

64<sup>th</sup> EAAP annual meeting, Nantes, 2013  
Session 29 "Pigs: Free communications"

**INRA**  
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## Accounting for variation among individual pigs in deterministic growth models

VAUTIER B., QUINIOU N., VAN MILGEN J. and BROSSARD L.  
[ludovic.brossard@rennes.inra.fr](mailto:ludovic.brossard@rennes.inra.fr)

28 / 08 / 2013

## PIG GROWTH MODELLING

- ❖ **Growth models: mecanist, dynamic, determinist**
  - Body weight (BW) or protein deposition = function of age
  - Daily feed intake (DFI) = function of BW
- ❖ **Simulation of an "average pig"**
  - Adjustment of average parameters
  - Simulation of an average response
- ➔ **Underestimates the nutrient requirements at the batch level**  
(Pomar et al., 2003; Brossard et al., 2007)

Balanced protein intake (kg/d)	Level of variation 0 (kg/d)	Level of variation 1 (kg/d)	Level of variation 2 (kg/d)
0.21	0.160	0.160	0.160
0.23	0.175	0.170	0.165
0.25	0.180	0.175	0.170
0.27	0.180	0.180	0.175
0.29	0.180	0.180	0.180

Requirement

Level of variation (times of natural s.d.)

- 0
- 1
- 2

Pomar et al., 2003

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## STOCHASTICITY IN MODELS

### ❖ Stochasticity

- Accounting for variation among pigs
- Mean and variance of response



### ❖ Stochasticity within individuals

- Random variation for each day of simulation (*Strathe et al., 2009*)
- Lack of knowledge on relations among days

### ❖ Stochasticity among individuals

- Repeated simulations with deterministic model using input parameters randomly generated (*Pomar et al., 2003*)
- Lack of knowledge on structure of relationships among parameters describing individuals



## AIM OF THE STUDY

- ❖ To analyze mean and covariance structure of growth model parameters describing DFI and growth in different groups of pigs
  - ➔ Analysis of variation through elements required for population generation (multivariate random process)
- ❖ To propose a covariance structure to be used to generate populations with realistic variation and relationships between individual parameters
  - ➔ To include stochasticity in growth model



## MATERIALS AND METHODS: data collection

### ❖ Animals

- 10 batches , each of 144 barrows and gilts
- Large White x Landrace sows
- 10 sire breeds
  - half a batch from Large White x Piétrain
  - other half from an alternative commercially available sire line
- 36 gilts and 36 barrows of each crossbred by batch

### ❖ Feeding: *ad libitum* with an automatic feed dispenser

### ❖ Housing: 12 / pen, 6 gilts + 6 barrows of the same crossbred

### ❖ Measurements

- Individual DFI
- BW: x6 over the growing-finishing period (at least every 3 weeks)



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## MATERIALS AND METHODS: data processing

### ❖ Growth profiles adjusted in InraPorc®

### ❖ Growth parameters

- ❖ Gompertz function
- ❖ **BW<sub>70</sub>** : BW at 70 days of age (kg)
- ❖ **PDm** : mean protein deposition between 70 d of age to 110 kg BW (g/d)
- ❖ **B<sub>Gompertz</sub>** : precocity of protein deposition (/d)

### ❖ DFI parameters

- ❖ Gamma function of BW
 
$$QI = (a \cdot (BW \cdot b \cdot \exp(-b \cdot BW)) + 1) \cdot c \cdot BW^{0.60}$$
- ❖ **DFI50** : DFI at 50 kg BW (MJ NE)
- ❖ **DFI100** : DFI at 100 kg BW (MJ NE)

➔ After profiles filtering (health problems, discontinuous patterns of growth and intake, unrealistic values), **1288 animals kept in database**



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## MATERIALS AND METHODS: statistics

### ❖ Mean level of parameters

- MIXED procedure (SAS v8.01)
- Fixed effects: sex, batch, crossbreed within batch + interactions
- Random effect: pen

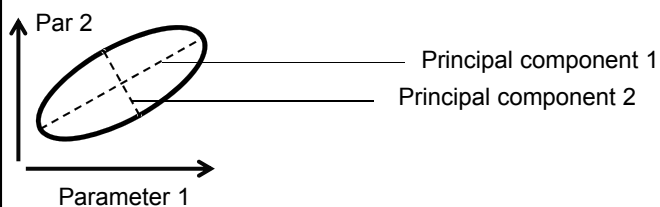
### ❖ Comparison of covariance matrices

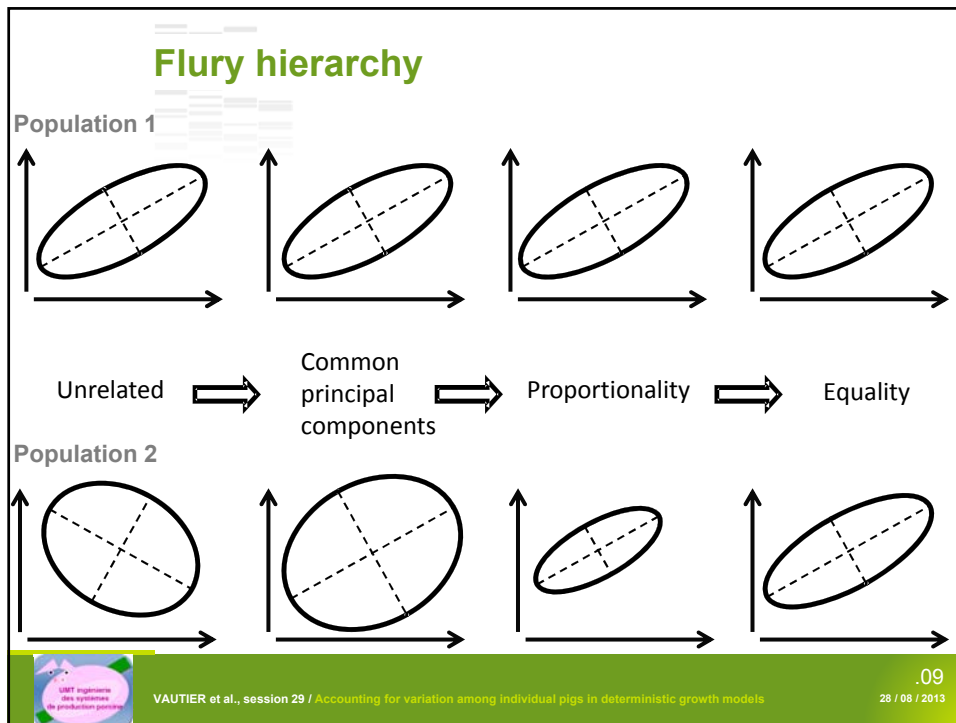
- According to Flury hierarchy (1988) (CPC program; Philips, 1999)
- Comparison depending on grouping criteria used:
  - batch, sex, crossbreed or their combinations
  - comparison between 2 to 40 matrices



## Flury hierarchy

### ❖ Representation of a covariance matrix of two parameters for a population





### RESULTS: mean levels

P values	BW <sub>70</sub>	PDm	B <sub>Gompertz</sub>	DFI50	DFI100
Batch	<0.01	<0.01	<0.01	<0.01	0.02
Sex	0.12	<0.01	<0.01	<0.01	<0.01
Crossbreed (batch)	0.65	0.01	0.74	0.77	0.06
Batch x Sex	0.56	<0.01	0.52	0.47	0.05
Sex x Crossbreed	0.98	0.13	0.07	0.15	0.25

❖ Mean levels of parameters depend on several factors

➔ Mean parameters to be estimated for each group

- Sex effect: predictable by adjusted means
- Batch effect: unpredictable

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## RESULTS: Comparison of covariance matrices

- ❖ All comparisons indicated unrelated covariance matrices, independently on grouping criteria
- ➔ A specific covariance structure for each subpopulation (defined by a batch, sex and crossbreed)
- ➔ Difficult to determine ex ante from a practical point of view



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## RESULTS: Generic covariance structure

- ❖ Proposition of a generic covariance structure based on the “median” matrix accounting for the size of 40 subpopulations
  - evaluation of deviation from the 40 subpopulations
  - comparison to the deviation from a “raw” matrix (computed from the 1288 individual profiles)



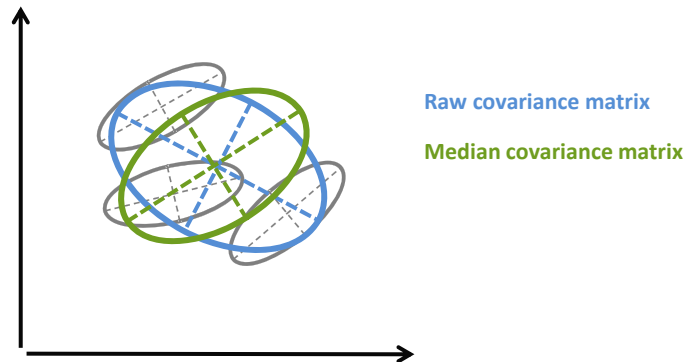
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## RESULTS: Generic covariance structure

- ❖ Proposition of a generic covariance structure based on the “median” matrix accounting for the size of 40 subpopulations



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## RESULTS: Generic covariance structure

- ❖ Proposition of a generic covariance structure based on the “median” matrix accounting for the size of 40 subpopulations

- evaluation of deviation from the 40 subpopulations
- comparison with the deviation from a “raw” matrix (computed from the 1288 individual profiles)
- deviation estimated using  $\chi^2$  distance from the equality v. unrelated test of the CPC program (smaller is better)

➔ Smaller deviation for 72% of the subpopulations matrices with the “median” matrix v. the “raw” matrix



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## CONCLUSION (1)

- ❖ Mean and covariance structure of growth model parameters
  - ➔ Elements required for population generation
- ❖ Effect of sex and batch on mean values of model parameters
  - ➔ Average parameters to be obtained on farm
- ❖ Specific covariance structure
  - for each combination of batch, sex and crossbreed
  - ➔ Proposal of a “median” generic covariance matrix



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## CONCLUSION (2)

- ❖ Mean and covariance structure of growth model parameters
  - ➔ Elements required for population generation
- ❖ Mean values + generic matrix
  - ➔ Pattern for generation of virtual populations of pigs
  - ➔ Evaluation by realistic simulations of nutritional/management strategies on performance and variability of groups of pigs



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- ❖ This study was funded by the French Ministry of Agriculture, Food, Fisheries, Rural Affairs and Spatial Planning
- ❖ B. Vautier gratefully acknowledges the ANRT, on behalf of the French Ministry of Higher Education and Research for partly supporting his PhD work

**THANKS FOR YOUR  
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