Genotype by environment interactions

when environments are defined from Herd-Test-Day profiles

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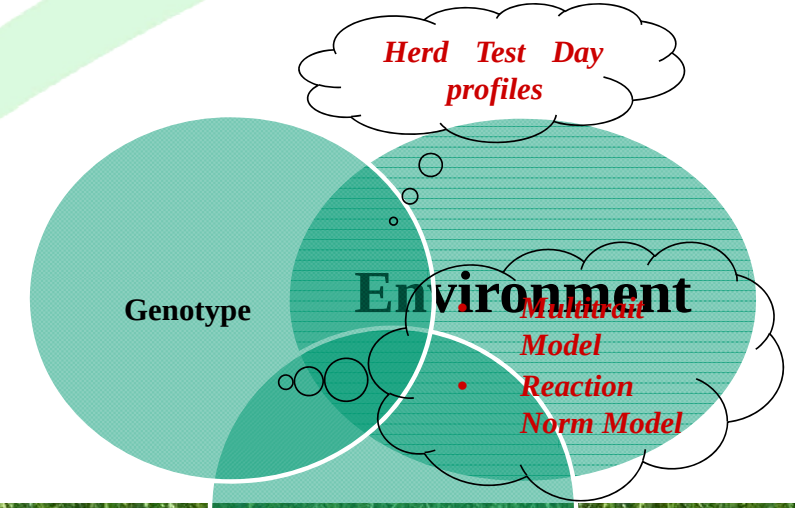
Aim of the study:
Genotype by environment interaction (G*E) study in France

✓Why?

- ✓ Absence of G*E in genetic models despite a wide range of environments in France
- ✓ Same animal ranking whatever the environment
- ✓ Same animal breeding values variability whatever the environment



Simple description of the environment /herd management



feeding


housing

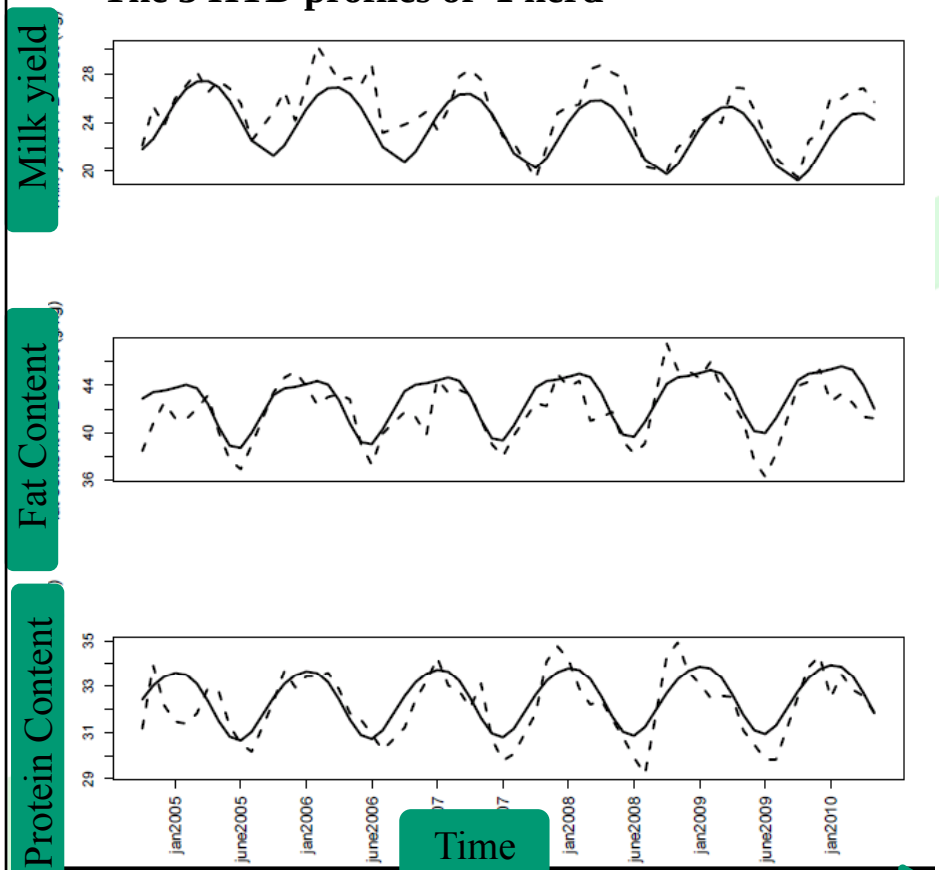
Herd management=environment

Simple description BUT data not available in national databases

*An other definition of the environment for G*E interaction study?*

Herd Test Day profiles depicts the environment

The 3 HTD profiles of 1 herd



Herd Test Day profiles:
•byproducts of the genetic Test Day Model

•Production of the cows of this herd only due to herd management over time

•HTD profile= reflect of the environment →environment definition in G*E study

Innovation
Huquet & al., 2012

The Herd Test Day profiles: advantages and drawbacks

- Available in national databases
- Reflect only herd management (contrary to other definitions of the environment e.g. performances which reflect also the genetic level)
- Summarize several effects of the environment (feeding, housing, climate…)

- But they are less intuitive than other definitions

Estimation of G*E interaction : models

For multitrait and reaction norm models: Animal model

Performance (animal $_i$)=Fixed effects + genetic random effect+ residual

Fixed effects=Herd*Year, Month at calving, Age at calving

Heterogeneity of residual variance

The expression of the genetic random effect depends on the model (through the definition of the environment).

Animal breeding values as functions of the environment

Multitrait Model

✓*Environment= herd groups*

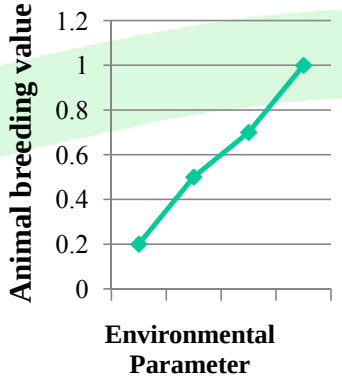
✓*Animal breeding values= One per herd cluster*

Reaction Norm Model

✓*Environment= continuum*

✓*Animal breeding values= f(1 Environmental Parameter)*

✓*Our innovation: Animal breeding values= f(several Environmental Parameters)*



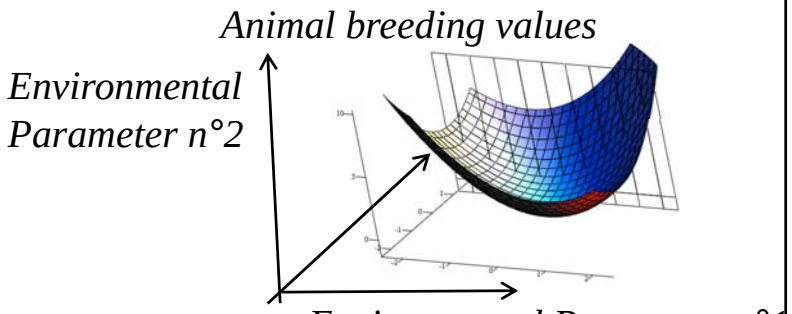
Innovation

$$\alpha_{ie} = \alpha_{0i} + \sum \alpha_{kie} * EP_k$$

Average breeding value

Breeding values depending on the environment

Environmental parameter



How to use HTD profiles to describe the environment in genotype by environment study?

- **Environmental parameters (quantitative variables) for a reaction norm model**

From HTD features, environmental descriptors were defined:

- ✓ Herd management « intensity » (HTD profiles with high or small mean level)
- ✓ Herd management « specialisation » (HTD profiles higher for milk yield or protein/fat contents)
- ✓ Herd management « seasonality » (does production due to management depend on the season?)

- **Herd clusters for a multitrait model**

Result of a clustering method:

- ✓ Herd cluster 1: an average production intensity rather specialized in milk production
- ✓ Herd cluster 2: a high production intensity and rather specialized in protein and fat contents
- ✓ Herd cluster 3: low herd management intensity

Estimation of G*E interaction : data

- 3 breeds: Holstein, Normande, Montbéliarde

- 5 traits: milk, protein and fat lactation yields, protein and fat contents
- Large datasets:

	Holstein	Normande	Montbéliarde
Number of records (L1)	250,000	125,000	43,000
Number of animals (pedigree)	400,000	200,000	70,000

Estimation of G*E interaction : genetic correlations (Holstein)

- Multitrait model

Genetic correlations equal to 1 between the 3 herd clusters

Small genetic correlations between extreme environments

In most of the environments: genetic correlations close to 1

- Reaction norm model

	Min	Mean	Max
Milk yield	0.68	0.97	1
Fat yield	0.60	0.96	1
Protein yield	0.64	0.96	1
Fat content	0.94	0.99	1
Protein content	0.99	0.99	1

Genotype*Environment interactions→no reranking

Estimation of G*E interaction : heritability (Holstein)

- Multitrait model

	Herd Cluster 1	Herd Cluster 2	Herd Cluster 3
Milk yield	0.43	0.36	0.34
Fat yield	0.42	0.36	0.32
Protein yield	0.38	0.33	0.30
Fat content	0.71	0.67	0.66
Protein content	0.67	0.63	0.60

- Reaction norm model

	Min	Mean	Max
Milk yield	0.12	0.42	0.66
Fat yield	0.15	0.40	0.63
Protein yield	0.07	0.36	0.64
Fat content	0.76	0.76	0.77
Protein content	0.63	0.64	0.66

Herd cluster 1: an average production intensity rather specialized in milk production
Herd cluster 2: a high production intensity and rather specialized in protein and fat contents
Herd cluster 3: low herd management intensity

Genotype*Environment interactions→Scale effect

Estimation of G*E interaction : Conclusion

- No reranking of animals except between very extreme environments
- Scale effect: the more intensive the herd management for milk yield, the larger the heritability
- Performances expected from an animal can differ according to the environment

- Results in agreement with other studies
- Innovations:
  - environment defined from HTD profiles
  - reaction norm model with several environmental descriptors

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Thank you for your attention

Questions?

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