An overview of pig production and pig breeding schemes in France

Jean Pierre Bidanel, Thierry Tribout

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J.P. Bidanel, T. Tribout

INRA – Station de génétique quantitative et appliquée
78352 Jouy-en-Josas cedex
Phone: +331 34 65 22 84 Fax: + 331 34 65 22 10
E-mail: bidanel@dga.jouy.inra.fr

Outline

- Some elements on pig production in France
- Pig breeding in France
- The National pig breeding scheme
- Perspectives

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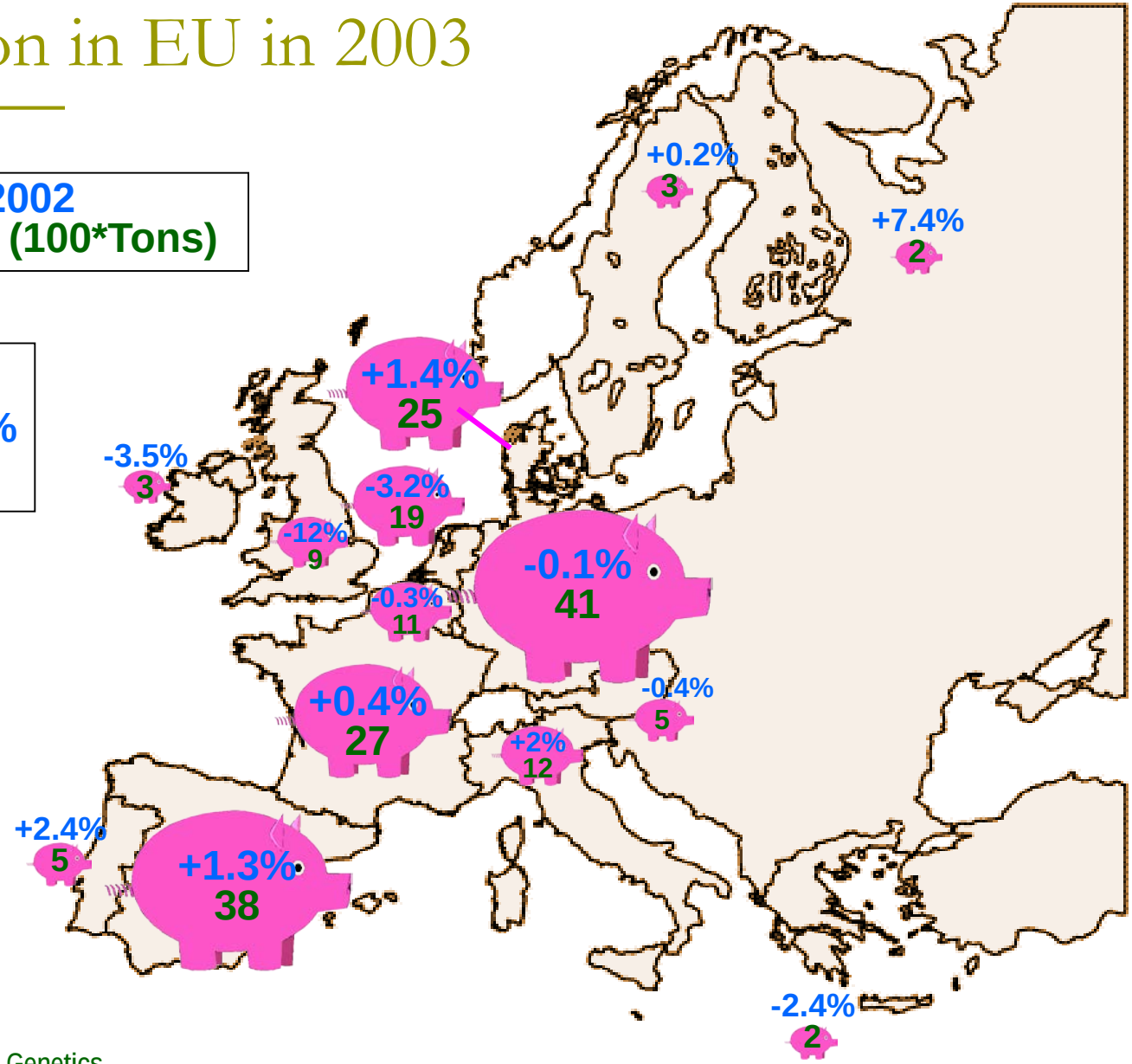
- Some elements on pig production in France
- Pig breeding in France
- The National pig breeding scheme
- Conclusion - Perspectives

Source : Eurostat

Pig production in EU in 2003

%2003 / 2002
2003 production (100*Tons)

UE 15
2003/02 : -0.2 %
2003 : 202

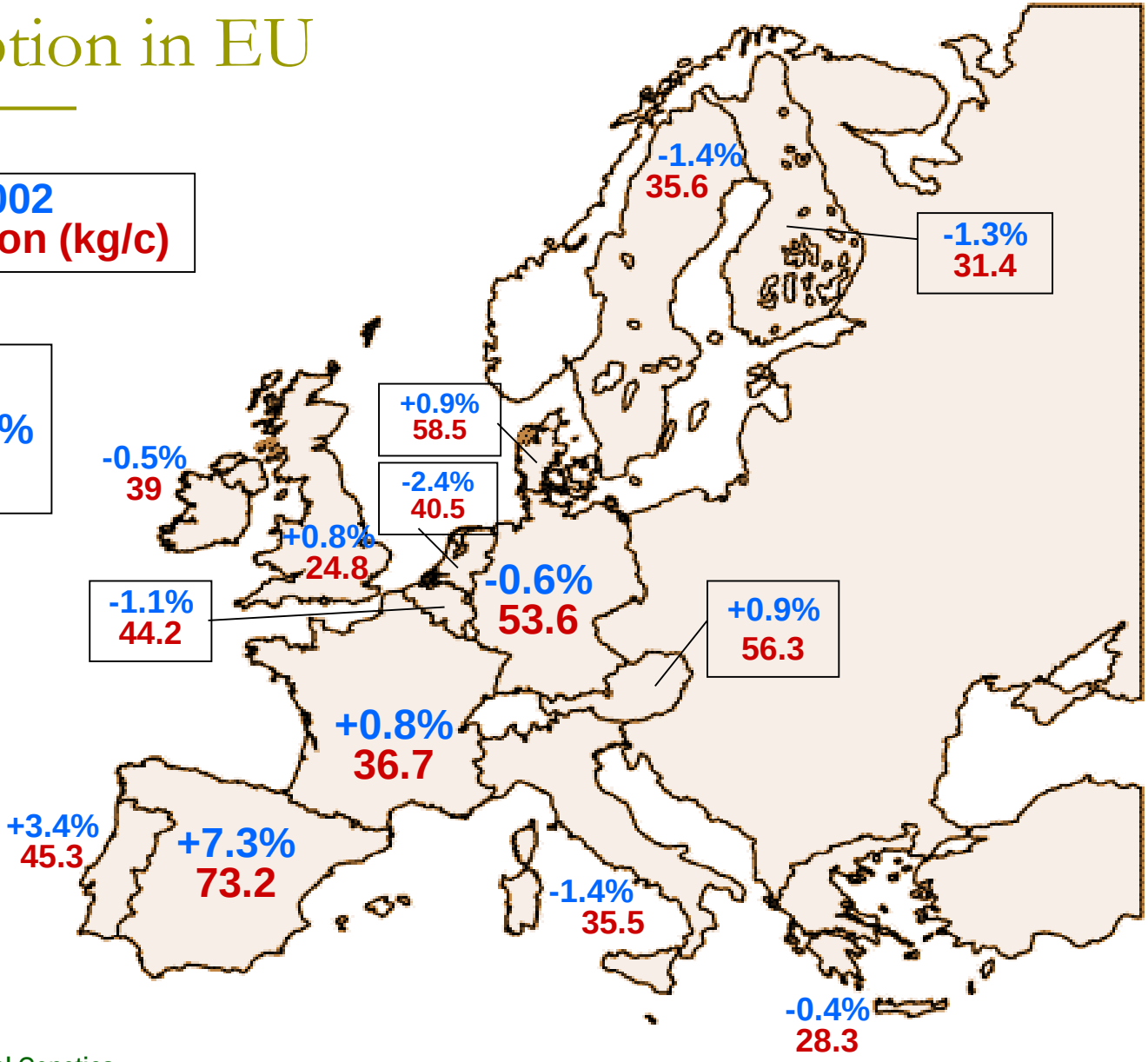


Source : Eurostat

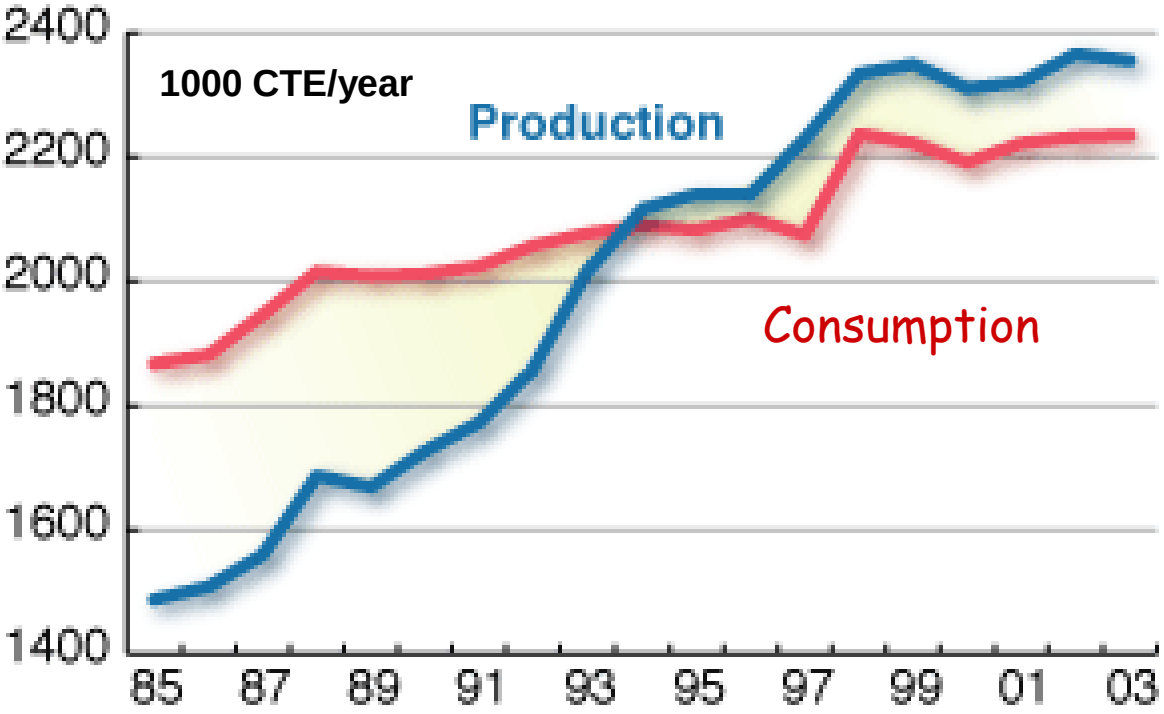
Pig consumption in EU

%2003 / 2002
2003 consumption (kg/c)

UE 15
2003/02 : +1.6 %
43.9 kg/c

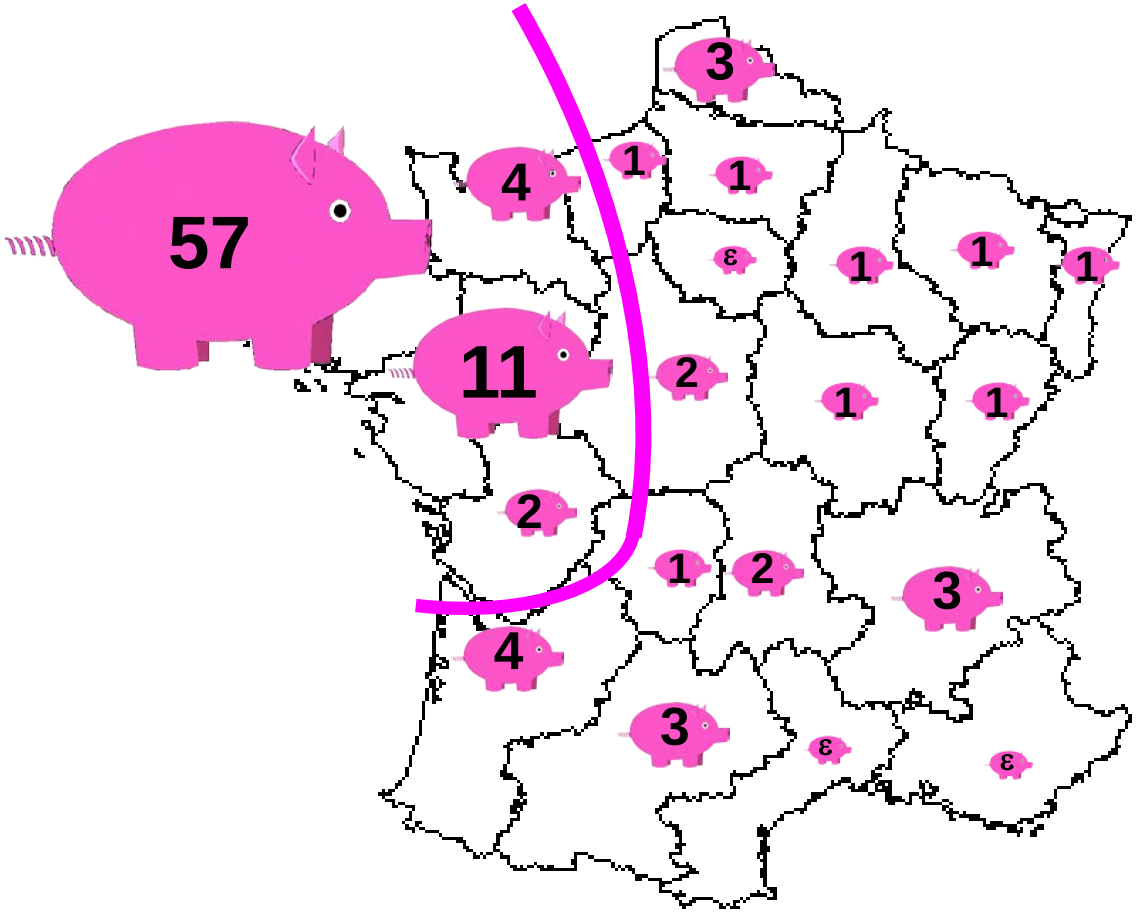


French pig production and consumption



Source : ITP-SCEES

Localisation of French pig production (2002)

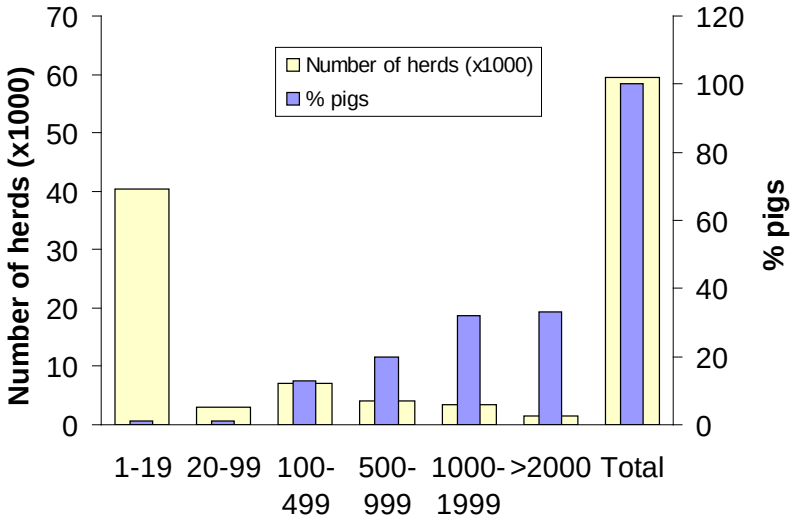


ε: < 0.5

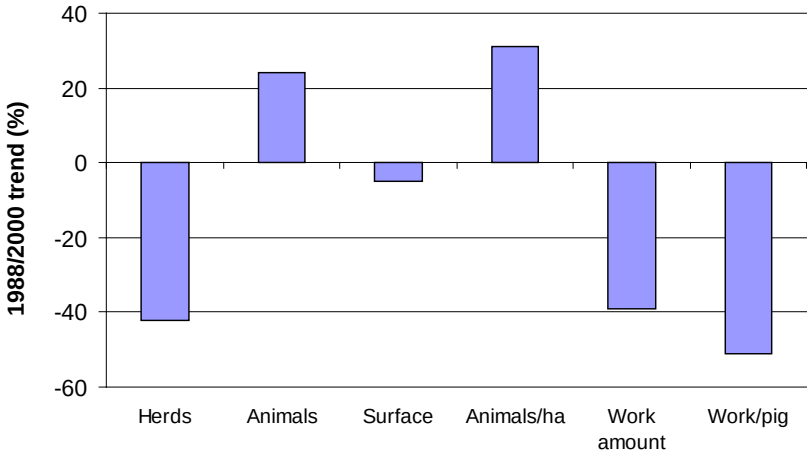
Source : ITP

Number and size of pig herds in France

2000



Evolution 1988-2000



Source : Agreste, 2002

Distribution of French pigs / herd type (May 2004)

Piglets (<20 kg)	**5 325**
Young pigs (20-50 kg)	**2 697**
Fattening pigs	**5 621**
Breeding sows	**1 320**
not mated	**415**
gilts	149
lactating/rest	266
mated	**905**
Gilts	164
Sows	741
Boars	**16**
Total	**14 978**

70% WF
28% F

83% WF
14% W

Source : Agreste

Typology of French farms with pigs

Pig production system		Area (ha)	# pigs	Income(€)	Farms #	Farms %	# pigs *10^6	# pigs %
Fatteners & Corn producers	Large	135	536	157 200	1 865	10	1.00	7
	Small	57	360	76 800	3 509	18	1.27	9
Large corn producers		95	1 810	206 400	884	5	1.60	11
Specialised WF producers		36	2 117	160 800	2 650	14	5.61	38
Small bovine oriented farms		45	184	46 800	2 770	14	0.51	3
Small pig oriented farms		7	669	48 000	1 360	7	0.91	6
Dairy cow + fattening pigs		58	276	84 000	2 679	14	0.74	5
Dairy cow + WF		77	840	145 200	3 571	19	3.00	20
Total		62	759	109 379	19 288	100	14.63	100

Source : ITP

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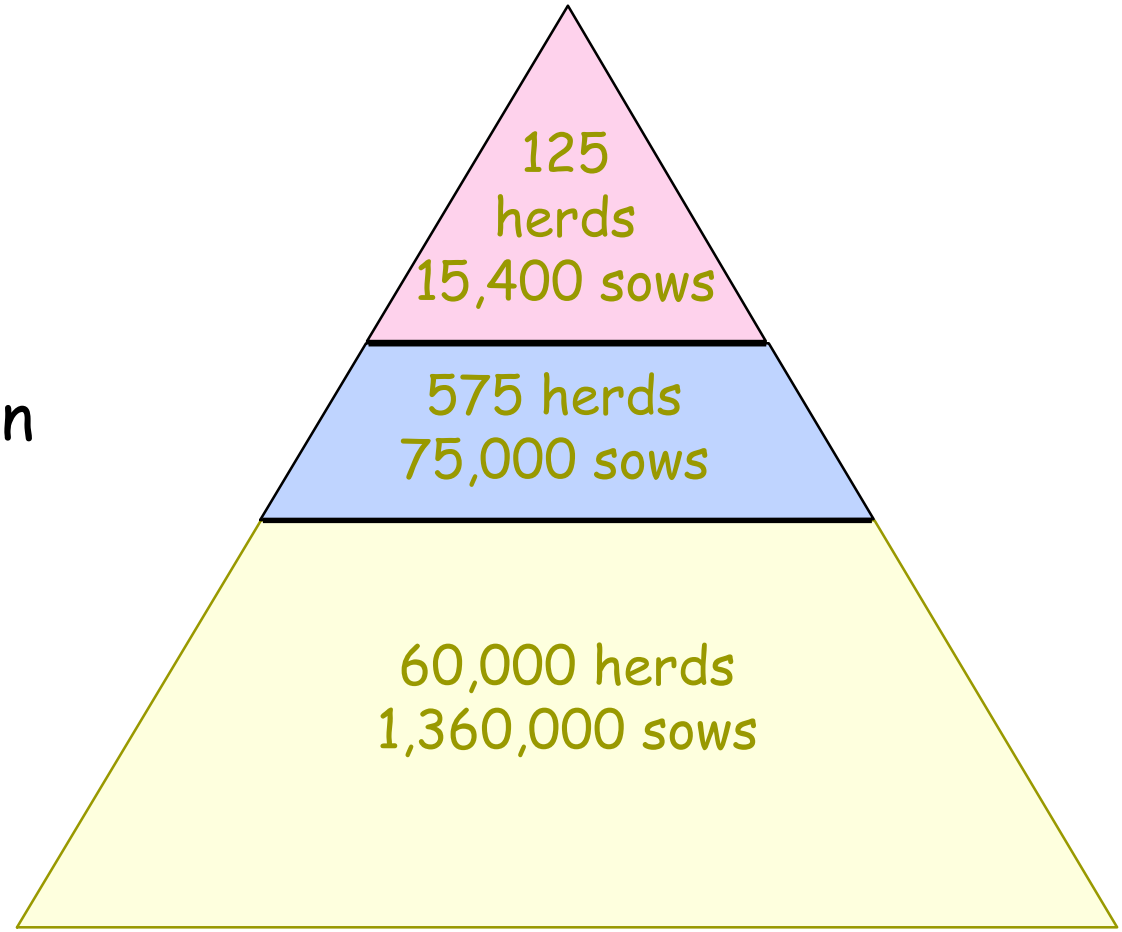
Distribution of sows / herds according to herd type (1)

Selection

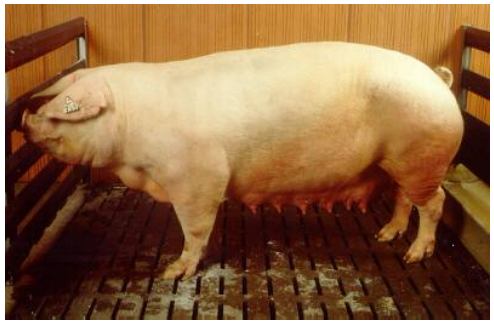
Multiplication

Production



Main pig breeds in France

Female lines



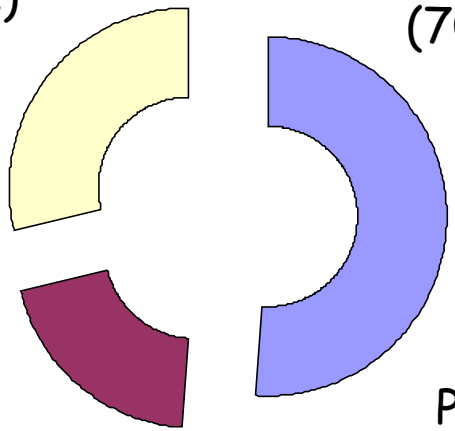
Composite lines involving Chinese Meishan

Male lines

Various composite lines involving LW, PI HA, DU

Pig populations in France

20 breed varieties
(223 sows / line on average)



4 breeds collectively selected
(700 to 4000 sows / breed)

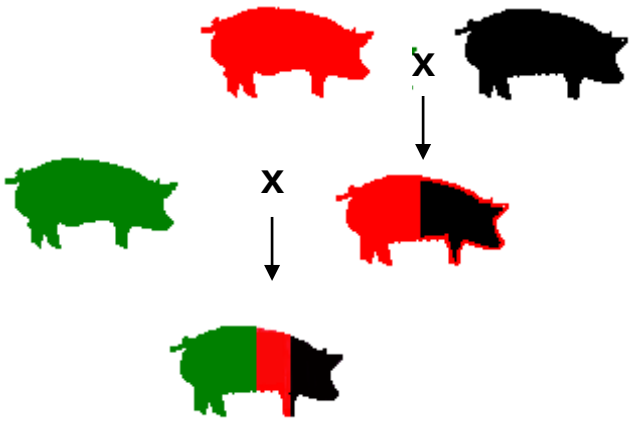
17 composite lines
(184 sows / line on average)

Pure breed multiplication has been integrated to selection

Source : French pig agency

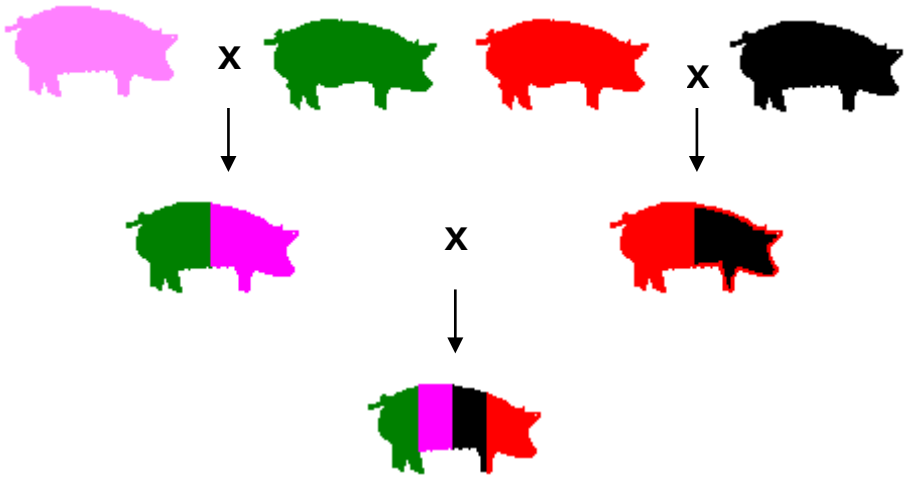
Main crossbreeding schemes

3-way cross



Ex : PI x (LR x LW)

4-way cross

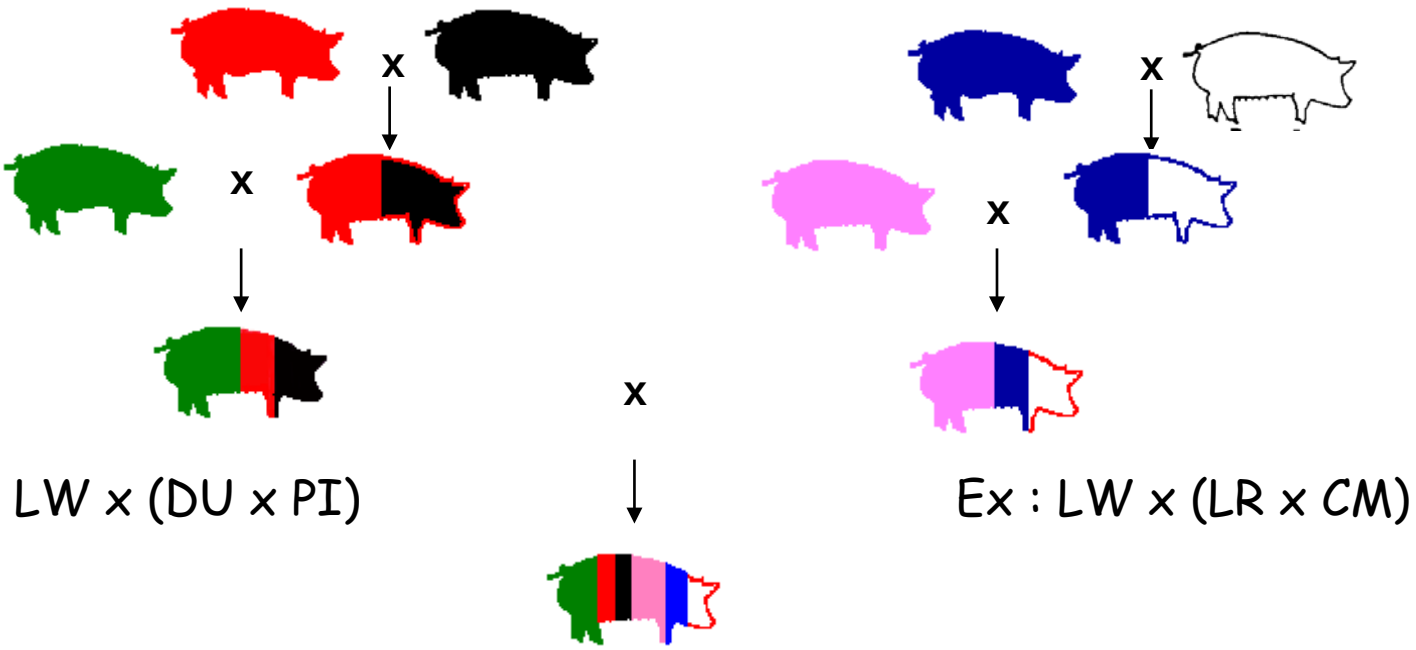


Ex : (LW x PI) x (LR x LW)
(DU x PI) x (LR x LW)

DU = Duroc; LR = Landrace; LW = Large White; PI = Pietrain

Main crossbreeding schemes

More complex systems have appeared over the last 10 years

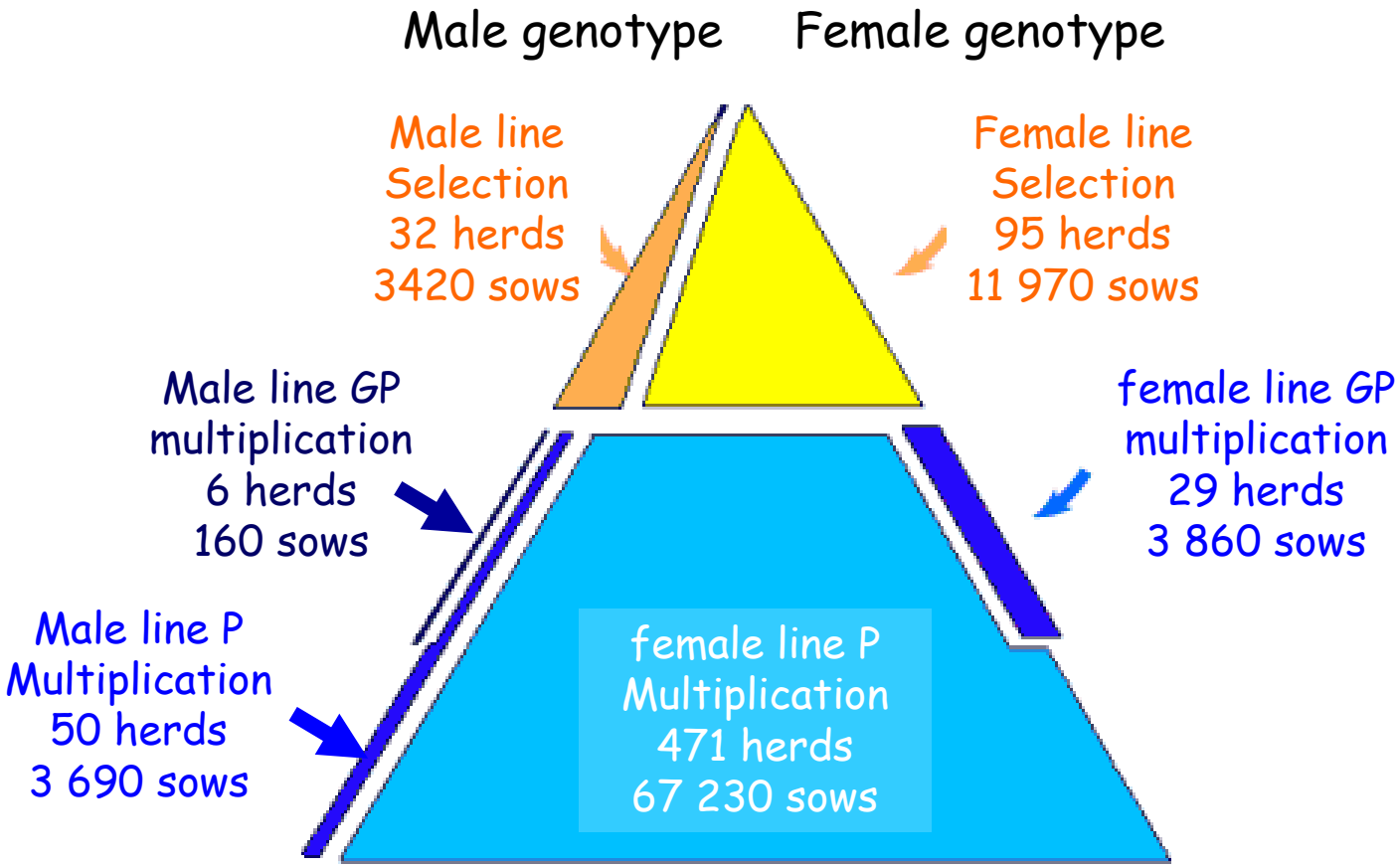


Ex : LW x (DU x PI)

Ex : LW x (LR x CM)

CM = composite Meishan line; DU = Duroc; LR = Landrace; PI = Pietrain

Distribution of sows / herds according to herd type (2)



French breeding organizations

	Selection		Multiplication		
NAME	Male line	Female line	GP	Terminal boars	Parental sows
NUCLEUS	626	2762	433	962	17481
GENE + / SCAPAAG	736	1702	2084	1031	11658
FRANCE HYBRIDES	387	1656	323	228	9362
PEN AR LAN	236	1954	49	516	8318
ADN	365	1501	40	310	7511
PIC France	623	944	665	268	6077
TOPIGS France S.A	128	509			3067
SELPA	127	74	329	101	2195
BRETAGNE PORC SELECTION	162	162		44	608
FRANCE SELECTION	143	484		78	508
COOP PROD. PORCS REUNION		118		55	400
RATTLEROW SEGHERS NV			94	0	179
PORFIMAD		60			70

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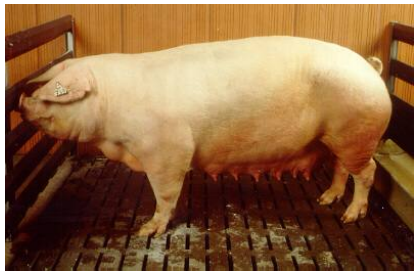
National breeding scheme – populations involved

- Four populations

2 female populations

Female
Large White

4400 sows
42 herds



French
Landrace

2600 sows
22 herds

2 male populations

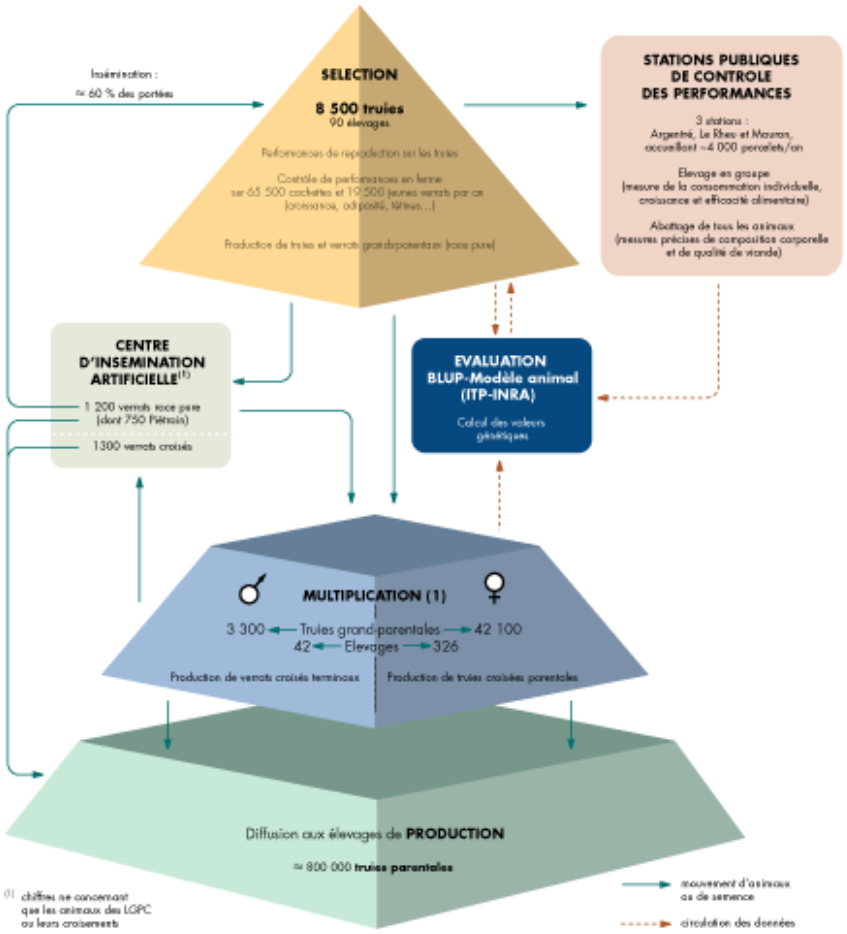
Male
Large White

650 sows
8 herds

Piétrain

800 sows
11 herds

National breeding scheme – General organization



National breeding scheme - Selection objectives

$$H = a_1\,ADG + a_2\,FCR + a_3\,D\% + a_4\,MU\% + a_5\,MQI\ (+\ a_6\,NBA + a_7\,GTEAT + a_8\,DFI)$$

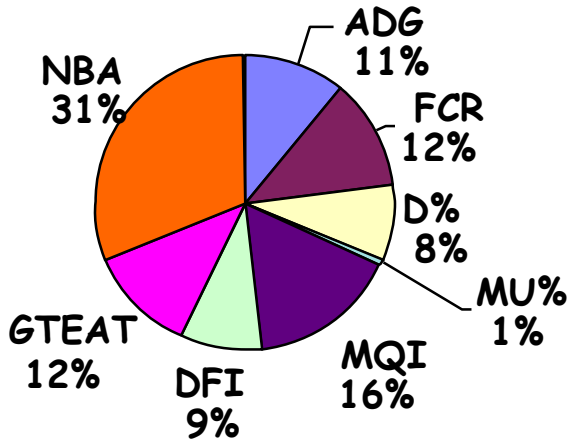
	All populations		Female lines	
	LWF	**LWM**	**LF**	**PI**
ADG	**0,243**(0,037)[a]	**0,243**(0,037)	**0,243** (0,037)	**0,243** (0,037)
FCR	**-109** (-16,6)	**-109** (-16,6)	**-109** (-16,6)	**-109** (-16,6)
D%	**13** (1,98)	**13** (1,98)	**13** (1,98)	**13** (1,98)
MU%	**1** (0,15)	**12** (1,8)	**1** (0,15)	**4** (0,6)
MQI	**13** (1,98)	**25** (3,81)	**13** (1,98)	**13** (1,98)
DFI	**50** (7,6)	-	**50** (7,6)	-
NBA	**20** (3)	-	**20** (3)	-
GTEAT	**20** (3)	-	**20** (3)	-

[a] FF (euros)

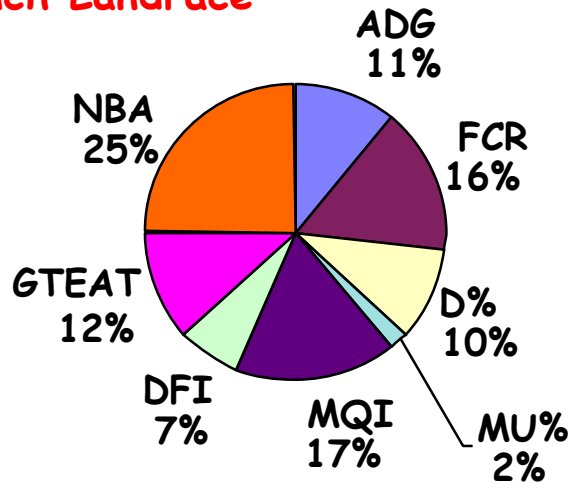
- Lack of halothane sensitivity allele (LWF, LWM, LR) and of RN- allele

National breeding scheme - Selection objectives

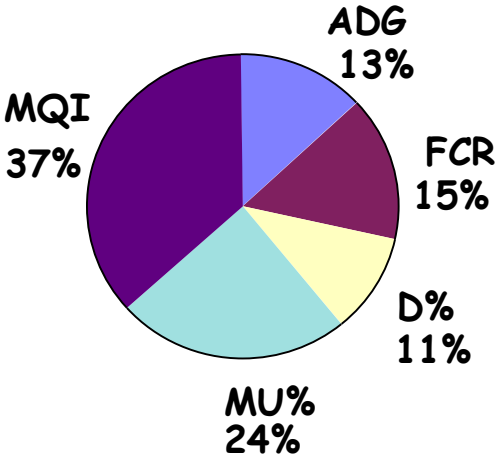
Large White – maternal line



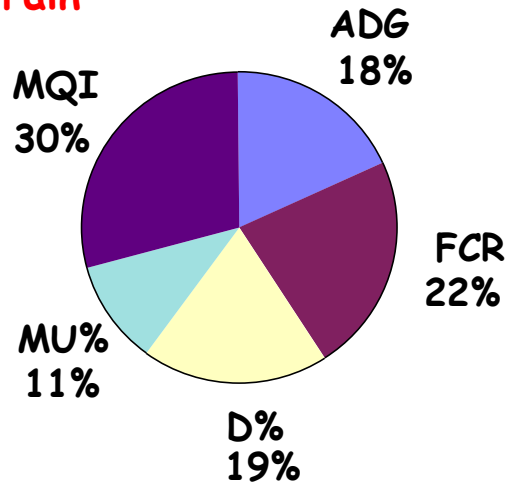
French Landrace



Large White – sire line



Piétrain

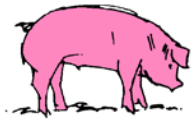


National breeding scheme – Performance tests

on-farm performance test

production traits

Young male and female candidates



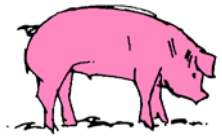
- age at 100 Kg
- backfat thickness at 100 Kg
- Loin depth (male lines)
- (Meat quality)

« reproduction » traits

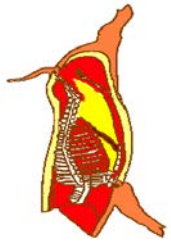
- numbers of liveborn piglets
- number of functional teats

station performance test

slaughtered sibs from young candidate males



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



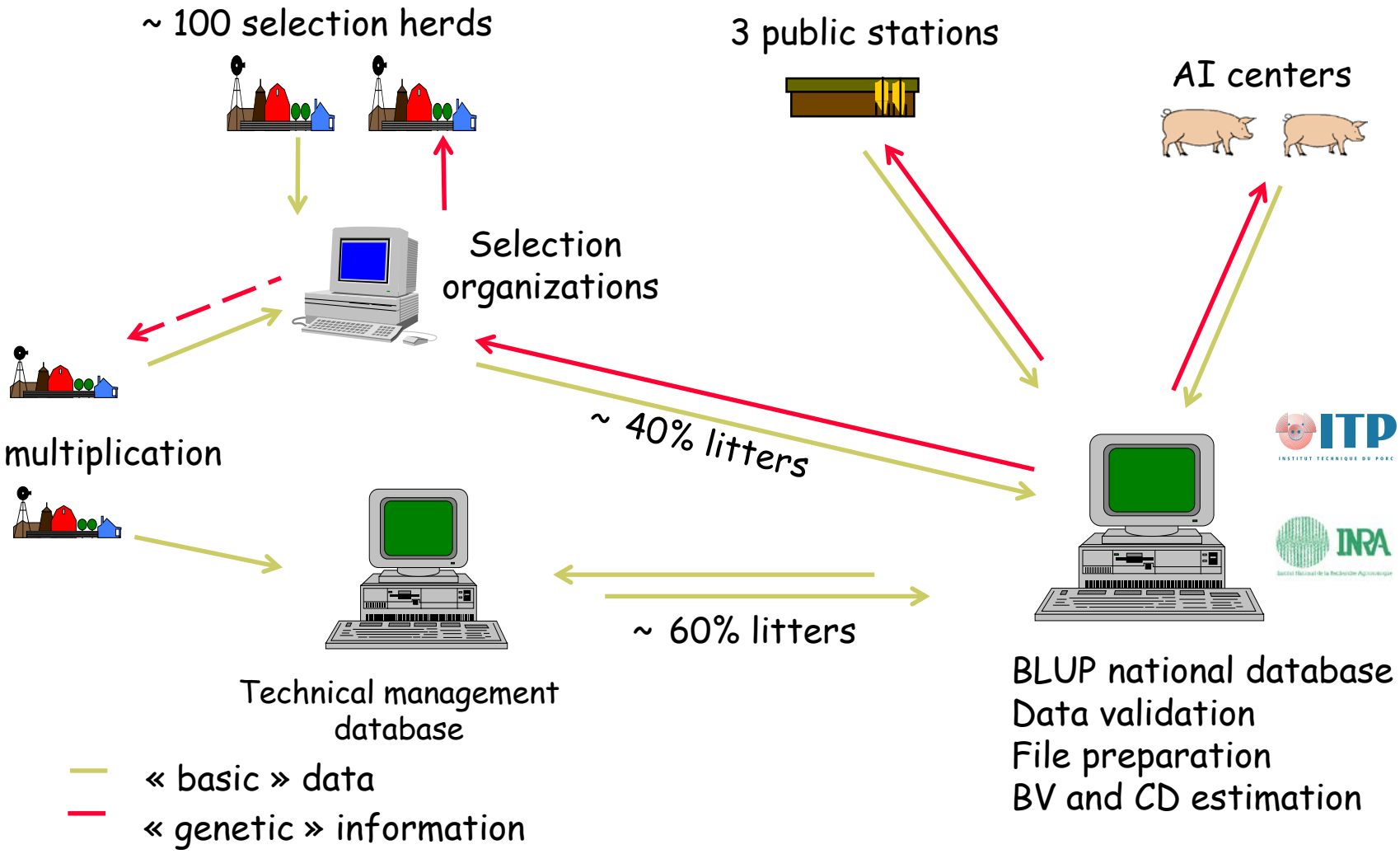
- dressing percentage
- carcasse lean content
- meat quality index

National breeding scheme - Amount of data

Example : Year 2002

- 70 000 matings
- 54 000 litters
- 367 500 identified piglets
- 107 000 on-farm tested pigs
- 3 000 station tested pigs

Information flow



National genetic evaluation of pigs

- based on animal model – BLUP
- evaluation performed independently in each population
- Evaluations for production and reproduction traits are performed independently (low genetic antagonism)
  - Multiple tait evaluation for production traits
  - single trait evaluation for NBA
- Use of the PEST package

Genetic evaluation of pigs – Production traits

- Combined on farm – station evaluation since 1996
- Multiple trait (10 / 11 traits) evaluation
- Monthly evaluation
- Collaboration between INRA - ITP
- Use of PEST software
- Breeds concerned : Large White, French Landrace, Piétrain
  (Large White male and female lines are jointly evaluated)

Genetic evaluation of pigs – Traits measured in test stations

	ADG	FCR	DFI	D%	MU%	MQI
Year*station*batch	x	x	x	x	x	
Slaughter batch						x
Unknown parent group	x	x	x	x	x	x
Initial weight	x	x				
Slaughter weight			x	x	x	x
Litter	x	x	x	x	x	x
animal	x	x	x	x	x	x

Fixed effect Covariable Random effect

Genetic evaluation of pigs – Traits measured in test stations

	A100	BF100	MQh	X5	GTEAT
Herd*year*batch*sex	x	x		x	x
Herd*Slaughter date*sex			x		
Unknown parent group	x	x	x	x	x
Litter	x	x	x	x	x
Animal	x	x	x	x	x

Fixed effect

Random effect

National genetic evaluation of pigs genetic parameters

Ex : Large White

	ADG	FCR	D%	MU%	MQI	DFI	A100	BF100	X5100	MQf	GTEAT	NBA
ADG	**0,25**	-0,47	-0,12	0,06	0,15	0,31	-0,57	-0,12	0,13	-0,05	0,00	0,00
FCR		**0,33**	0,06	-0,67	**0,25**	**0,29**	0,12	0,59	-0,18	**0,22**	0,00	0,00
D%			**0,43**	0,01	-0,09	-0,05	0,10	0,08	0,25	**-0,25**	0,00	0,00
MU%				**0,68**	**-0,20**	**-0,34**	0,08	-0,73	0,32	**-0,20**	0,00	0,00
MQI					**0,29**	0,13	-0,01	**0,17**	0,09	0,67	0,00	0,00
DFI						**0,44**	-0,10	**0,25**	-0,06	0,10	0,00	0,00
A100							**0,29**	-0,03	0,13	0,05	0,00	0,00
BF100								**0,43**	0,13	0,04	0,00	0,00
X5100									**0,31**	0,11	0,00	0,00
MQh										**0,26**	0,00	0,00
GTEAT											**0,24**	0,00
NBA												**0,10**

Heritabilities on the diagonal

Genetic correlations above diagonal

National genetic evaluation of pigs
Size of the systems of equations

Combined on fram – station evaluation

	LW	LR	PI
Data file	395 000	205 000	39 500
test station data	10 200	5 000	750
On farm data	385 000	200 000	38 700
Pedigree file	412 000	215 000	47 000
Litters	73 000	38 500	7 200
Year * station * batches	125	100	35
Herd * year * sex * batches	7 400	4200	850
Number of equations	5 925 000	2 850 000	553 000
Computing time[a]	36'	16'	4 min

[a] on a P670+ IBM WS with 12 Power P4 1500 MHz processors

National genetic evaluation of pigs – Litter size

- Set up in january 1995
- In *Large White* and *French Landrace* breeds
- Trait = Number born alive considered as independent from other traits
- Monthly evaluation in each breed independantly
- use of PEST software
- performances of all purebred (selection + multiplication) sows

→ about 38 000 (LR) and 67 000 (LW) new performances each year (1/4 selection – 3/4 multiplication)

- 10 years of performances and 5 generations of ancestors considered

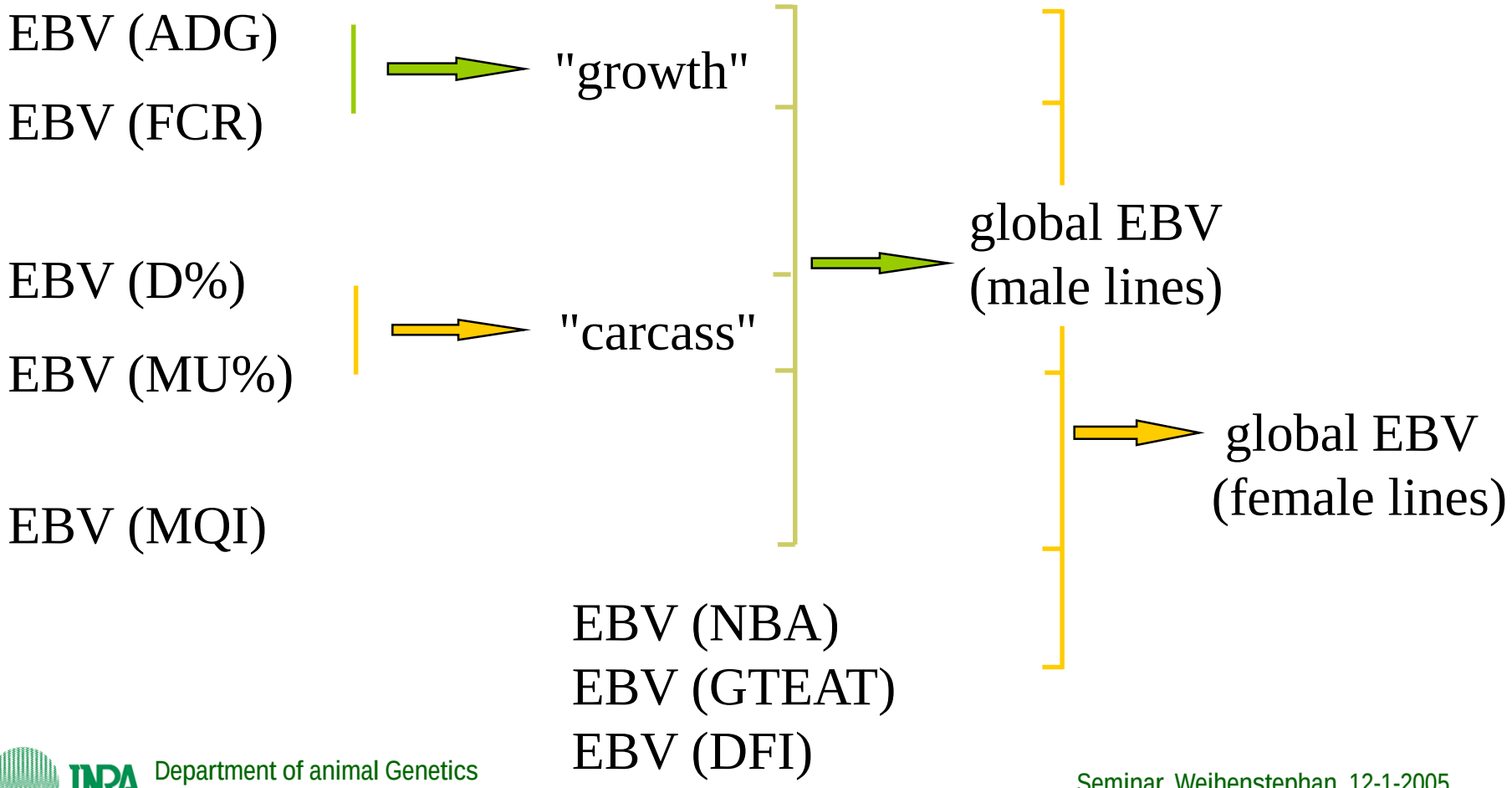
National genetic evaluation of pigs – Litter size

Repeatability animal model

• covariable	Age at farrowing within parity
• fixed effects	Herd x year x type of fertilisation
	Farrowing month
	Parity
	Unknown parent group
• Random effects	Sow permanent environment
	Additive genetic value of the sow
	Litter sire

National genetic evaluation of pigs – Combined EBVs

EBVs for each trait are combined as follows :



National genetic evaluation of pigs
Results sent to breeders

- after each evaluation :

  Growth, carcass and reproduction EBVs + accuracies

  - of all boars and sows of the herd
  - of all AI boars
  - of young males and females tested on farm

- every six months :

  Estimated genetic trends (per breed, herd, sex)

  Estimated breeding values of pigs sent to multiplication herds

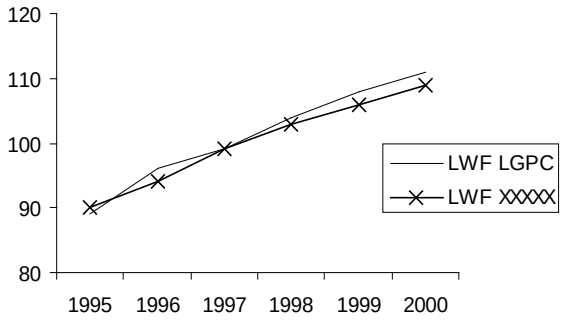
  Elements on Connectedness, management of genetic variability

National genetic evaluation of pigs
Results sent to breeders

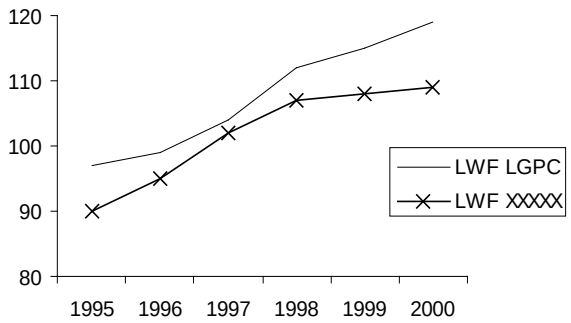
Estimated genetic trend from 1995 à 2000

BIANNUAL RESULTS
2001 - SEMESTER 1

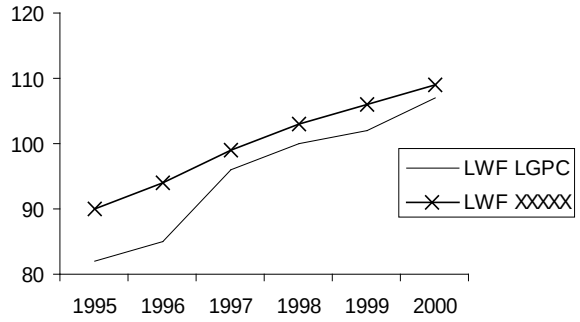
Average daily gain



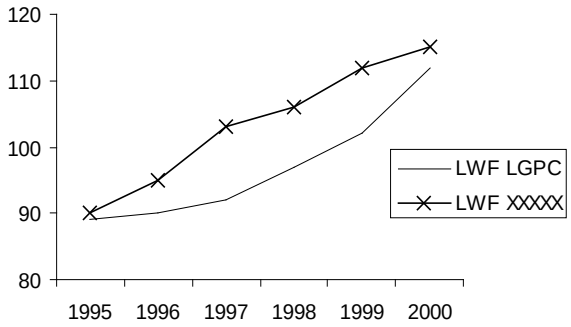
Food conversion ratio



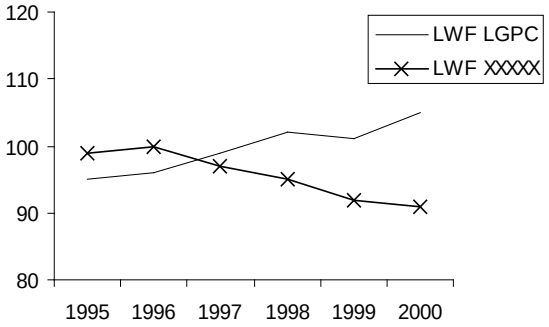
Dressing %



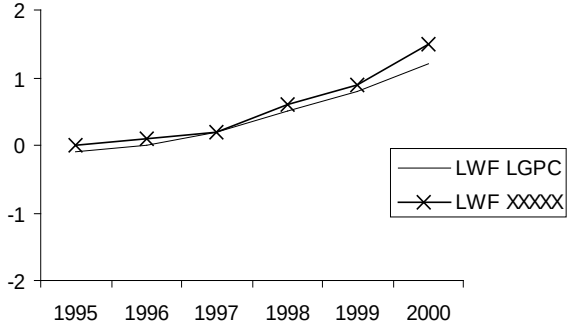
Carcass lean content



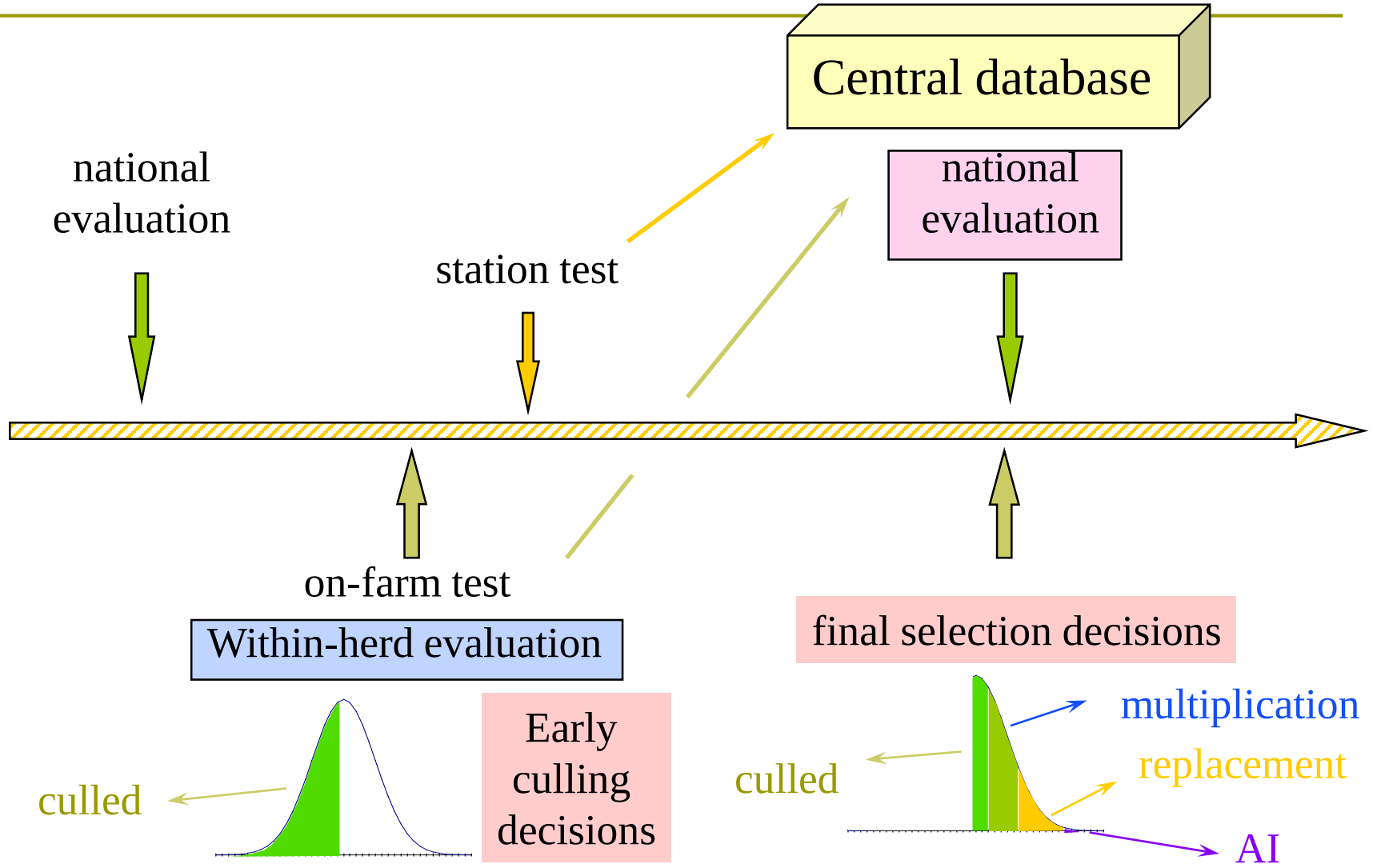
Meat quality index



Litter size at birth



Within – herd genetic evaluation



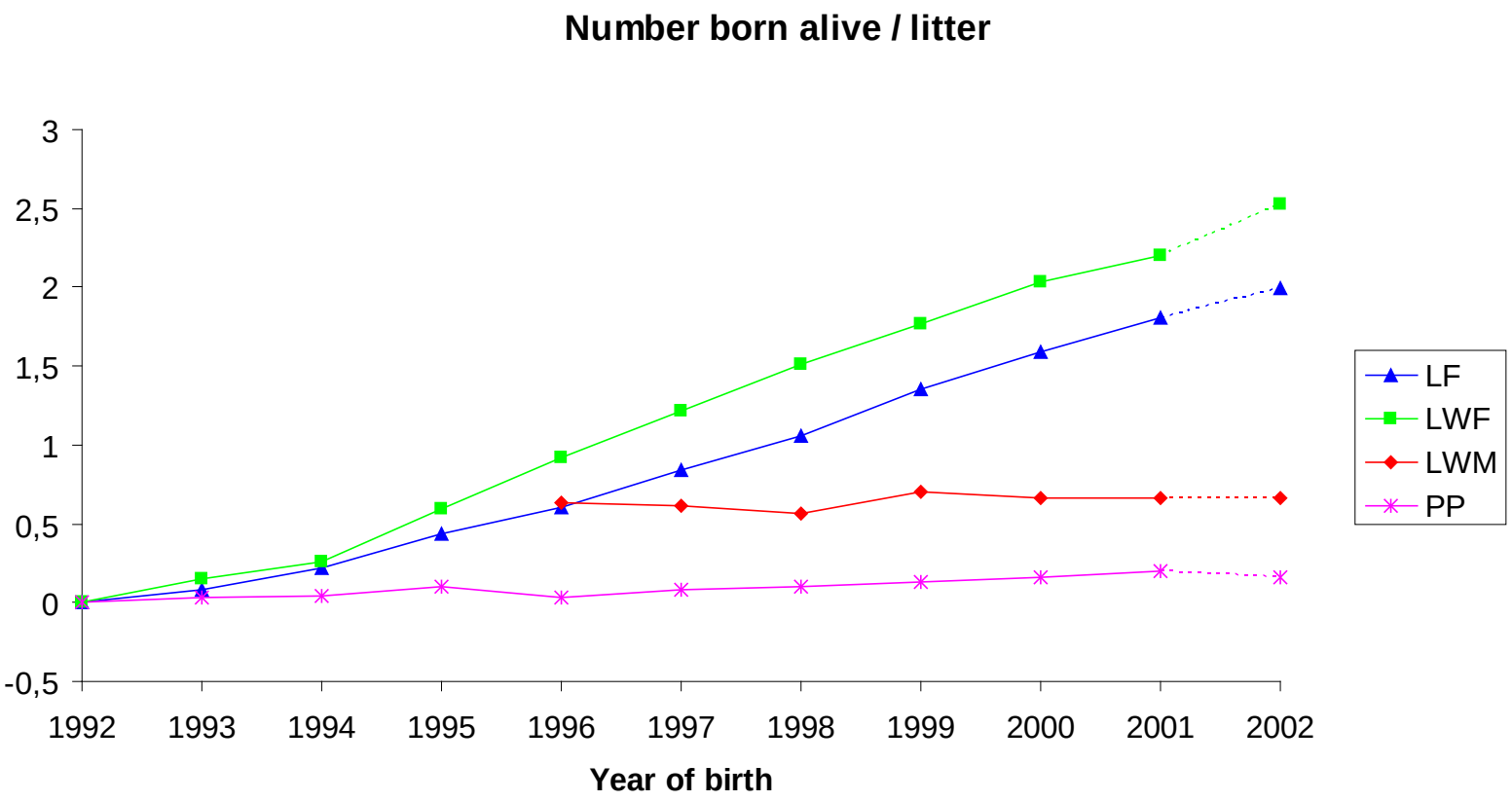
Within – herd genetic evaluation

$$\hat{VG}_{within} = \frac{1 - CD_{ind}}{1 - CD_{ind}\,CD_{asc}}\,\hat{VG}_{asc} + \frac{1 - CD_{asc}}{1 - CD_{ind}\,CD_{asc}}\,EBV_{ind}$$

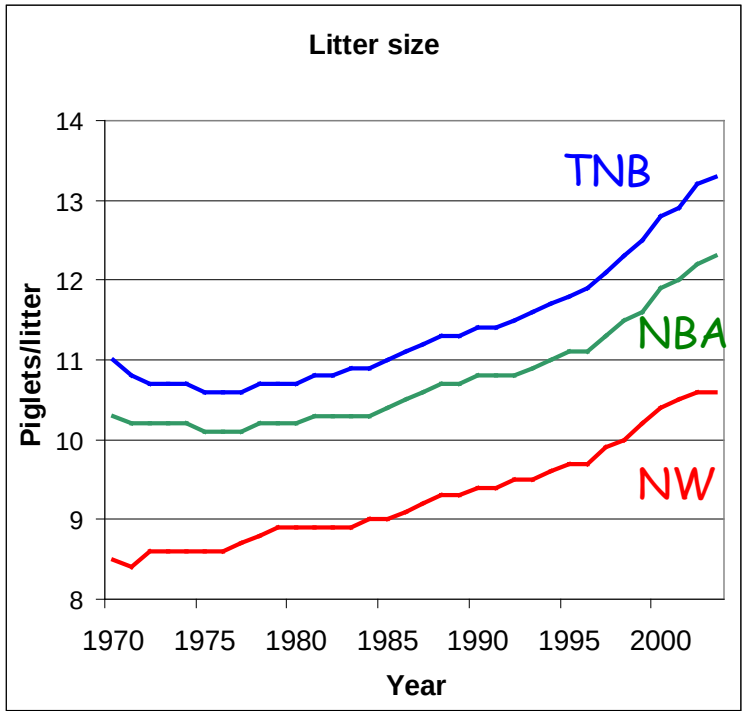
with $\hat{VG}_{asc} = \frac{\hat{VG}_{sire} + \hat{VG}_{dam}}{2}$ $CD_{asc} = \frac{CD_{sire} + CD_{dam}}{4}$

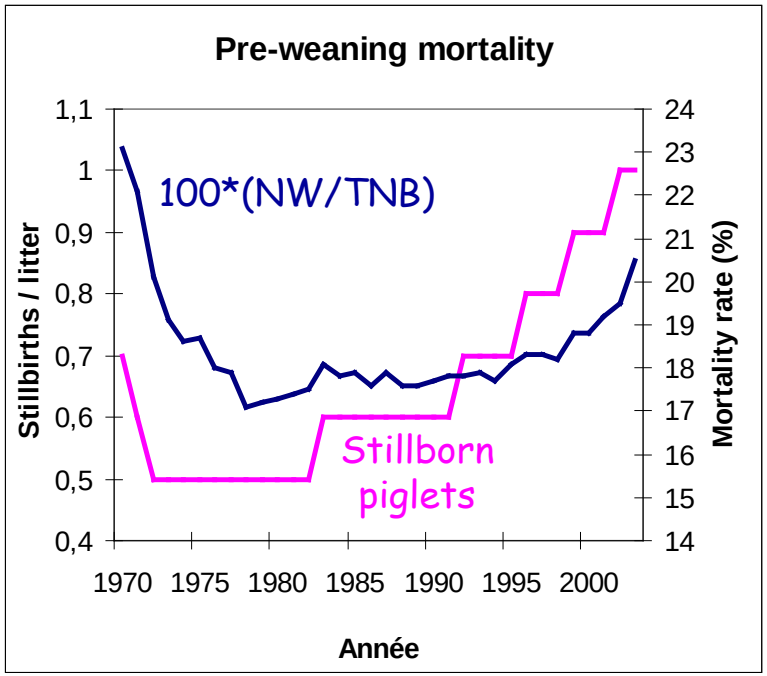
$EBV_{ind} = b_1 (A100^*) + b_2 (BF100^*)$ CD_{ind} = constant

Checking the efficiency of breeding schemes
Estimated genetic trend for litter size



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



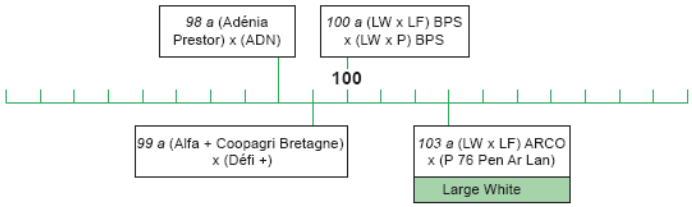


Checking the efficiency of breeding schemes
Control of terminal products

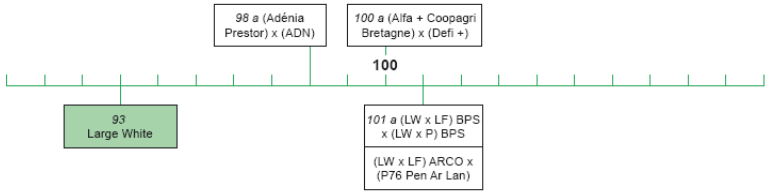
- Sample of slaughter pigs from different breeding organisations compared in an official test station
- Results officially published by the ministry of Agriculture

Ex : 24rd TP test

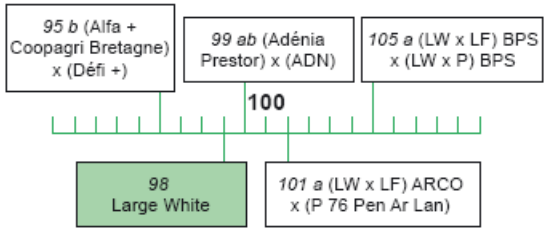
Growth index; 10 points = 2.30 euros



Carcass index; 10 points = 3.08 euros

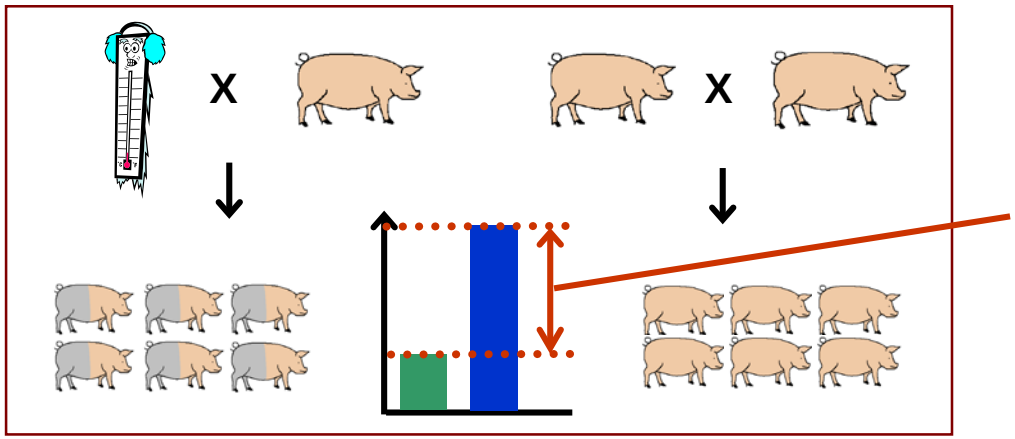


Meat quality index; 10 points = 1.16 euros



Checking the efficiency of breeding schemes
Use of frozen semen

SMITH, 1976 : use of frozen semen



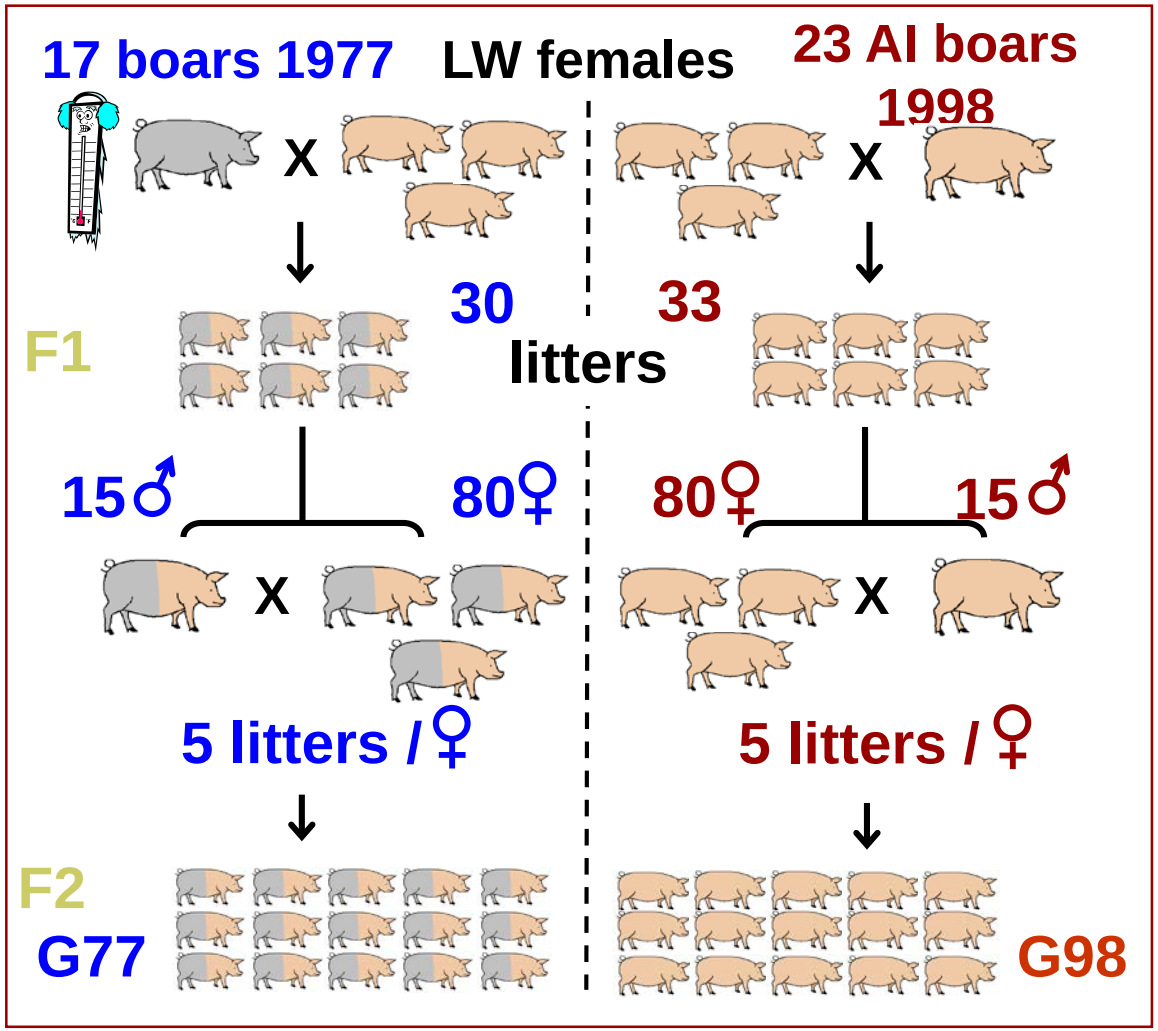
$$= \frac{\text{genetic trend}}{2}$$

1978 : stock of frozen semen of 1977 LW boars

1999 : INRA, ITP & French Ministry of Agriculture

reproduction, production, quality

Checking the efficiency of breeding schemes
Use of frozen semen



Experimental design

Reproduction traits

- **production traits**
- **meat and fat quality**

Estimation of genetic trends using frozen semen - results

Growth rate

	Mean perf.	σ_{ph}	ΔG	P-value for H0 $\Delta G=0$
ADG weaning / slaughter (g/d)	737	62	+74.8	0.0003

Estimation of genetic trends using frozen semen - results

Carcass fatness

	Mean perf.	σ_{ph}	ΔG	P-value for H0 $\Delta G=0$
avg. US backfat thickness at 20 woa (mm)	13.5	1.86	-5.23	<0.0001
backfat weight (kg)	3.0	0.60	-1.41	<0.0001
belly weight (kg)	5.3	0.45	-0.26	0.0560

Estimation of genetic trends using frozen semen - results

Carcass leanness

	Mean perf.	σ_{ph}	ΔG	P-value for H0 $\Delta G=0$
ham weight (kg)	9.7	0.50	+0.56	0.0053
loin weight (kg)	10.5	0.68	+0.85	0.0043
loin eye thickness (mm)	52.1	5.4	+5.97	0.0054
estimated carcass lean content (kg/100kg)	55.7	3.5	+8.60	<0.0001

Estimation of genetic trends using frozen semen - results

Muscles physico-chemical characteristics (1)

pH_{45}, : low negative trend (-0.032 to -0.083), not significant

	Mean perf.	σ_{ph}	ΔG	P-value for H0 $\Delta G=0$
pHu of *Gluteus superficialis*	5.74	0.19	-0.10	0.0897
pHu of *Semimembranosus*	5.81	0.21	-0.16	0.0150
L* of *Gluteus medius*	44.0	4.0	+2.50	0.0434

Longissimus dorsi, Gluteus superficialis **: no change in L***

Estimation of genetic trends using frozen semen - results

Muscles physico-chemical characteristics (2)

	Mean perf.	σ_{ph}	ΔG	P-value for H0 $\Delta G=0$
Glycolytic potential of *Longissimus dorsi* (µmol/g)	**54.8**	**16.4**	**+16.7**	**0.0049**

signif. improvement of water holding capacity of *Gluteus superficialis*

Intramuscular fat content of *Longissimus dorsi* (g/100g)	**2.45**	**0.84**	**+0.19**	**0.6323**

Estimation of genetic trends using frozen semen - results

Litter size

Parity 1, 2, 3 (4)

	MMC_{77}	MMC_{98}	ΔG	Pr>|t| for H0 $\Delta G=0$
Total number born	11,01	12,45	+2,88 p	0,0011
Number born alive	10,21	11,25	+2,08 p	0,0155
Stillbirths	0,79	1,14	+0,7 p	0,0248

Estimation of genetic trends using frozen semen - results

Components of litter size

Parity 1, 2, 3 (4)

	MMC_{77}	MMC_{98}	ΔG	Pr>|t| pour H0 $\Delta G=0$
Number of corpora lutea	18,5	20,5	+4	0,0015
Embryo survival rate (%)	61,9	64,5	+5,2 %	0,3436

Estimation of genetic trends using frozen semen - results

Piglet individual weight at birth

	MMC_{77}	MMC_{98}	ΔG	Pr>|t| for H0 $\Delta G=0$
Weight at birth (g)	1433	1470	+74 g	0,3308
Weight at birth(g) *Ajusted for litter size*	1368	1459	+182 g	0,0052
Within-litter standard deviation of birth weight (g)	249	287	+76 g	0,0003

Weight of the lightest piglet stable

Weight increase of the heaviest piglet

Estimation of genetic trends using frozen semen - results

Weight gain from birth to 21 days

Nurse A77	7 or 13 A77 and A98 piglets
Nurse A98	7 or 13 A77 and A98 piglets

	MMC_{77}	MMC_{98}	ΔG	Pr>|t| for H0 $\Delta G=0$
ADG_{0-21}(g/j) (piglet effect)	222	217	-10 g/j	0,2103
ADG_{0-21} (g/j) (nurse effect)	225	214	-22 g/j	0,0283

$DM_{prod} = k \times \overline{ADG_{0-21}} + c$ (NOBLET and ETIENNE,1989)

→ -16 g DM / piglet x day between 1977 and 1998

Outline

- Some elements on pig production in France
- Pig breeding in France
- The National pig breeding scheme
- Conclusion - Perspectives

Future trends for pig breeding

- Breeding objectives
  - Diversification of production systems
    - Diversification of breeding objectives
      - High quality pigs with low growth rate
        - Different aspects of meat and fat quality
      - outdoor systems
        - Importance of « robustness »
        - resistance to parasites (?)
      - free sows during gestation and after farrowing

Future trends for pig breeding

- Breeding objectives
  - More or less optimum level for carcass composition
  - Quality aspects
    - What are the major determinants of increased meat quality ?
    - Is it possible to change rates of tissue deposition, e.g. ?
      - High intra-muscular fat (IMF) content in the loin
      - No increase of IMF in the ham
    - Is it possible to obtain more homogeneous products by reducing environmental sensitivity ?

Future trends for pig breeding

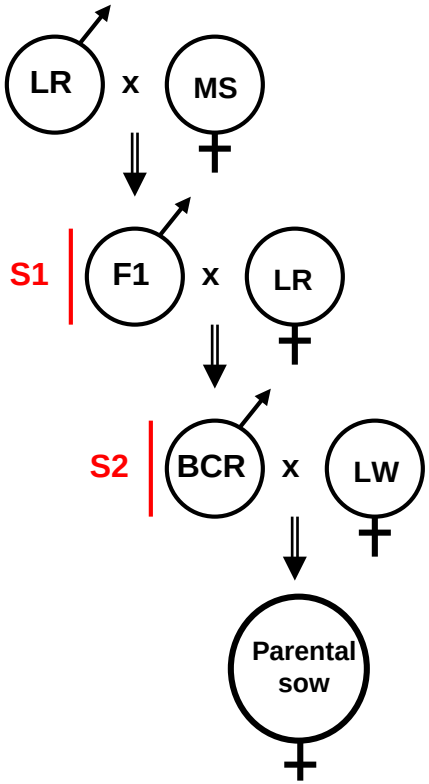
- Breeding objectives
  - Increasing importance of sow maternal abilities and behavioural traits
    - Higher litter sizes at birth
    - Increasing age at weaning
    - Free nursing sows
    - Sows managed in groups
    - Welfare aspects
  - Increasing importance of resistance do diseases
    - decreasing use of antibiotics
    - Outdoor systems
    - Welfare aspects

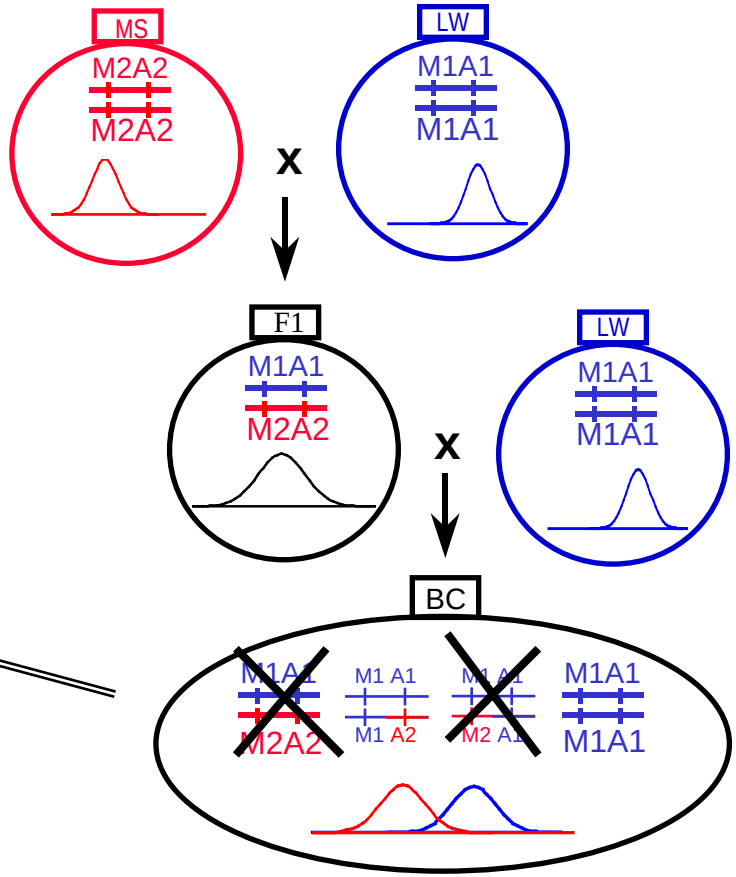
Future trends for pig breeding

- New technologies
  - No agricultural future for transgenic pigs ?
    - Pigs with reduced phosphorus output
  - Marker (MAS) and genotype (GAS) assisted breeding
    - Selection
      - Limited impact of MAS in situations of linkage equilibrium
      - Potential impact of LD-MAS and GAS
      - Few interesting genes at the moment (Hal, RN, IGF-2)
      - Long term impact on genetic variation ?
    - Crossbreeding
      - Much easier to use
      - Small exemple in France

Exemple of marker assisted breeding

Crossbreeding scheme to produce
1/8 Meishan (MS) sows





S1, S2 : selection steps

Backcross pigs carrying the unfavourable marker (and QTL) alleles are culled

Conclusion

Thank you for your attention.

Questions ?