Modelling as a tool to improve understanding of complex systems: Examples from Meat quality, Meat Safety and Animal Welfare

Karel de Greef et al.

QPC Module VI (modelling and meta-analysis)

&

Livestock Research of Wageningen UR

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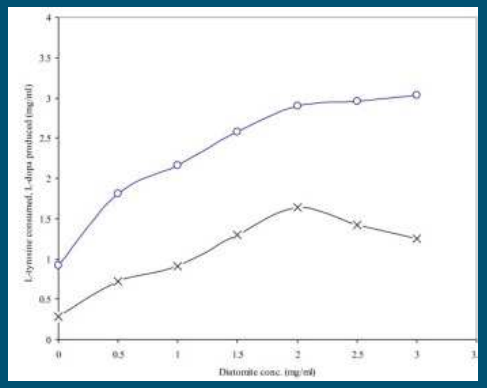
Modelling and Meta-anaysis

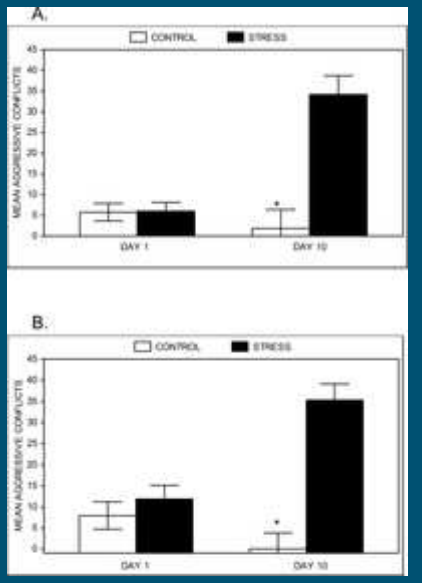
- Modelling: integrating existing data or knowledge into a ‘representation of the real world’
- Meta-analysis: re-analysis of several studies together
- Both:
  - better use of existing information
  - Helps in conceptual thinking

Two types of questions

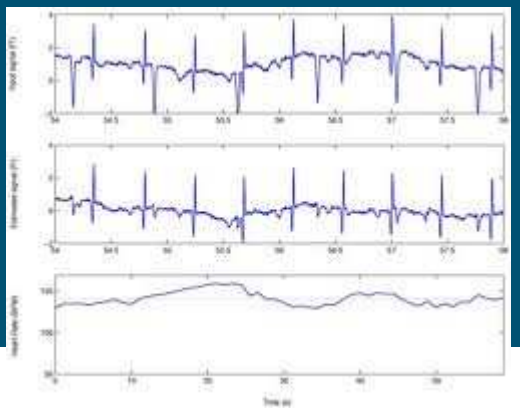
- What happens if .... (cause and effect)

  = The effect of x on y





- What's happening? (descriptive)



Modelling and Meta-anaysis

Applied on three themes

- Meat Quality
- Meat Safety
- Animal Welfare

Today: not “a full overview of the results”

but “an illustration of added value of Modelling & Meta-analysis”

Demo that Meta-analysis and Modelling have added value

Major contributors

- *Pre-thinking & module-building:* Claudia Terlouw
- *Meat Quality:* Andrea Wilson; Lutz Bunger; Laszlo Trefan; Catherine Larzul, Btissam Salmi
- *Meat Safety* Declan Bolton, Claire Ivory, Francis Butler, Ilias Soumpasis
- *Animal Welfare*
- Karel de Greef, Marie-Christine Salaun, Ludovic Brossard, Xavi Averos, Sandra Edwards, Helen Edge, Jessica Cornelissen
- *Database and website:* Jesper Blom-Hanssen; Chris-Claudi Magnussen; Torben Kvamm

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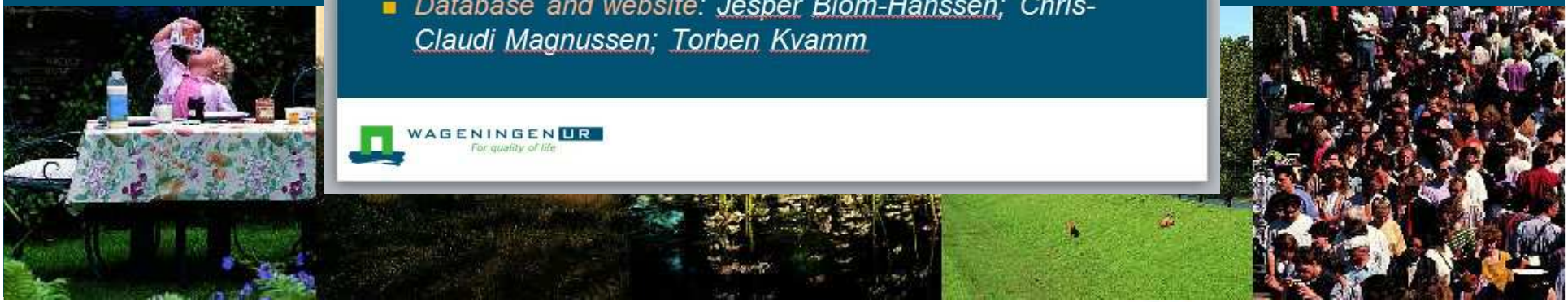

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Meat Quality

SAC and INRA (+DMRI)

Andrea Wilson; Lutz Bunger; Laszlo Trefan; Catherine Larzul, Btissam Salmi

Jesper Blom-Hanssen; Chris-Claudi Magnussen; Torben Kvamm

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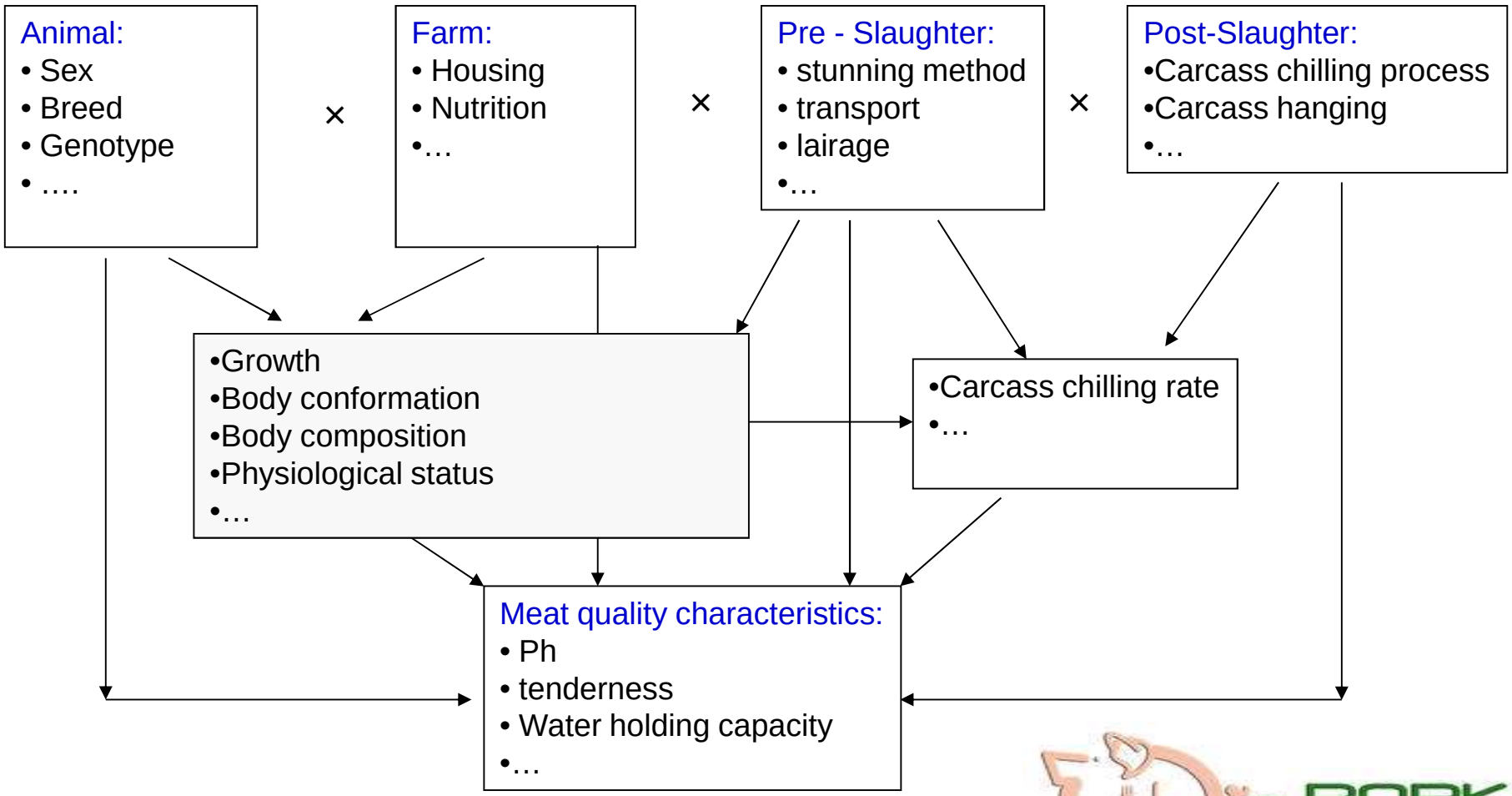
Objective: combine existing information to develop prediction models for pork quality accounting for a wide range of factors



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Input for meta-analysis: Vitamin E studies

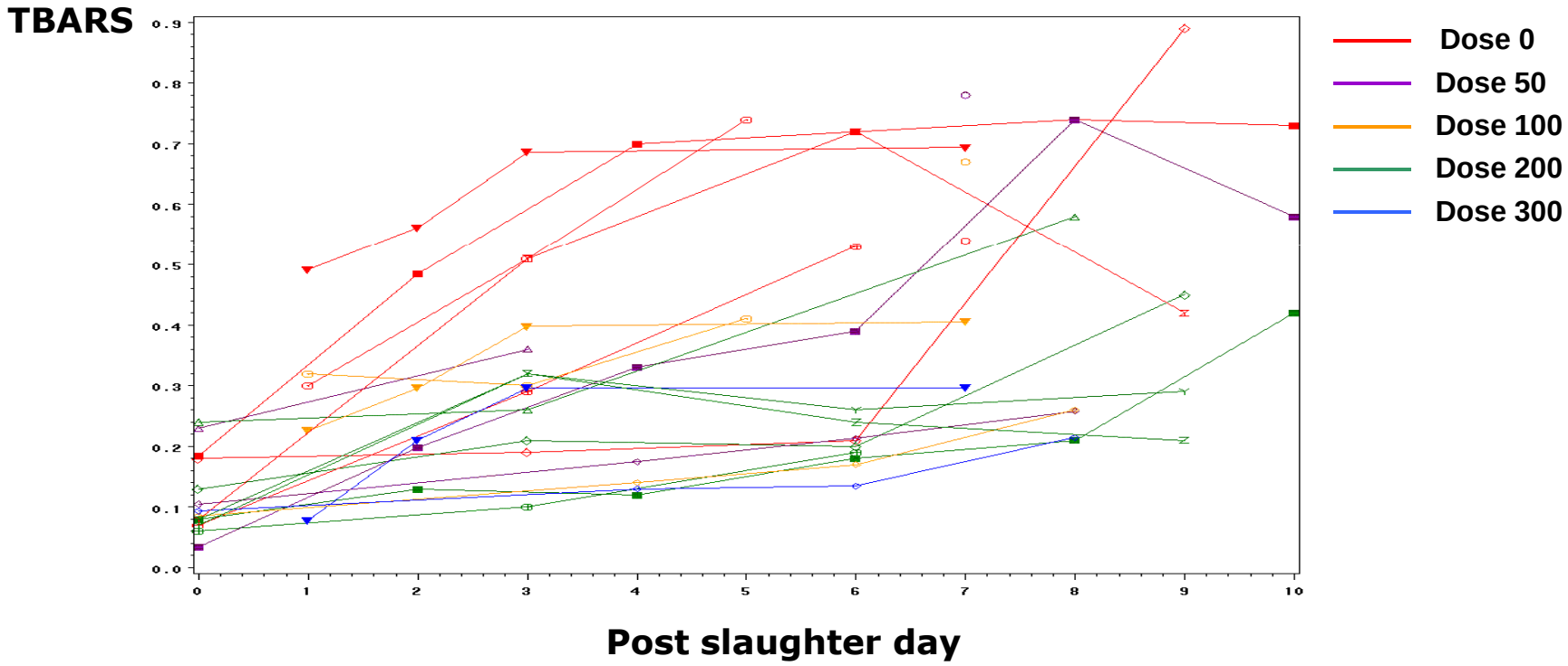

Figure1: Least square (LS) means of TBARS changes over time for various doses of vitamin E from 10 different experimen

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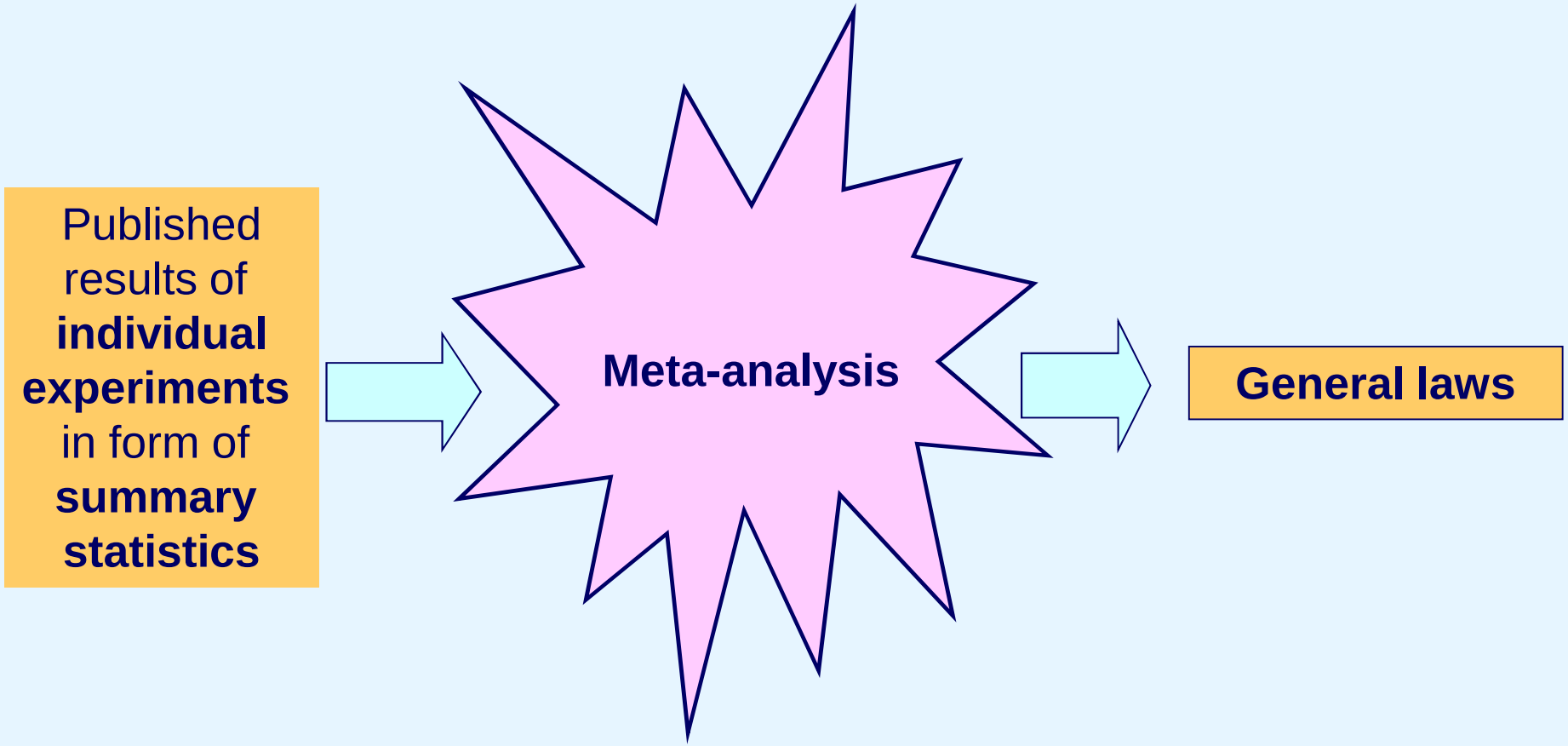
Meta-analysis (MA)



Input for meta-analysis: Vitamin E studies

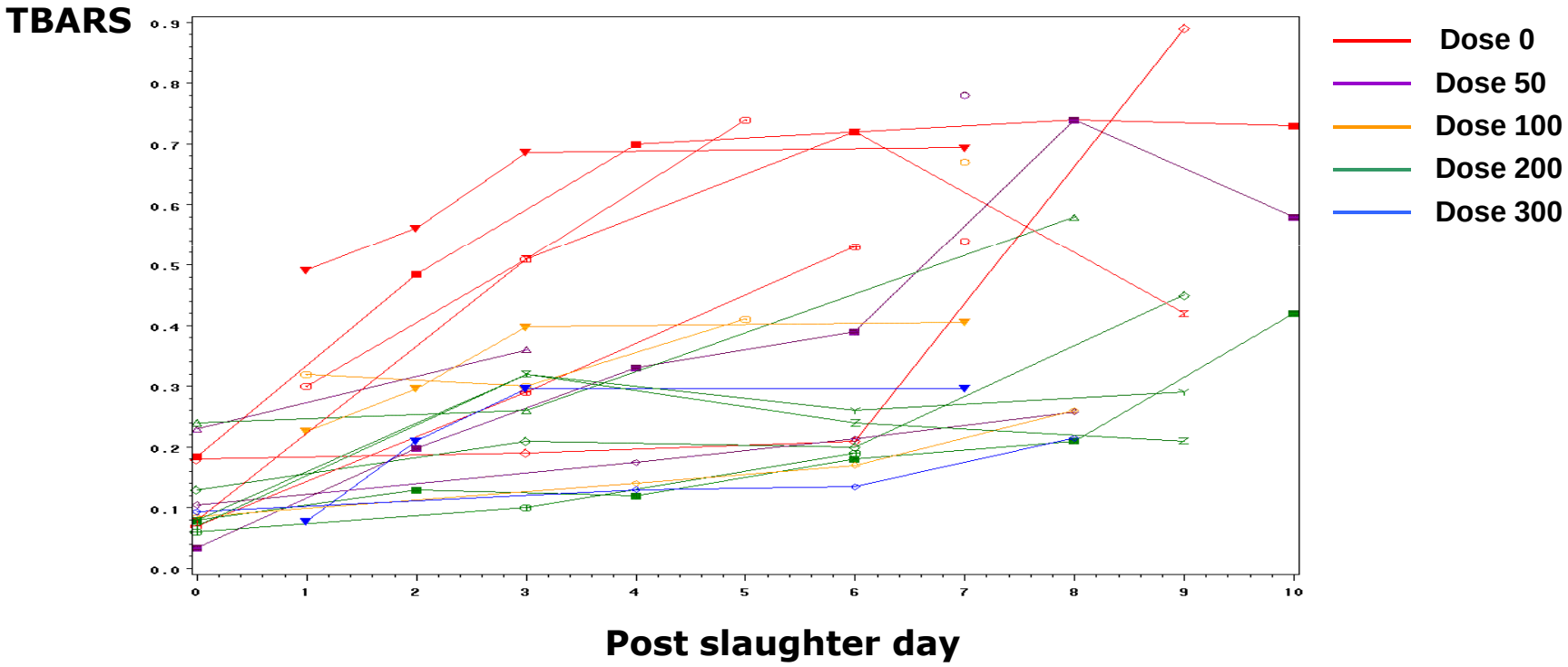
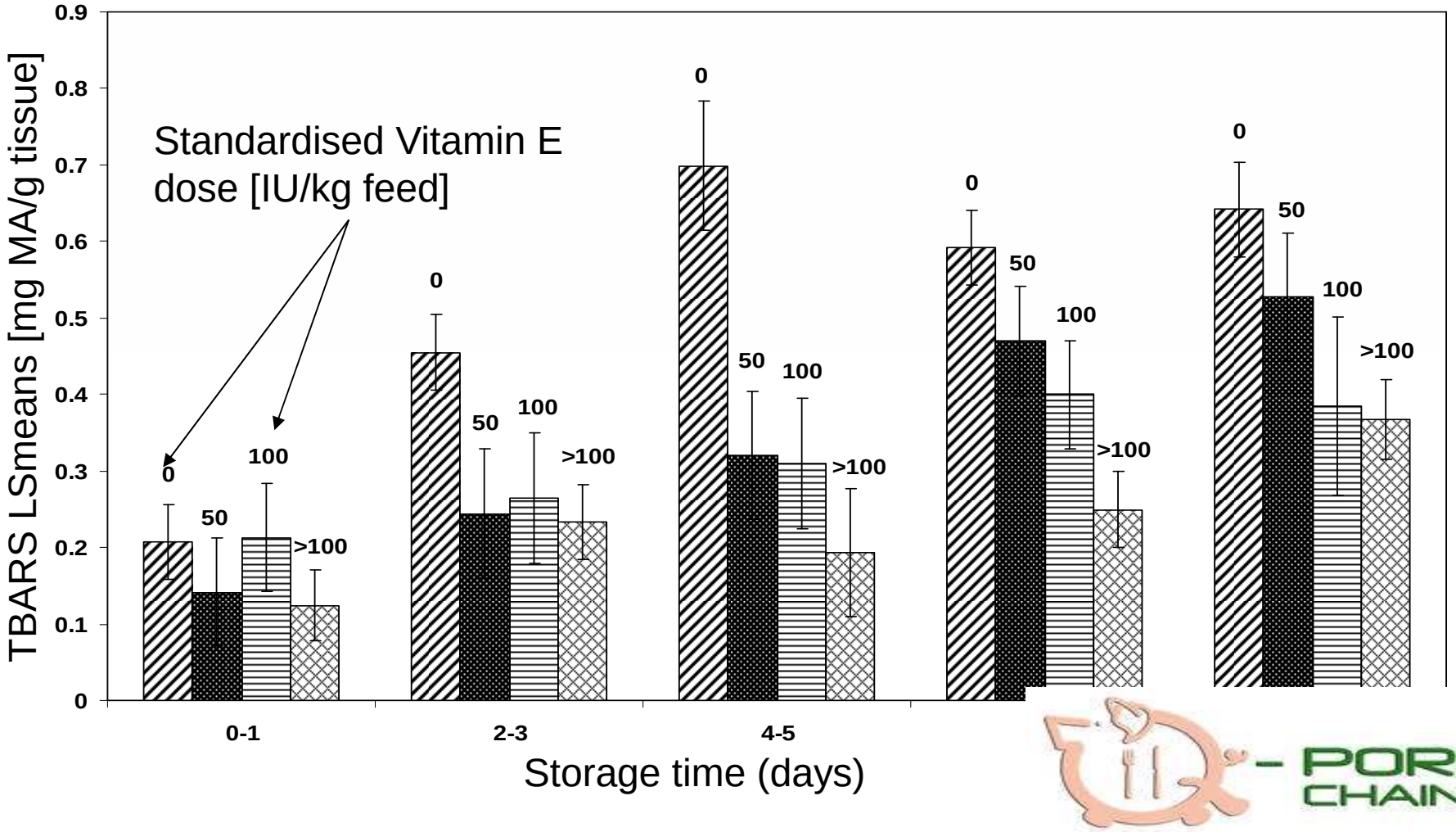


Figure1: Least square (LS) means of TBAS changes over time for various doses of vitamin E from 10 different experiments

Meta-analysis results: Effect of dietary vitamin E supplementation on lipid oxidation



MA II: Statistical analysis

Linear Mixed Models:

$$TBARS_{ijk} = ß_1 TOC\_cont_{ij} + ß_2 Tsupp_{ij} + StoreTime_k + e_{ijk} \quad (A)$$

$$TBARS_{lmn} = Dose_m + StoreTime_n + e_{lmn} \quad (B)$$

TBARS is the abbreviation for Thiobarbituric Acid Reactive Substances, substances formed as a byproduct of lipid peroxidation (i.e. as degradation products of fats) which can b
TBARS assay usin
reagent. WIKI

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MA III: Statistical analysis

Linear Mixed Models:

$$a^*_{ijkl} = ß_0 TOC\_cont_{ij} + ß_1\ Time_{ijk} + ß_2\ Time^2_{ijk} + ß_3\ Time^3_{ijk} + StoreLight_l + e_{ijkl} \quad (1)$$

$$a^*_{mnpq} = (TOC\_cont*StoreTime)_{mnp} + StoreTime_p + StoreLight_q + e_{mnpq} \quad (2)$$

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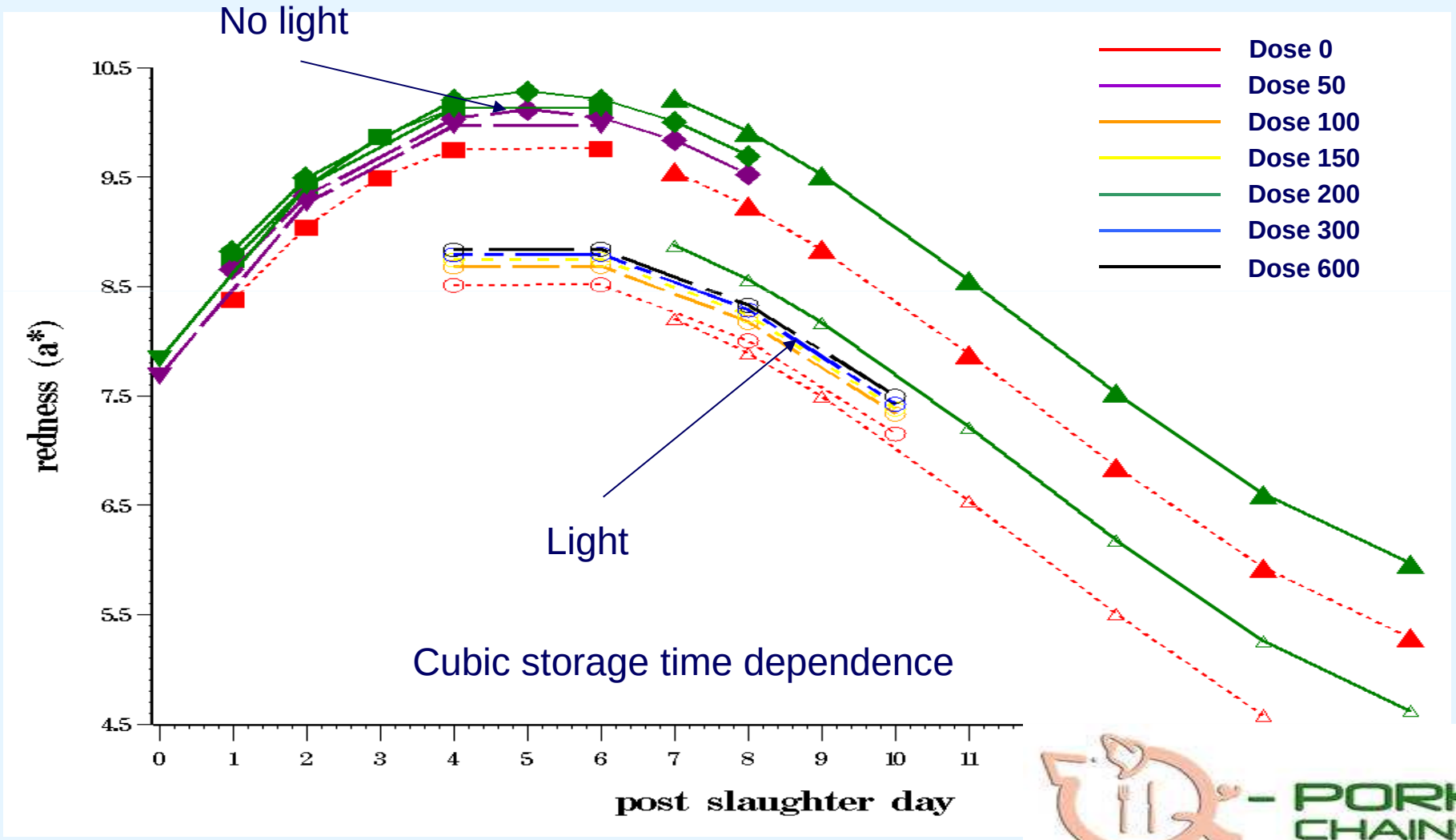
Publications

- Trefan,L., Bünger,L., Rooke,J., Blom-Hansen,J., Salmi,B., Larzul,C., Terlouw,C. & Doeschl-Wilson,A. (2010). Meta-analysis of effects of storage conditions and supplementary vitamin E on stability of pork redness (a*). *Archives of Animal Breeding* ,53, 564-577
- Trefan,L., Bünger,L., Bloom-Hansen,J., Rooke,J., Salmi,B., Larzul,C., Terlouw,C. & Doeschl-Wilson,A. (2011). Meta-analysis of the effects of dietary vitamin E supplementation on α-tocopherol concentration and lipid oxidation in pork. *Meat Science*, 87, 305-314
- Trefan,L., Doeschl-Wilson,A. , Rooke,J., Bloom-Hansen,J., Terlouw.C. & Bünger,L. (2011). Meta-analysis of effects of gender in combination of carcass weight and breed on pork. *Journal of Animal Science,* in preparation

MA III: Prediction for redness from model (1)



Meat Safety

"Modelling Salmonella along the pork chain"

Teagasc and UCD

Declan Bolton, Claire Ivory,
Francis Butler, Ilias Soumpasis

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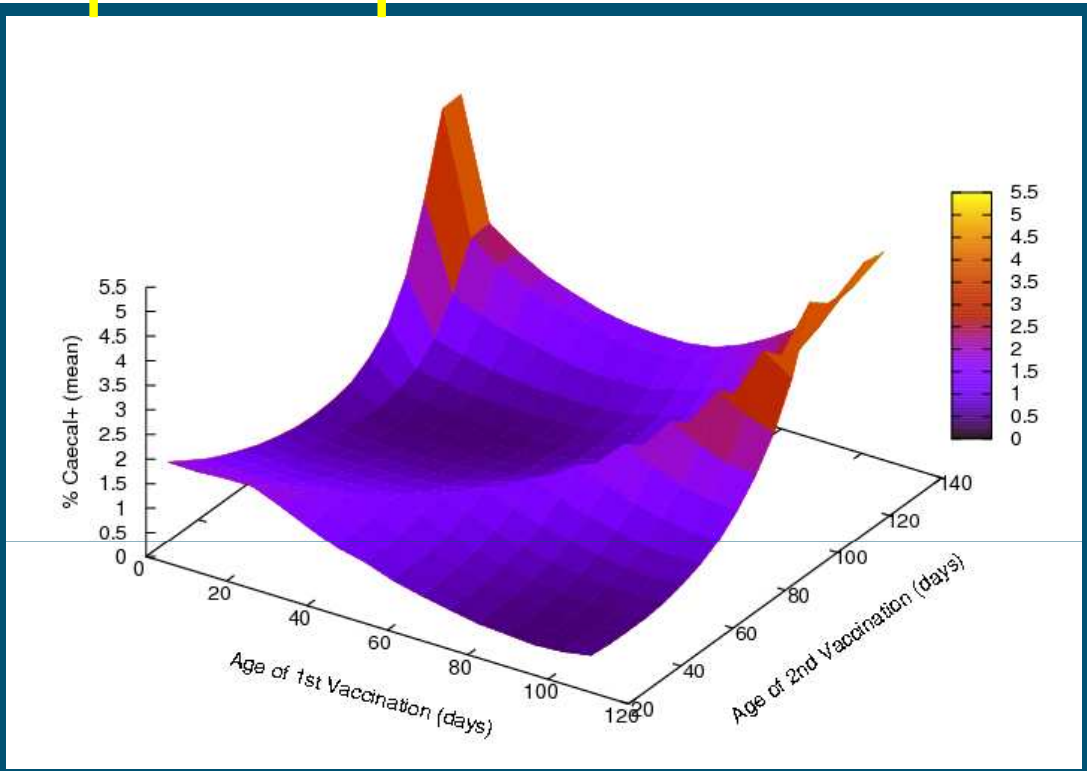
One example output



"Prevalence of Salmonella at slaughter age versus the age of first and second vaccination for a category 2 farm"

Animal Welfare

UN, INRA and Wageningen UR

Marie-Christine Salaun, Ludovic Brossard,
Xavi Averos, Jean-Yves Dourmad,
Sandra Edwards, Helen Edge,
Jessica Cornelissen, Karel de Greef

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Animal Welfare

- The Animal
- The Farmer
- The Consumer
- The Citizen

“What happens if we change the husbandry conditions?”

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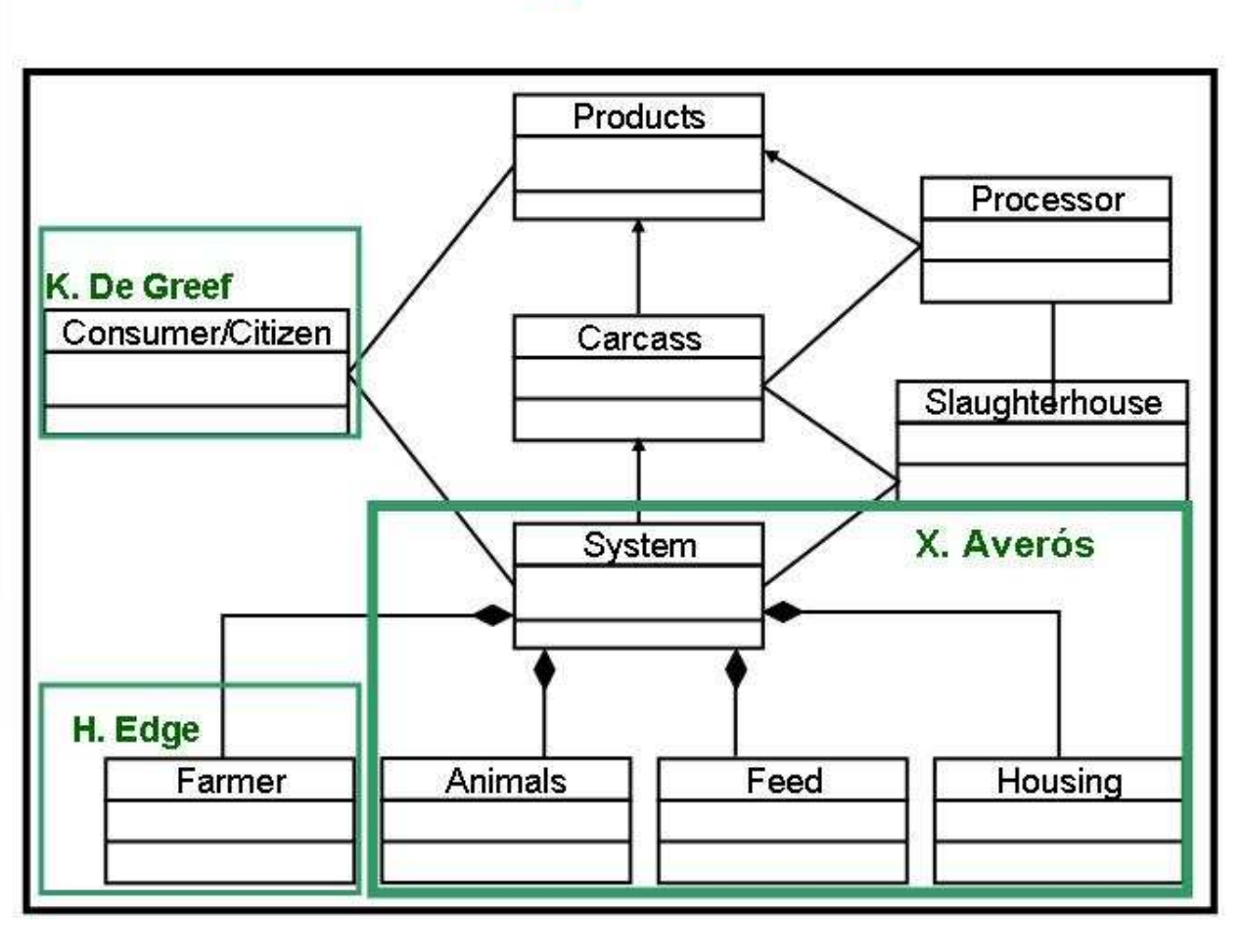
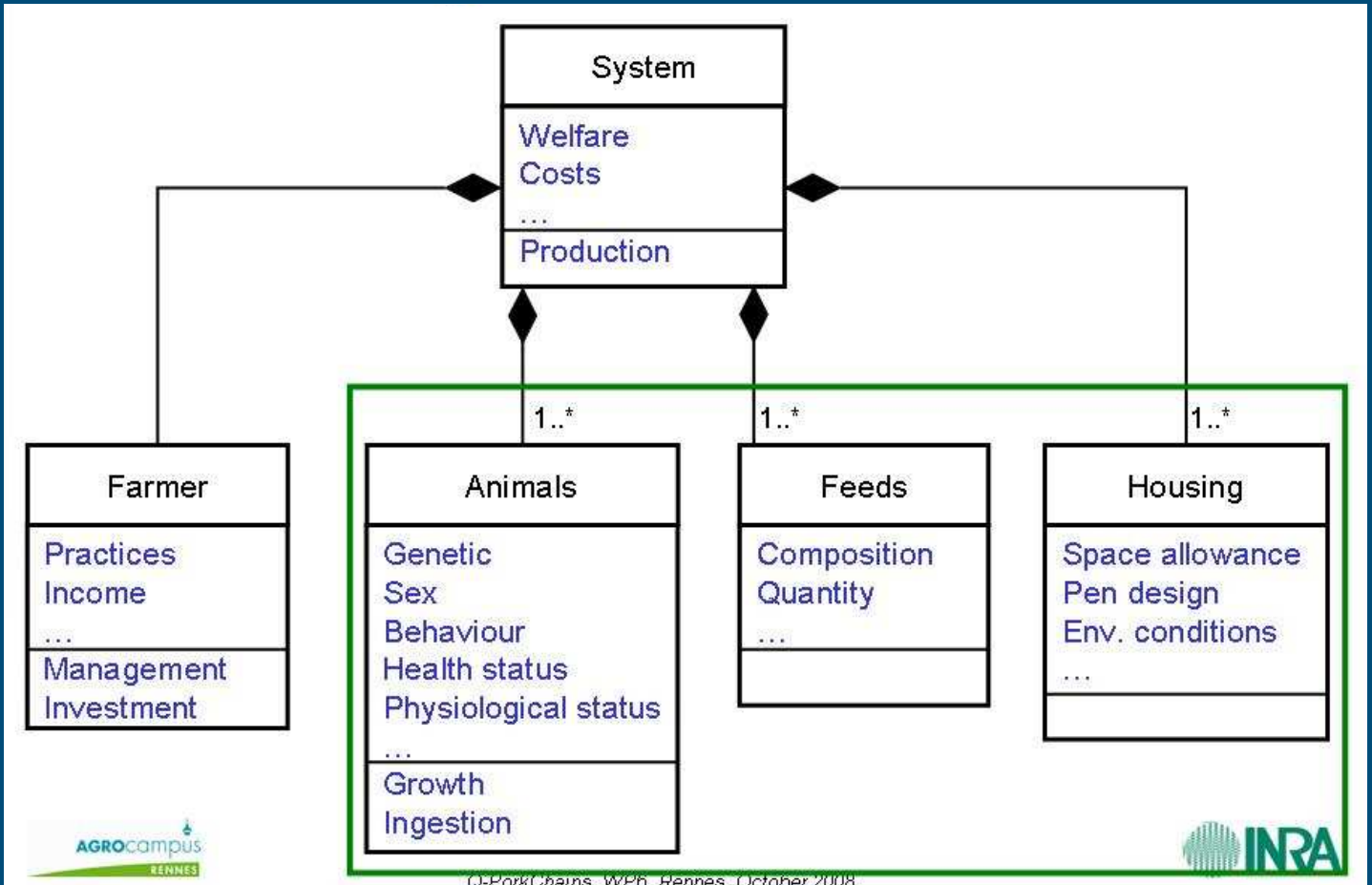
The animal, consumer, farmer and citizen



The animal



INRA

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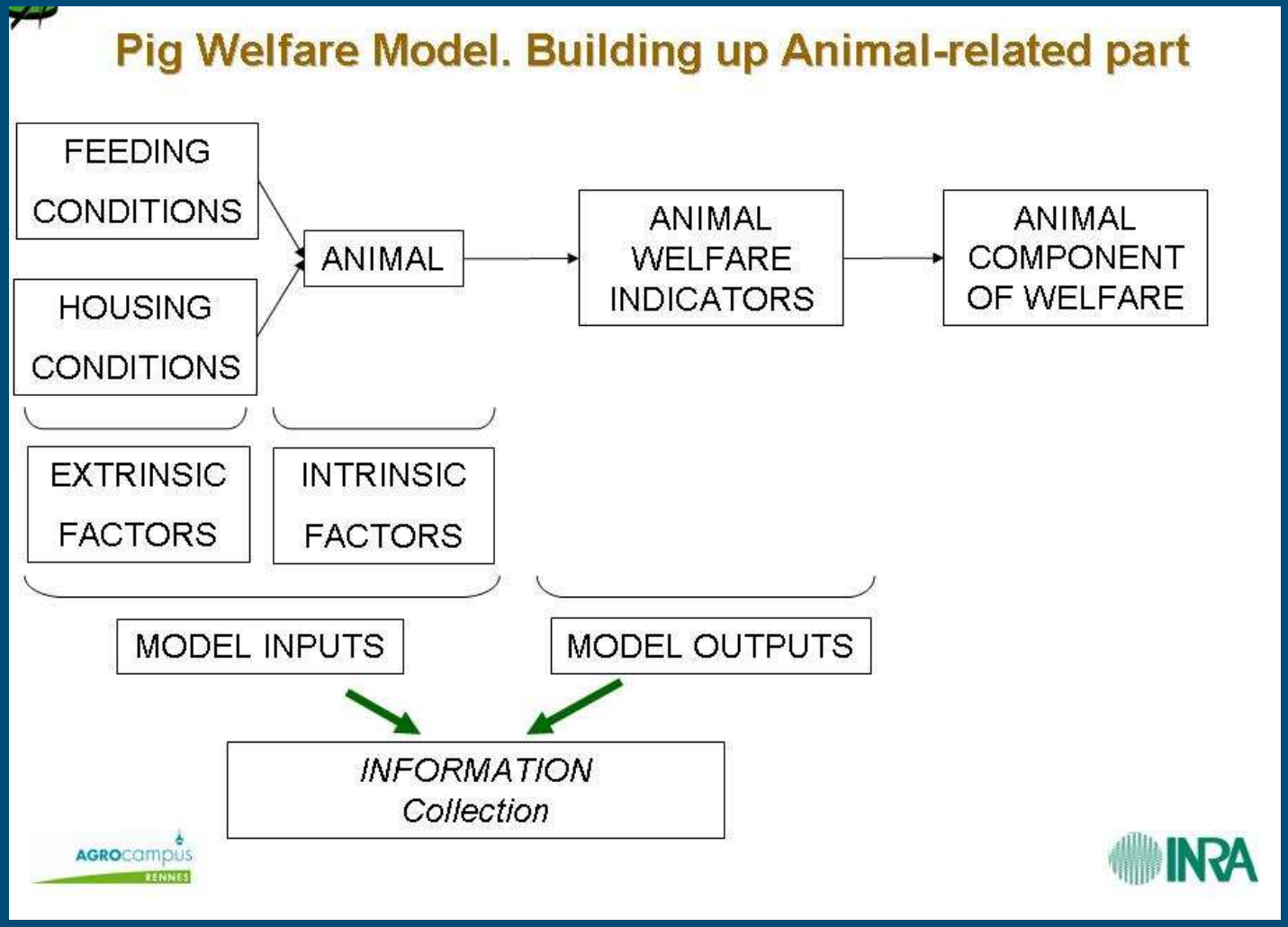
The animal



INRA

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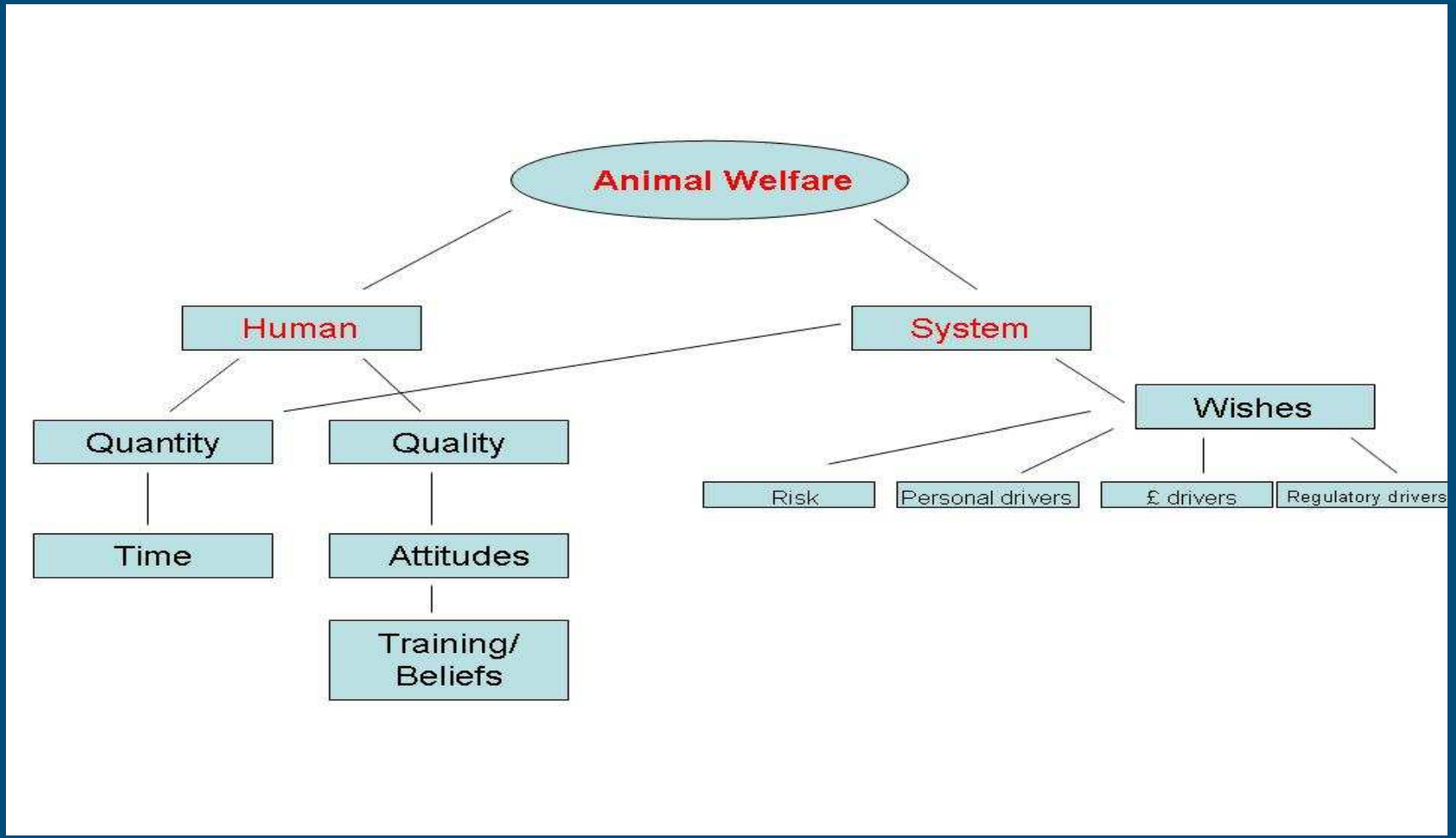
The farmer



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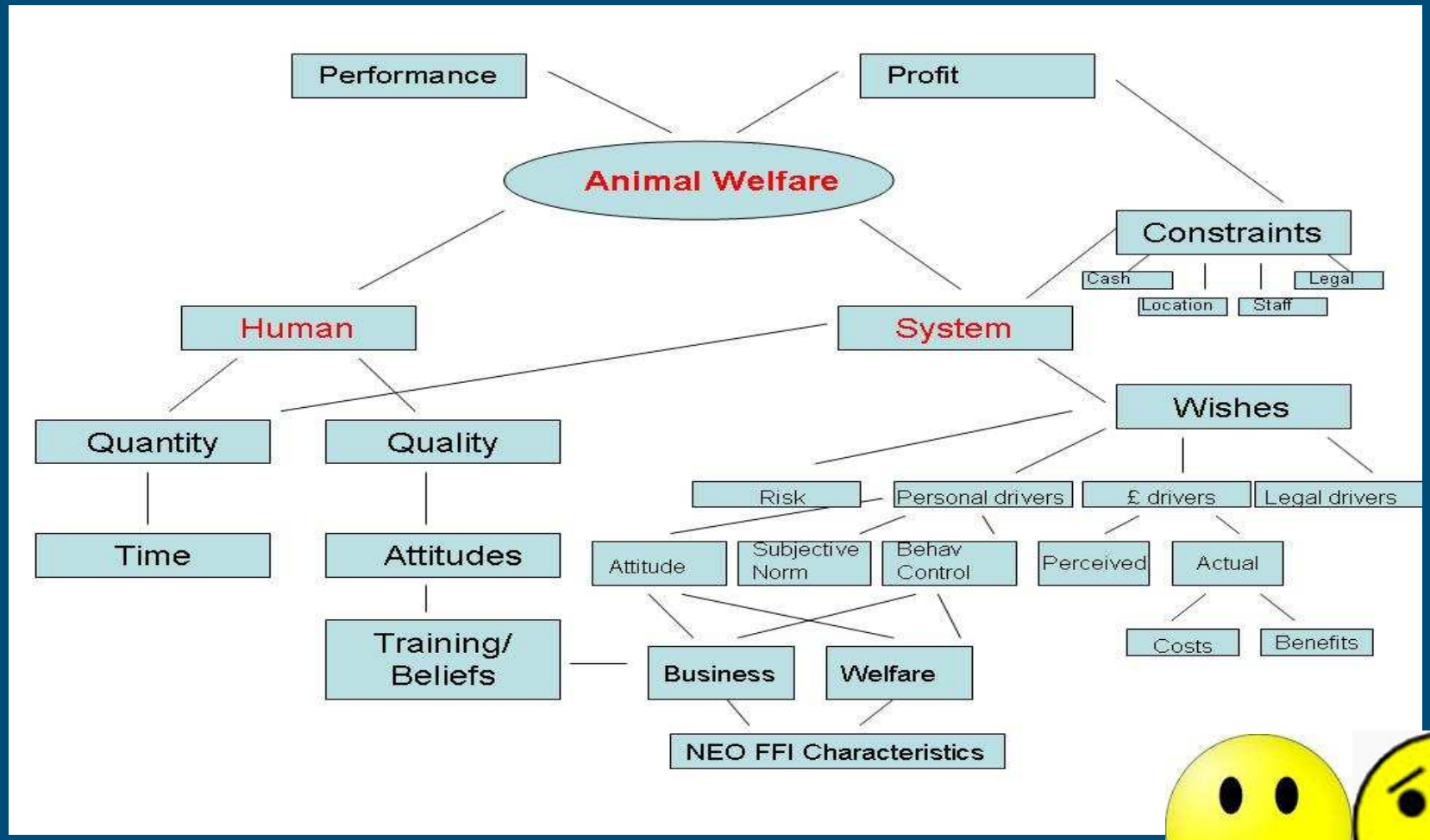
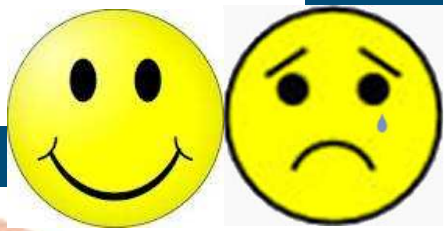
The farmer





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The consumer & the citizen

Knowledge Attitude Behaviour

Consumer

label info*
food essentials*

Assess meat utility

purchase

PC

donation

Citizen

pastoral view
media issues*

Judge acceptability

join
protest
vote

LIVESTOCK RESEARCH
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The consumer

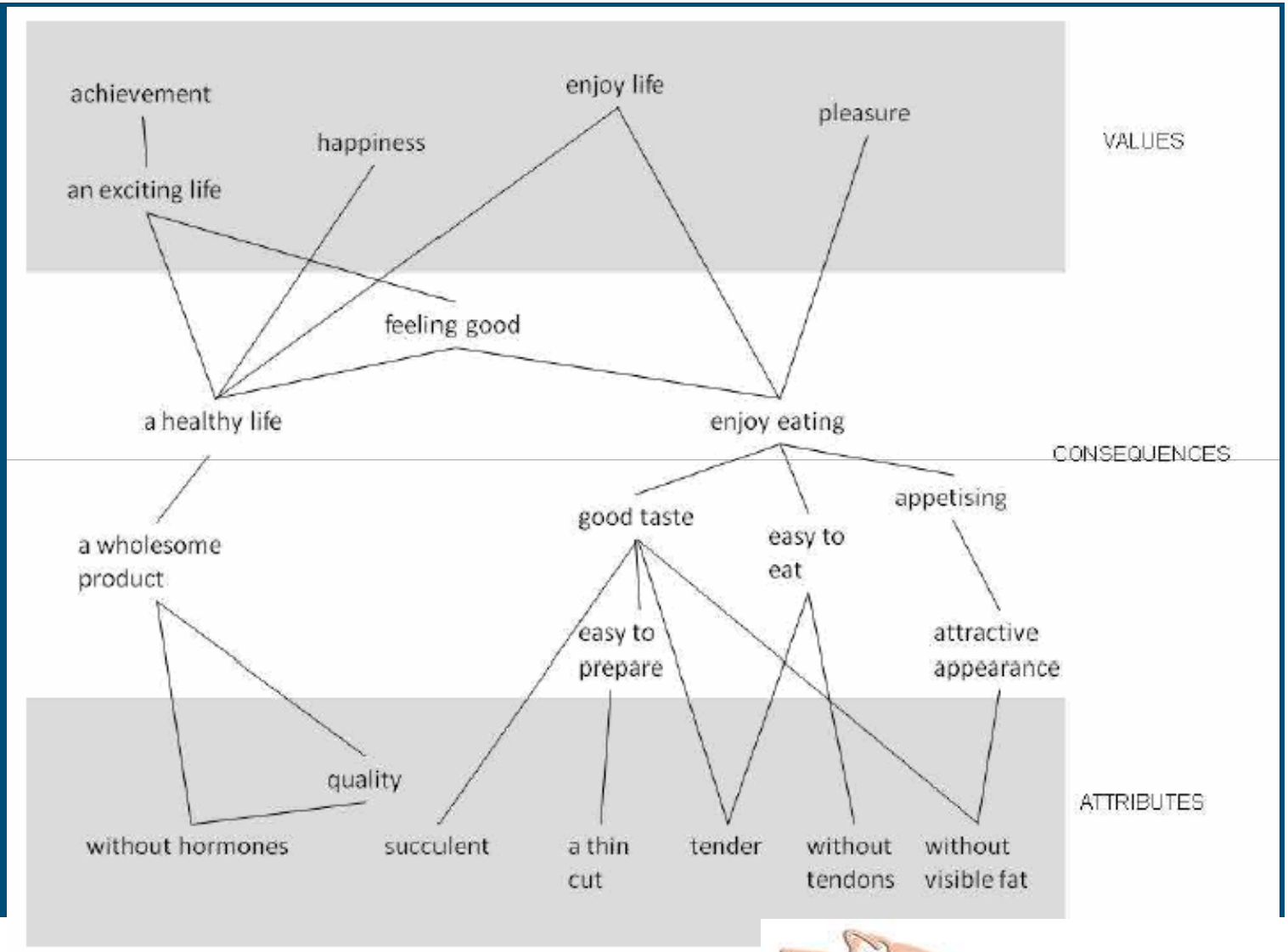
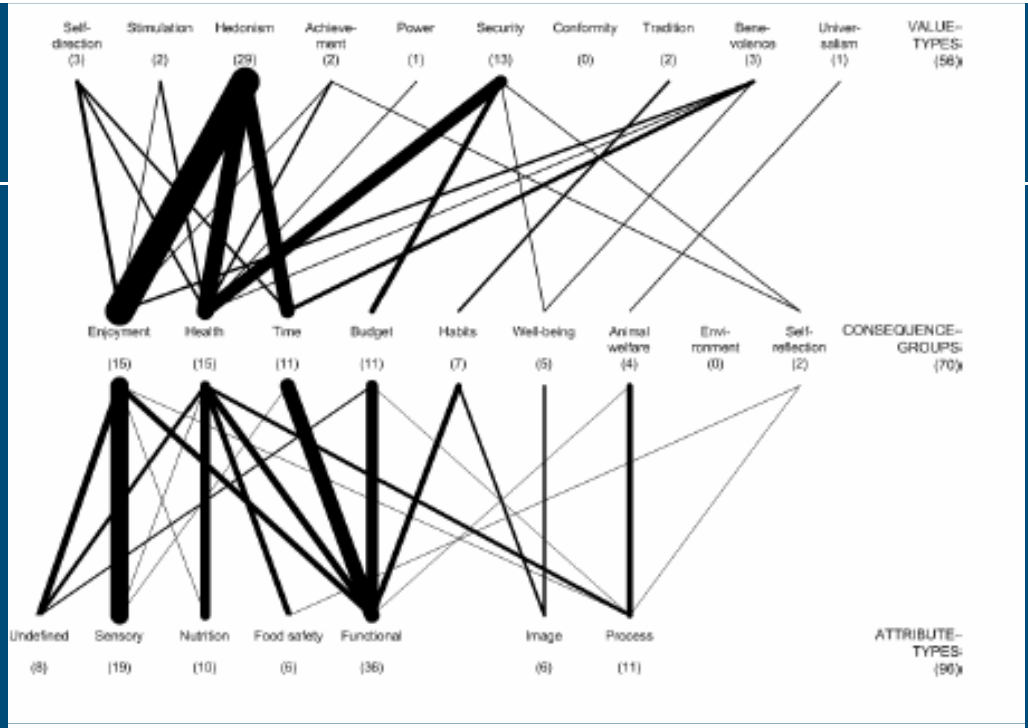


Figure 1: example of a HVM (derived from Audenaert and Steen

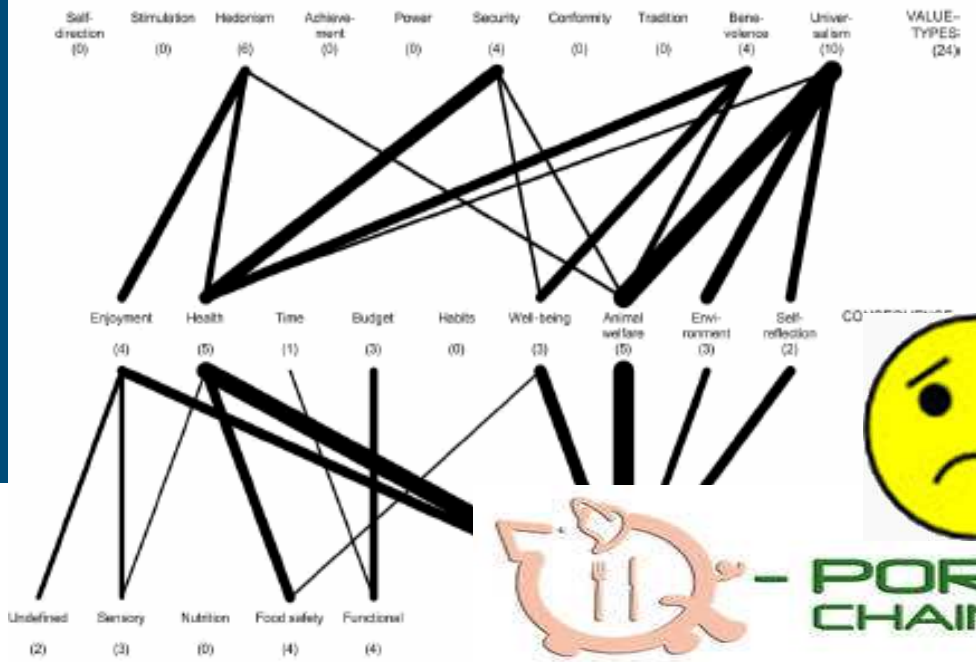
The consumer

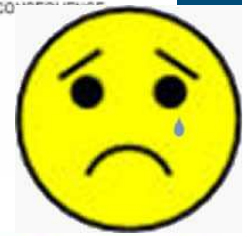
Conclusion:

Consumer choice behaviour is 1st motivated by own interests!



igure 3: collective HVM for regular meat consumption





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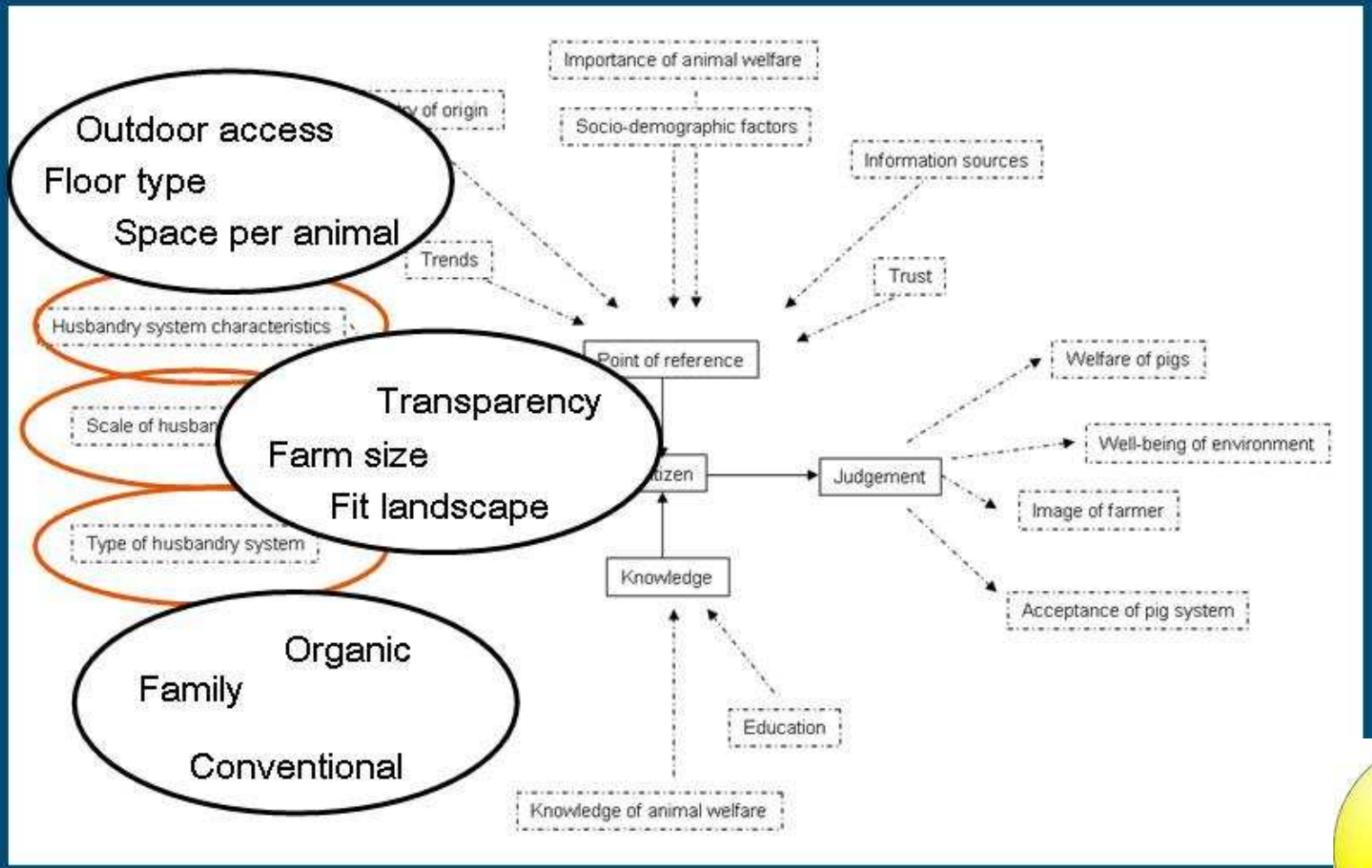
(The consumer &) the citizen



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Animal Welfare

- The Animal
- The Farmer
- The Consumer
- The Citizen

“What happens if we change the husbandry conditions?”

→ *Focus on the animal!*

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Animal welfare - from a strict animal science entry

Modelling and quantification of

" *Effects of husbandry factors on animal welfare*"

Using meta-analysis

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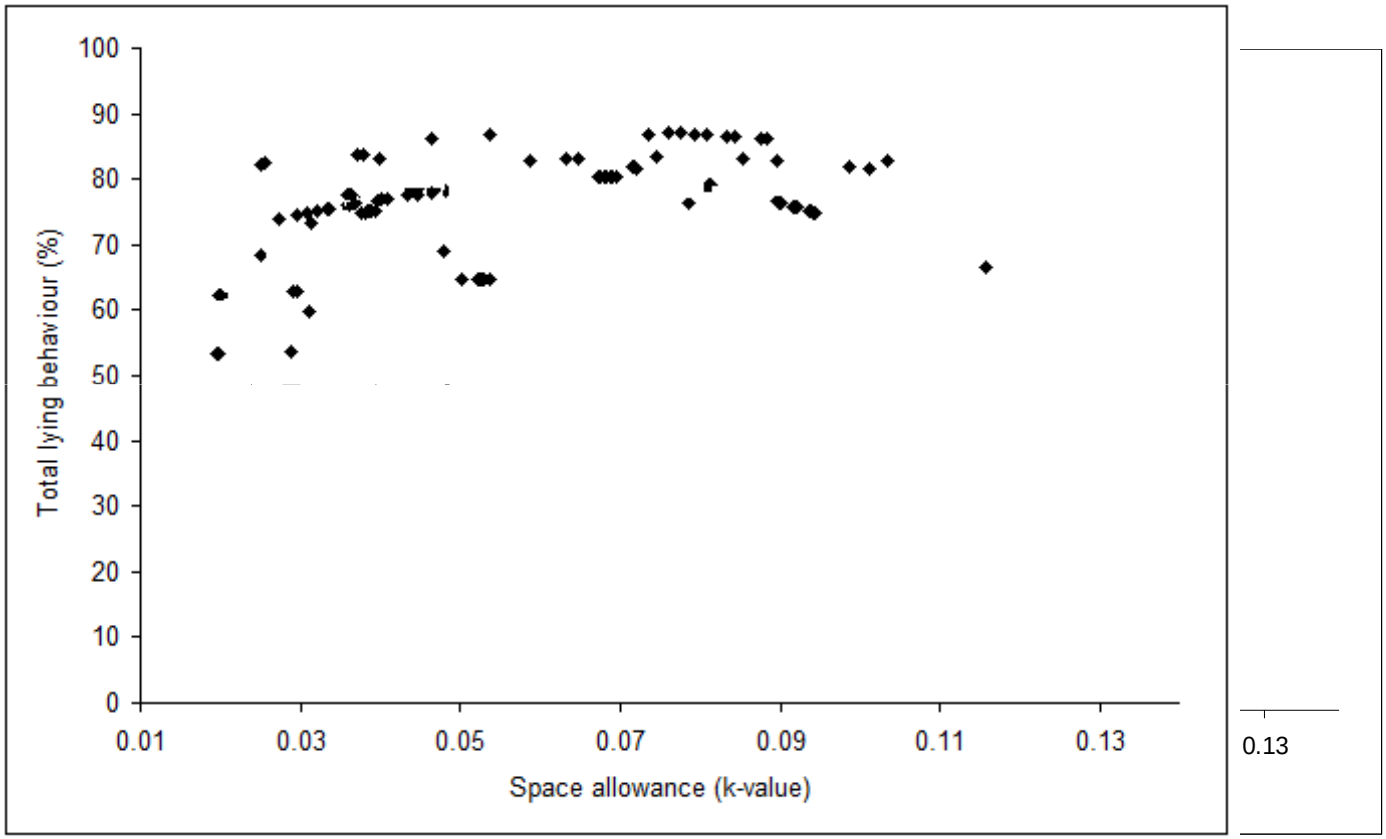
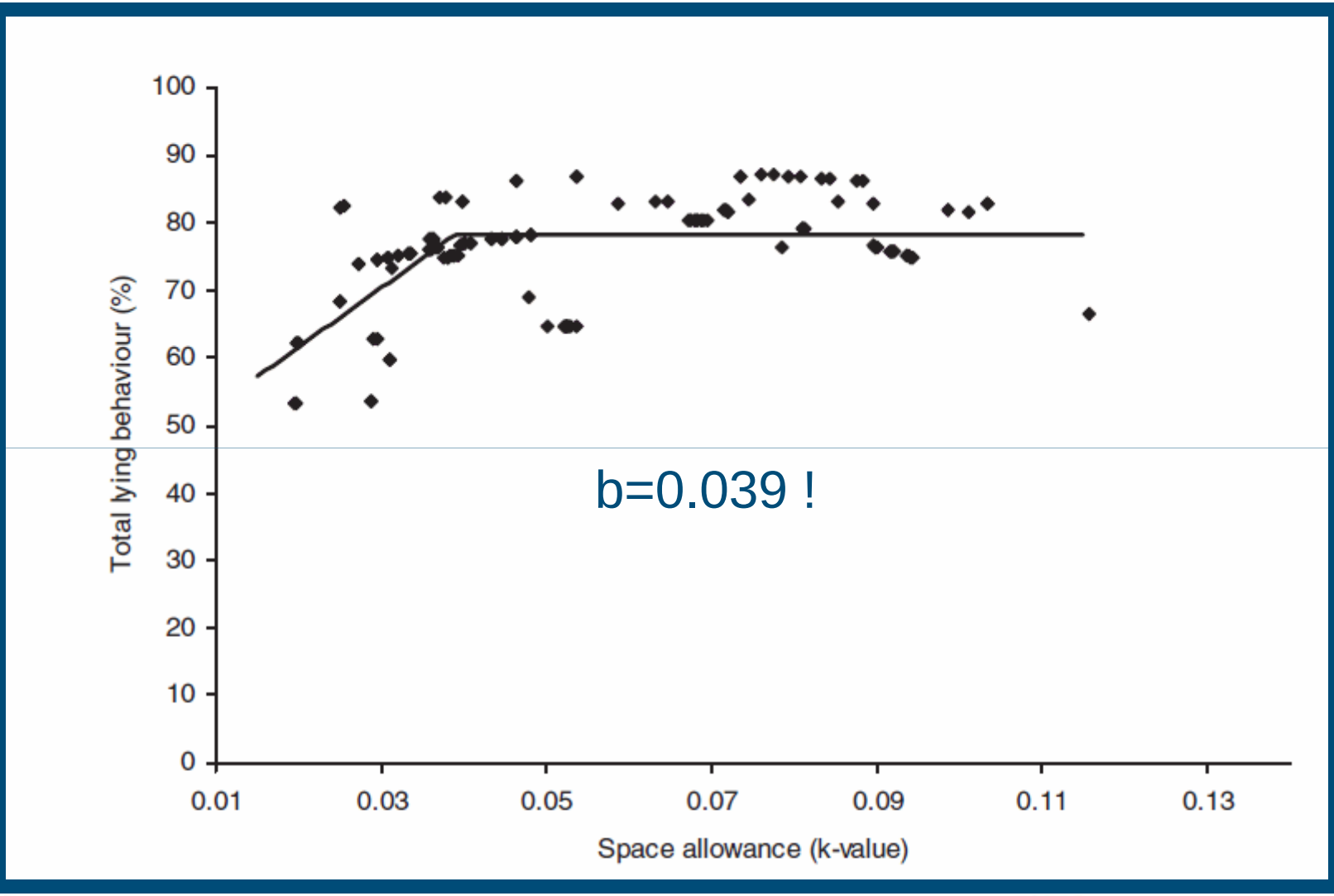
Modelling at its simplest



The animal


100
90
80
70
60
50
40
30
20
10
0
Total lying behaviour (%)
0.01
0.03
0.05
0.07
0.09
0.11
0.13
Space allowance (k-value)
b=0.039 !

SENAH

Modelling husbandry impacts on animal welfare

Cause: (horizontal axis)

- **Husbandry factors as influencing factors**

Effect: (vertical axis)

- **Behaviour traits as welfare indicators**

+ statistics

For * Space allowance ; * environmental enrichtment ; * feeding conditions

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INRA

Animal component of the Welfare model:

Aims :

Quantify the effect of individual (genotypic/phenotypic) traits, and of factors related to housing and feeding conditions, on different welfare indicators (behaviour, body score) and performance

Methods : Meta-analysis of scientific literature

Factors tested:

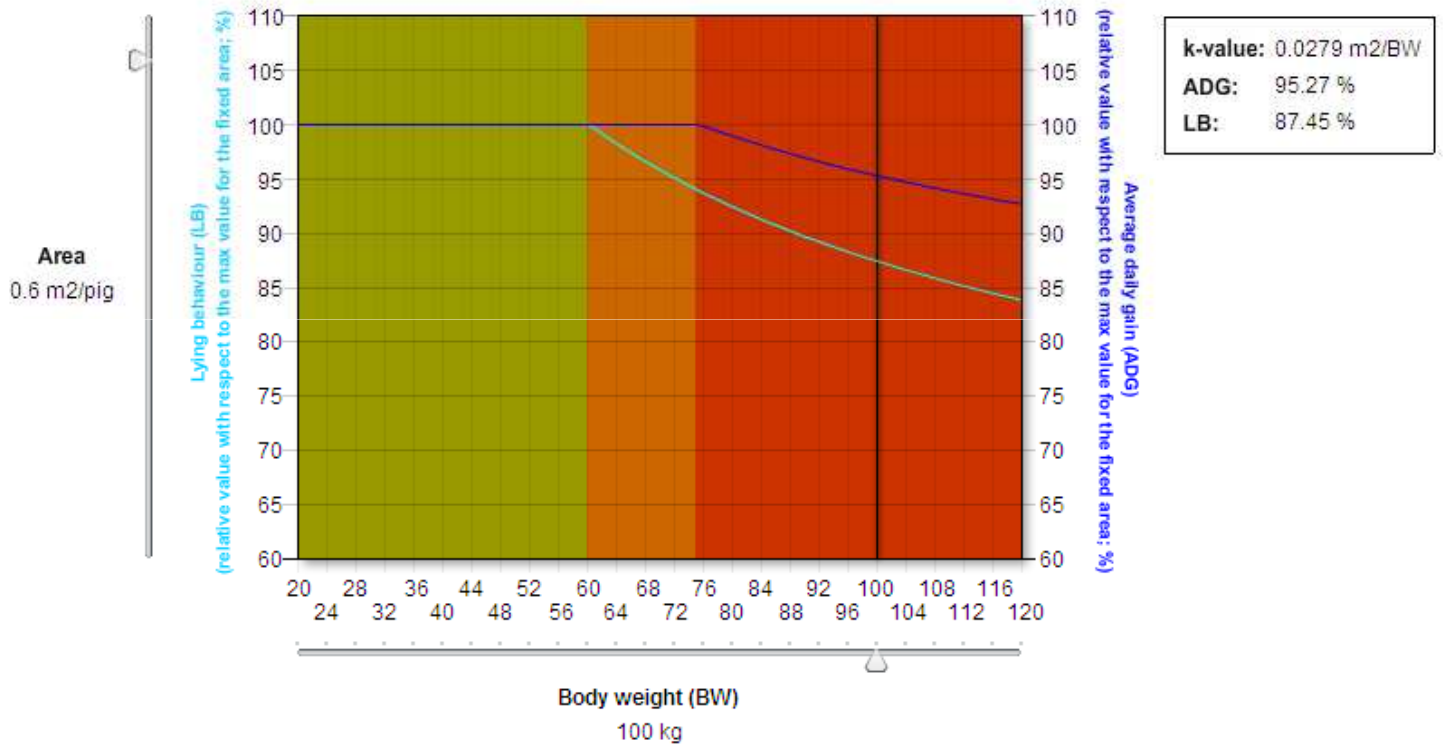
- **Pen design : space allowance, group size, floor characteristics, temperature**
- **Enrichement : straw bedding, recreative object**
- **Feeding : nutrient content, feeder design, feed allowance**
- **Pigs' traits : sex, initial bodyweight, genetic**

Results : 3 scientific paper in peer-reviewed journals

Animal component of the Welfare model:

Effect of space allowance on performance and behaviour

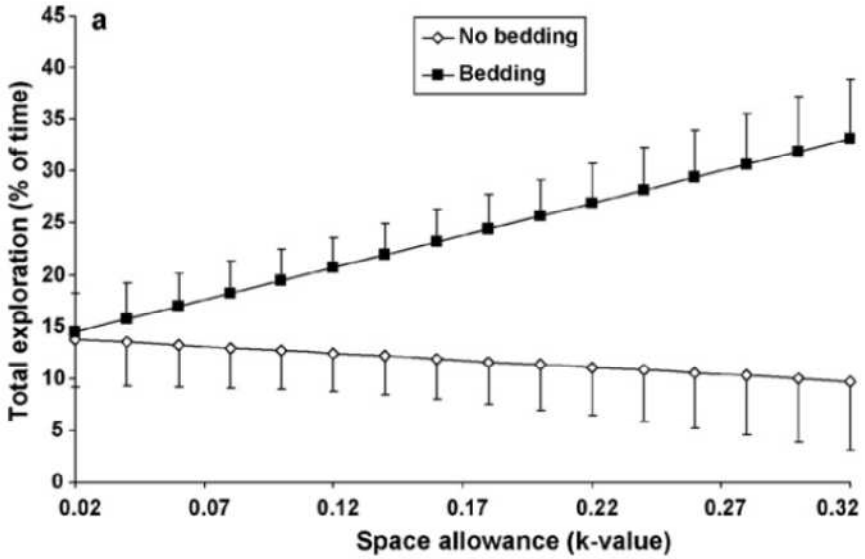
http://www.qpc-models.dk



Optimal space allowance is larger for welfare than for performance

Animal component of the Welfare model

Interaction : Enrichement x Space allowance



The effect of space allowance on investigatory behaviour depends on the presence of bedding

The Animal Welfare Model

- Identified four key interest perspectives
  - Animal
  - Farmer
  - Consumer
  - Citizen
- Not easy to combine into one model
  - but is not impossible (*Agent based modelling)*
- Meta-analysis is very well possible
  - Valuable to science and practice

Modelling and Meta-anaysis

Applied on three themes

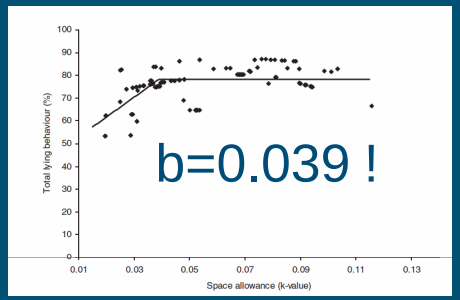
- Meat Quality
- Meat Safety
- Animal Welfare

Lessons learned

Lessons learned

1) Good meta-analysis requires elegant statistics

2) Even simple modelling is valuable
   1) In data: to bring order
   2) In idea's: to demonstrate knowledge



3) Some factors are difficult to combine
   → new approaches needed

   [animal welfare: human & animal-technical] -> CAS and ABM

Message

Take time to integrate the knowledge that you have

More efficient and more understanding

Hire young quality scientists for this

Btissam, Claire, Ilias, Laszlo, Xavi,

http://www.qpc-models.dk

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Major contributors

- *Pre-thinking & research set-up: Claudia Terlouw*
- *Meat Quality: Andrea Wilson; Lutz Bunger; Laszlo Trefan; Catherine Larzul, Btissam Salmi*
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