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## Selection for feed efficiency as a tool to improve sustainability of poultry production

Sandrine Grasteau, Agnès Narcy, Bertrand Méda, Michel Lessire, Nabeel Alnahhas, Cécile Arnould, Anne-Christine Lalmanach, Pascale Quéré, Fabien Brossier, Nathalie Meme, et al.

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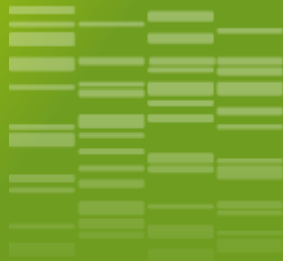
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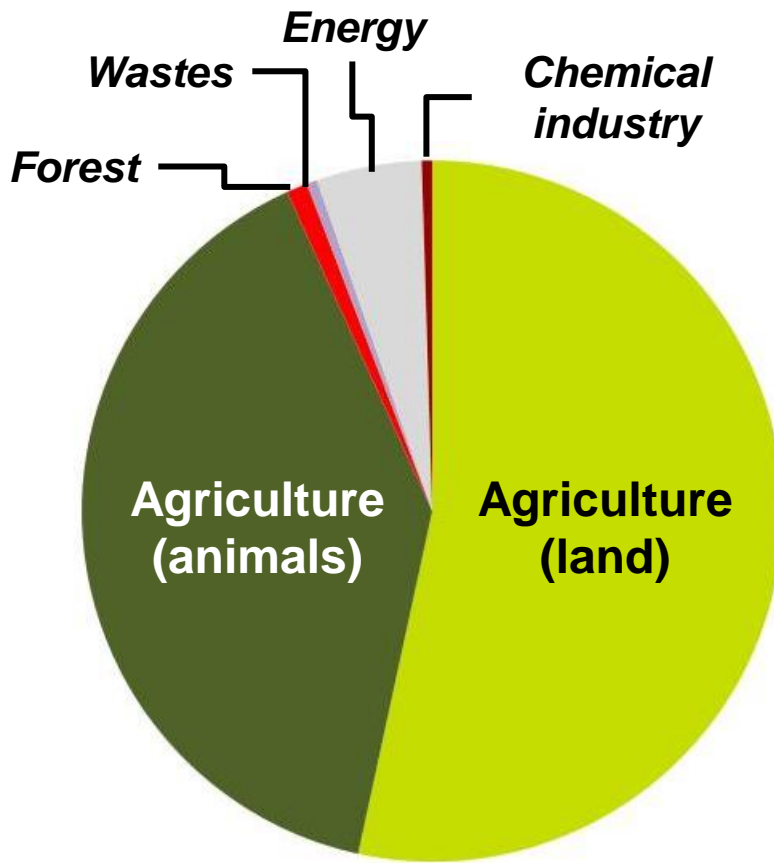
## **Selection for feed efficiency as a tool to improve sustainability of poultry production**

**S. Mignon-Grasteau, A. Narcy, B. Méda, M. Lessire, N. Alnahhas, C. Arnould, A.C. Lalmanach, P. Quéré, F. Brossier, N. Même, L. Sedano, A. Niepceron, H. Marty, N. Chanteloup, A. Trottereau, Y. Le Vern, N. Lallier, J.M. Brigant, O. Callut, E. Guitton, P. Cousin, B. Campone, S. Lavillatte, M. Hassouna, and C. Schouler**

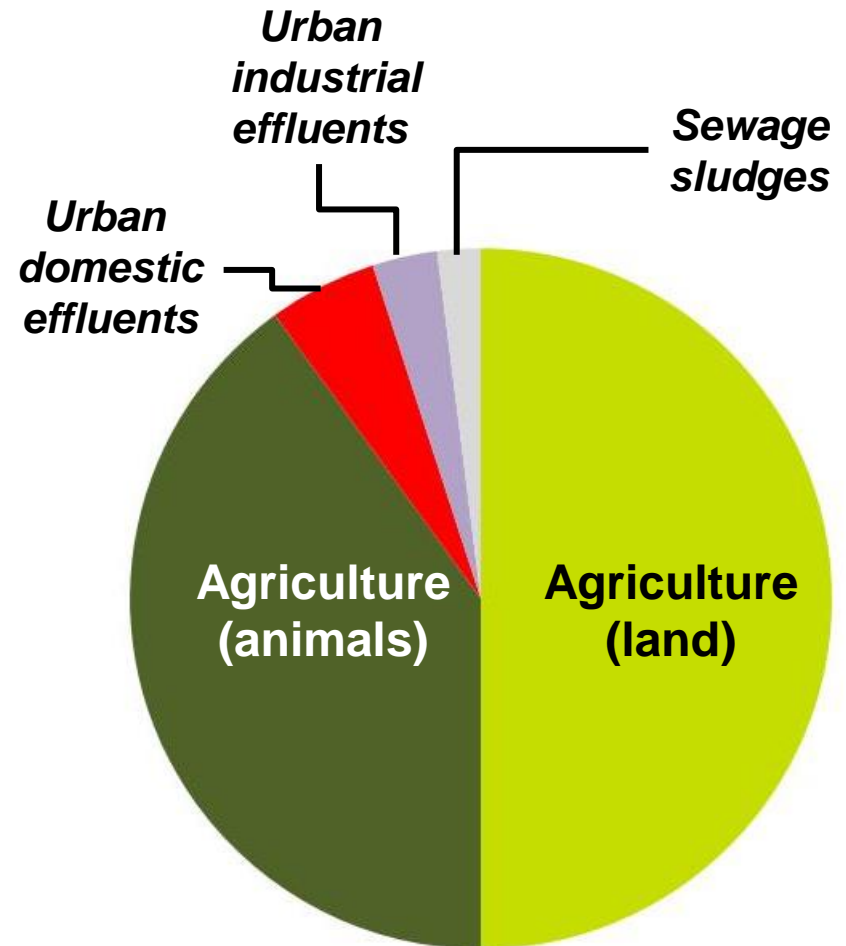


# Animals represent 50% of human activities emissions

## NH3 emissions



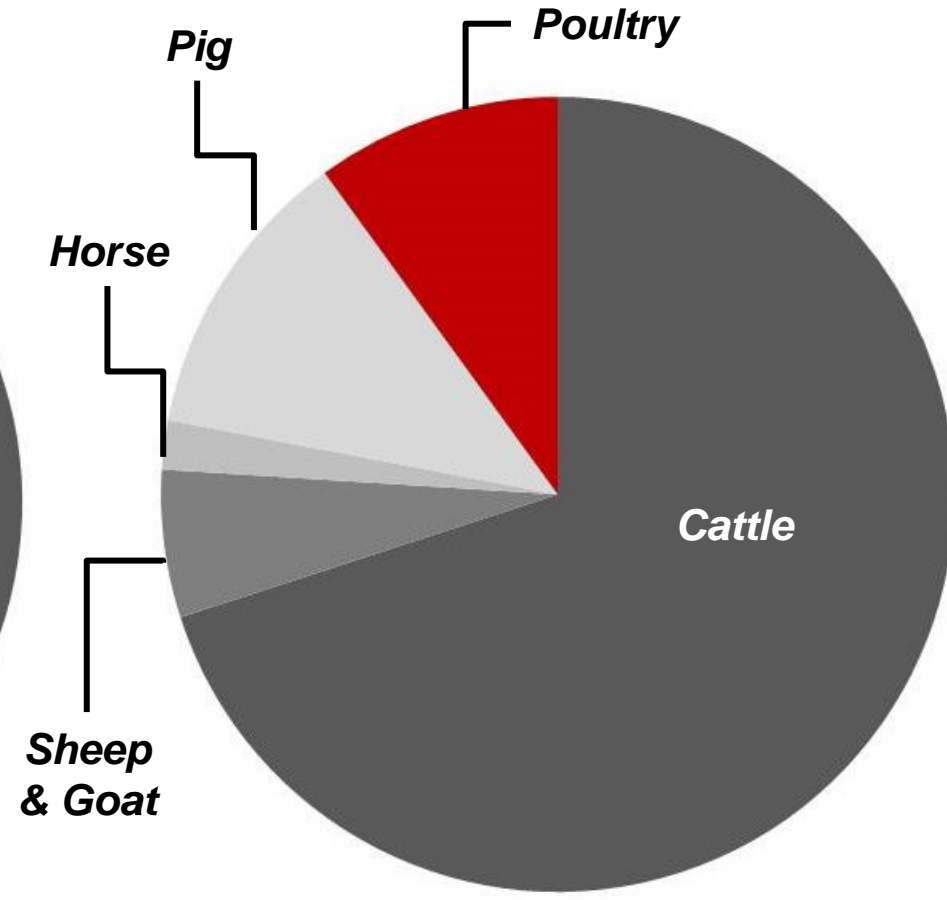
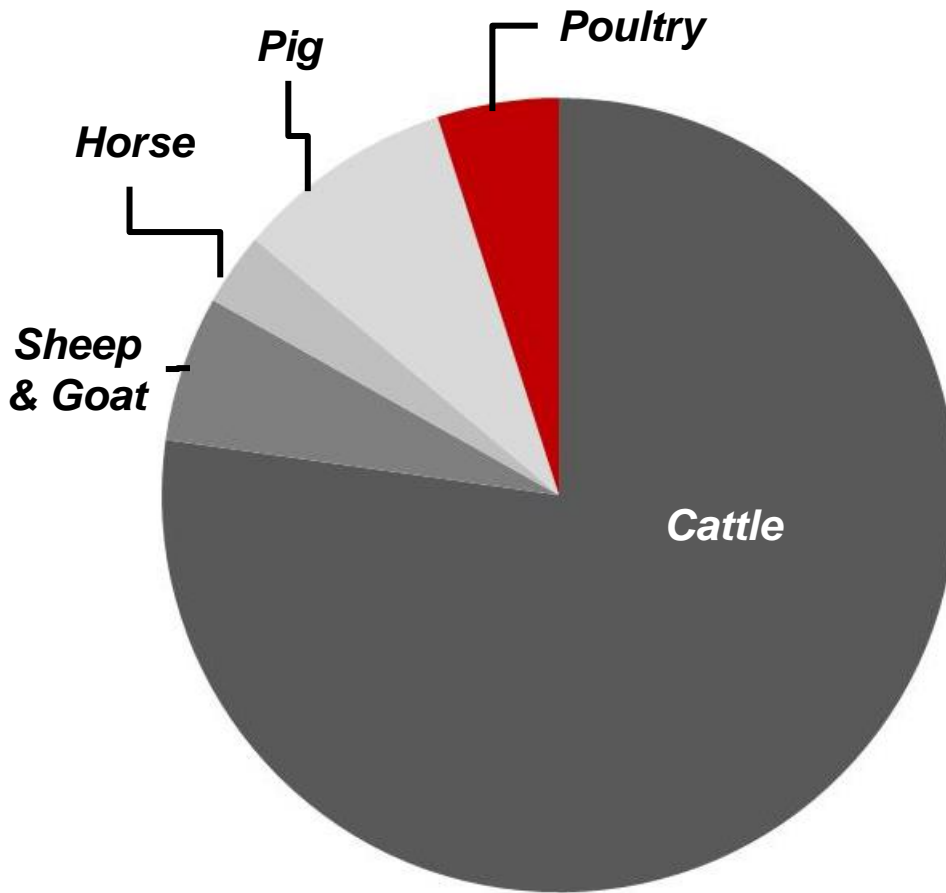
## Phosphorus emissions



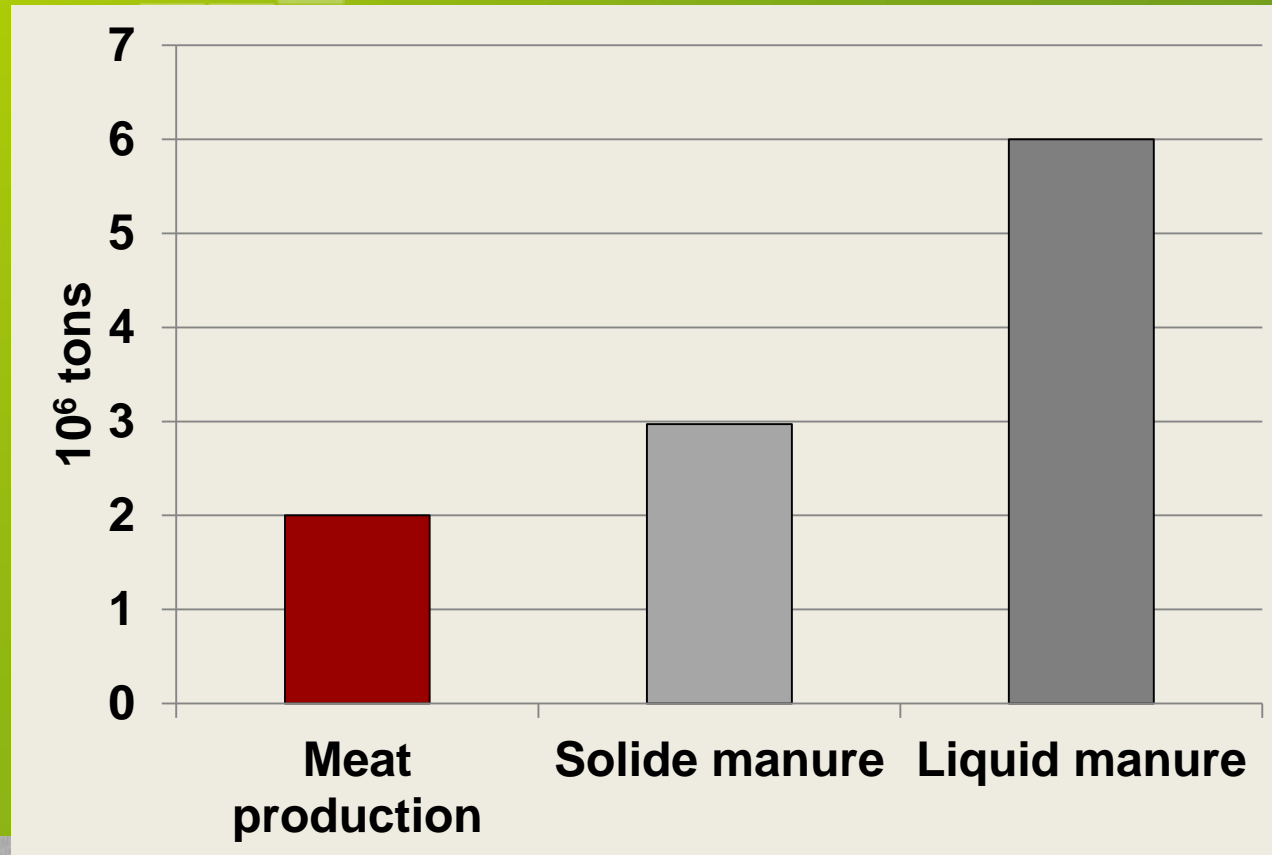
# Poultry represent 5-10% of animal emissions

NH3 emissions

Phosphorus emissions



# Situation in 2005, in France



# Situation in 2005, in Europe

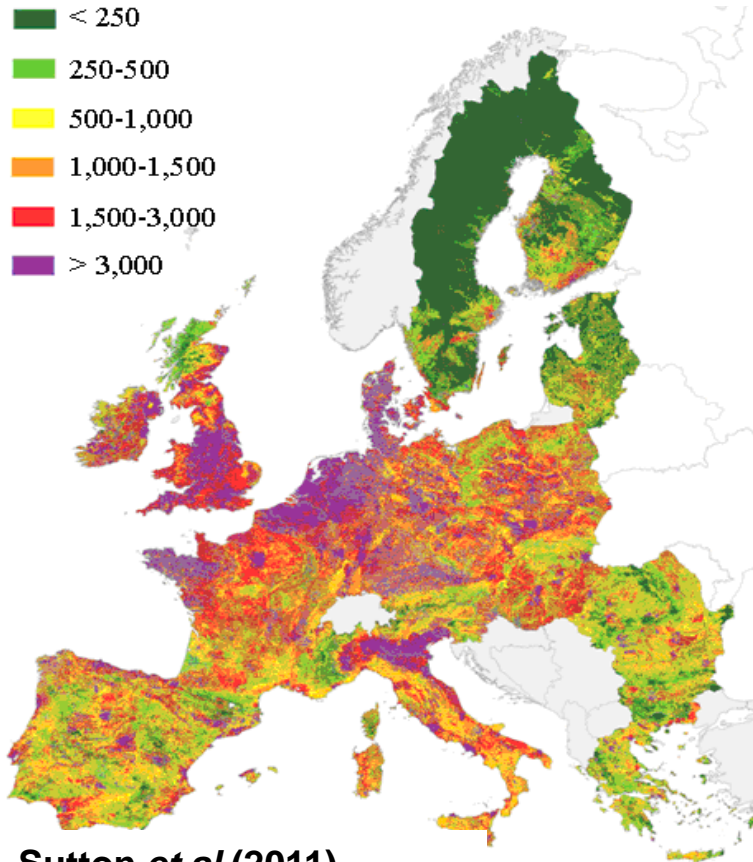
Zones of poultry production  $\neq$  Zones of cereals production



Large impact of poultry manure in specific regions in Europe

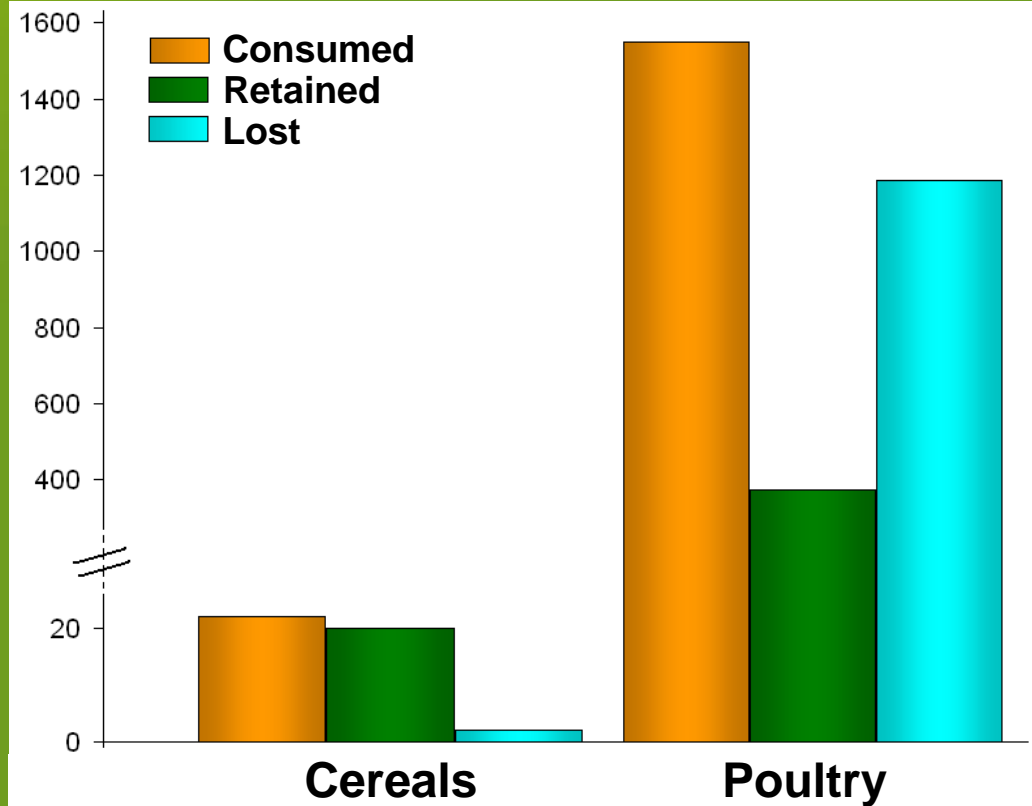
## Total nitrogen emissions in the air (kg N.km<sup>-2</sup>.year<sup>-1</sup>)

- < 250
- 250-500
- 500-1,000
- 1,000-1,500
- 1,500-3,000
- > 3,000



Sutton *et al* (2011)

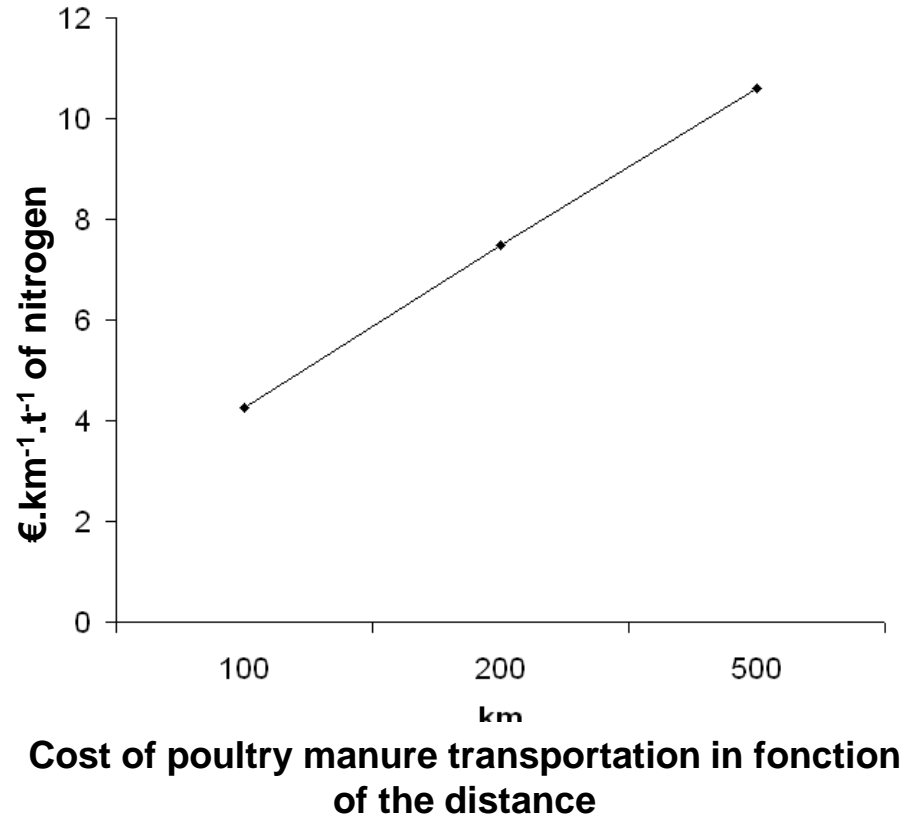
## Phosphorus (kg.ha<sup>-1</sup>.year<sup>-1</sup>)



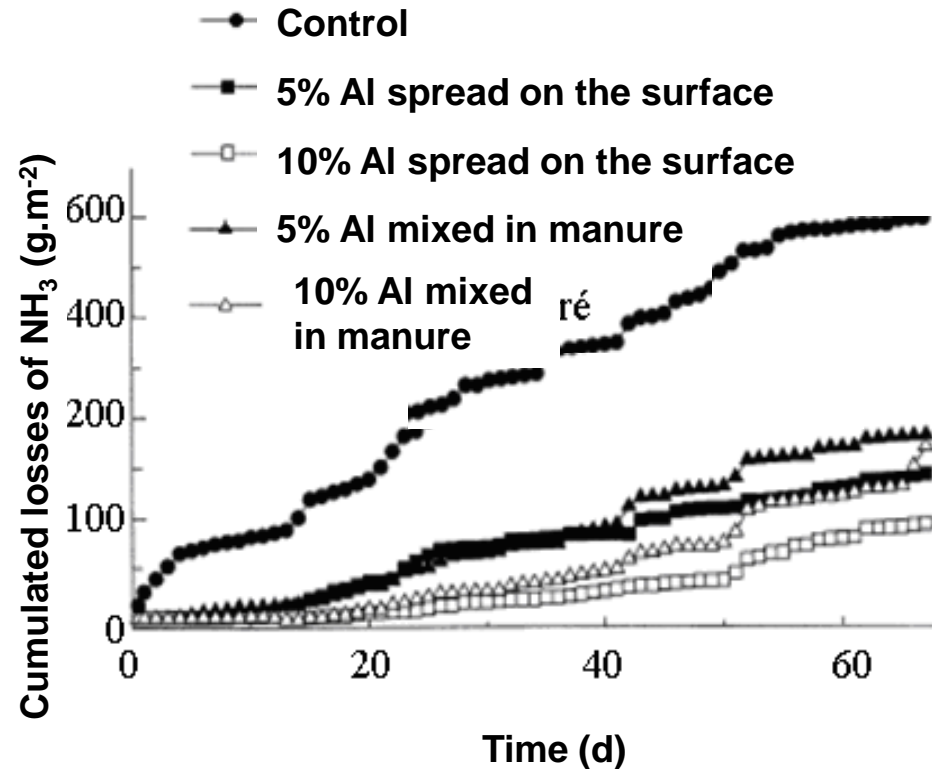
Sharpley *et al* (1999)

# How can we reduce environmental impact on production: post-excretion treatment

## Transportation

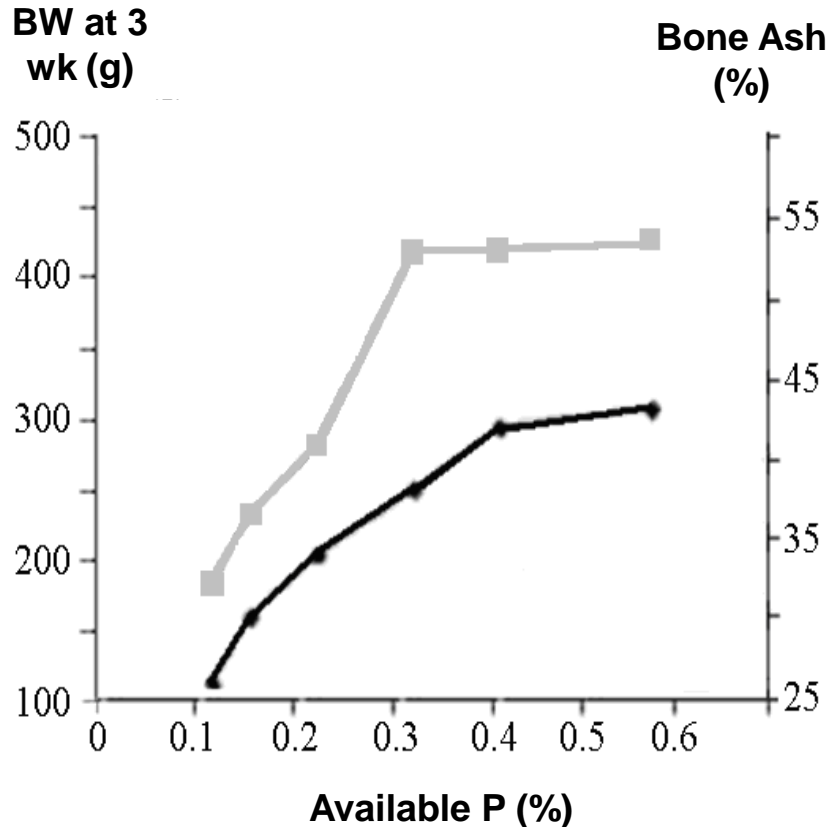


## Post-excretion treatment

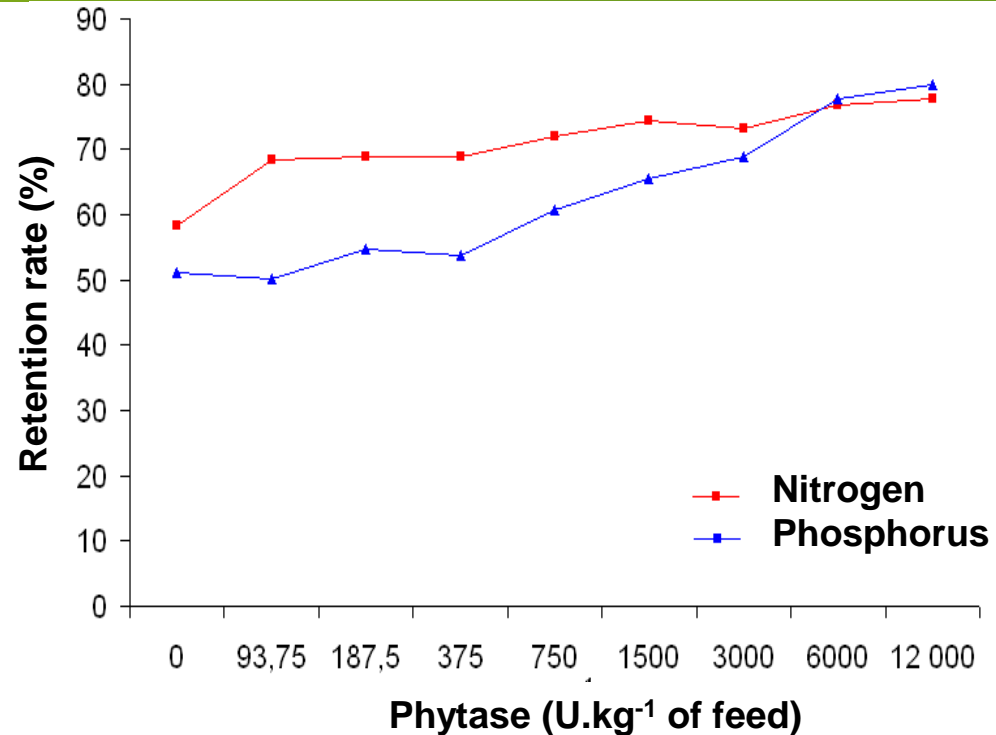


# How can we reduce environmental impact on production: nutrition

## Adequation of diets to needs

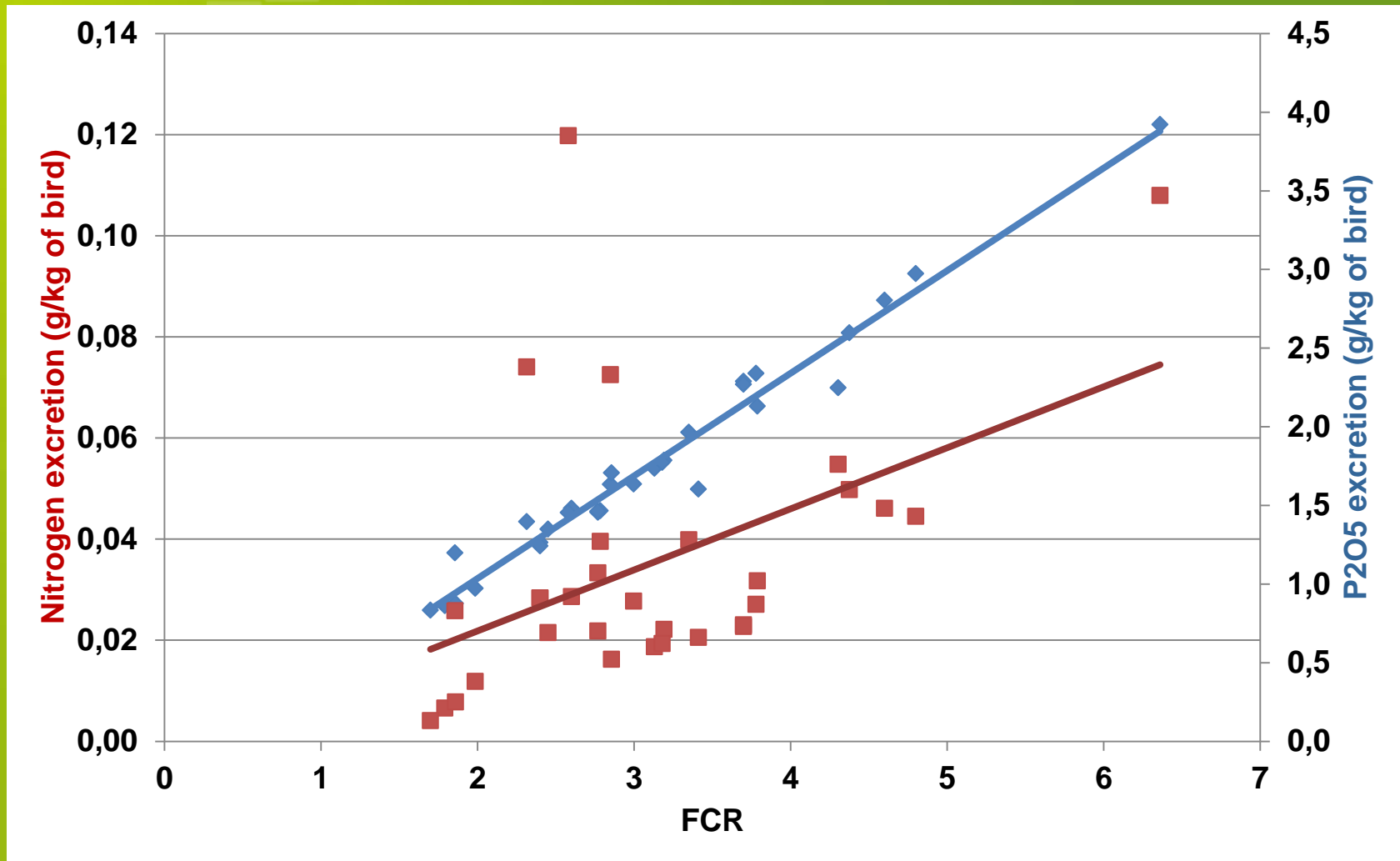


## Addition of additives





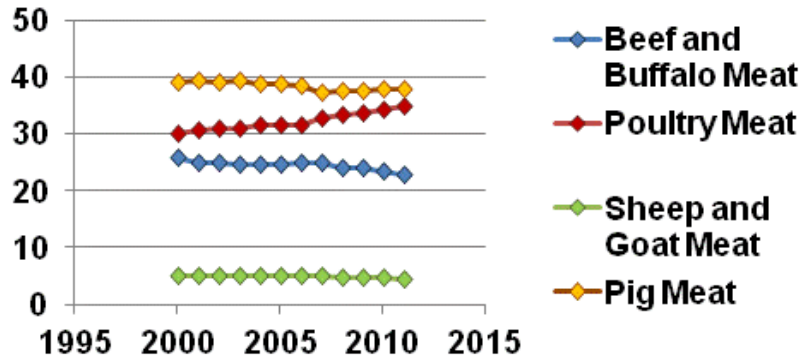
# How can we reduce environmental impact on production: genetics



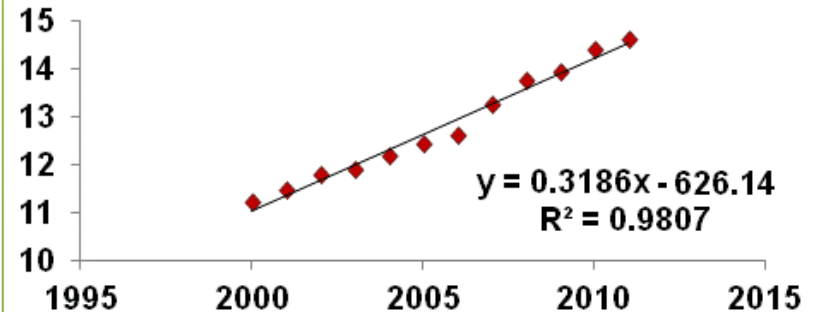
Relationship between FCR and nitrogen and phosphorus excretion in different types of poultry production (CORPEN, 2006)

# Increased needs for poultry meat

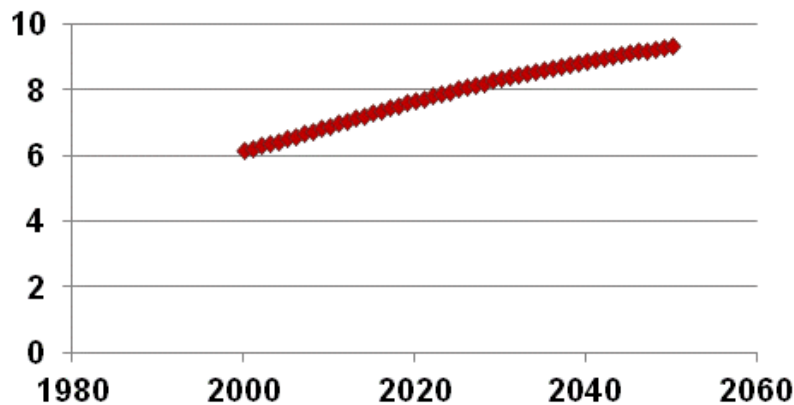
Proportion of each type of meat (%)



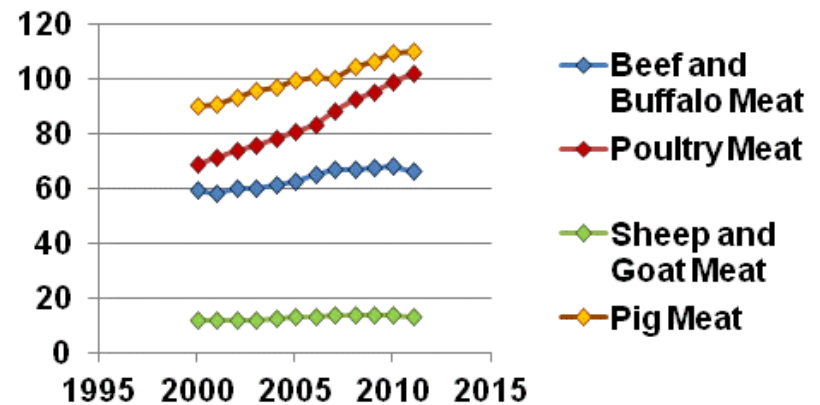
Poultry meat production/Population (kg.year<sup>-1</sup>.hab<sup>-1</sup>)



Population (in billions)

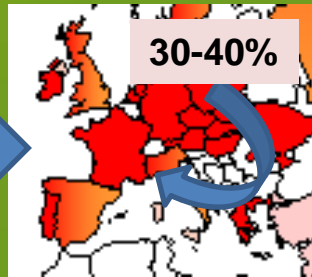
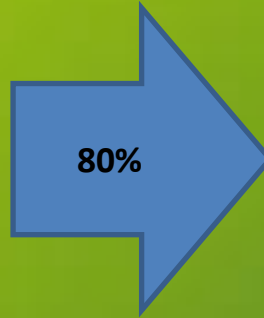


Production of meat (in 10<sup>6</sup> tons)



~100 10<sup>6</sup> t today  
~250 10<sup>6</sup> t in 2050

# Increased needs for cereals and proteins



**Increasing the digestive efficiency to include alternative feedstuffs and maintain a sustainable system**

# The D+ / D- lines selected on digestive efficiency

« Fast » growing broilers

2.0 kg at 49 d

2.4 kg at 56 d



Dwarf hens



**Commercial products**

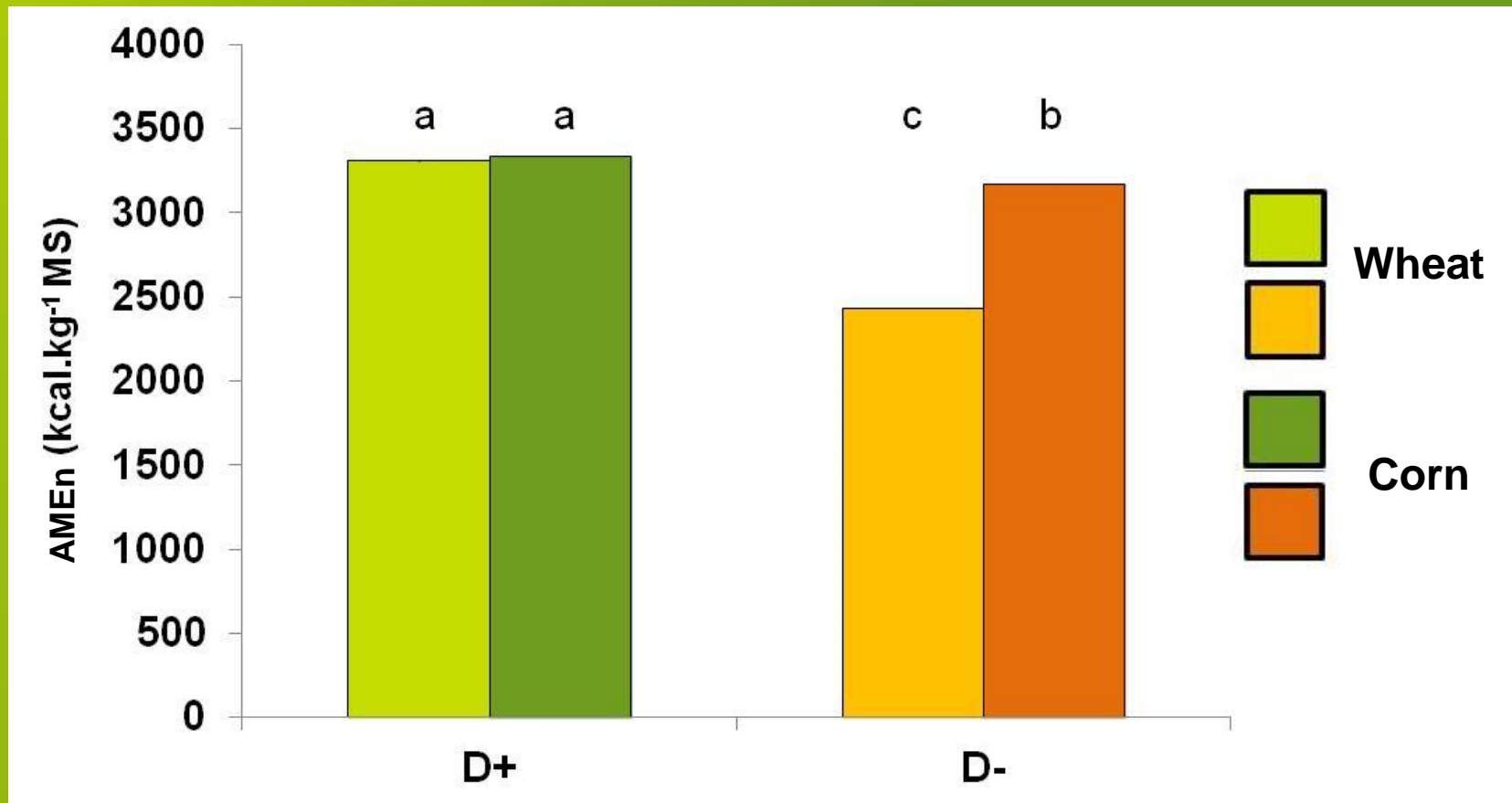
**Medium growing broilers**

**Used in certified colored production**

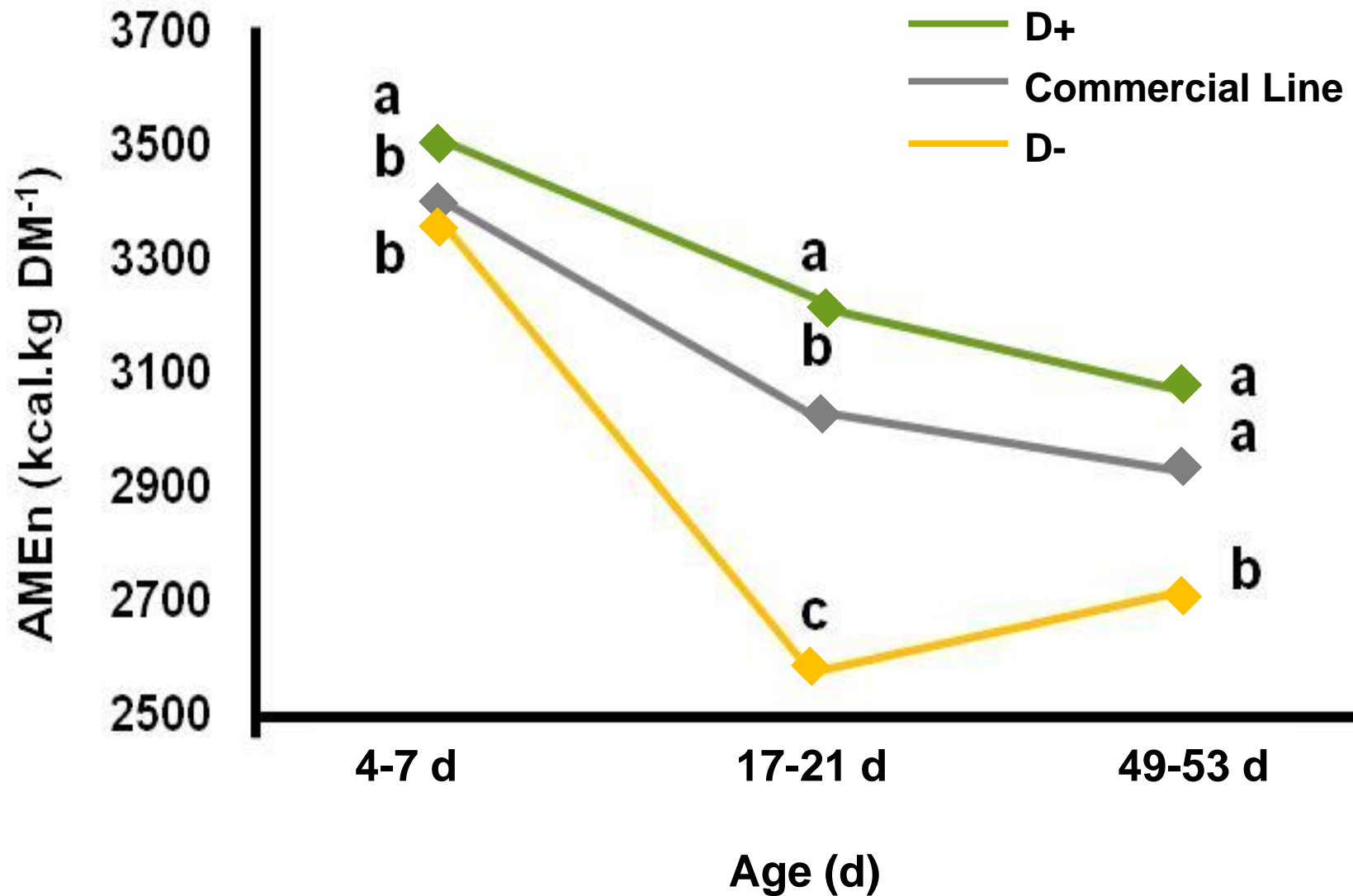
**2.2 kg at 56 d**

# The D+/D- lines selected on digestive efficiency

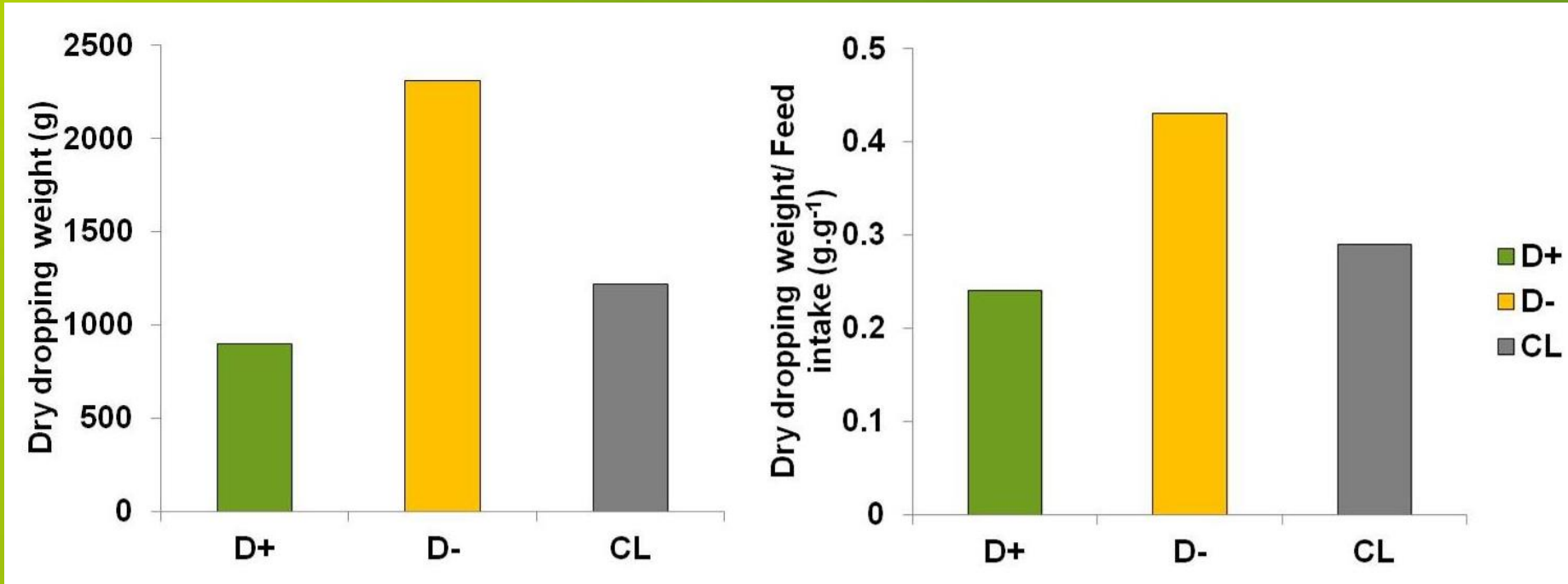
Selection during 8 generations on a Rialto wheat diet  
Criterion of selection: AMEn



# The D+ / D- lines selected on digestive efficiency

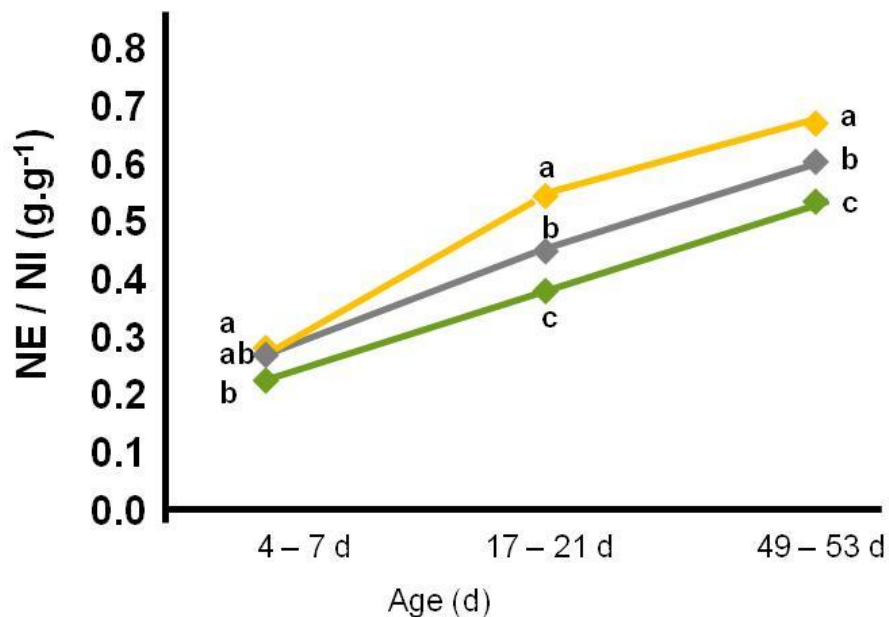


# Selection on AMEn: consequences on manure production



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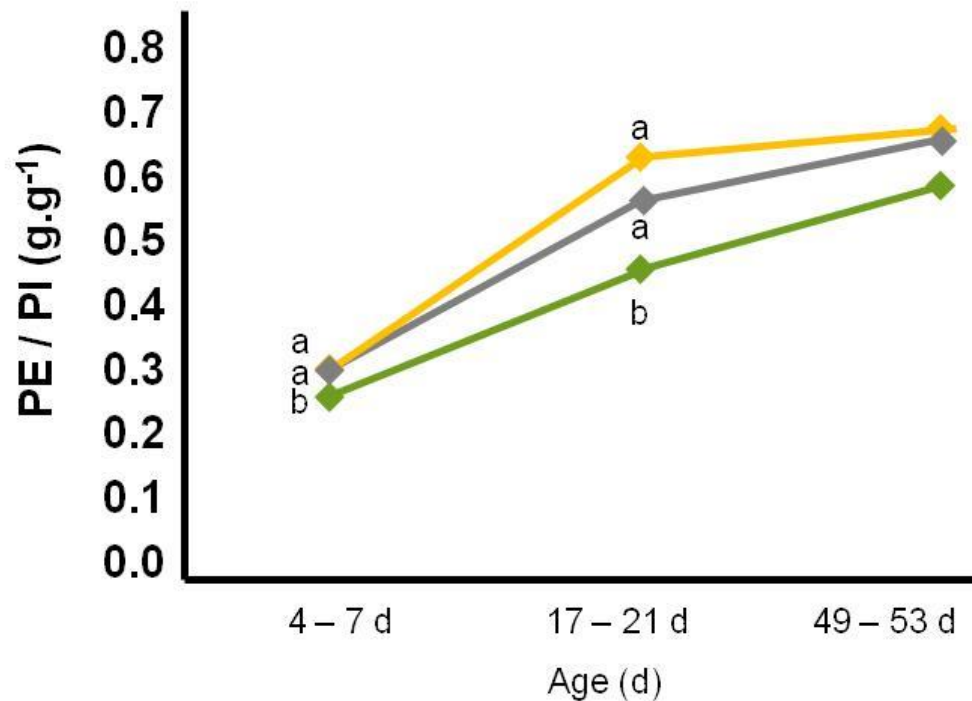
## Nitrogen (excretion/intake)



Legend:

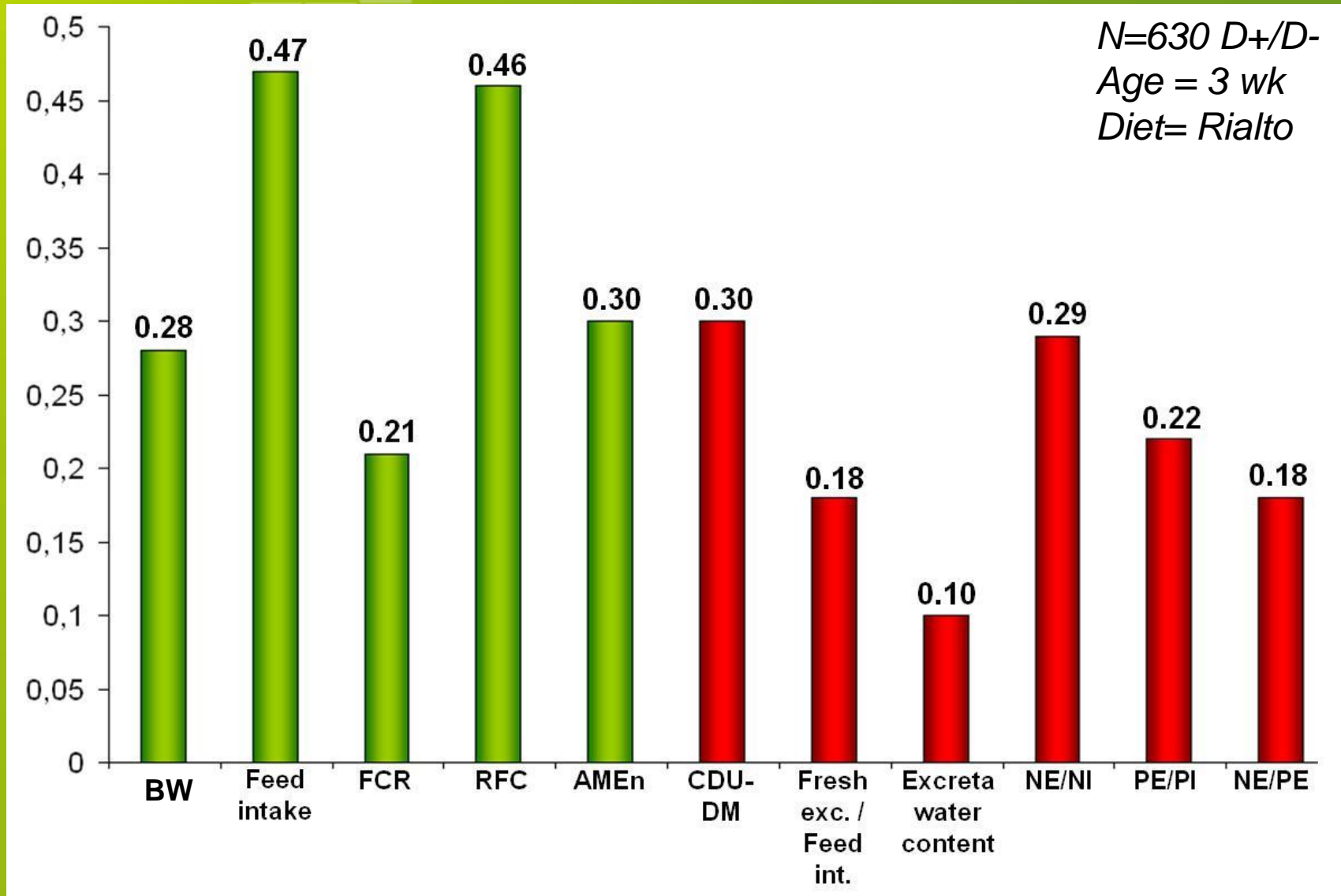
- D+ (Green line)
- Commercial Line (Grey line)
- D- (Yellow line)

## Phosphorus (excretion/intake)

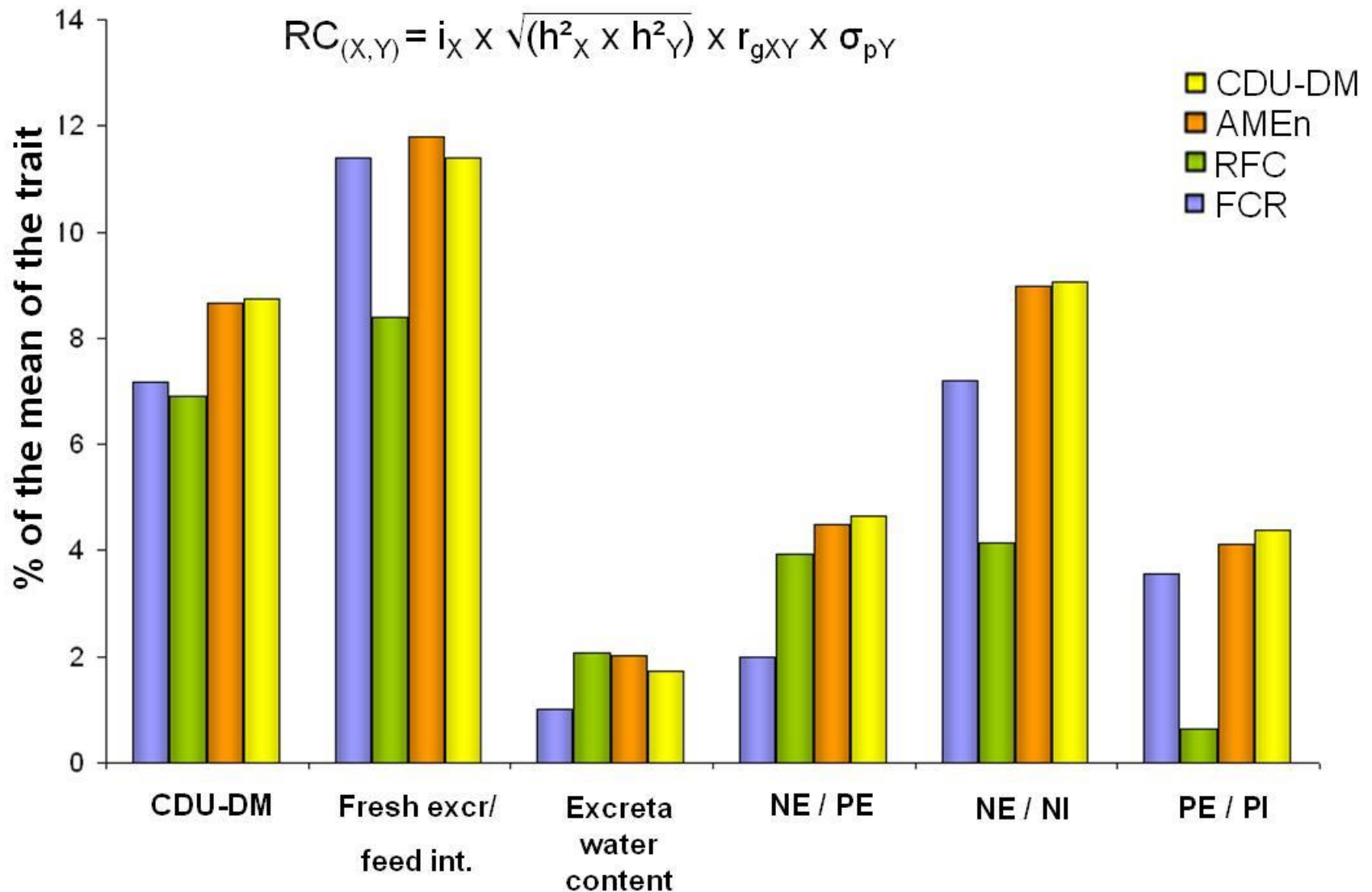




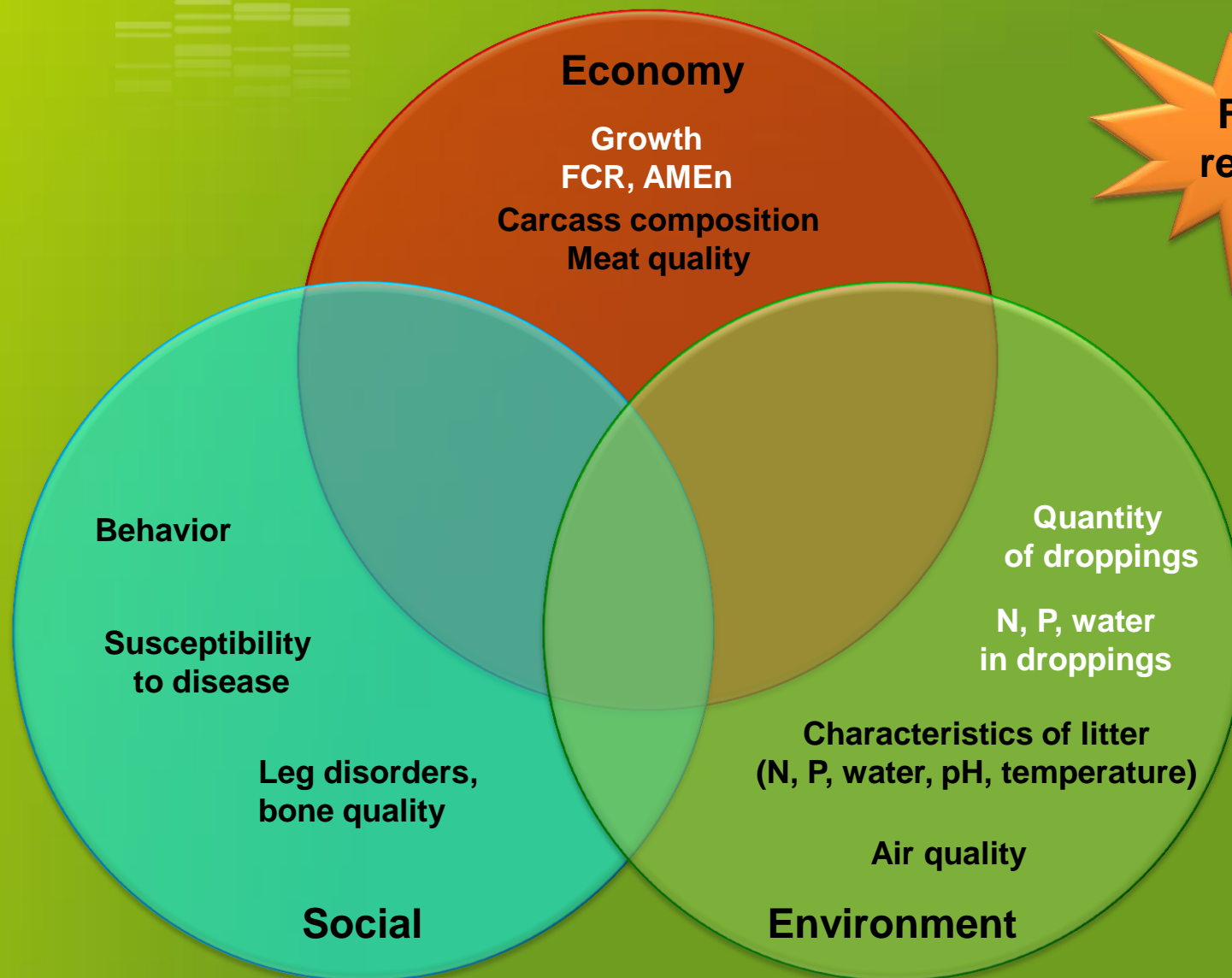
# Selection on AMEn: which traits can we select?



# Selection on AMEn: which traits can we select?



# What was still missing to assess sustainability?



# Filling the gaps

**32 pens**

**846 males and females  
D+ and D-  
On floor**

**2 diets**



## Classical diet (CD)

Corn : 61% (0-14 d); 69% (14-53 d)  
Soybean : 35% (0-14 d); 26% (14-53 d)

## Alternative diet (AD)

Rialto wheat : 54% (0-14 d); 62% (14-53 d)  
Soybean : 28% (0-14 d); 16% (14-53 d)  
Sunflower meal : 5% (0-14 d); 6% (14-53 d)  
Rapeseed cake : 6% (0-14 d); 6% (14-53 d)

# Measurements on the 3 pillars

## Economy

Growth: BW0, 1, 2, ..., 8 wk

Efficiency:

- FCR: weekly by pen
- Dig. Phosphorus (3, 7 wk)

Body composition:

- Abdominal and breast yield (8 wk)
- Gizzard, Intestine yield (8 wk)

Meat quality:

- L, a\*, b\* of the breast (8 wk)
- pH of the breast (8 wk)

## Social

Behavior: Scan sampling (1, 3, 5, 7 wk):

- eating, drinking, walking,
- standing, laying down

Leg quality:

- Pododermatitis, breast blisters, tibia burns (1, 3, 5, 7 wk)
- Tibia yield, ash % of the tibia (3, 7 wk)

Susceptibility to disease (3 wk):

- E. coli (bacteraemia, lesion score)
- Susceptibility to E. tenella (growth, lesion score)
- Genes of the immune system (IFN $\gamma$ , IL6, IL1 $\beta$ )

## Environment

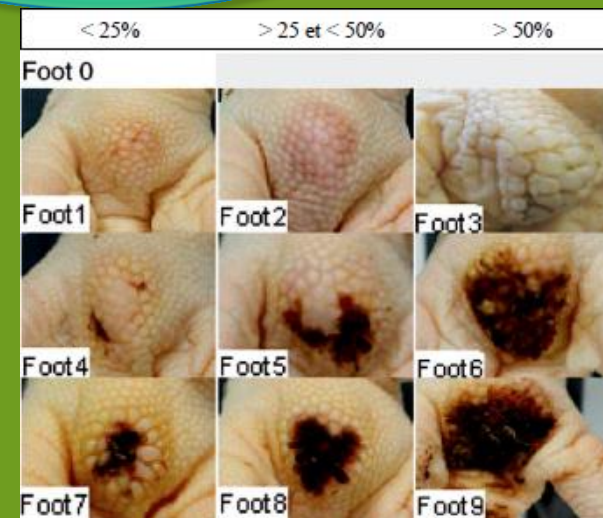
Litter quantity (8 wk)

Litter characteristics (1, 3, 5, 8 wk):

- pH, temperature (surface+deep), humidity
- Nitrogen, ammonia, phosphorus content

Air quality (1, 3, 7 wk):

- NH<sub>3</sub>
- N<sub>2</sub>O
- CO<sub>2</sub>



# Analyses

## Analyses of variance trait by trait:

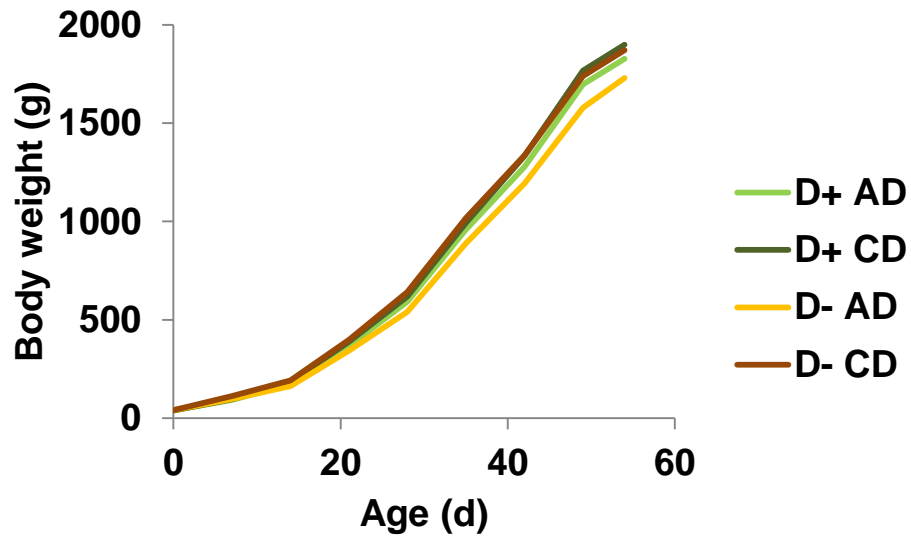
- All traits: line, diet, linexdiet interaction
- Depending on trait: sex, weight, observer

## Multifactorial analyses:

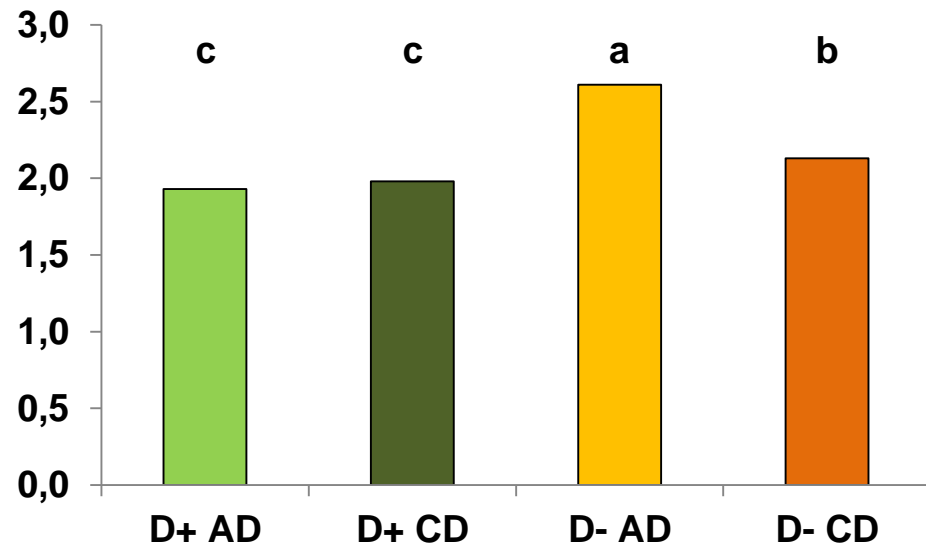
- 1 analysis by pillar on a selection of traits
- Done at the pen level
- Means of individual values (body weight, digestibility, ...)
- Value of the pen (FCR, litter quality)
- Each trait was cut in 2 categories (high-low) with equal frequencies
- SPAD7.0 software

# Results (economy)

## Growth

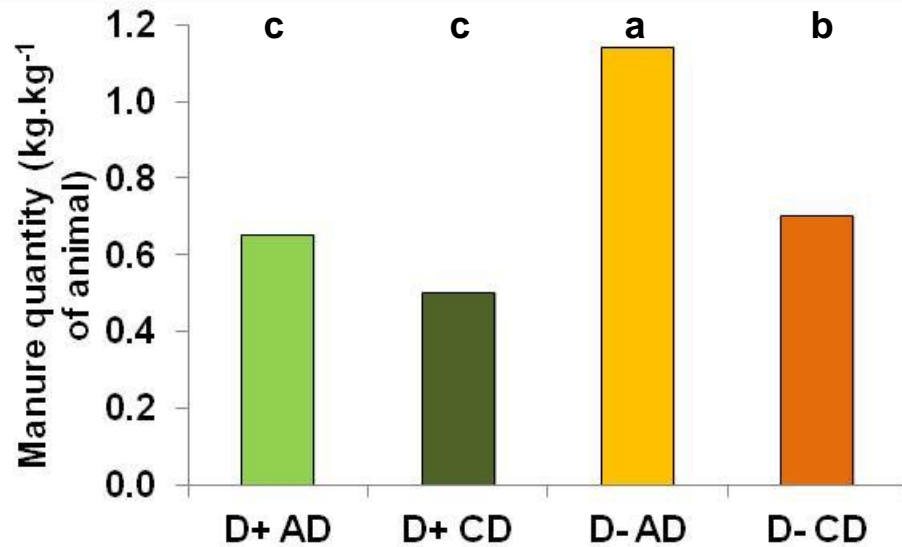


## FCR (0-8 wk)

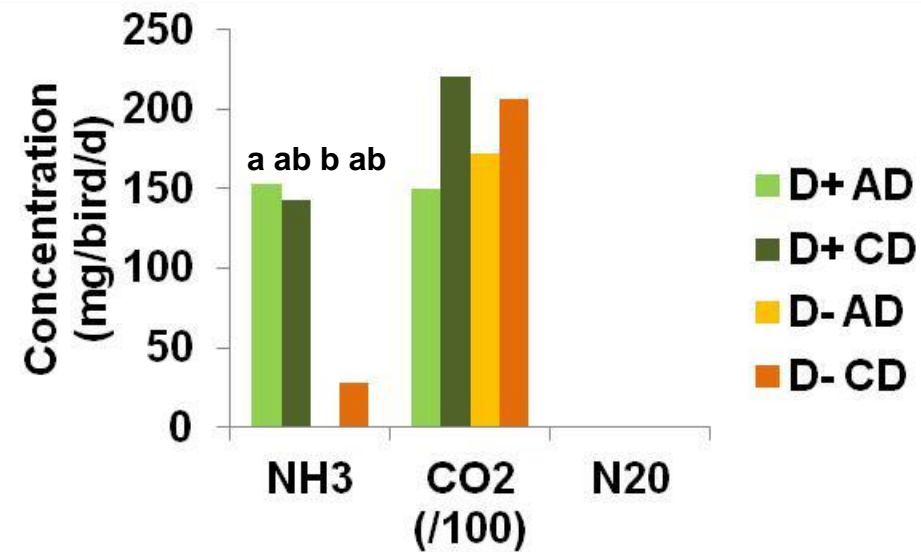


# Results (environment)

## Manure quantity



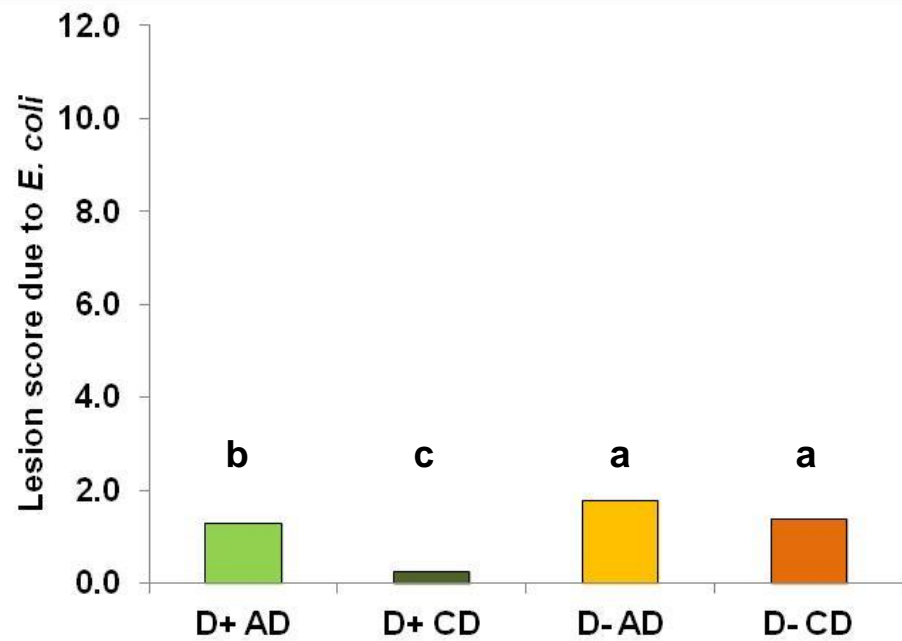
## Air quality



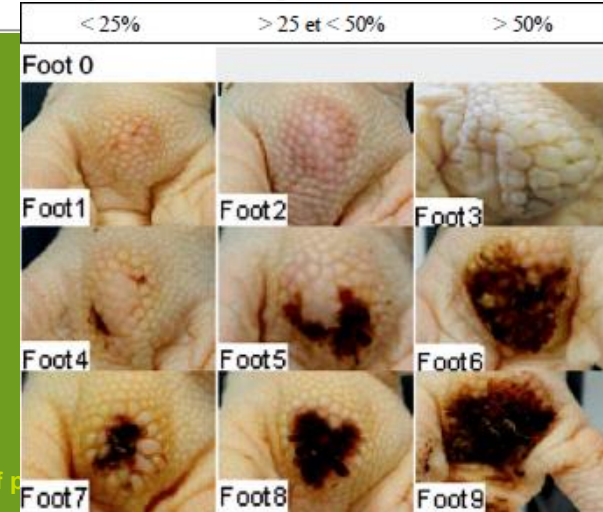
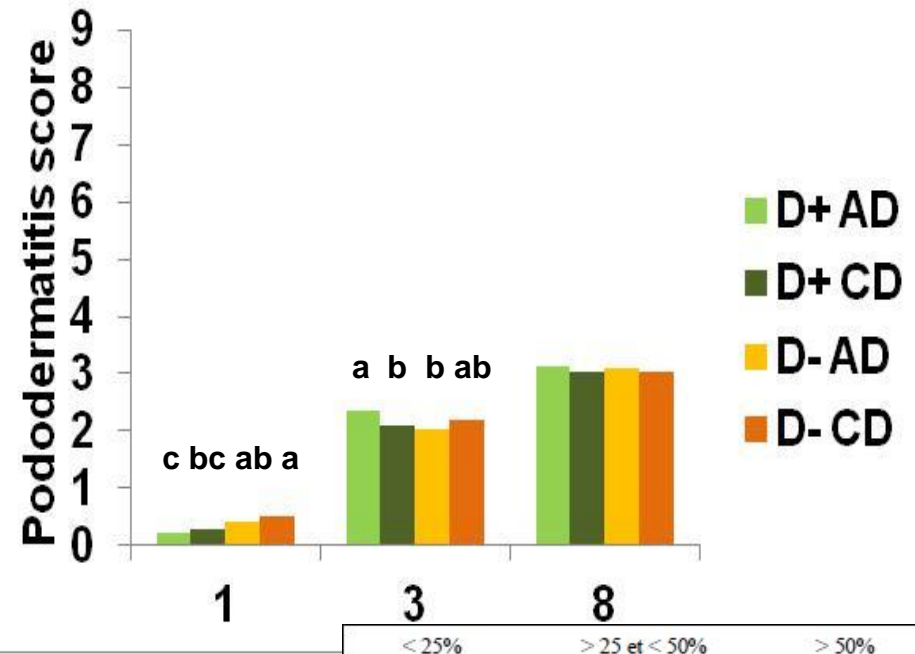


# Results (social)

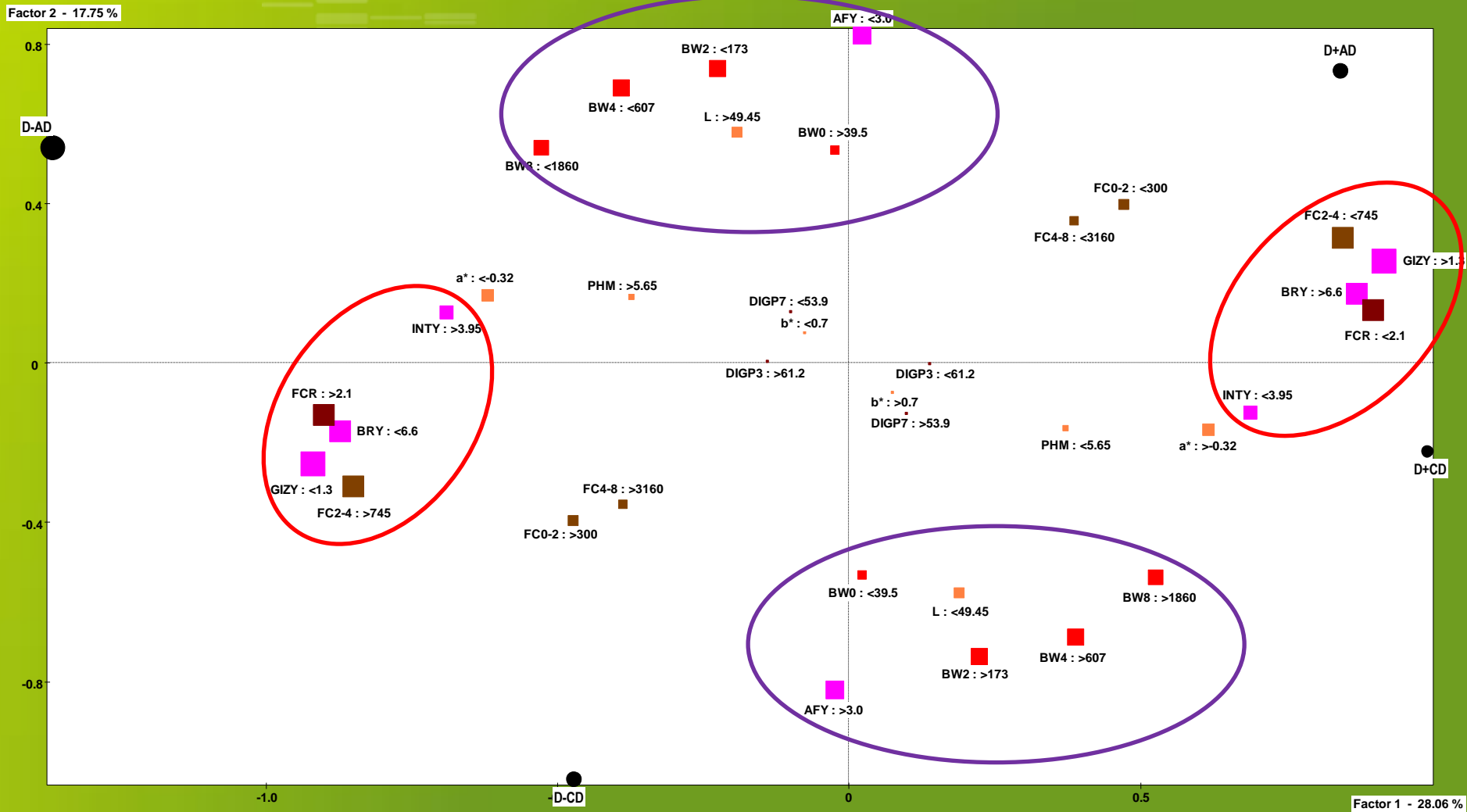
## Susceptibility to *E. coli*



## Pododermatitis score

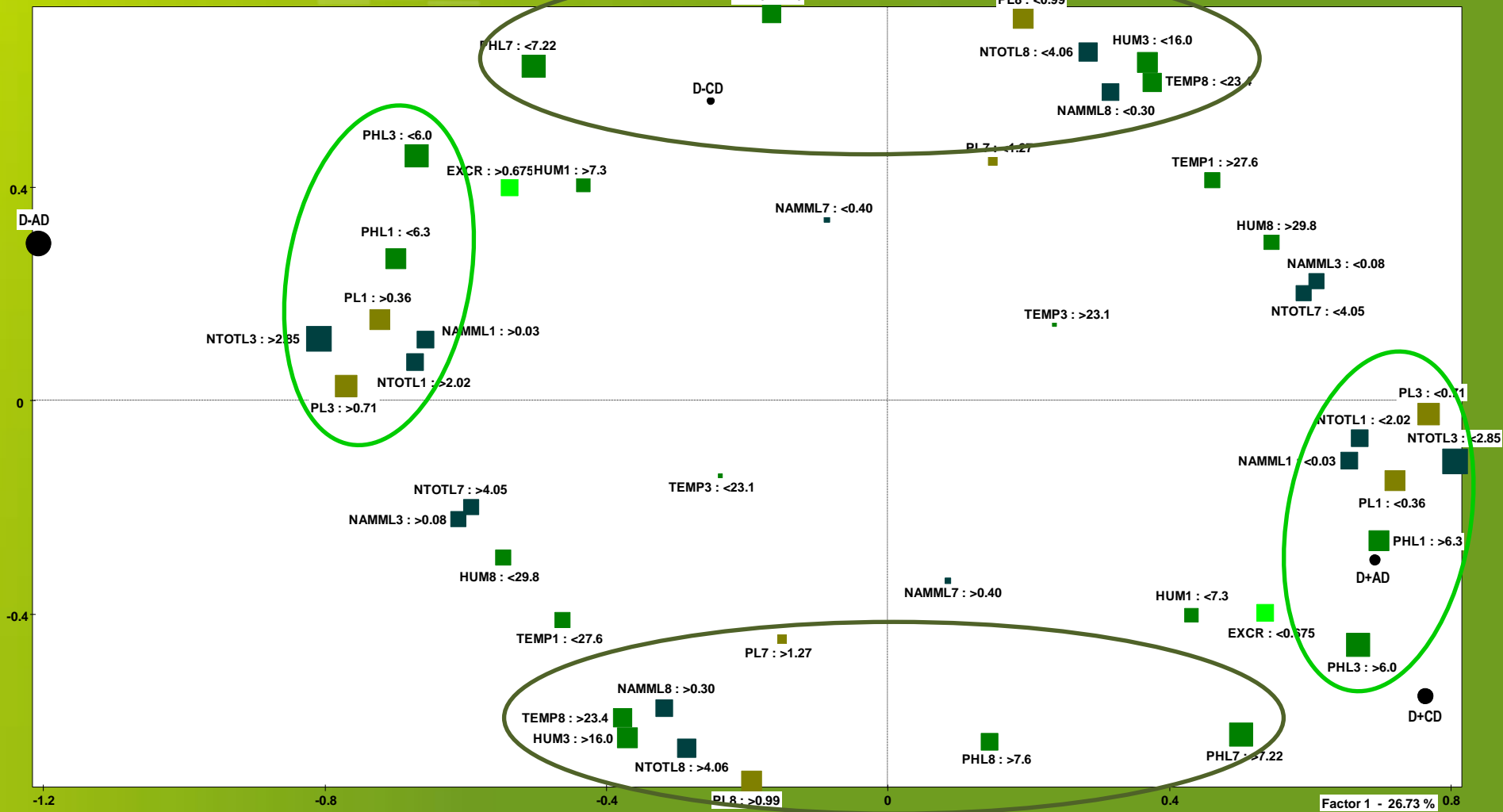


# Multifactorial Analyses: economy



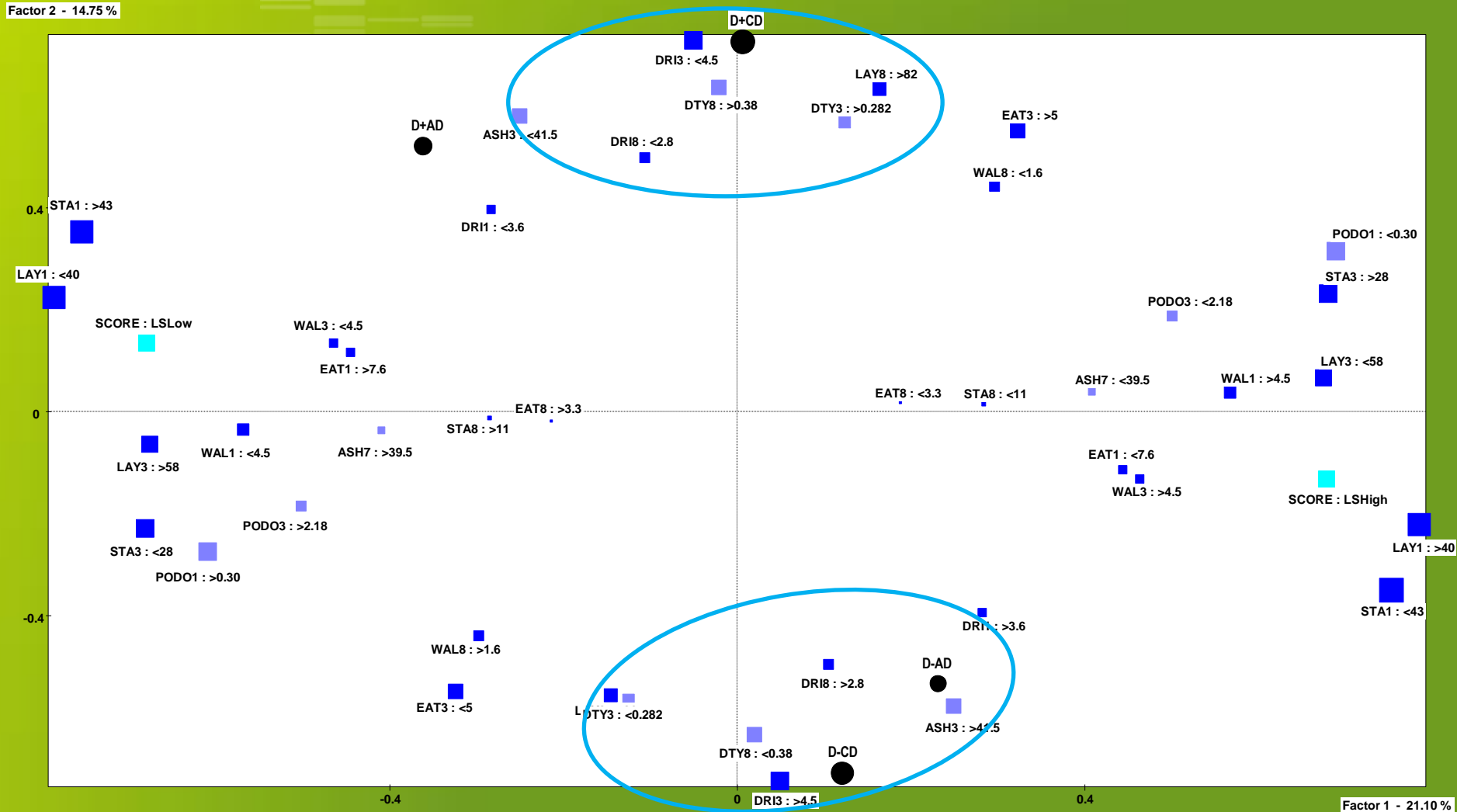
# Multifactorial Analyses: environmental

Factor 2 - 18.39 %



Factor 1 - 26.73 %

# Multifactorial Analyses: social



# Conclusions

**Criteria as CDUDM or NE/NI can be selected**

**Selection on CDUDM or AMEn more efficient than on RFC or FCR for environmental purposes**

**Selection for digestive efficiency**

- Improves economic performances
- Improves environmental performances
- Does not modify or slightly improve social performances

**Birds with improved digestive efficiency are less susceptible to diet change**