# Environmental impact of pig production, modeling and reducing the flow of nutrient to the environment

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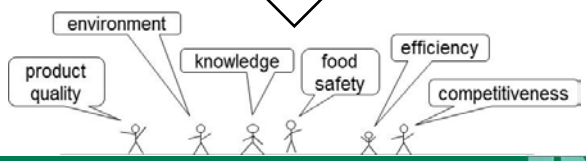
## What is UMR Pegase working on?

resources → **« animal »** *or* **« system »** → production products

**high flow rate**
**highly efficient (/ha, /€, or /capita)**
**in regions with high production densities**

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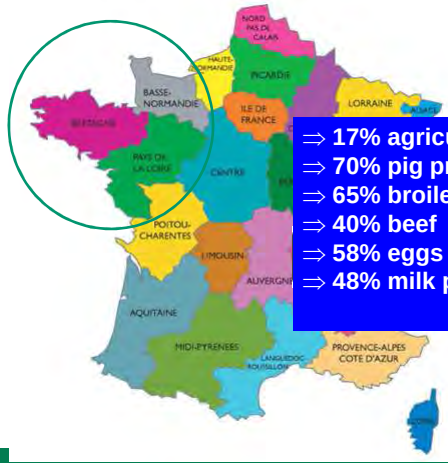
## Animal production systems of West of France : Brittany, Pays de la Loire, Lower Normandy




⇒ 17% agricultural area
⇒ 70% pig production
⇒ 65% broilers
⇒ 40% beef
⇒ 58% eggs
⇒ 48% milk production

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## A unit with 2 missions

« share what we know »

**research**

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**teaching & training**

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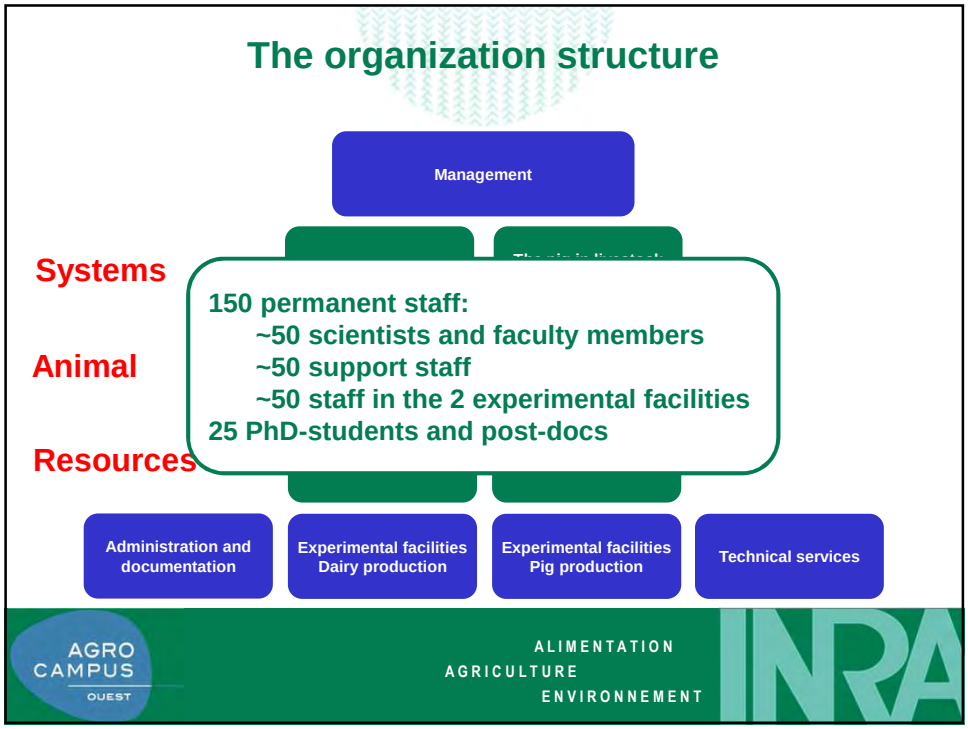
The organization structure
Management
Systems
Animal
Resources
150 permanent staff:
~50 scientists and faculty members
~50 support staff
~50 staff in the 2 experimental facilities
25 PhD-students and post-docs
Administration and documentation
Experimental facilities Dairy production
Experimental facilities Pig production
Technical services
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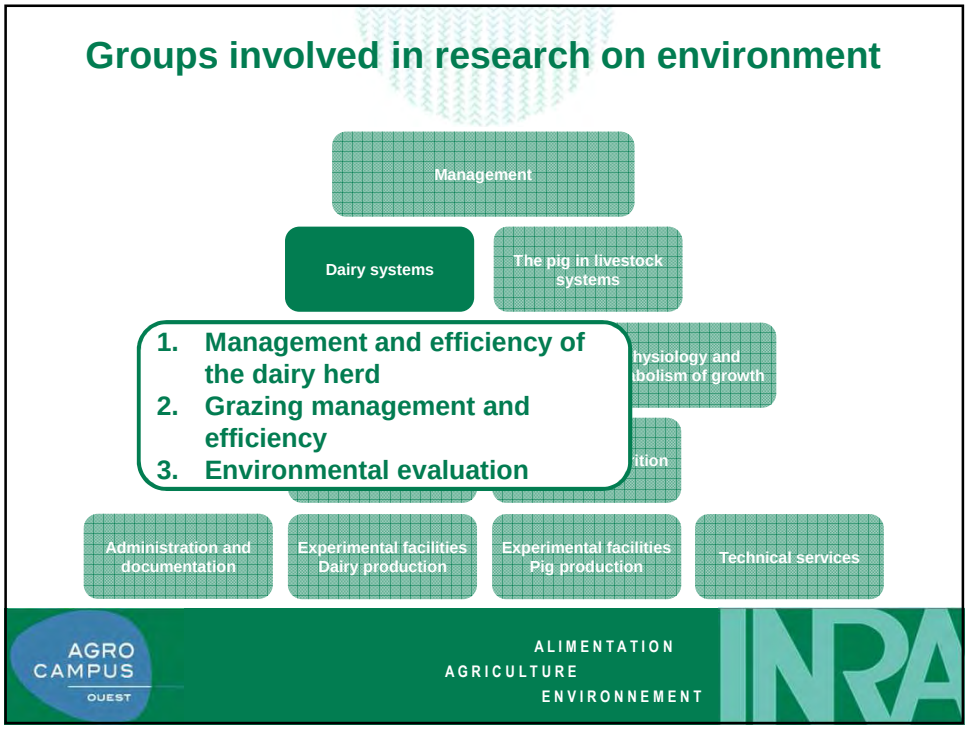
Groups involved in research on environment
Management
Dairy systems
The pig in livestock systems
1. Management and efficiency of the dairy herd
2. Grazing management and efficiency
3. Environmental evaluation
Administration and documentation
Experimental facilities Dairy production
Experimental facilities Pig production
Technical services
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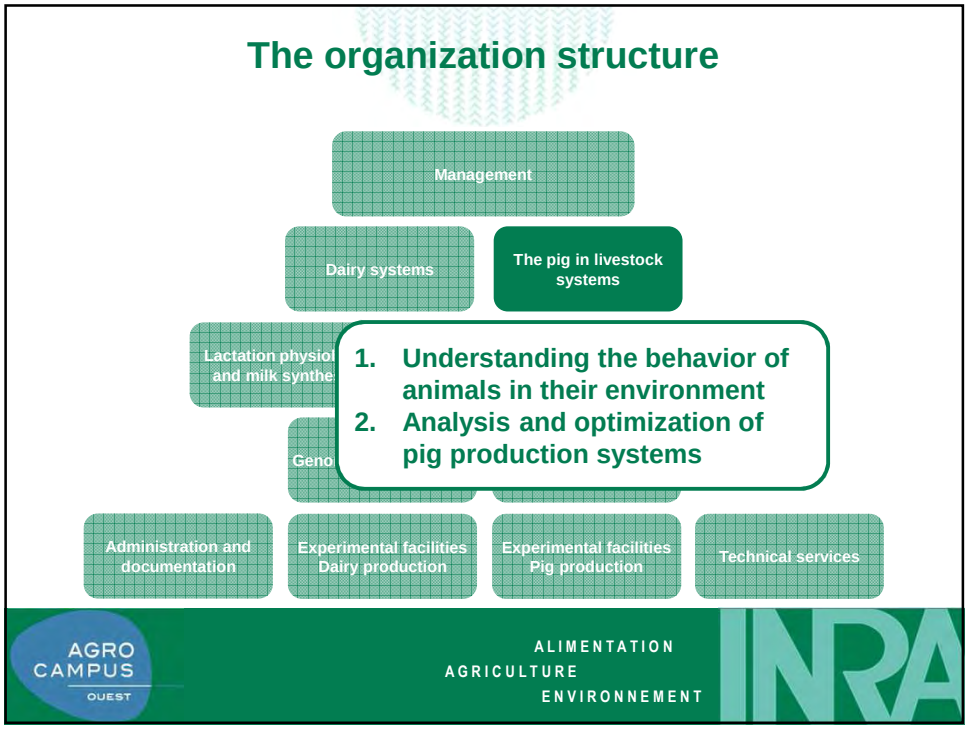
The organization structure
Management
Dairy systems
The pig in livestock systems
Lactation physiol and milk synthe
Geno
1. Understanding the behavior of animals in their environment
2. Analysis and optimization of pig production systems
Administration and documentation
Experimental facilities Dairy production
Experimental facilities Pig production
Technical services
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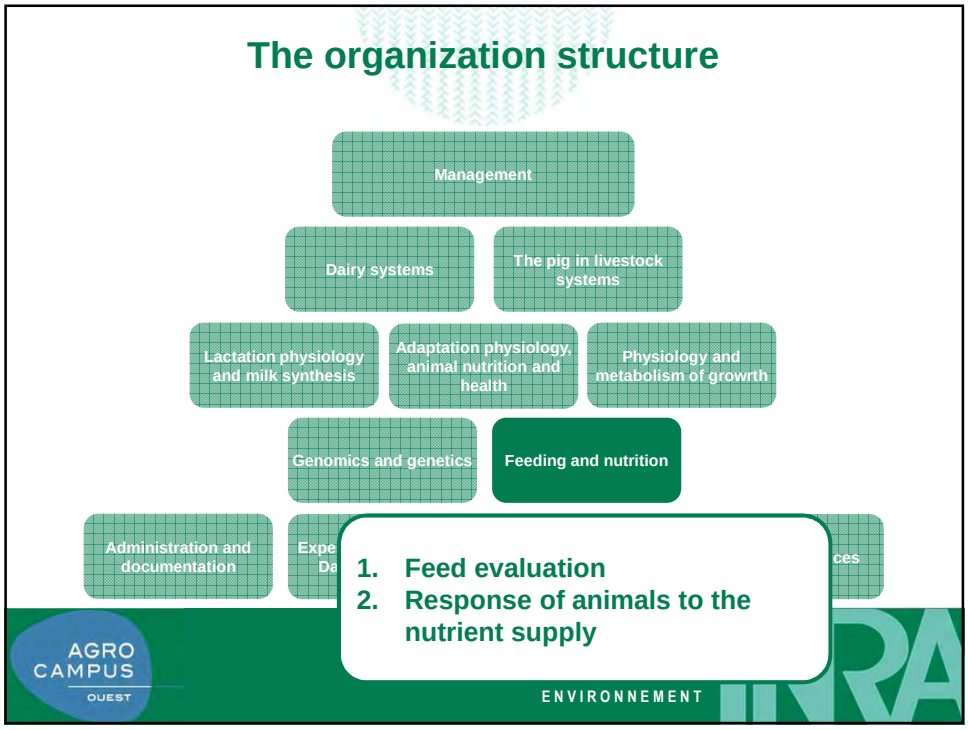
The organization structure
Management
Dairy systems
The pig in livestock systems
Lactation physiology and milk synthesis
Adaptation physiology, animal nutrition and health
Physiology and metabolism of growrth
Genomics and genetics
Feeding and nutrition
Administration and documentation
ces
1. Feed evaluation
2. Response of animals to the nutrient supply
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# Environmental impact of pig production: modeling and reducing the flow of nutrient to the environment

- **Nutritional approaches for reducing nutrient excretion and emissions**
  - Nitrogen excretion and ammonia emissions
  - Phosphorus and trace elements
  - Greenhouse gases
- **Modeling of emissions from pig production**
  - Applied models => Corpen (official French reference)
  - Research models (Animals, Pig Unit, Farm)
- **Integrated evaluation of impacts using LCA**
  - Nutritional approaches
  - Comparison of production system

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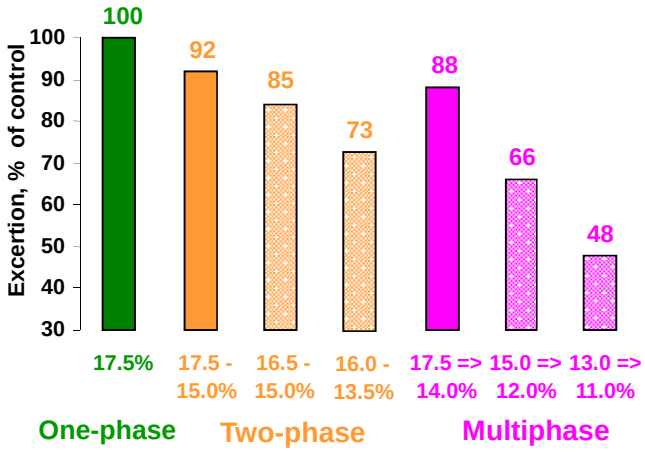
# Effect of phase feeding and protein quality on N excretion by fattening pigs




Dourmad et al., 1993
Latimier and Dourmad, 1993
Bourdon et al., 1993

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## Effect of CP on slurry characteristics and ammonia volatilization in fattening pigs

| | Dietary crude protein content | | |
|---|---|---|---|
| | 20% | 16% | 12% |
| **Slurry composition** | | | |
| Amount, kg/d | 5.7 | 5.1 | 3.6 |
| DM, % | 4.4 | 4.6 | 5.9 |
| Total Kjeldahl N (g $N.kg^{-1}$) | 5.48 | 4.30 | 3.05 |
| Ammoniacal N (g $N.kg^{-1}$) | 4.32 | 3.13 | 1.92 |
| pH | 8.92 | 8.61 | 7.57 |
| **N balance (g.$pig^{-1}$.$d^{-1}$)** | | | |
| Retention | 23.2 | 23.5 | 21.9 |
| Excretion | 40.7 | 27.6 | 15.0 |
| Ammonia volatilization | 17.4 | 13.8 | 6.4 |
| Soil (available for plants) | 23.3 | 13.8 | 8.6 |

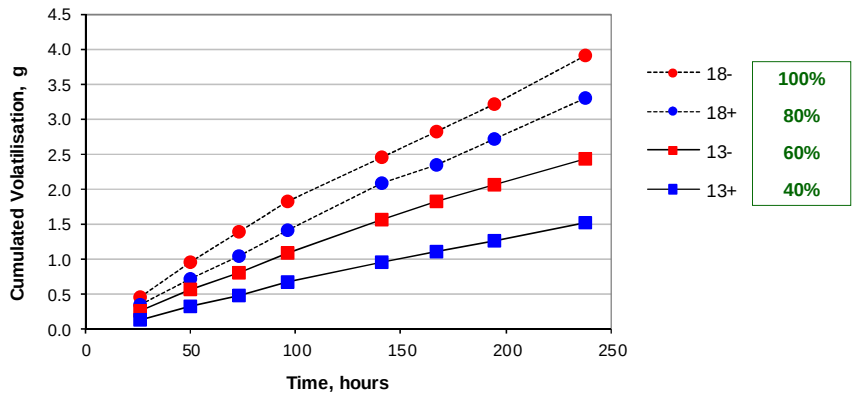
Portejoie et al., 2005

## Effect of fiber content in fattening pigs diet on composition of excreta, N balance and ammonia emission

| | Control | High-fibre | |
|---|---|---|---|
| Crude Fiber, g/kg | 29.4 | 49.0 | |
| N balance, g/d | | | |
| Intake | 55.9 | 55.5 | |
| Excretion | 28.7 | 30.3 | |
| % in faeces | **26.3** | **40.0** | *** |
| pH urine | **8.28** | **7.15** | *** |
| pH faeces | **8.39** | **8.11** | *** |
| VFA in faeces, mg/L | **62.6** | **260** | *** |
| Ammonia emission (% excretion) | **17.9** | **12.4** | *** |

Jarret et al., 2011

## Effect of dietary protein content (18 or 13%) and addition of benzoic acid ( + or -) on ammonia volatilization
(cumulated emission during 10 d)




Daumer et al., 2007

## Effect of fiber content in fattening pigs diet on volatile solid of excreta (VS), and enteric and manure $CH_4$ emission

| | Control | High-fibre* | |
|---|---|---|---|
| Crude Fibre, g/kg | 29.4 | 49.0 | |
| Digestible fibre, g/kg feed | 74.8 | 110 | *** |
| Enteric $CH_4$, L/pig/d | 3.1 | 4.6 | *** |
| Volatile Solids, g DM/pig/d | 192 | 315 | *** |
| $B_0$, L $CH_4$ / kg VS | 377 | 376 | |
| $CH_4$ production, L/pig/d | | | |
| Storage simulation (100 d) | 55 | 97 | *** |
| Methane Conv. Factor, % | 71% | 77% | * |

* soybean meal replaced by wheat DDGS and rapeseed meal

Jarret et al., 2011

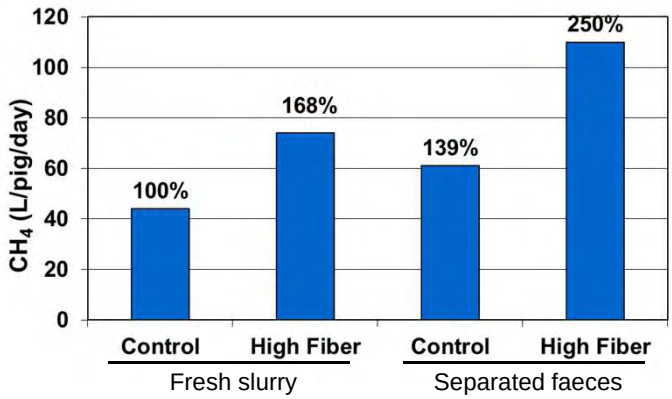
## Effect of type of diet and duration of storage on methane conversion factor (MCF, %) of slurry in mesophyllic conditions

| | Duration of anaerobic storage simulation, days | | | | |
|---|---|---|---|---|---|
| | 10 | 30 | 50 | 70 | 100 |
| High protein | 1.3% | 1.8% | 2.1% | 3.5% | 18.3% |
| Low protein | 4.6% | 9.2% | 25.7% | 38.4% | 48.3% |
| High fiber | 5.7% | 32.0% | 54.2% | 65.4% | 74.6% |

**IPCC : For liquid effluent and slurry without natural crust cover and warm temperature (>28 °C), the proposed MCFs are at 80% on average**

Jarret et al., 2011

## Effect of fiber content in fattening pigs diet and type of manure on methane production (L/pig/d) in a mesophyllic digester (37 days retention time)




Control : CF = 2,9%
High fiber : CF=4,9% (Soybean meal => RSM + DDGS)

Jarret et al., 2011

## Environmental impact of pig production: modeling and reducing the flow of nutrient to the environment

- Nutritional approaches for reducing nutrient excretion and emissions
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  - Phosphorus and trace elements
  - Greenhouse Gases
- **Modeling of emissions from pig production**
  - **Applied models => Corpen (official French reference)**
  - **Research models (Animals, Pig Unit, Farm)**
- Integrated evaluation of impacts using LCA
  - Nutritional approaches
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## Applied models for the determination of excretion and amounts of N, P, K, and trace elements in manure

- **Balance approach**
  - Excretion = intake – retention
  - Emission factors : volatilization of N compounds
  - Contribution of the litter in case of solid manure
- **Variation factors**
  - Composition of feed (N, P, Cu, Zn, K)
  - Animal performance
  - Manure handling (slurry, straw or sawdust bedding)
  - Ambient Temperature

## Practical application to the determination of official reference in France (France)

- **Corpen (ministry of agriculture & environment)**
  - **has proposed to consider nutrition in the calculation of N and P in pig manure ( 2003)**
- **Different types of manure handling**
  - **Slurry**
  - **Straw of sawdust litter with or without composting**
- **Differens ways of calculation of N and P in manure**
  - **standards values : no effort put on feeding**
  - **reduced values : effort for reducing N and P in feeds**
  - **simplified "input - output" farm balance (real N and P value of feed and animal performance)**
  - ➢ **Induced a rapid reduction in diets composition**

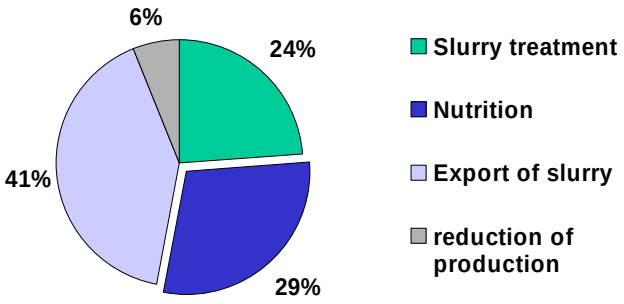
## Official references for the determination of N and P excretion by pigs

| | Nitrogen (N) | | Phosphorus($P_2O_5$) | |
|---|---|---|---|---|
| | Standard | "*corpen*" | Standard. | "*corpen*" |
| Sow, kg/year | 17.5 | 14.5 | 15.0 | 11.8 |
| Post weaning, kg/pig | 0.44 | 0.40 | 0.31 | 0.25 |
| Fattening, kg/pig | 3.25 | 2.70 | 2.10 | 1.45 |

Maxi. protein "*corpen*": gestation: 14.0%; lactation: 16,5%; phase 1: 20%; phase 2: 18%; growing: 16.5%; finishing: 15%

Maxi. total P "*corpen*": gestation: 0.50%, lactation: 0.60% , phase 1: 0.68%, phase 2: 0.58%, growing: 0.48%; finishing: 0.44%

## Contribution of nutritional measures to the reduction of N excess in Brittany




## "Research" models for the evaluation of environmental impacts of animal production systems

- **MELODIE : a whole farm model to study the dynamic of nutrient in dairy and pig farms)**
  - Dynamic evaluation of the effect of farming practices of environmental impacts
  - Consider the long term effects
  - Used for the evaluation of real situations and/or innovative strategies

*Animal*, page 1 of 12 © The Animal Consortium 2010
doi:10.1017/S1751731110000492

animal

# Modelling of manure production by pigs and $NH_3$, $N_2O$ and $CH_4$ emissions. Part I: animal excretion and enteric $CH_4$, effect of feeding and performance

C. Rigolot[1,2,3†], S. Espagnol[2], C. Pomar[4] and J.-Y. Dourmad[1]

# Modelling of manure production by pigs and $NH_3$, $N_2O$ and $CH_4$ emissions. Part II: effect of animal housing, manure storage and treatment practices

C. Rigolot[1,2,3†], S. Espagnol[2], P. Robin[4], M. Hassouna[1,4], F. Béline[5], J. M. Paillat[4,6] and J.-Y. Dourmad[1]

[1]*INRA, UMR1079 Systèmes d'Elevage, Nutrition Animale et Humaine, F-35000 Rennes, France;* [2]*IFIP Institut du Porc, F-35651 Le Rheu, France;* [3]*INRA, UMR1080 Production du Lait, F-35000 Rennes, France;* [4]*INRA, UMR1069, Soil Agro and hydroSystem, F-35000 Rennes, France;* [5]*CEMAGREF, Unité de Recherche Gestion environnementale et traitement biologique des déchets, 17, av. de cucillé, CS 64427, F-35044 Rennes Cedex, France;* [6]*CIRAD, UpR Recyclage et risque, F-34398 Montpellier cedex 05, France*

INRA SCIENCE & IMPACT

*Animal* (2012), **6:10**, pp 1711–1721 © The Animal Consortium 2012
doi:10.1017/S1751731112000687

animal

# MELODIE: a whole-farm model to study the dynamics of nutrients in dairy and pig farms with crops

X. Chardon[1,2,3], C. Rigolot[1,2,4], C. Baratte[1,2], S. Espagnol[5], C. Raison[3], R. Martin-Clouaire[6], J.-P. Rellier[6], A. Le Gall[3], J. Y. Dourmad[4,7], B. Piquemal[1,2], P. Leterme[8,9], J. M. Paillat[8,9], L. Delaby[1,2], F. Garcia[1,2], J. L. Peyraud[1,2], J. C. Poupa[10,11], T. Morvan[8,9] and P. Faverdin[1,2†]

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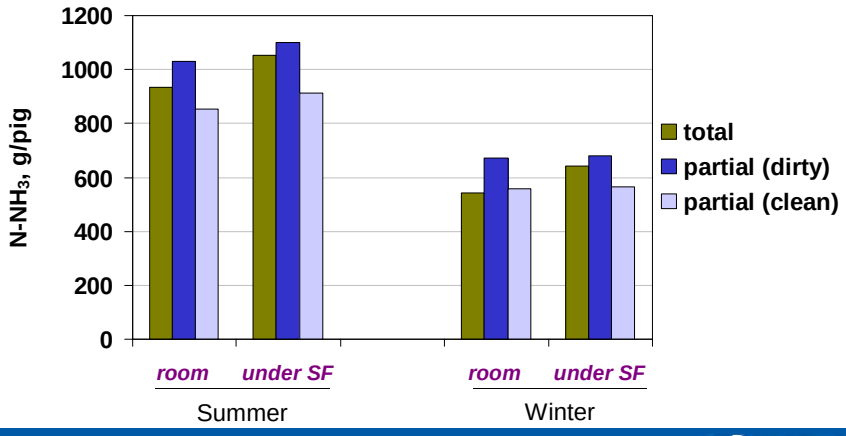
## "Research" models for the evaluation of environmental impact of animal production

- **A dynamic model of ammonia emission and concentration in fattening pig buildings**
  - Integrated dynamic model of ventilation, climate, emissions and concentrations in a room for fattening pigs
  - Prediction of $NH_3$ concentration and emission

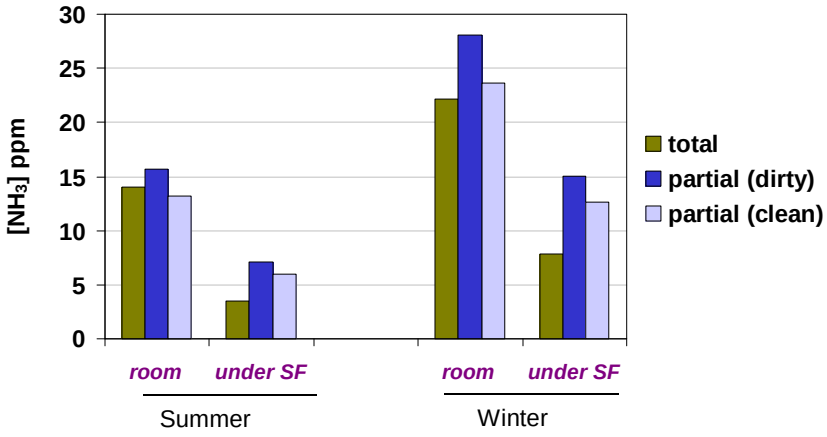
Dourmad JY, Moset-Hernandez V., Espagnol S., Hassouna M., Rigolot C., 2012

## Predicted effects of season, slatted floor (total, partial) and ventilation (in the room / under slated floor) on cumulated N-$NH_3$ emission




Dourmad et al., 2012

## Predicted effects of season, slatted floor (total, partial) and ventilation (in the room / under slatted floor) on $NH_3$ concentration in the room




Dourmad et al., 2012

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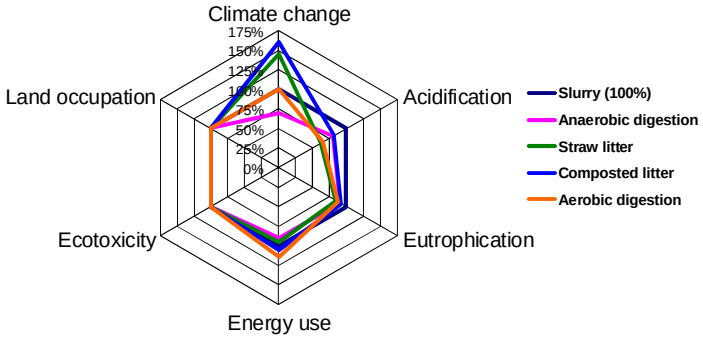
  - **Nutritional approaches**
  - **Comparison of production system**

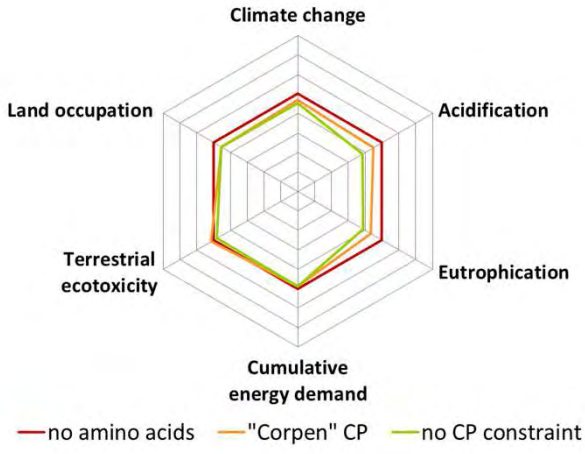
## Effect of strategy of manure management on environmental impacts evaluated using Life Cycle Analysis




Meda et al., 2008

## Effect of feeding strategy on environmental impacts evaluated using Life Cycle Analysis -

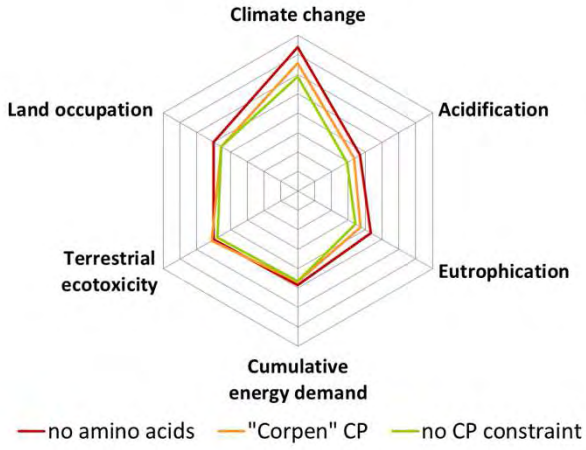
**Slatted floor - Liquid slurry**



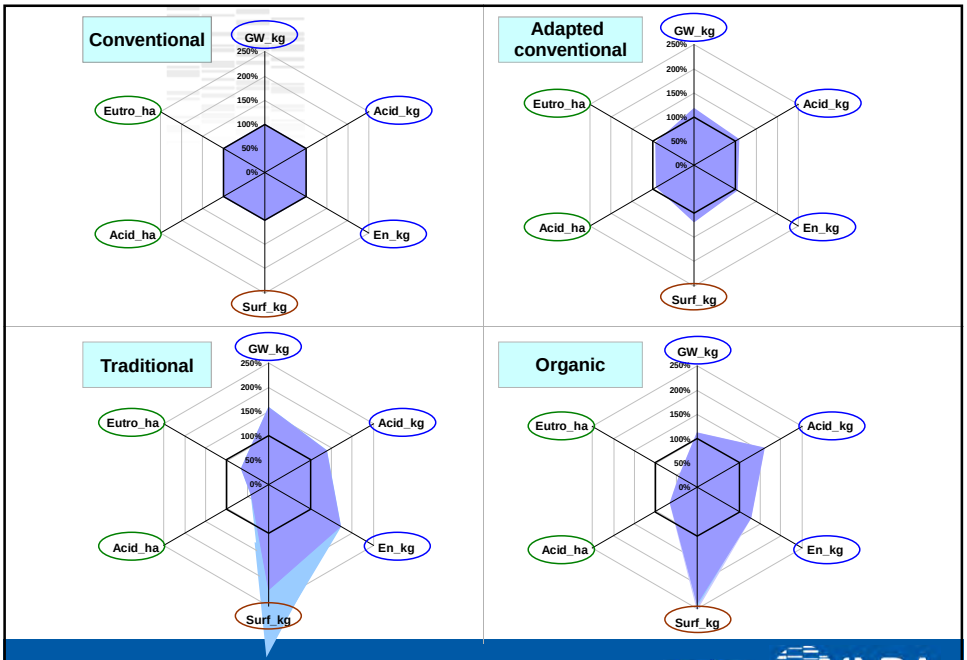

Garcia-Launay et al., 2013

## Effect of feeding strategy on environmental impacts evaluated using Life Cycle Analysis -

**Litter bedding - Solid manure**




Garcia-Launay et al., 2013




Comparison of systems (EU – Q-PorkChains)
Dourmad et al., 2014