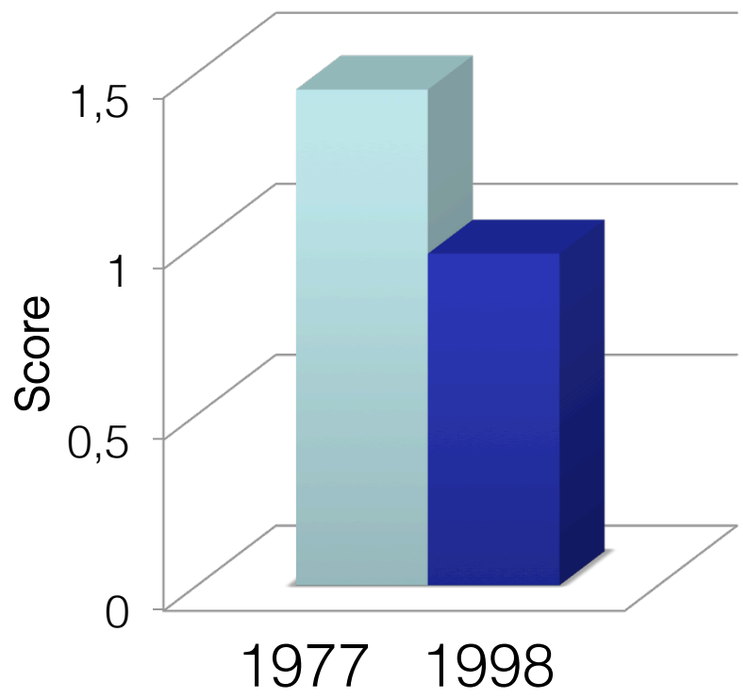
Respiratory Difficulties (score)

1.1 ± 0.6 +



Mobility score

-0,48 ± 0.05 ***



Source: Canario, PhD th, 2006

Piglet maturity at birth (1)

	G77 mean	G98 mean	ΔG	Pr> |t| H0: ΔG=0
Dry matter (%)	**20.6**	**19.1**	-3.00	***
P- (%)	**12.1**	**11.1**	-2.00	***
Liver Weight (g)	**30.3**	**25.5**	-9.6	***
Liver Glycogen (g/kg)	**6.4**	**4.7**	-3.4	*
Blood albumin	**8.90**	**7.41**	-2.90	*

Lower maturity of G98 piglets at birth …

Source: Canario et al, Animal (2007)

Piglet maturity at birth (2)

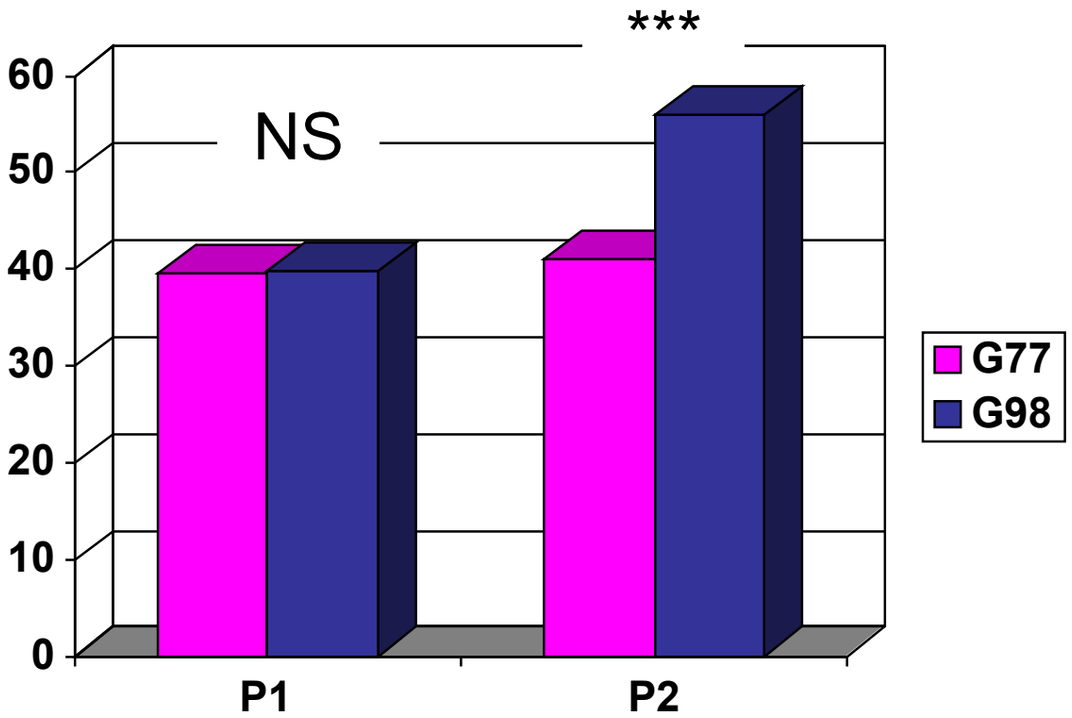
	G77 mean	G98 mean	ΔG	Pr> |t| H0: ΔG=0
RNA / Protein (µg/g)	**15.8**	**18.8**	+6.0	+
Protein % (LD)	**20.2**	**25.5**	+10.6	+

… But higher protein synthesis and growth potentials

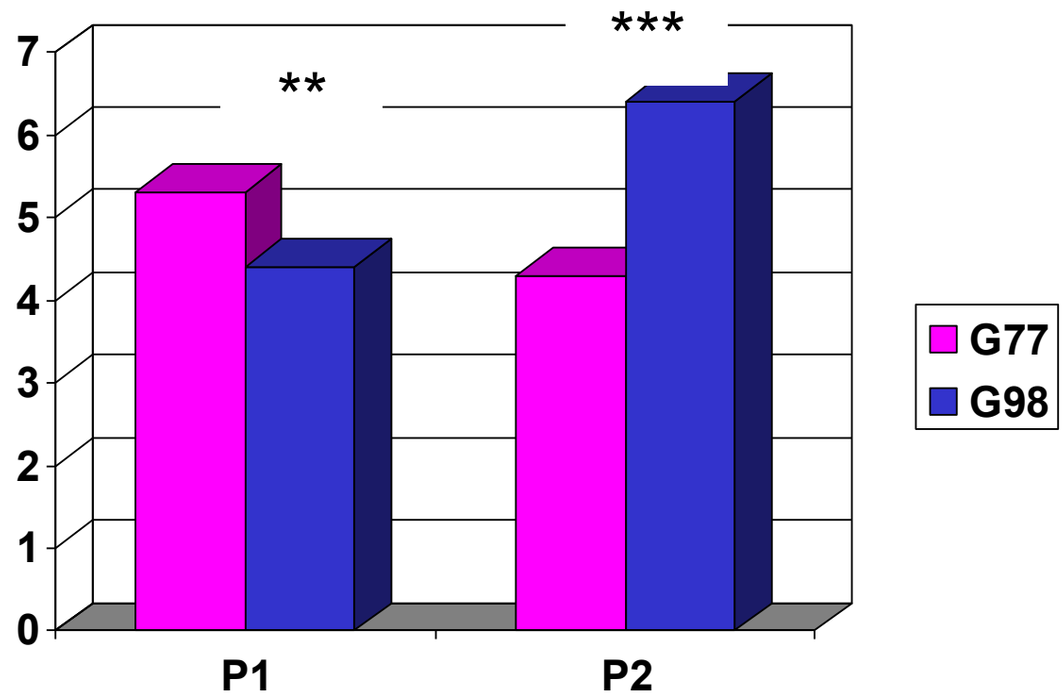
Source: Canario et al, Animal (2007)

Mobilisation of reserves during lactation

Weight loss (kg)



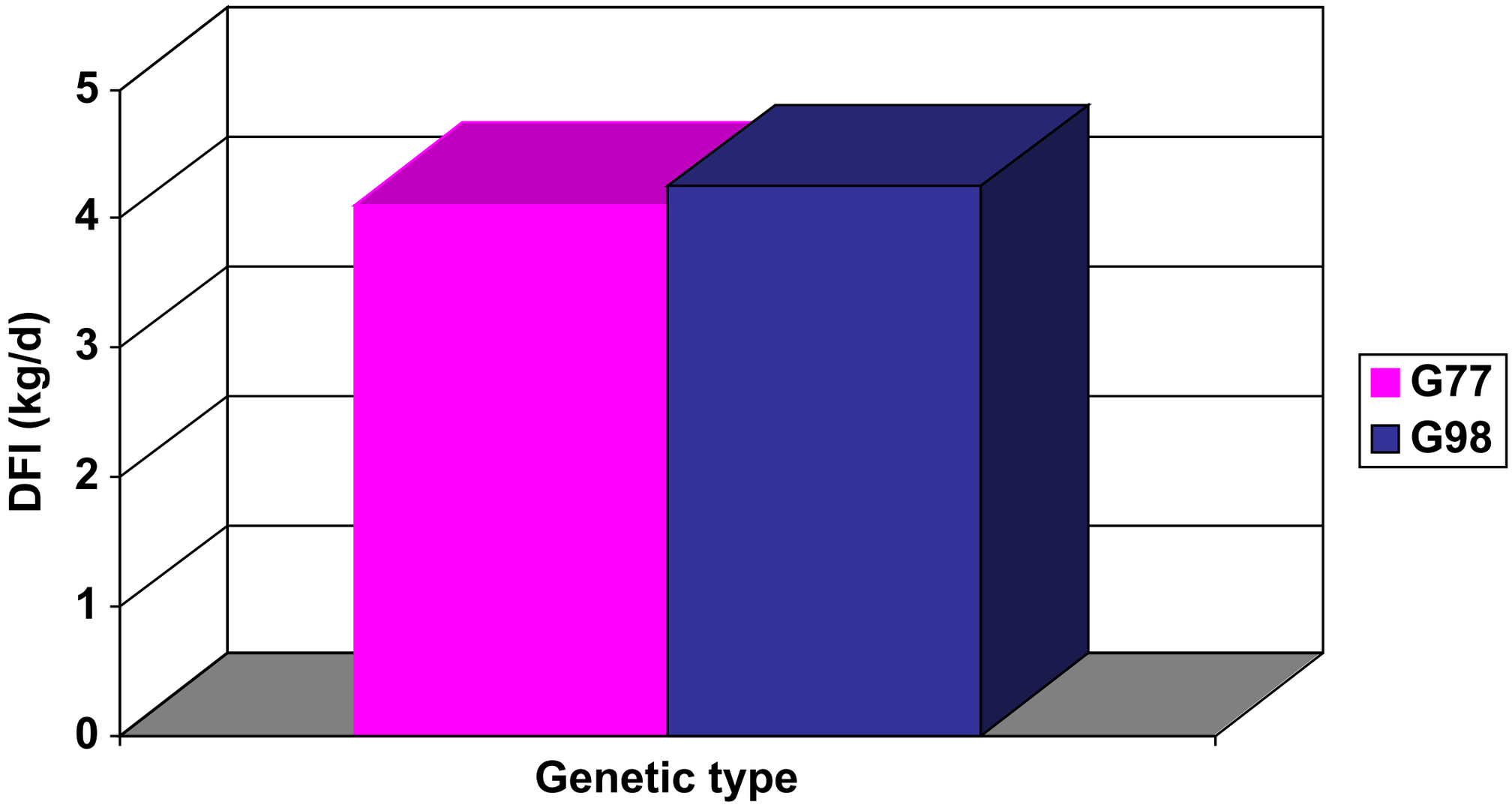
Backfat loss (mm)



- Interaction with parity
- Higher mobilisation in 2nd parity G98 sows

Source: Canario, PhD th, 2006

Sow feed intake during lactation



No significant difference in feed intake

Source: Tribout et al, unpublished

Piglet weight homogeneity at birth

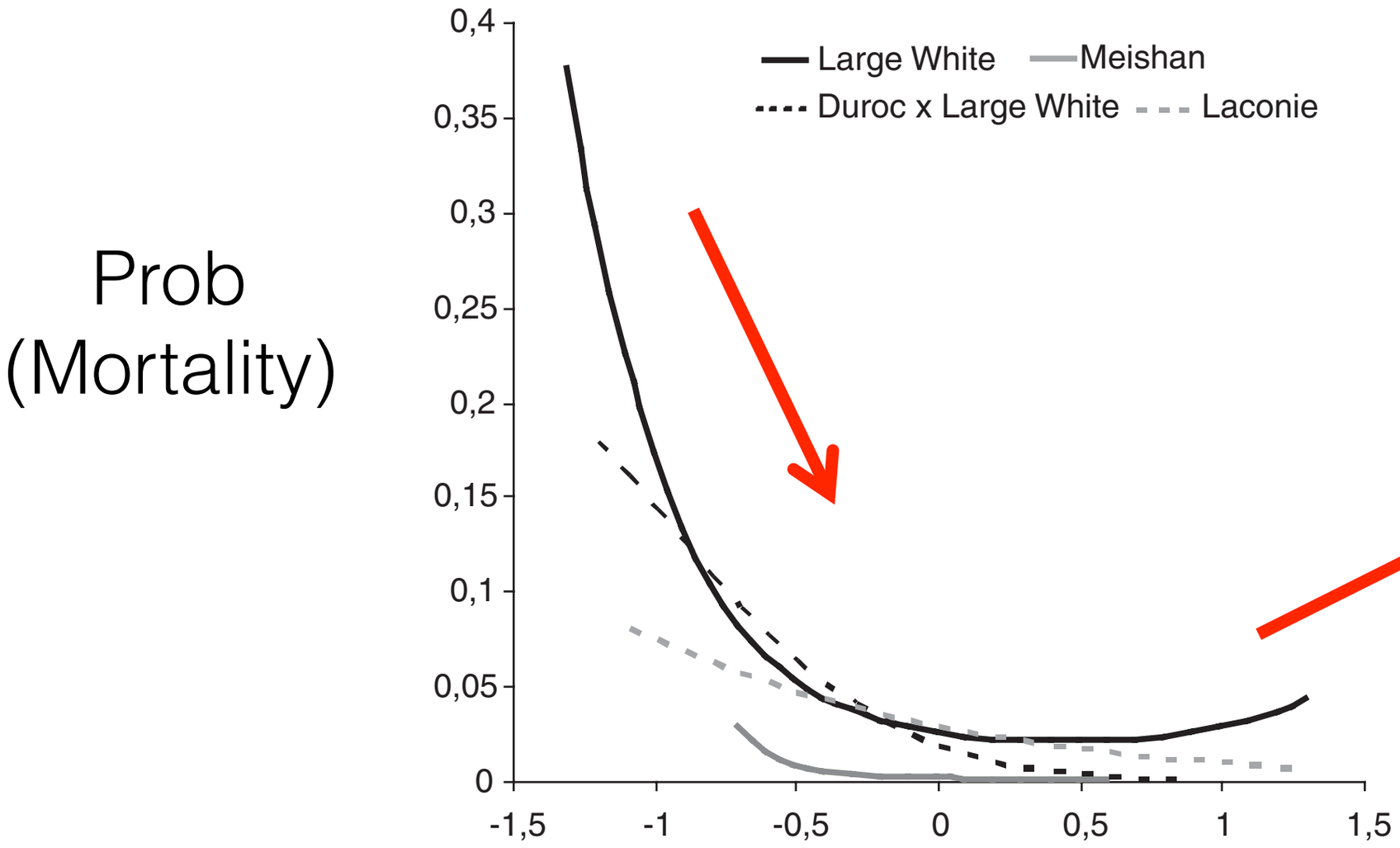
	G77 mean	G98 mean	ΔG ± se	ΔG Pr> |t| H0: ΔG=0
StdDev Wt	0.26	0.29	+ 0.06 ± 0.03	*
Min Wt	0.94	0.98	+ 0.08 ± 0.08	NS
Max Wt	1.79	1.93	+ 0.27 ± 0.08	***

Piglet birth weights are more heterogeneous within a litter

=> associated with an increase in very high birth weights

Source: Tribout et al , JRP 2003

Piglet birth weight and mortality



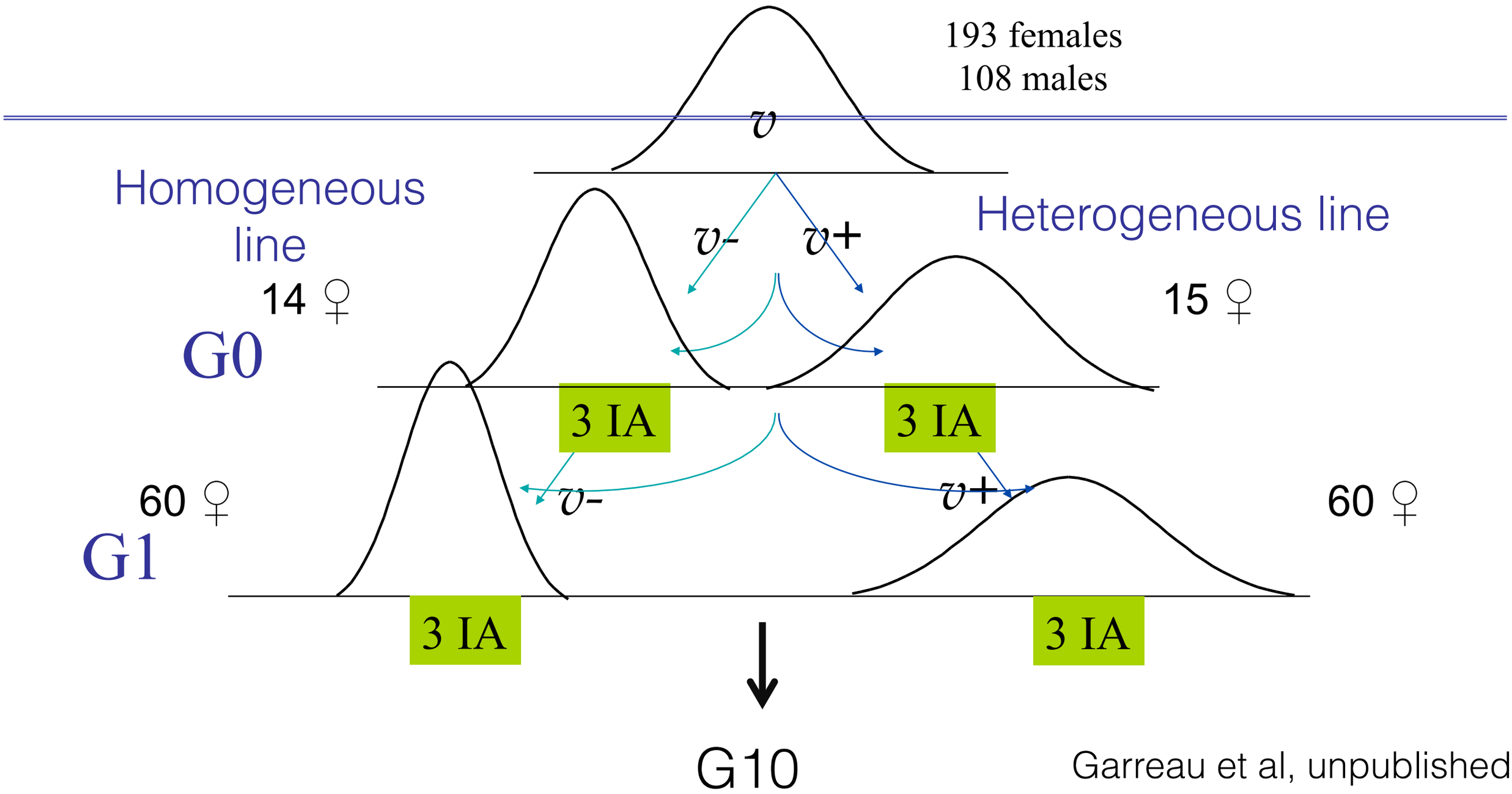
From Canario et al, JAS, 2006

Relationship between litter heterogeneity and survival

	LW		LR	
	P	G	P	G
Stillbirths	0,10	-	0,08	-0,44
BW mortality (%)	0,04	0,28	0,13	0,21

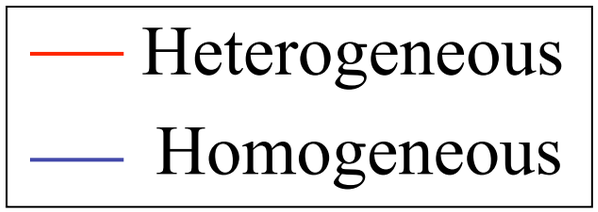
from Mérour et al (2010)

Divergent selection experiment for birth weight homogeneity in rabbits

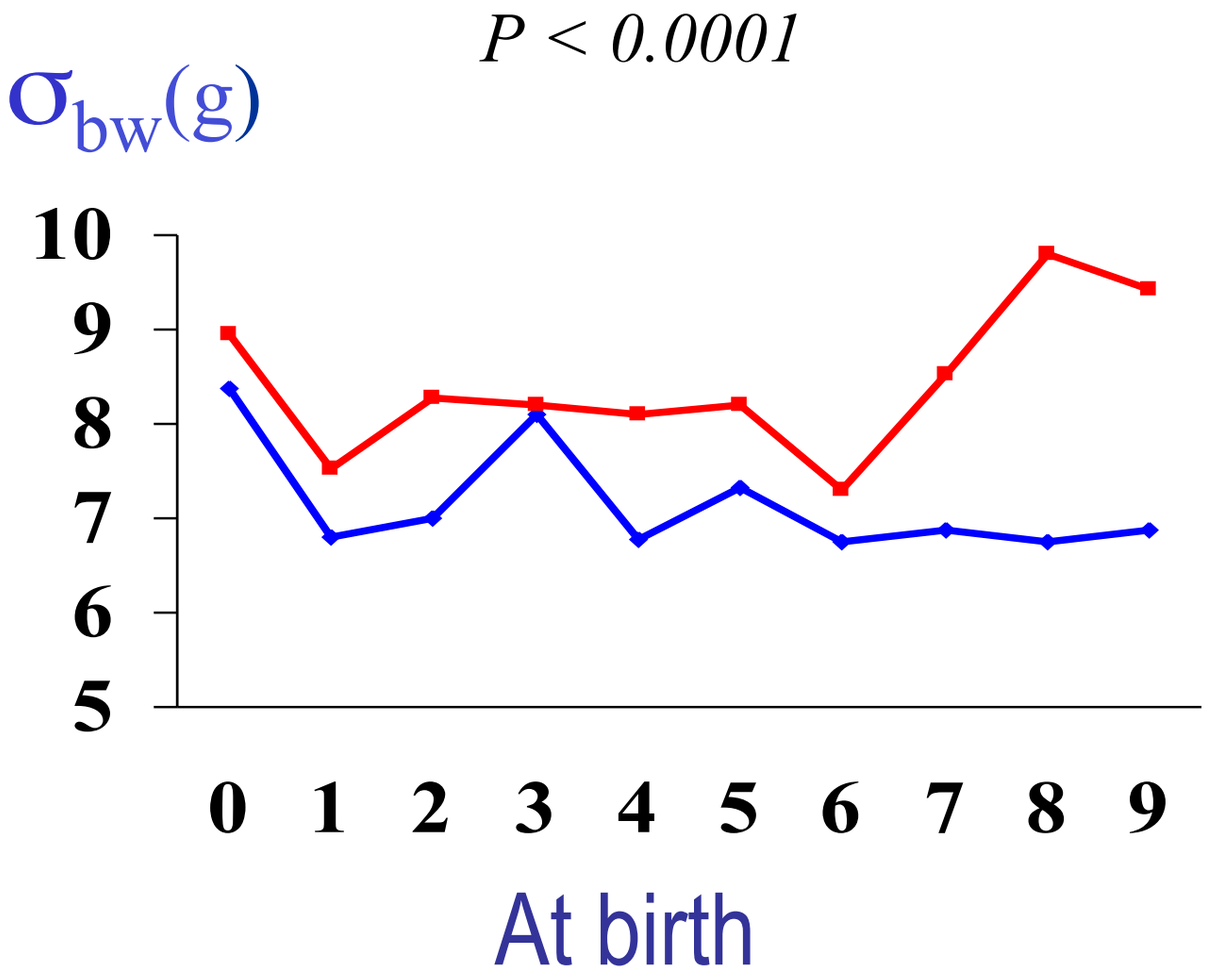


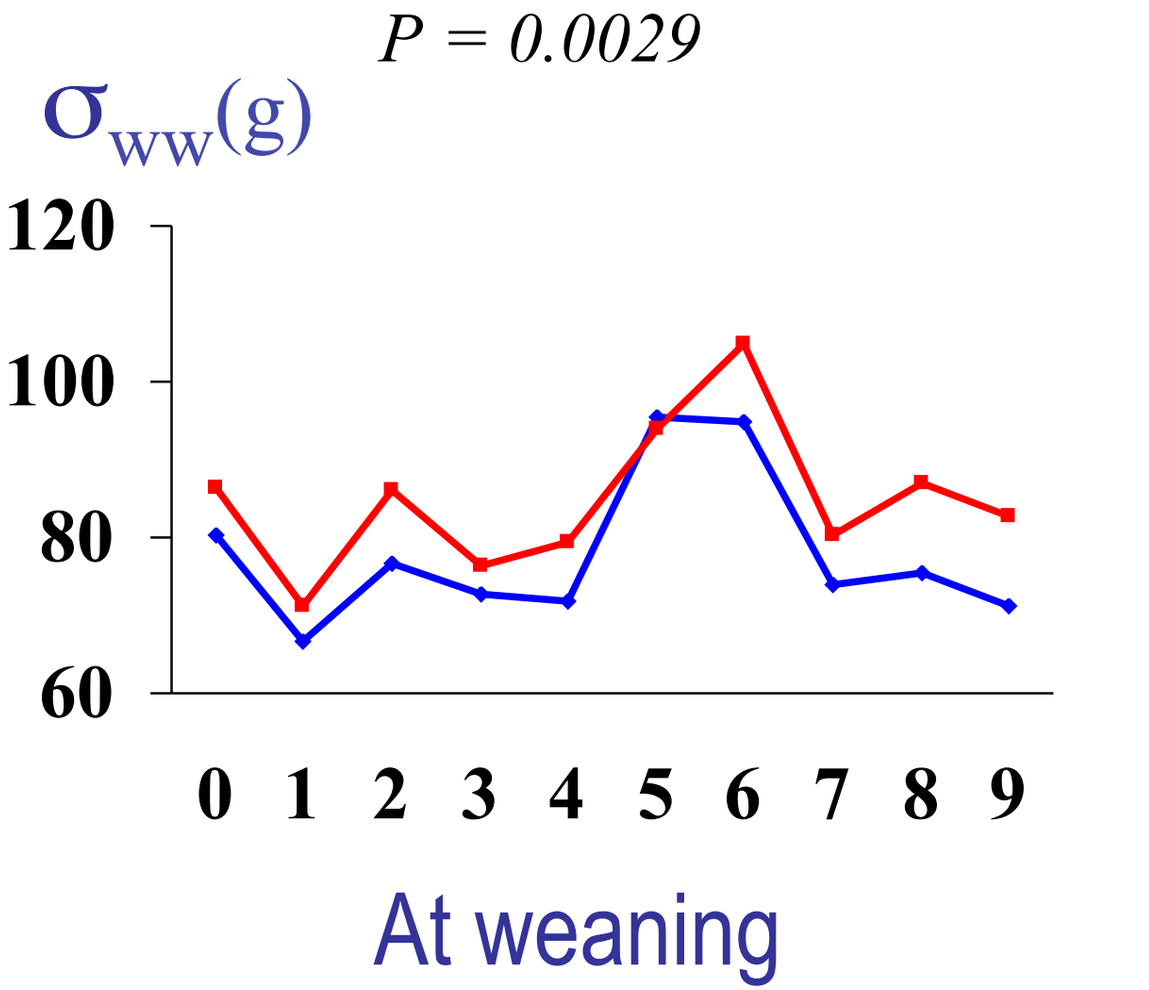
Garreau et al, unpublished

Divergent selection experiment for birth weight homogeneity in rabbits



Line differences



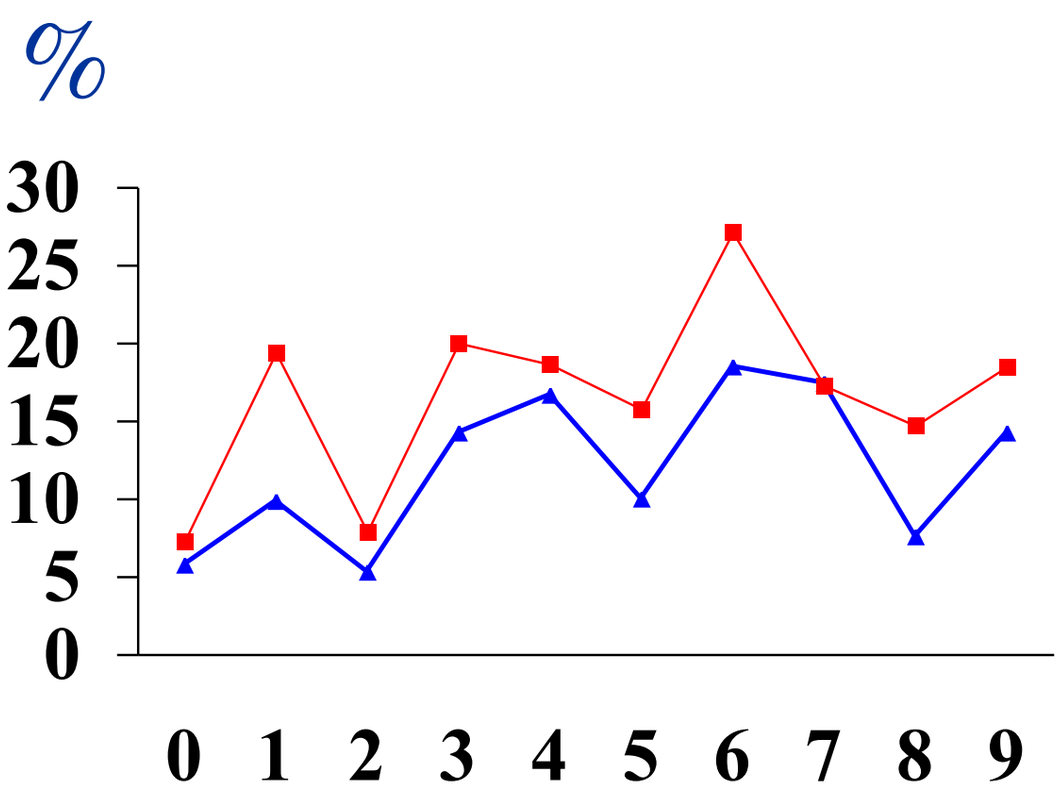


From Garreau et al, unpublished

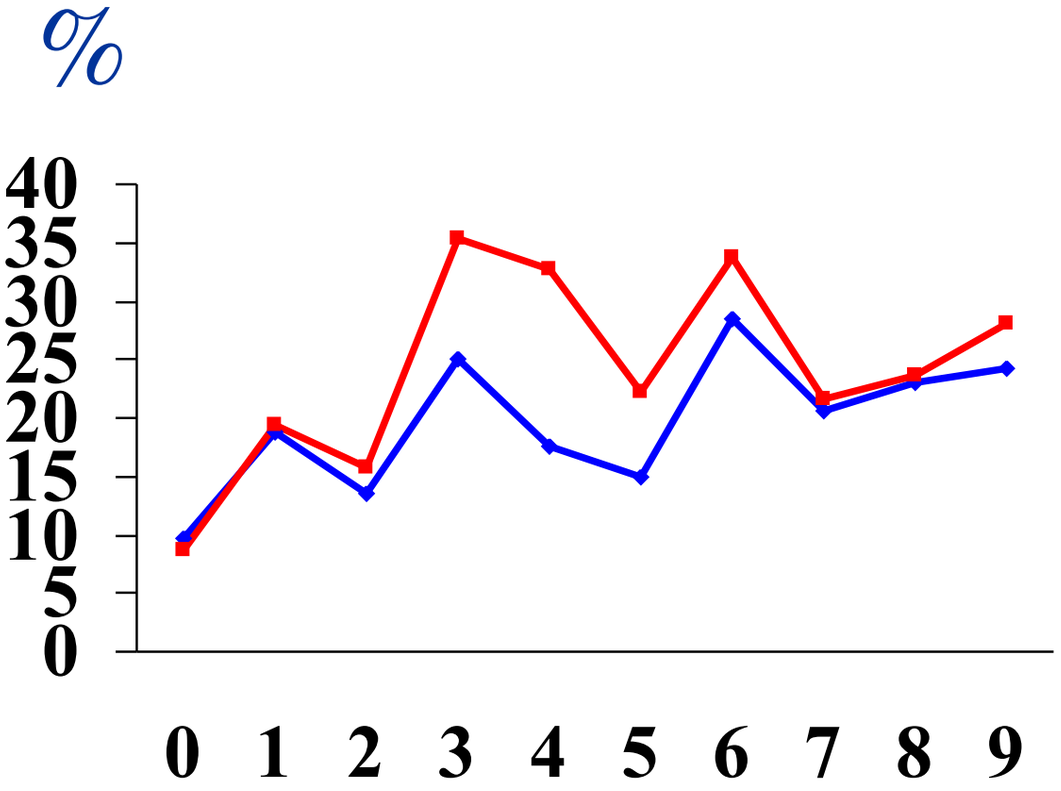
Divergent selection experiment for birth weight homogeneity in rabbits

Heterogeneous
Homogeneous

Line differences



Stillbirths



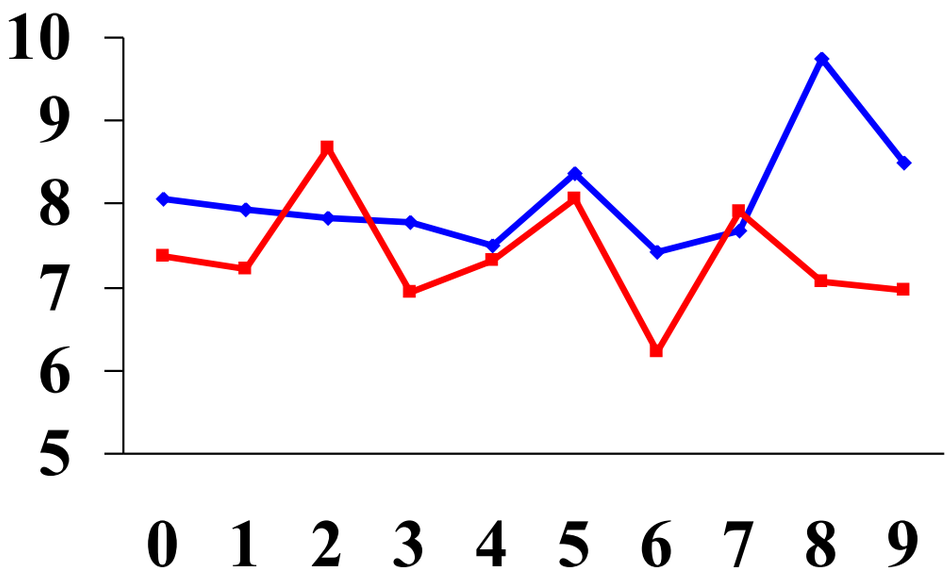
Birth to weaning mortality

From Garreau et al, unpublished

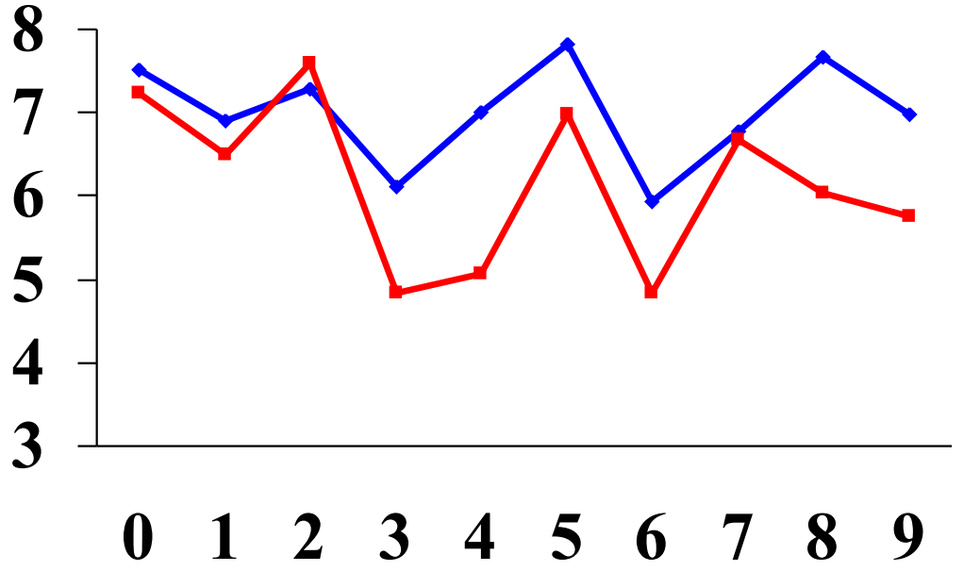
Divergent selection experiment for birth weight homogeneity in rabbits

Heterogeneous
Homogeneous

Line differences



Number born alive



Nombre weaned

From Garreau et al, unpublished

First conclusions (1/3)

- Selection for Total number born / litter has been efficient to increase litter size at weaning, but has led to :
  - an increase in the proportion of stillborn piglets
  - A small increase in birth to weaning mortality

- Selection for number born alive/ litter has allowed to
  - (slightly) reduce the proportion of stillbirths
  - does not improve birth to weaning survival

First conclusions (2/3)

- Optimising selection for litter size at weaning (LSW)
  - Direct selection for LSW
  - Index involving NBA and survival rate or probability ?

  Question which similar to selection for Litter size vs ovulation rate and prenatal survival

- Optimising selection for litter size at weaning (LSW)
  - Indirect criteria
    - Teat number ?
    - Homogeneity of litter weights ?

First conclusions (3/3)

Some concerns

- The decreased maturity of piglets at birth
  - Consequence of selection for growth ?
  - Currently being investigated in program funded by the French National Research Agency
- Sow capacity to raise larger and larger litters
  - Carcass lean content is still increasing
  - Sow volontary food intake does not increase much

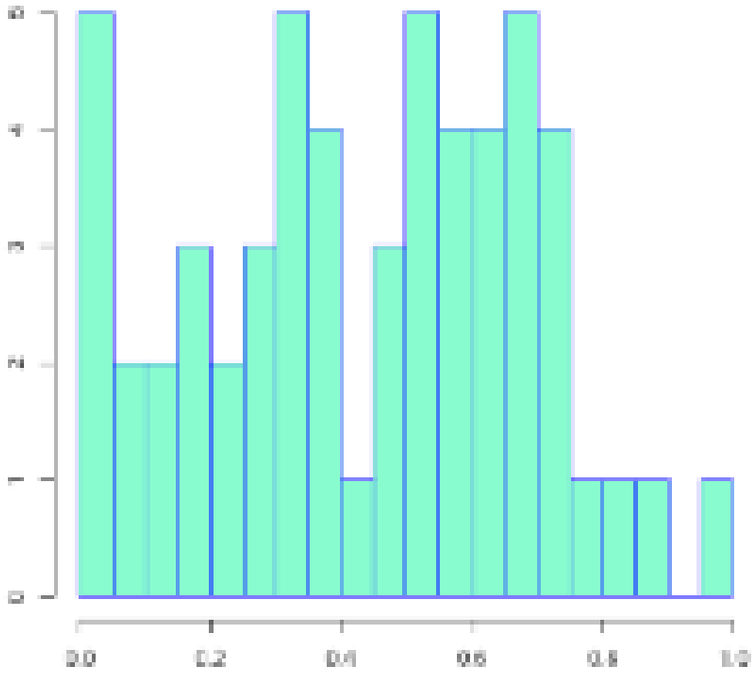
  => Will it become a problem ?

New traits in the breeding goal of pig maternal lines

Resistance to disease

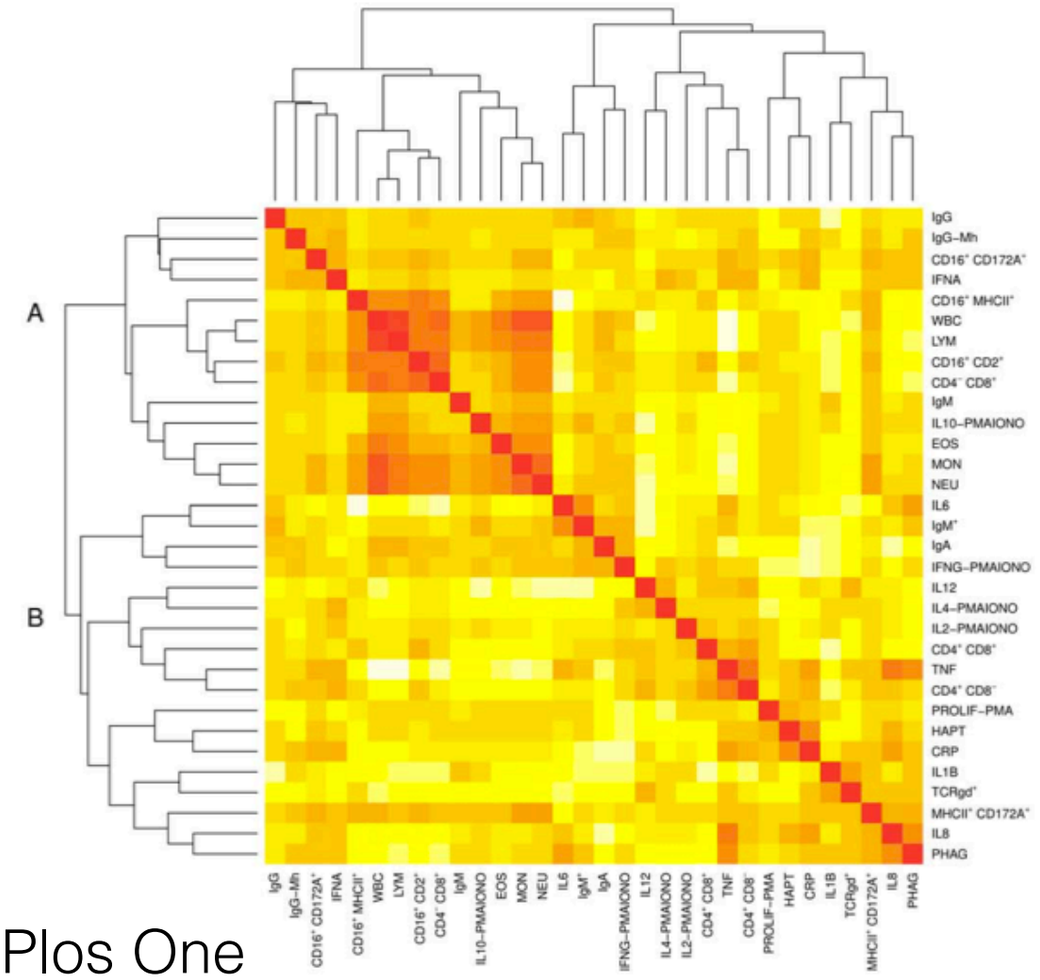
- « General » vs Specific resistance
- to disease
- Efficiency of vaccinal response

Distribution of h2 estimates
Of immune response parameters



From Flori et al, 2011, Plos One

Heatmap of genetic
Correlations between 32 traits



New traits in the breeding goal of pig maternal lines

Sow behaviour

- Towards more « autonomous » sows
- Reduce aggressiveness (among pigs, towards humans
  - How to measure it ?
  - Interest of Chinese (synthetic) breeds

Selection against boar taint

- Leads to a delayed age at puberty , which may be be a problem in maternal lines
- Can it be avoided through marker technologies
- Is it necessary a BIG problem ?

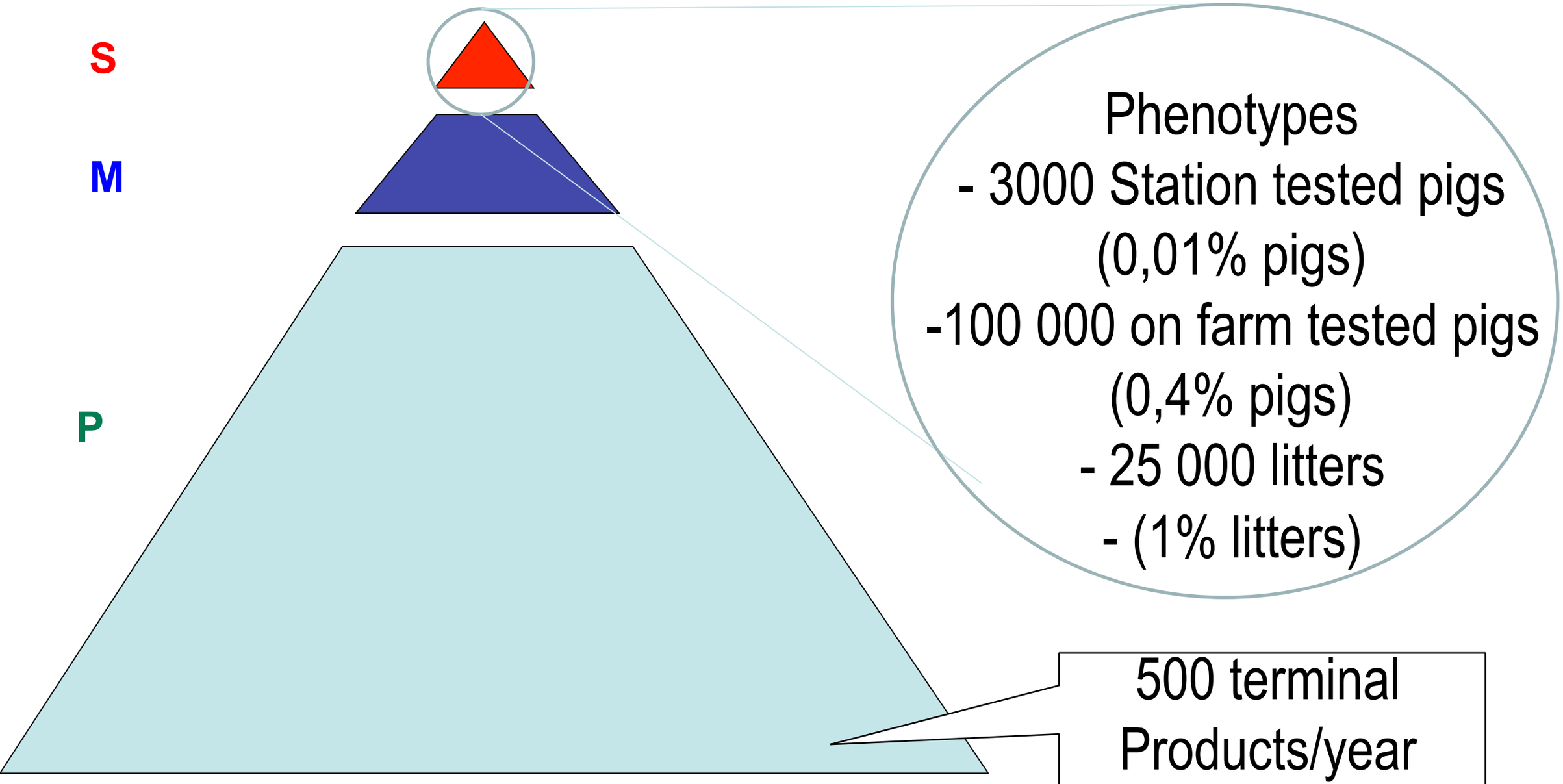
Use of new technologies

Three major areas

- Computing technologies
- High throughput phenotyping
- Use of genomic technologies

Computing technologies

Very low proportion of animals measured



Computing technologies

Many data already available, but are not centralised (farms, slaughterhouses, …)

Could be useful for genetic improvement purposes

- Increase the efficiency of selection at commercial level ?
- Investigate G x E interactions
- Investigate G x G interactions

….

Requires logistic and standardisation, but technically feasible

High throuhput phenotyping

Get large amounts of data from new technologies (computed tomography, bloo parameters …)

Often associated with high throughput genotyping / sequencing : e.g. for reference populations for Genomic selection. Good idea ?

Very useful to better understand the consequences of Selection, anticipate unfavourable trends,…

Use of genomic information

Genomic selection : the new graal for geneticists

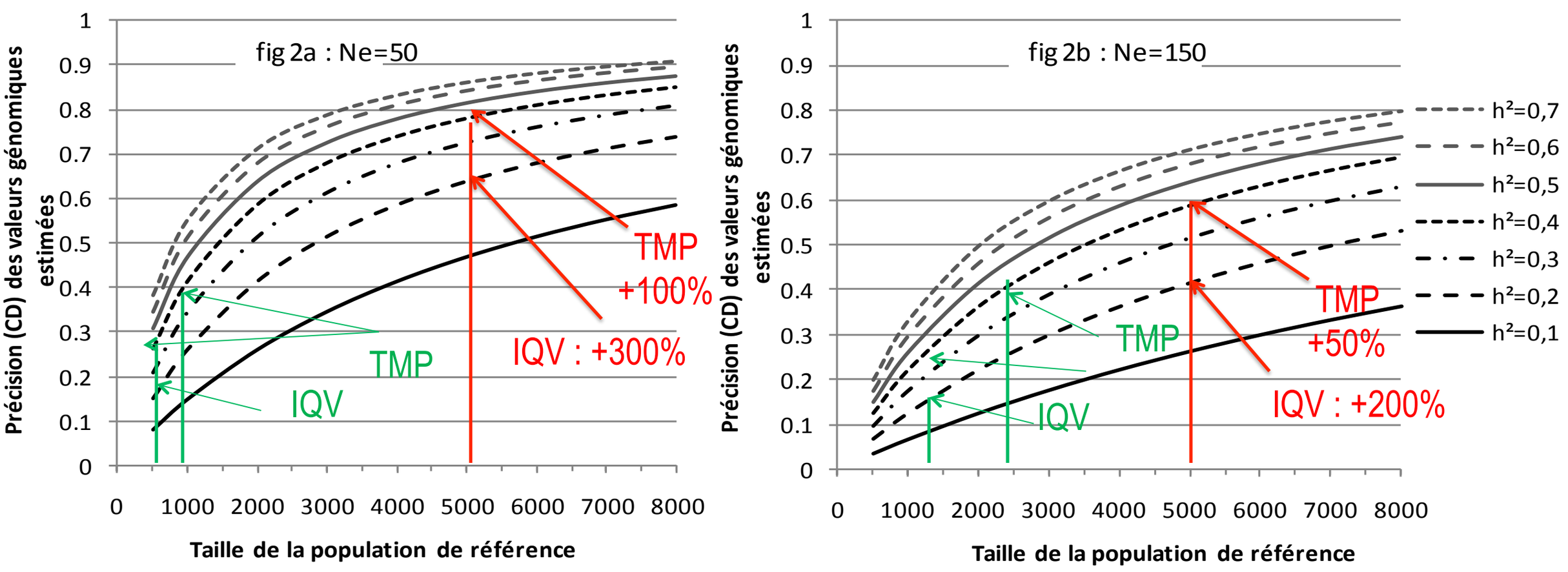
Strong potential in pigs in the context of crossbreeding Schemes or new traits that are difficult to phenotype

Yet, things are not as straightforward as in dairy cattle.

Many questions:

- Context of crossbreeding schemes
- Costs / returns considerations
- Reference populations
- …

Size of reference populations



Ne : effective size of the population

Tribout et al, JRP 2011

Conclusion

Large improvement in litter size are being obtained

There is no real reason that it will stop in the near future
Given :

- The economic importance of the trait
- No obvious physiological limit
- New potentially very efficient selection methods

Yet, one has to be careful about the high-yielding animals We produce, both from a management point of view and from a breeding point of view, in particular when defining the global breeding goal (e.g. consider sow ADFI or teat number)