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**Agroscope**

# Protein efficiency in pigs:

## from phenotyping to estimating genetic parameters and beyond

**Claudia Kasper**
Animal GenoPhenomics Unit
Agroscope



Zürich, June 08, 2022
SABRE-TP

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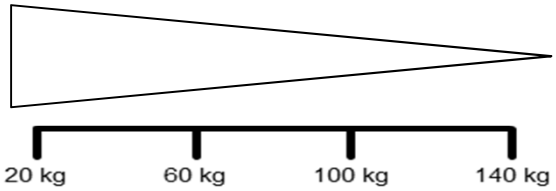
# «The first generation»

(Isabel Ruiz-Ascacibar Peter Stoll & Giuseppe Bee)

Protein requirement in finishing pigs is ***lower*** than assumed!

~ 30% of pigs in low-protein diets exhibited ***similar growth rate*** compared with pigs in control diets

Protein efficiency: ♂ > ♀ ≈ ♂






Ruiz-Ascacibar et al. 2017. Animal. doi:10.1017/S1751731116001634



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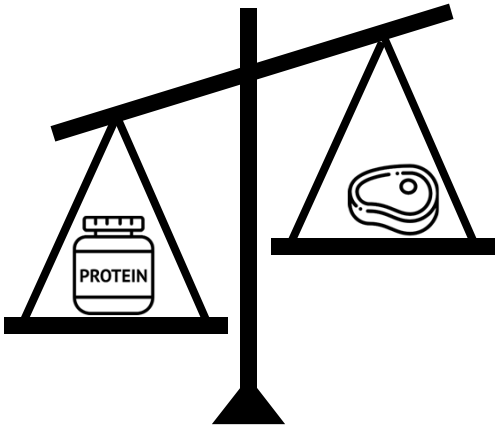
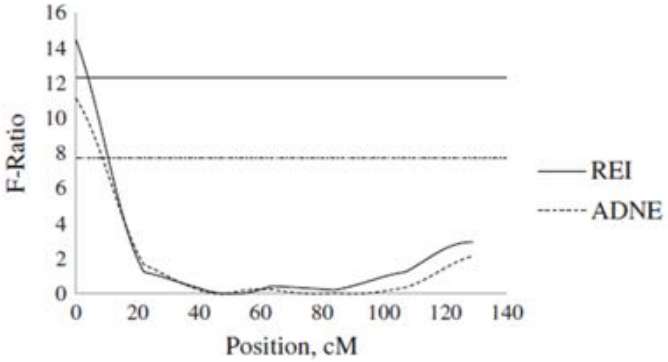
# Protein efficiency




- New trait
- Economic and environmental importance
- Little information on differences and overlaps with classical feed efficiency traits
- Studies rare, not recent, use rough proxies

23 QTL for nitrogen excretion traits detected:

- some ***unique*** to nitrogen efficiency
- some ***overlapping*** with production traits




Shirali et al. 2013. BMC Genetics. doi:10.1186/1471-2156-14-121



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# Can we breed pigs with increased **protein efficiency**?

Or is that already done via **FCR**?

# Genetics of protein efficiency in pigs

- Project March 2018 – January 2023
- PhD Esther Ewaoluwagbemiga

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# 1. Pilot study

- N = 294
- 4 nutrition experiments
- ***I. Ruiz-Ascacibar****, P. Stoll, G. Bee*
- 17 sires, 56 dams
- 2 diets (LP, C)
- several slaughter target weights
- PE via chemical analysis
- Animal model (Bayesian)

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# Phenotyping

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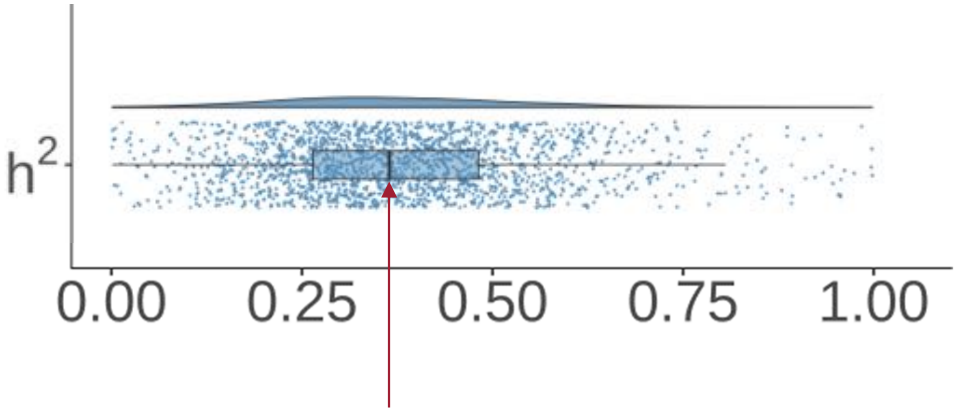
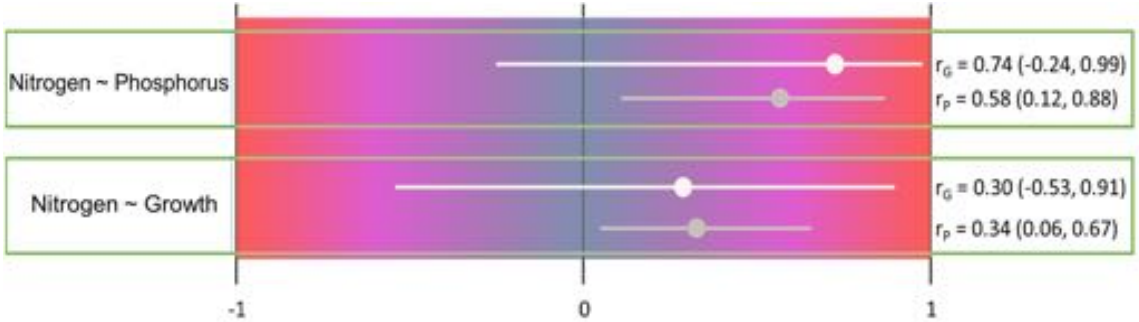
# 1. Pilot study






***Protein efficiency is***

- heritable
- genetic correlations with other traits unclear



Kasper C., Ruiz-Ascacibar I., Stoll P. & Bee G. 2020. Journal of Animal Breeding and Genetics

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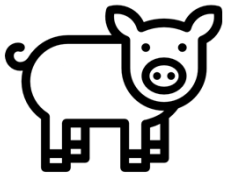
# 2. Follow-up study



Larger **sample size**, improved **experimental design**, **additional phenotypes**

PhD project of Esther Ewaoluwagbemiga

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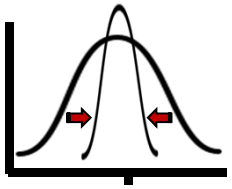
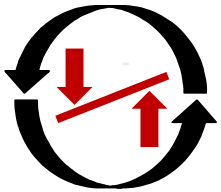
# 2. Follow-up study

PhD project of Esther Ewaoluwagbemiga

## Goals:



**Improved estimates of genetic parameters** (Heritability, genetic correlations)



Estimation of **genetic and phenotypic correlations** with phosphorus efficiency, performance, meat quality, animal welfare

Identification of **genomic regions** associated with protein efficiency

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# Experimental design

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## Phenotyping

682, ♀ & ♂

80% protein content
soy-free

ca. 100 kg live weight

## Genotyping

~1,000 pigs

HD- Genotyped and low-pass (1X – 4X) sequenced



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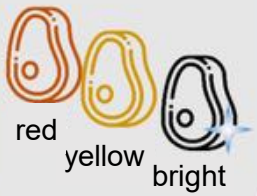
# Additional traits

Meat colour




Intramuscular fat

Drip loss

Sensory analysis

(N = 37)

Cooking loss

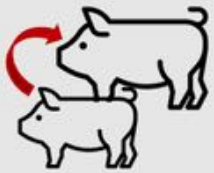
Shear force

LMA

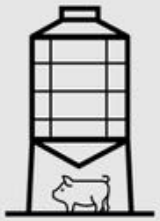
Backfat thickness

Ø Feed ingestion

ADG



FCR



Phosphorus efficiency

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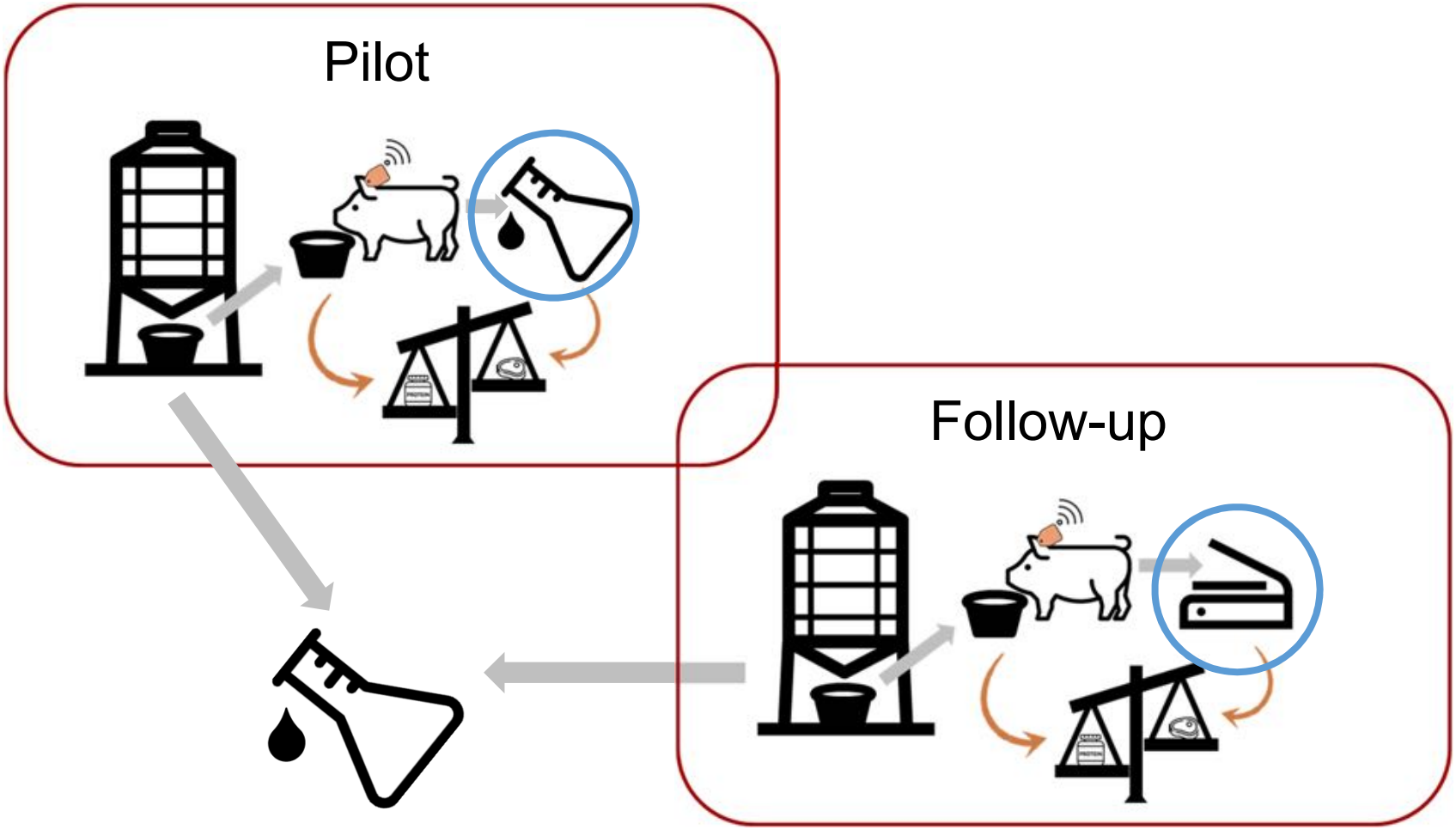
# Phenotyping



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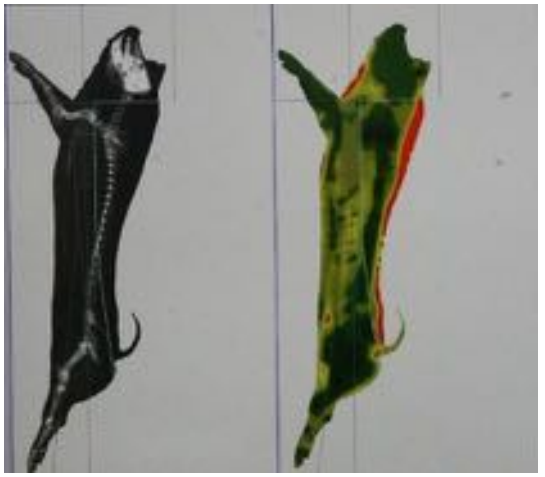
# Muscle mass in the carcass

Dual energy X-ray absorptiometry (DXA)



Protein efficiency of **62 pigs** of pilot study via
wet-chemistry + DXA



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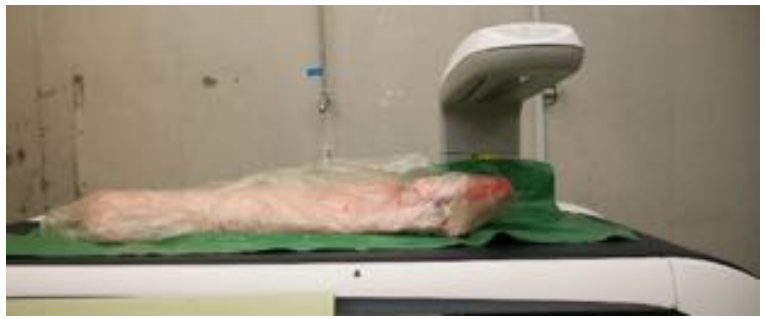
# Calibration study

≈



**62 pigs via wet-chemistry and DXA**

$$\widehat{CP} = \text{-482.745 + 0.23} \times \text{lean}_{DXA}$$

$$\widehat{P} = \text{-6.388 + 1.09} \times \text{bone}_{DXA} + \text{1.09} \times \text{lean}_{DXA}$$



Kasper C., Schlegel P., Ruiz-Ascacibar I., Stoll P. & Bee G. 2021. Animal

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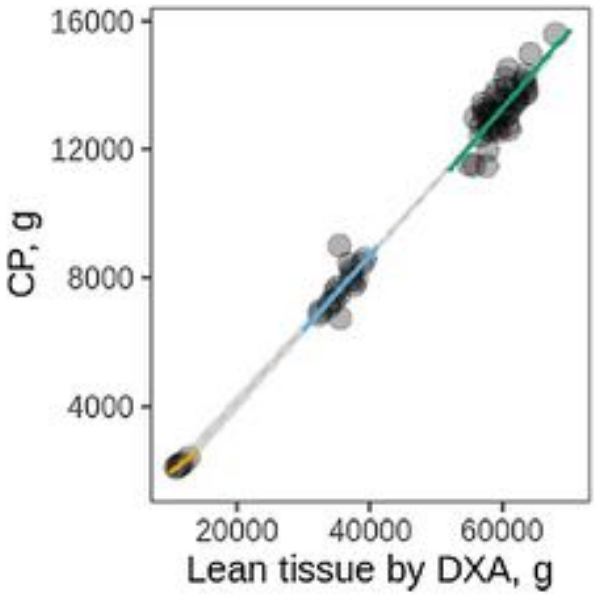
# Calibration study

- Calibration study lean meat content DXA vs. protein/N content by wet chemistry
- High accuracy ($R^2$=0.98) and precision (standardized error rCV=4.4%)
- Half carcasses, but also live scans (light anaesthesia)

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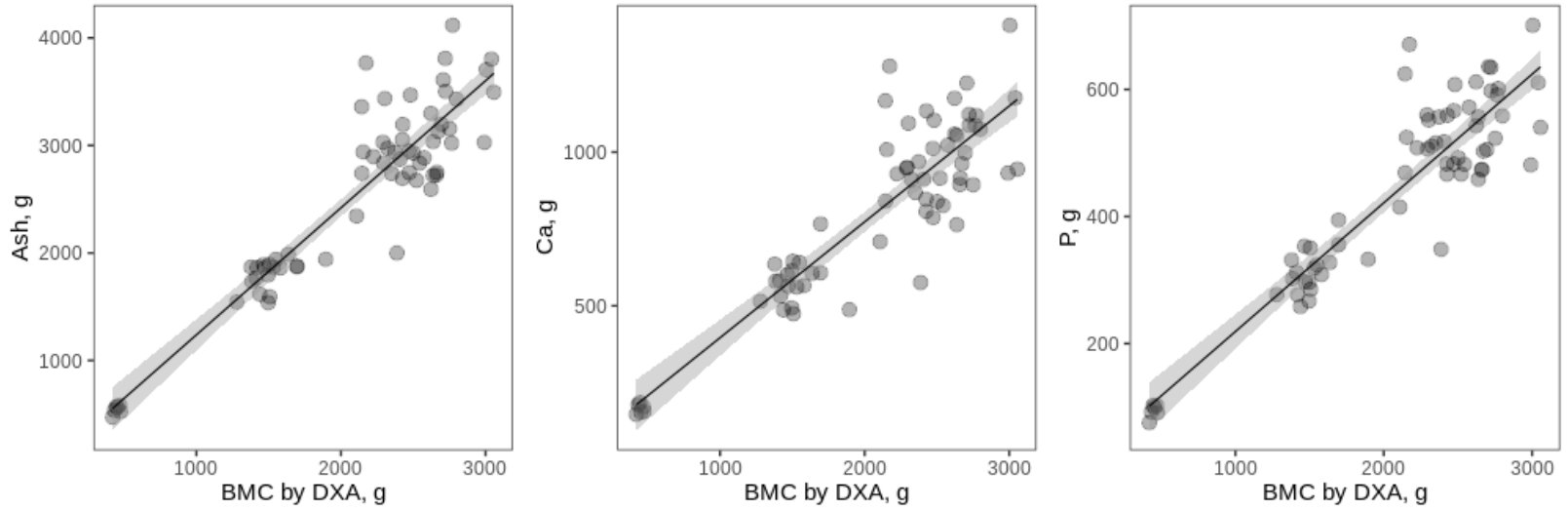
Kasper C., Schlegel P., Ruiz-Ascacibar I., Stoll P. & Bee G. 2021. Animal

# Calibration study

- Bone mineralisation (ash, Ca & P) possible
- Lower accuracy ($R^2$=0.86) and precision (standardized error rCV=13%)

continuous improvement of method! – N × 2






Kasper C., Schlegel P., Ruiz-Ascacibar I., Stoll P. & Bee G. 2021. Animal

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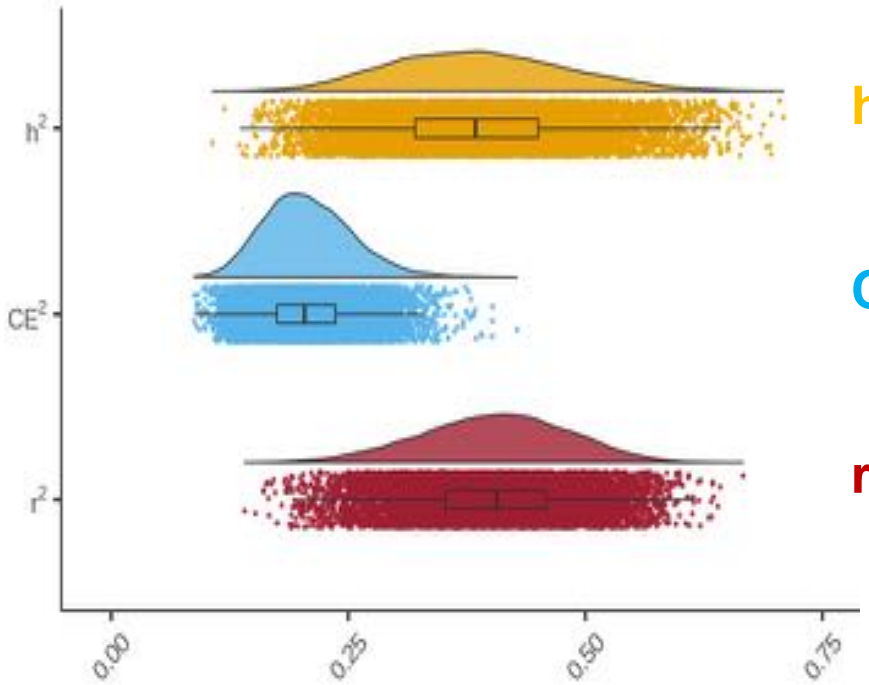
# Heritability of protein efficiency




$h^2$ = 0.39 (0.22, 0.58)

$CE^2$ = 0.20 (0.12, 0.30)

$r^2$ = 0.40 (0.24, 0.25)



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# 3. Full study

- Combination of different data sets from:
  - *Pilot study* (SMVG95, 96, 98 & 101)
  - *Follow-up study* (PigEff3)
  - *Further nutrition studies* (PigEff1 & 2)

fondation sur la croix
Projekte Landwirtschaft

- N = 1,071

- Combination of different
  - Slaughter weights
  - Diets
  - Phenotyping strategies

2012 - 2021

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Upcoming talk at WCGALP conference

Ewaoluwagbemiga et al. *in prep*

# Effects on protein efficiency

- Slaughter weight

- Dietary treatments

reduced protein > control

- Sex

♂ > ♀ > ♂

- Temperature

Upcoming talk at WCGALP conference

Ewaoluwagbemiga et al. *in prep*



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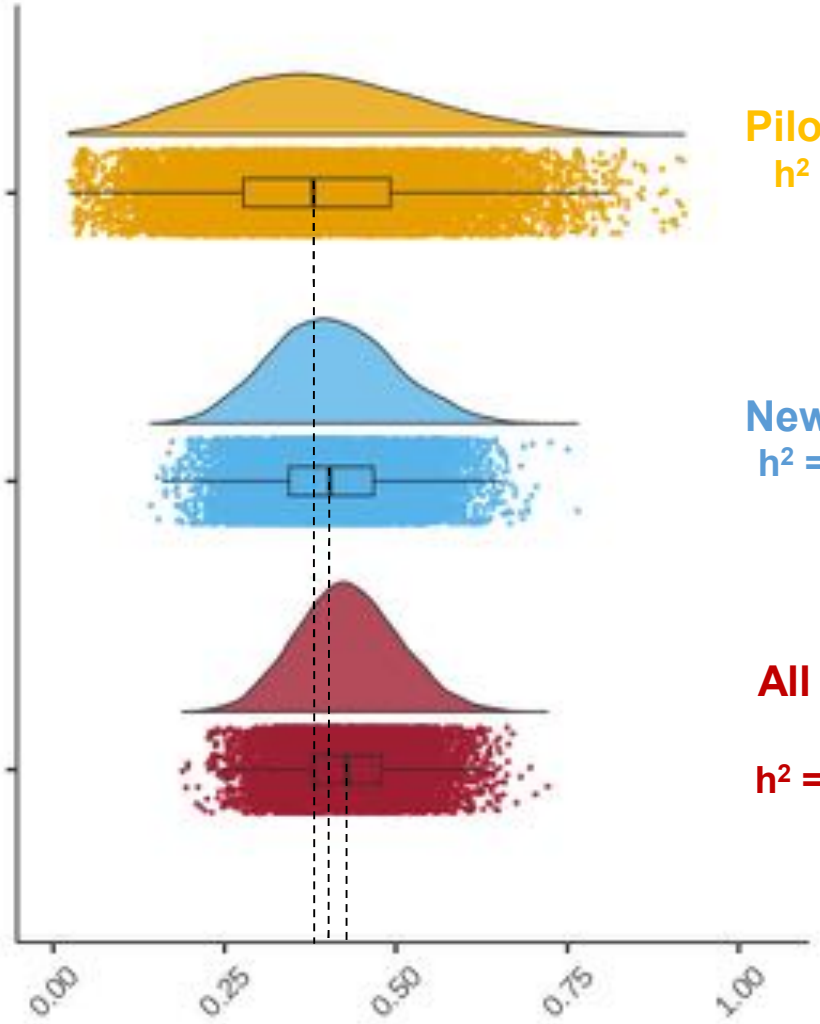
# $h^2$ across studies

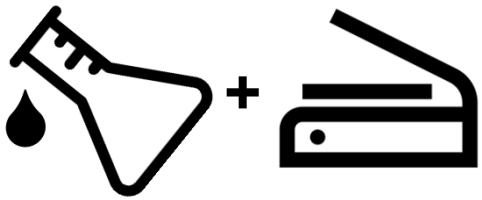
Phenotype




**Pilot study (N = 294)**
$h^2$ = 0.35 (0.10, 0.70)

**New data (N = 681)**
$h^2$ = 0.40 (0.23, 0.58)

**All available data (N = 1,071)**
$h^2$ = 0.44 (0.28, 0.58)





Saintilan et al. 2013 J Anim Sci

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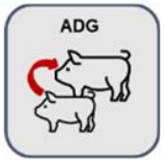
# $h^2$ of all traits

| | |
|---|---|
| PE | 0.43 (0.29 – 0.58) |




| | |
|---|---|
| ADG | 0.55 (0.36 – 0.72) |

| | |
|---|---|
| FCR | 0.47 (0.28 – 0.63) |

| | |
|---|---|
| ADFI | 0.61 (0.41 – 0.83) |

| | |
|---|---|
| ShF | 0.23 ($3.5 \times 10^{-6}$ – 0.48) |

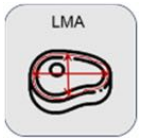
| | |
|---|---|
| DL | 0.13 ($2.0 \times 10^{-4}$ – 0.29) |

| | |
|---|---|
| CL | 0.31 (0.13 – 0.52) |

| | |
|---|---|
| L* | 0.21 ($1.5 \times 10^{-4}$ – 0.46) |

| | |
|---|---|
| a* | 0.77 (0.44 – 0.99) |

| | |
|---|---|
| b* | 0.39 (0.06 – 0.72) |




| | |
|---|---|
| LMA | 0.34 (0.09 – 0.59) |

| | |
|---|---|
| IMF | 0.85 (0.60 – 0.99) |

| | |
|---|---|
| BT | 0.46 (0.25 – 0.69) |



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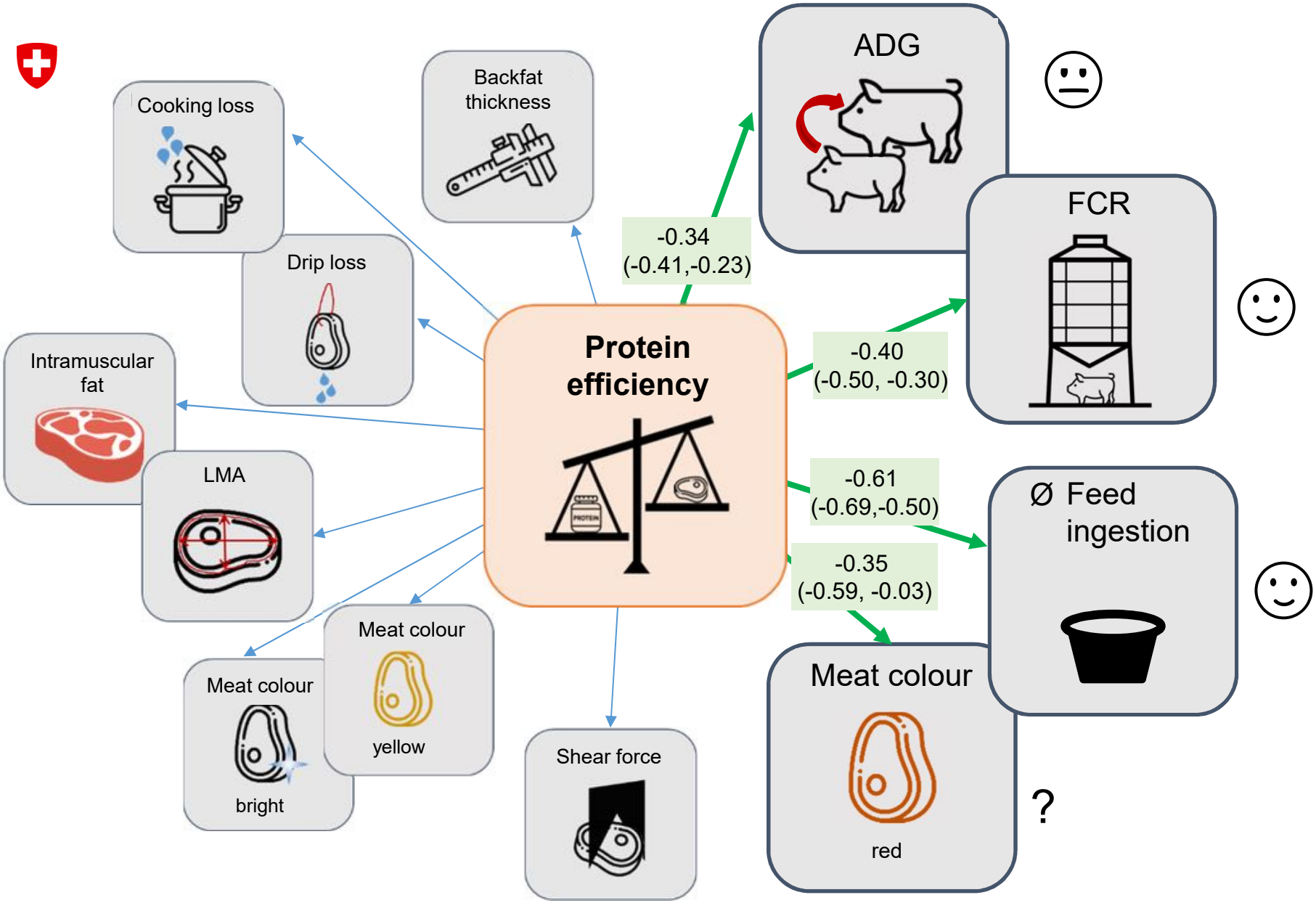
Cooking loss
Backfat thickness
ADG
Drip loss
-0.34 (-0.41,-0.23)
FCR
Intramuscular fat
Protein efficiency
-0.40 (-0.50, -0.30)
LMA
-0.61 (-0.69,-0.50)
Ø Feed ingestion
-0.35 (-0.59, -0.03)
Meat colour
yellow
Meat colour
bright
Shear force
Meat colour
red
?



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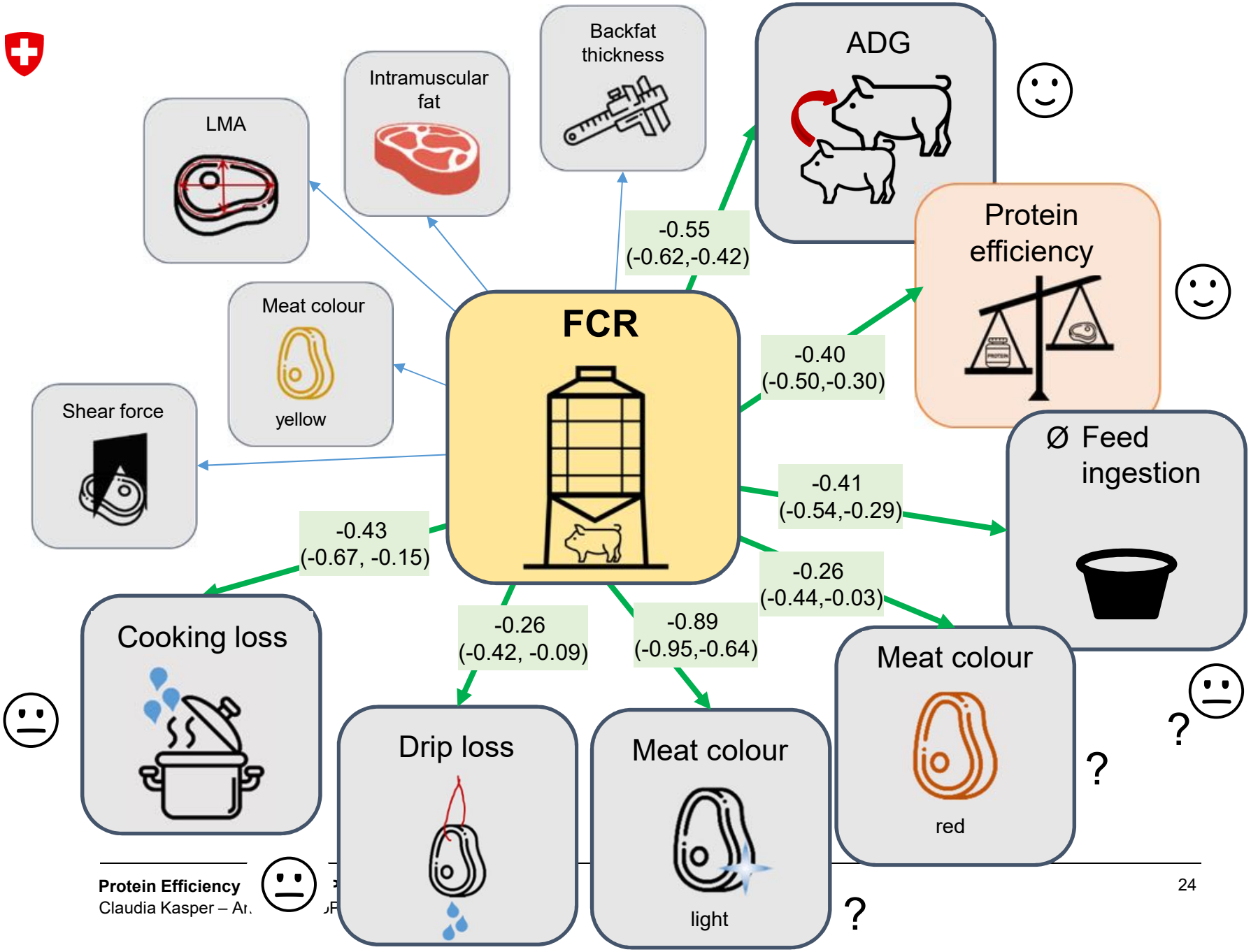

Backfat thickness
ADG
Intramuscular fat
LMA
-0.55 (-0.62,-0.42)
Protein efficiency
Meat colour
yellow
FCR
Shear force
-0.40 (-0.50,-0.30)
Ø Feed ingestion
-0.41 (-0.54,-0.29)
-0.43 (-0.67, -0.15)
-0.26 (-0.44,-0.03)
Cooking loss
-0.26 (-0.42, -0.09)
-0.89 (-0.95,-0.64)
Meat colour
red
Drip loss
Meat colour
light
?
?
?

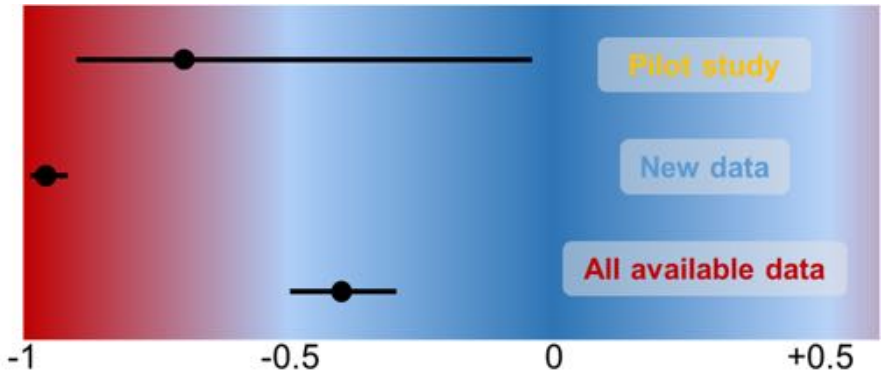
# Protein efficiency = FCR?

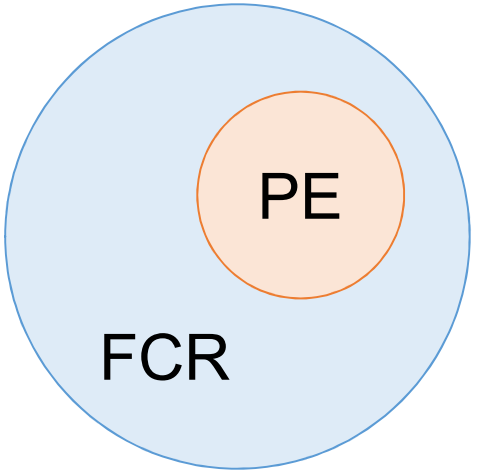
- $r_G$ (depends on subset!)
  - *Kasper et al. 2020 JABAG: (N=294)*

    **$r_G$ = −0.70 [−0.90, −0.04]**
  - *PigEff3 data set: (N=510)*

    **$r_G$ = −0.96 [−0.97, −0.95]**
  - *Total data set: (N=1071)*

    **$r_G$ = −0.40 [−0.50, −0.30]**
- Physiology
- QTL
- Simulation study



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# Phenotyping

***Wanted: prediction method!***

*Feeding patterns?*

| | |
|---|---|
| Protein efficiency | ▪ $R^2$=0.33<br>▪ RMSE=0.02 |
| Energy efficiency | ▪ $R^2$=0.54<br>▪ RMSE=0.02 |
| Lipid gain | ▪ $R^2$=0.82<br>▪ RMSE=8.35 |

Ewaoluwagbemiga E.O., Bee G. & Kasper C., 2021. Animal



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# Conclusions I

**Phenotyping via DXA seems to work well**

- *High-precision phenotyping* important -
  - new traits
  - small N
- Still *expensive* (1.1 M CHF ~ 1’500 CHF per pig)
- *Facilitate phenotyping*
- *Early phenotyping* for breeding but also nutrition studies

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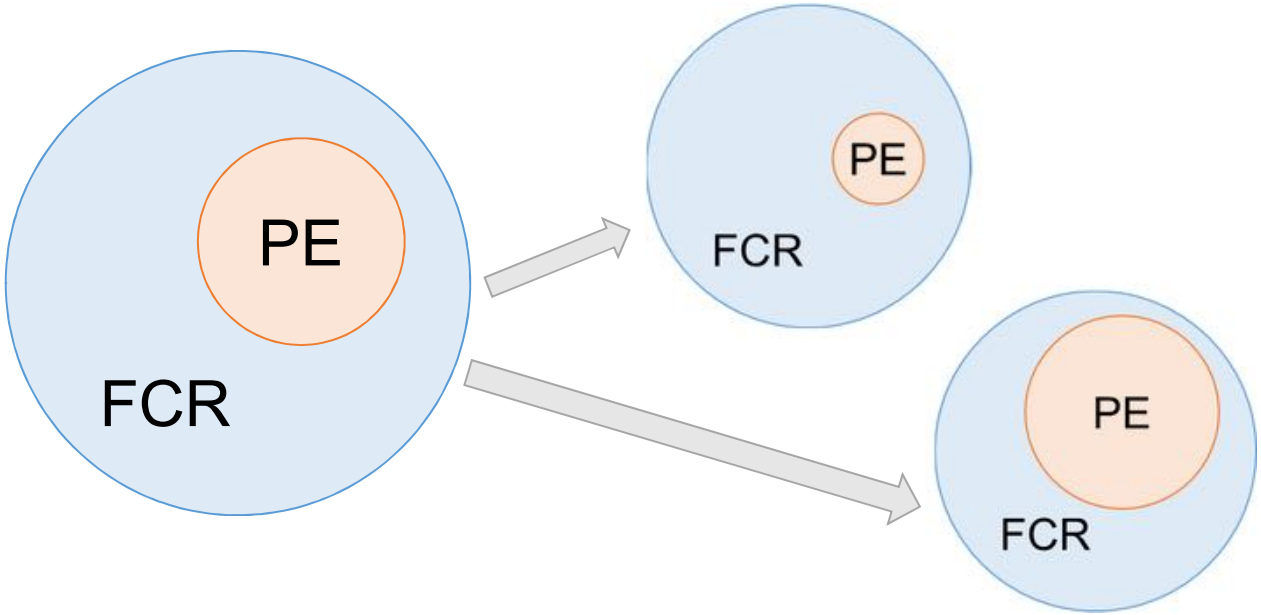
# Conclusions II

- Protein efficiency $\not\equiv$ feed efficiency
- Protein efficiency $\subseteq$ feed efficiency
- Interpret $r_G$ with caution!
- Simulation needed to disentangle selection for both traits



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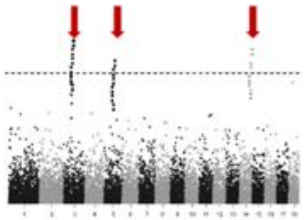
# Outlook

**Genomewide association study** – *in progress*



**Improved phenotyping method** – *to do*

**Breeding and selection simulation to disentangle FCR and protein efficiency** – *to do*

**Functional genetics / eQTL** – *to do*

Collaboration!

# Thank you!

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Projekte Landwirtschaft

**Esther Ewaoluwagbemiga** (PhD student)

Swine Research Unit:
- Guiseppe Bee (pig nutrition)
- Marion Girard (pig nutrition)
- Patrick Schlegel (Suissebilanz, nutrient cycles, DXA)
- Catherine Ollagnier (veterinarian)

Experimental Farm and Abattoir:
- Guy Maïkoff
- Bertrand Egger
- Fabrice Sansonnens

Chemistry and Biology labs:
- Sébastien Dubois
- Paolo Silacci

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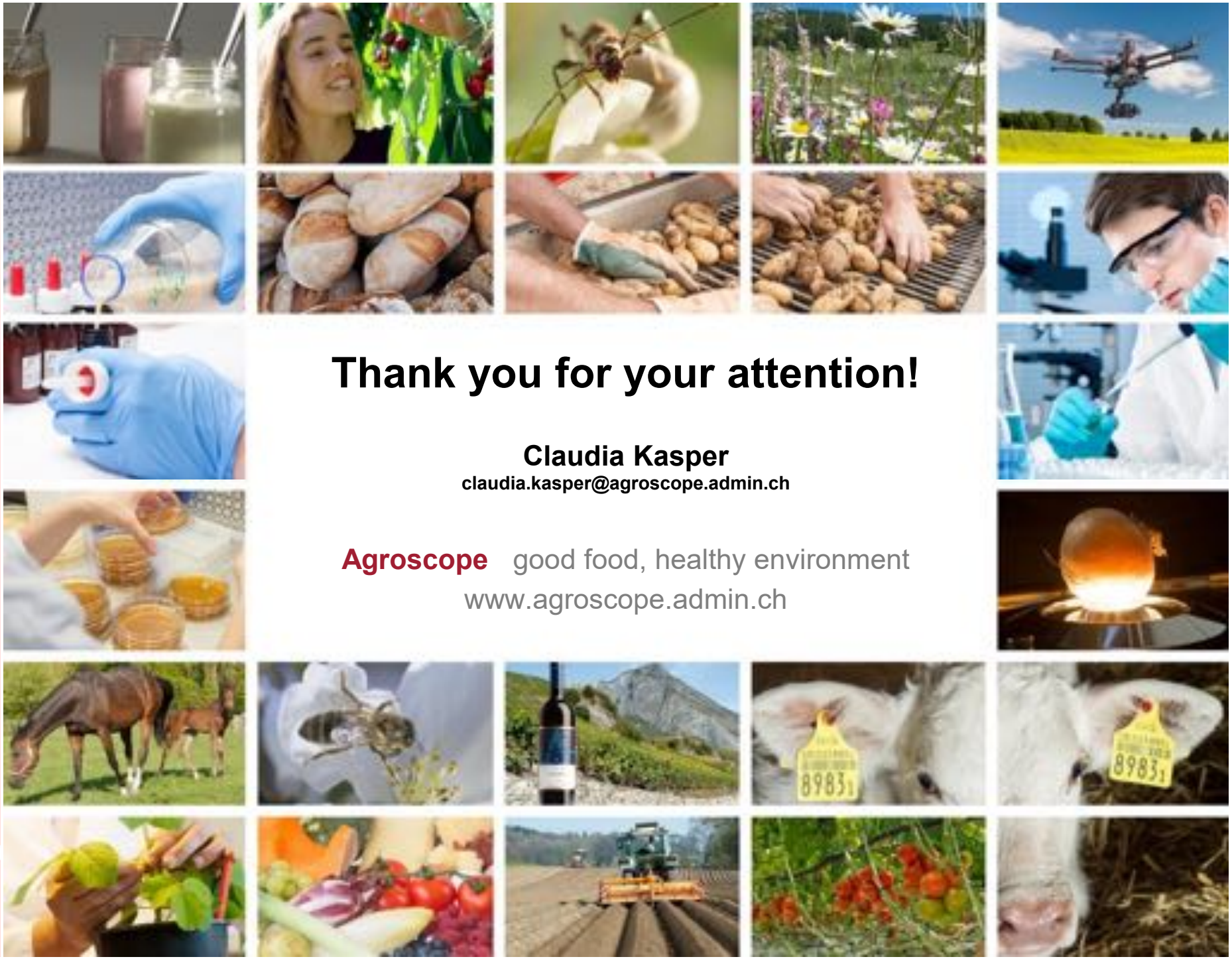

# Thank you for your attention!

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