NATURAL ^{15}N ABUNDANCE OF ANIMAL PROTEINS: A PROMISING BIOMARKER OF FEED EFFICIENCY IN BEEF CATTLE

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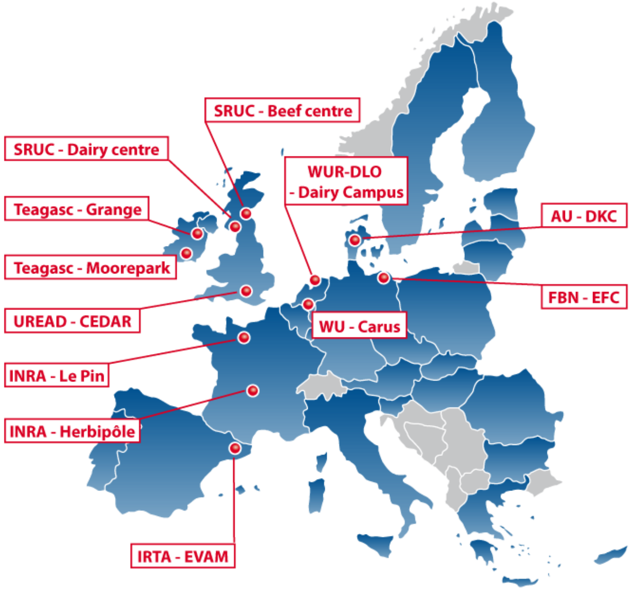
INRAE

SmartCow

an integrated infrastructure for increased research capability and innovation in the European cattle sector

AN INTEGRATED INFRASTRUCTURE FOR INCREASED RESEARCH CAPABILITY AND INNOVATION IN THE EU CATTLE SECTOR

SmartCow



Key EU cattle research infrastructures:

- 7 countries
- 11 research infrastructures (18 installations)
- 3500 cattle

Work package 6:

Developing and evaluating promising biomarkers to predict feed efficiency and its determinants

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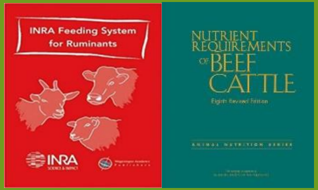
The SmartCow project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°730924

CONTEXT (i)

Improving animal feed efficiency (FE) may contribute to the sustainability of the beef cattle sector (Hill, 2012)

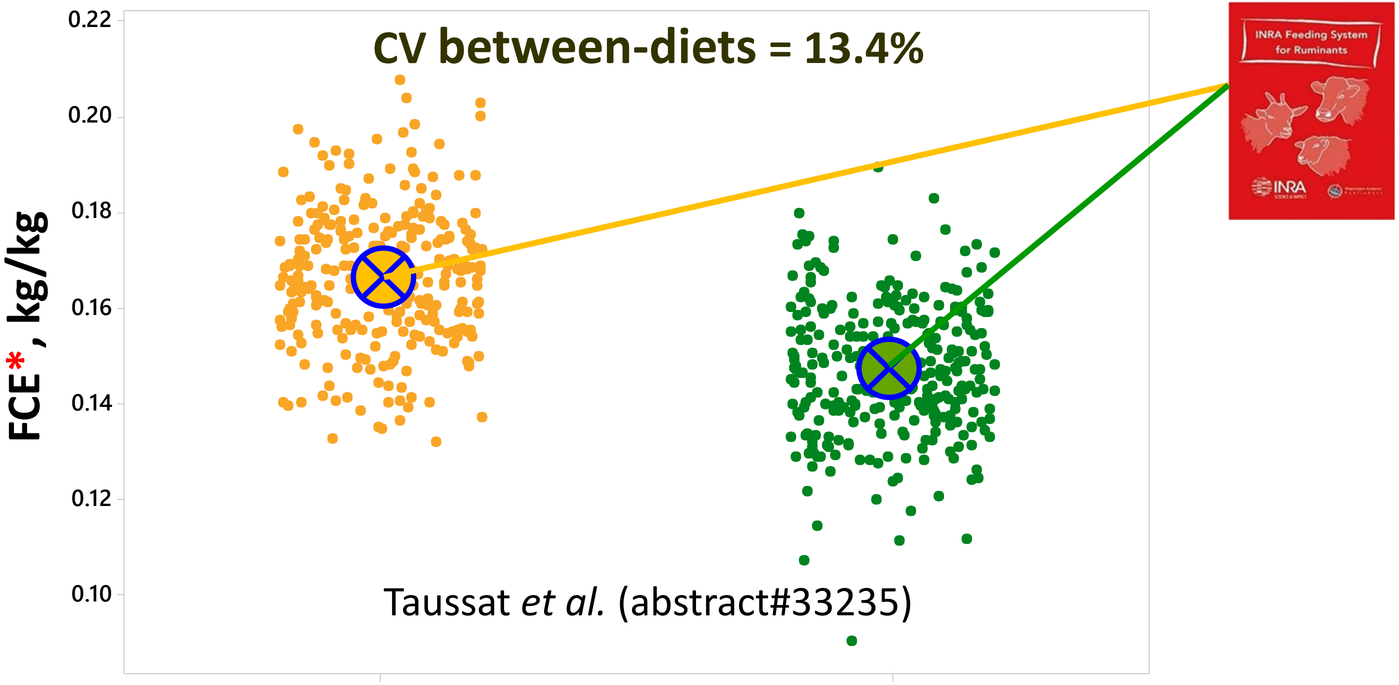
- **NUTRITION:** « DIET as a driver » ➡ Group of animals



- **GENETICS:** « ANIMAL as a driver » ➡ Between-animal variation

- **NUTRITION × GENETICS:** « One ANIMAL, one DIET » ➡ Precision feeding

NUTRITION VS GENETICS



CORN DIET
CV = 8.4%

GRASS DIET
CV = 9.5%

**adjusted for the effects of the contemporary group*

CONTEXT (ii)

Phenotyping FE is costly, labor- and time-consuming !!
…….and sometimes not feasible (grazing)

=> PROXIES to assist the genetic selection and precision feeding
=> None have been proposed & validated for predicting FE in beef cattle (yet genomics appears promising)

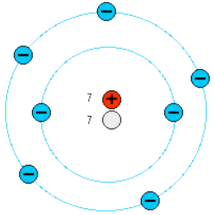
<u>ISOTOPIC NITROGEN DISCRIMINATION</u> has a potential to reflect animal-to-animal variation in FE in beef cattle
(Wheadon et al., 2014; Cantalapiedra-Hijar et al., 2015)

WHAT THE H*LL IS ISOTOPIC DISCRIMINATION?

NITROGEN ISOTOPES IN THE NATURE

^{14}N

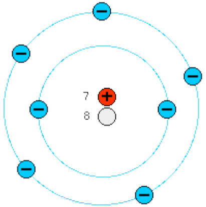
LIGHT



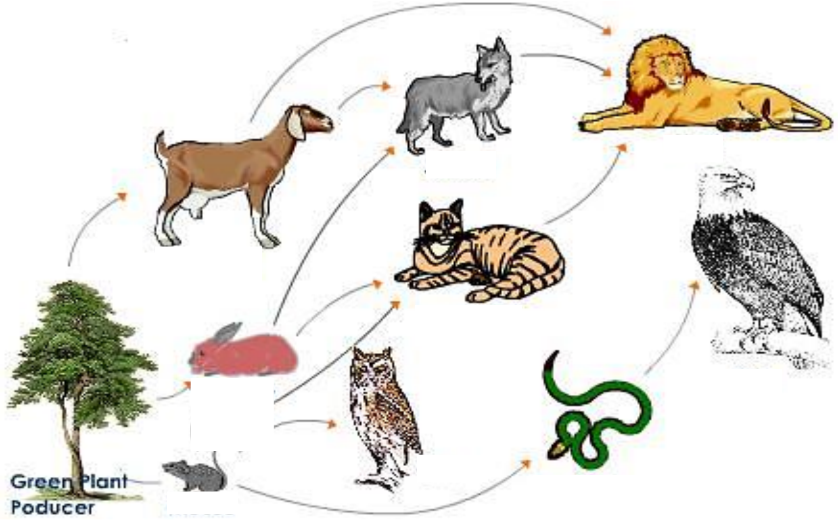
Abondance 99.63%

^{15}N

HEAVY



Abondance 0.37%



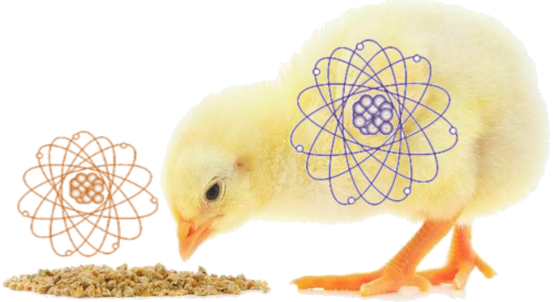
DIFFERENT ISOTOPE DISTRIBUTION

ISOTOPIC TRANSFER FROM DIET TO TISSUES

WE ARE WHAT WE EAT

NOT COMPLETELY TRUE FROM AN ISOTOPIC POINT OF VIEW!

BUT ……



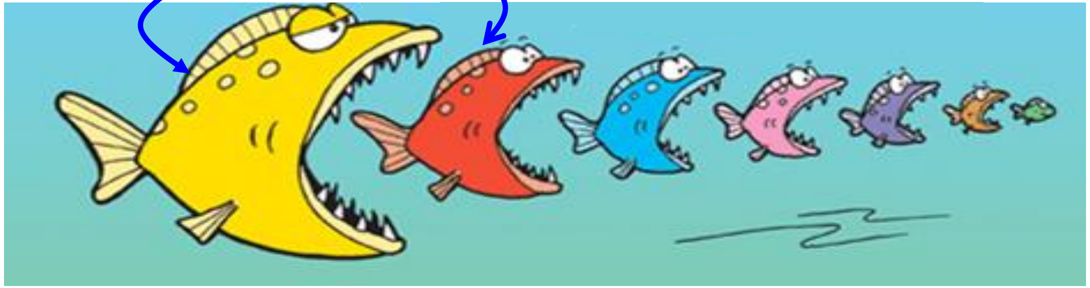
Journal of Archaeological Science (1999) **26,** 667–673
Article No. jasc.1998.0391, available online at http://www.idealibrary.com

Isotope Fractionation: Why Aren't We What We Eat?

Dale A. Schoeller

ISOTOPIC DISCRIMINATION IN ECOLOGY

$\delta^{15}N_{predator} - \delta^{15}N_{prey} = \Delta^{15}N = 3.5‰ \pm X$

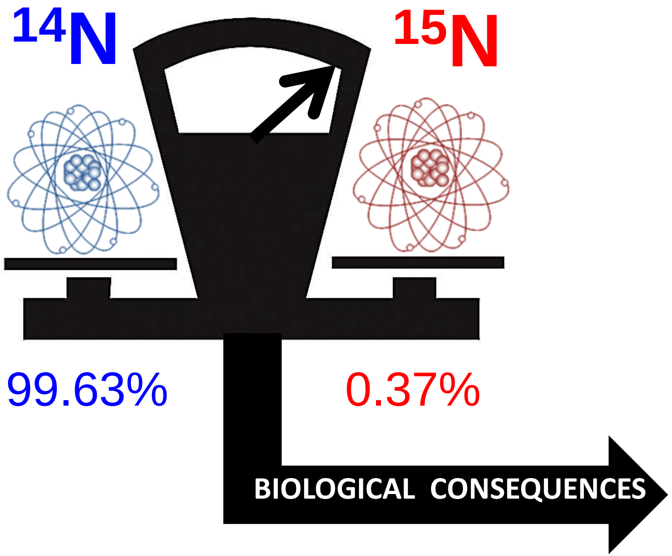


\+ $\delta^{15}N$ ($^{15}N/^{14}N$, ‰) -

± X may translate differences in N assimilation across individuals

« Organisms are ^{15}N enriched relative to their diets because not all ingested proteins are retained (some are excreted) and **some metabolic pathways may discriminate ^{15}N vs ^{14}N during the nitrogen assimilation process** »

ISOTOPIC NITROGEN DISCRIMINATION IN RUMINANTS



ENZYMES

HEPATIC AMINO ACID (AA) CATABOLISM :

Affinity for ^{14}N-AA > ^{15}N-AA

(Macko et al., 1986)

- **Animal proteins naturally more enriched in ^{15}N when AA CATABOLISM increases**

  (Cantalapiedra-Hijar et al., 2015)

N ASSIMILATION BY RUMEN BACTERIA :

Affinity for ^{14}N-NH_3 > ^{15}N-NH_3

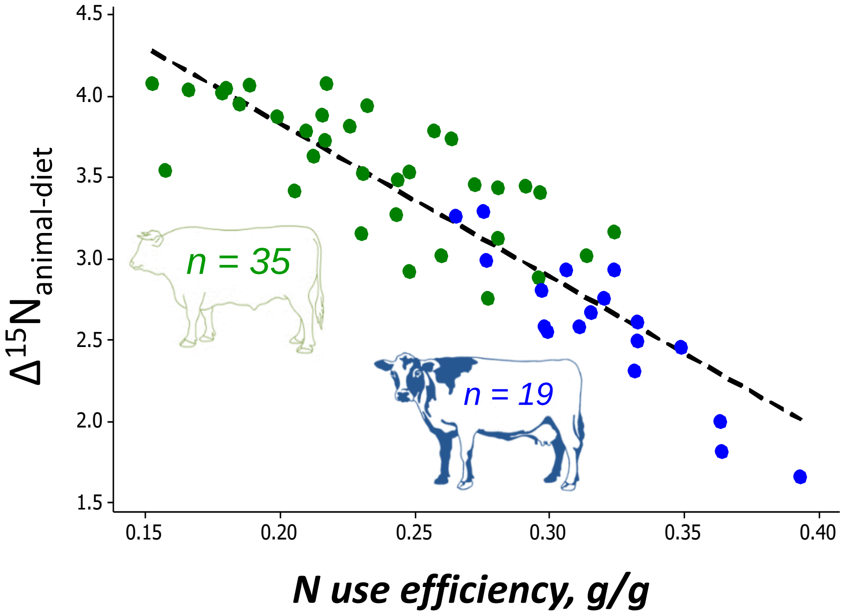
(Wattiaux and Reed, 1995)

- **Animal proteins naturally more enriched in ^{15}N when MICROBIAL N ASSIMILATION decreases**

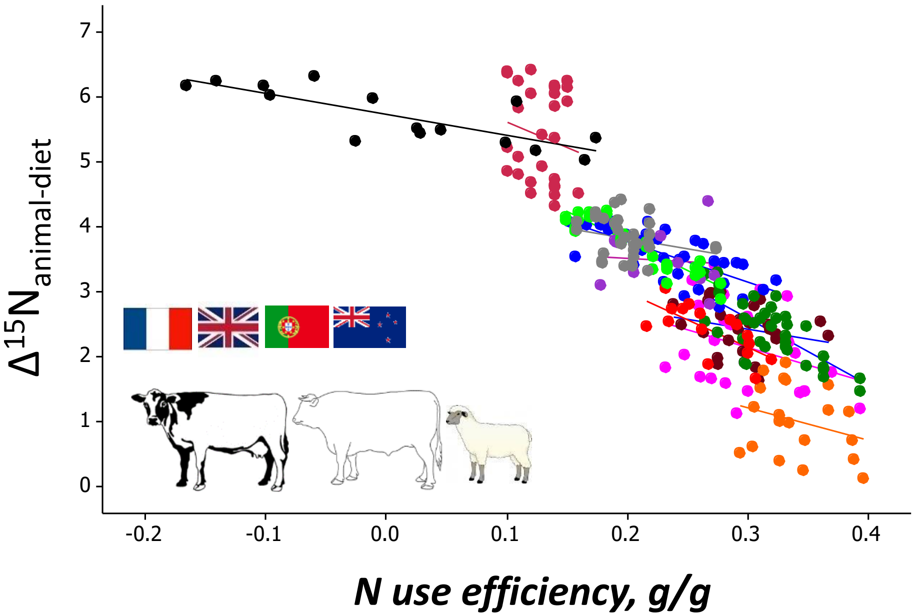
  (Cantalapiedra-Hijar et al., 2016)

PROTEIN EFFICIENCY AND ISOTOPIC N DISCRIMINATION

PROOF OF CONCEPT → CONFIRMATION BY META-ANALYSIS



Cantalapiedra-Hijar et al., 2015



Cantalapiedra-Hijar et al., 2018

PROTEIN EFFICIENCY AND FEED EFFICIENCY ARE CLOSELY RELATED AT THE INDIVIDUAL LEVEL!!

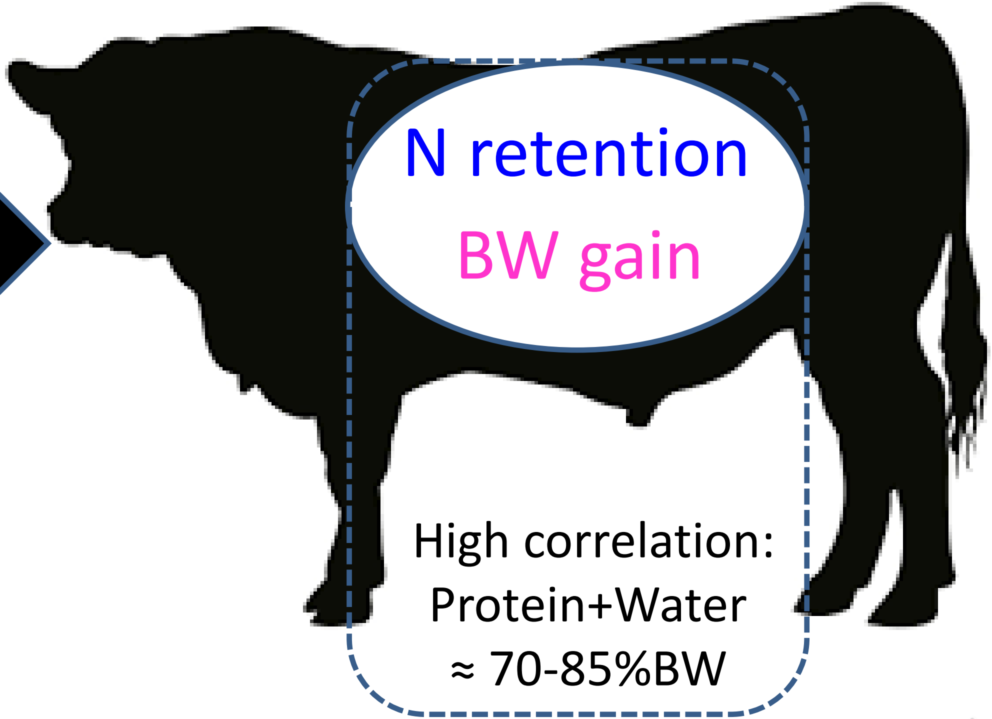
Prot Eff

Feed Eff

N intake

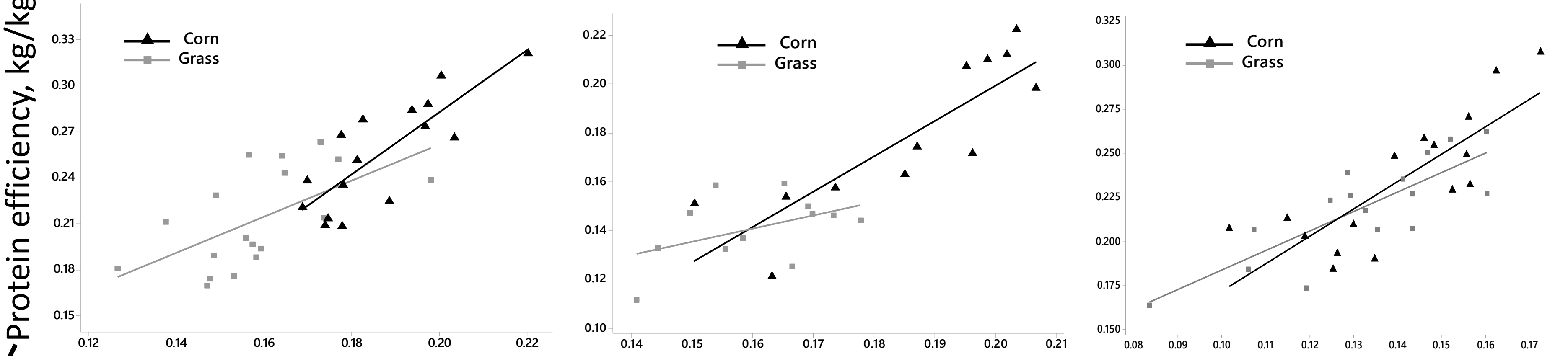
DM intake

Correlation = 1
If not sorting



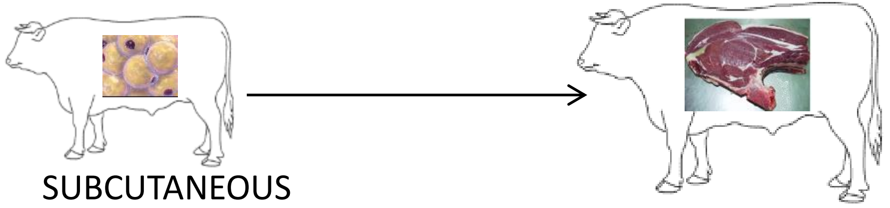
LINK BETWEEN PROTEIN EFFICIENCY AND FEED EFFICIENCY

Cantalapiedra-Hijar et al., 2015 | *Nasrollahi et al., 2020* | *Guarnido et al., unpublished*



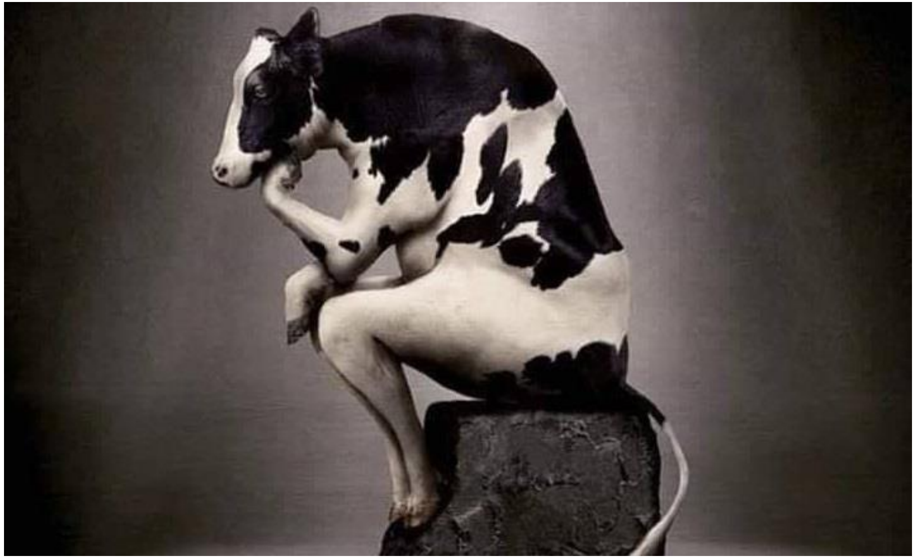
Feed conversion efficiency, kg/kg

ESTIMATION OF PROTEIN RETENTION



SUBCUTANEOUS ADYPOCITES SIZE

6th RIB DISSECTION



Source: https://edairynews.com/

SYLLOGISM:

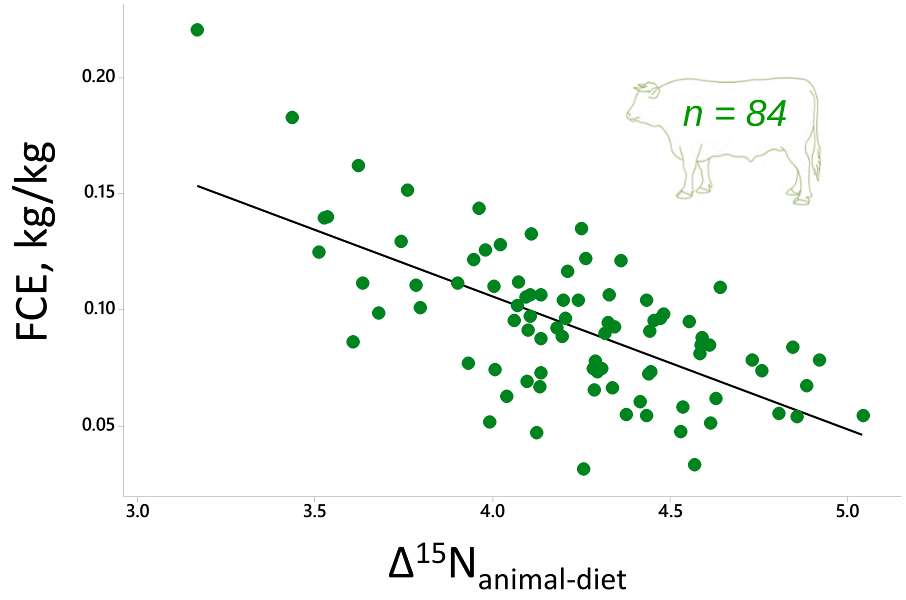
IF $\Delta^{15}N$ IS CORRELATED TO PROTEIN EFFICIENCY

AND PROTEIN EFFICIENCY IS CORRELATED TO FEED EFFICIENCY

THEN…………..

FEED EFFICIENCY AND $\Delta^{15}N$

PROOF OF CONCEPT



Wheadon et al., 2014

CONFIRMED IN SOME MORE STUDIES

- *Cantalapiedra-Hijar et al., 2015*
- *Meale et al., 2017*
- *Meale et al., 2018*
- *Nasrollahi et al., 2020*
- *Cantalapiedra-Hijar et al., 2020*

INCONSISTENT WITH RFI

- *Non-Significant:*
  - *Wheandon et al., 2014;*
  - *Meale et al., 2017*
- *Significant:*
  - *Cantalapiedra-Hijar et al., 2020*

OBJECTIVES

To confirm by meta-analysis the potential of $\Delta^{15}N_{animal\text{-}diet}$ to reflect animal-to-animal variation of feed conversion efficiency in different EU beef production systems

***To test if this biomarker could equally work for residual feed intake (not originally included in the EAAP abstract)**

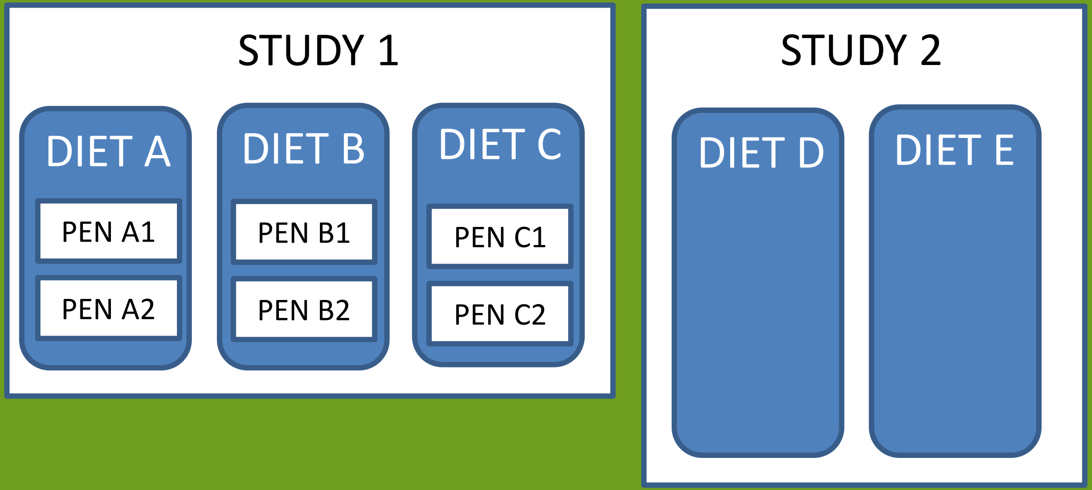
MATERIAL AND METHODS (I)

- 9* studies from 3 countries (FR, UK, CH) with FE test lasting from 60 to 200d
  Wheadon et al., 2014; Cantalapiedra-Hijar et al., 2015, 2020; Meale et al., 2017,2018; Nasrollahi et al., 2020 + 3 unpublished studies
- 570* individual data from growing-fattening bulls (6), steers (2) or heifers (1)
- Pure Charolais (25%) or crossed breeds (Lim x Sim, Sim x Hol, Ang x Lim..)
- 27* different fattening diets (9 to 84 individuals per diet)
  - 65% data from diets based on grass silage (>50%DM)
- Feed pooled for the whole FE test and blood/muscle sampling at the end
- Plasma, muscle and feed samples analyzed for $\delta^{15}N$ by EA-irms

** One more study has been added to this analysis in relation to the EAAP abstract*

MATERIAL AND METHODS (II)

What we consider to be « at the individual level » in this study ?



Animals reared in similar conditions:

- **Same study (location)**
- **Same diet at the same time**
- **But NOT the same pen (info not available yet)**

At the individual level = Within-DIET regressions => No need ^{15}N from diet!

MATERIAL AND METHODS (III)

2 statistical approaches to explore relationships at the individual level:

- **I) MIXED-EFFECT MODEL**

$$\mathbf{FCE} = (A + \alpha) + (B + \beta) \times \mathbf{\Delta^{15}N} + \varepsilon$$

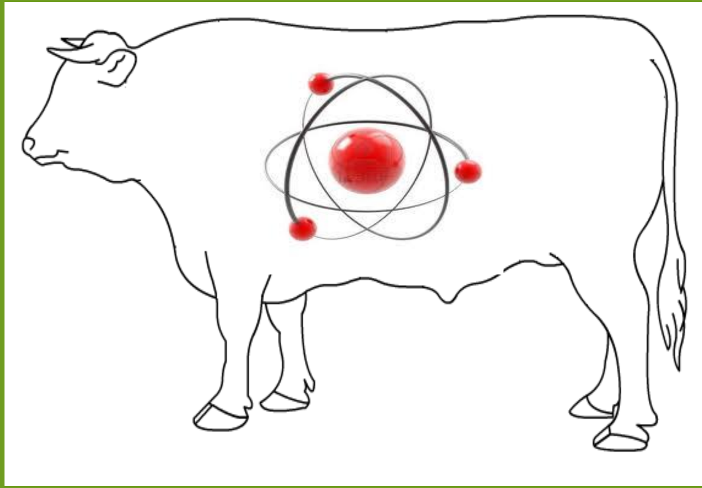
α and β: random effects (study and diet within study)

- **II) SIMPLE REGRESSION** when the effect of study and diets were first removed from both FE and $\Delta^{15}N$

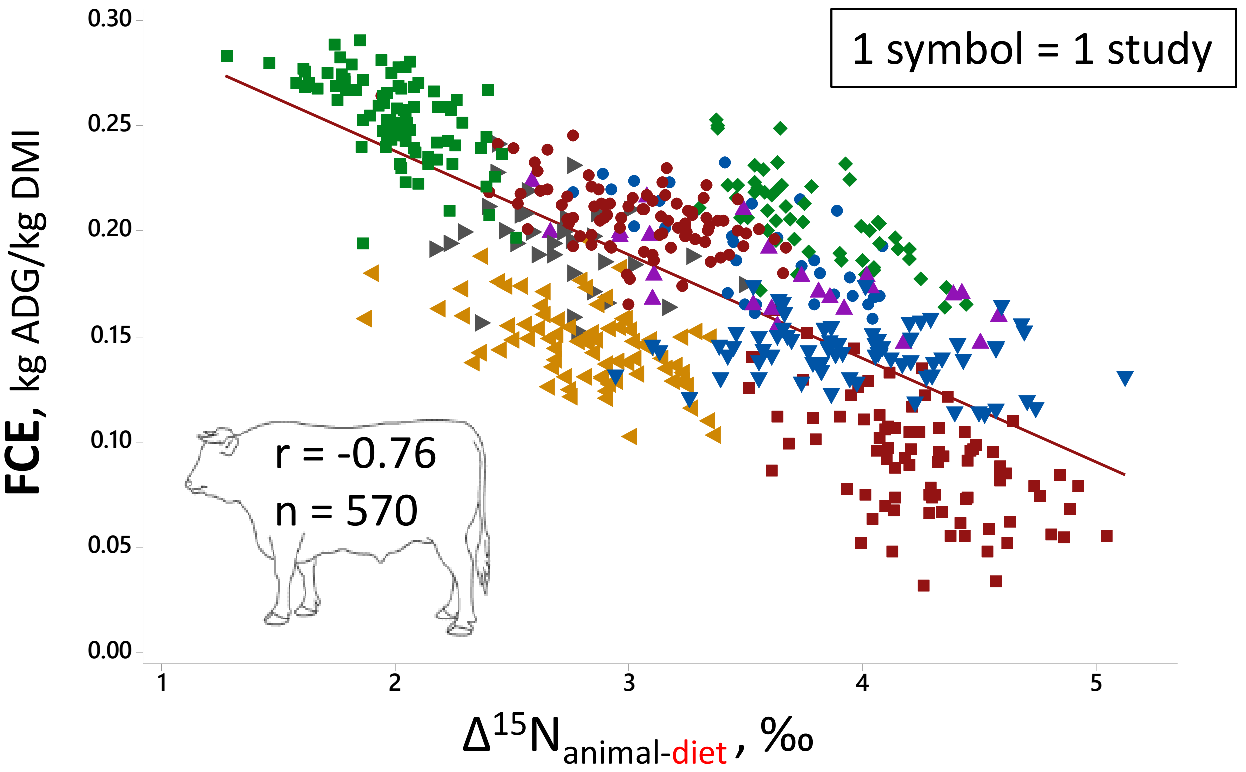
a) Residuals FCE = A + B × Residuals $\Delta^{15}N$

b) RFI = A + B × Residuals $\Delta^{15}N$

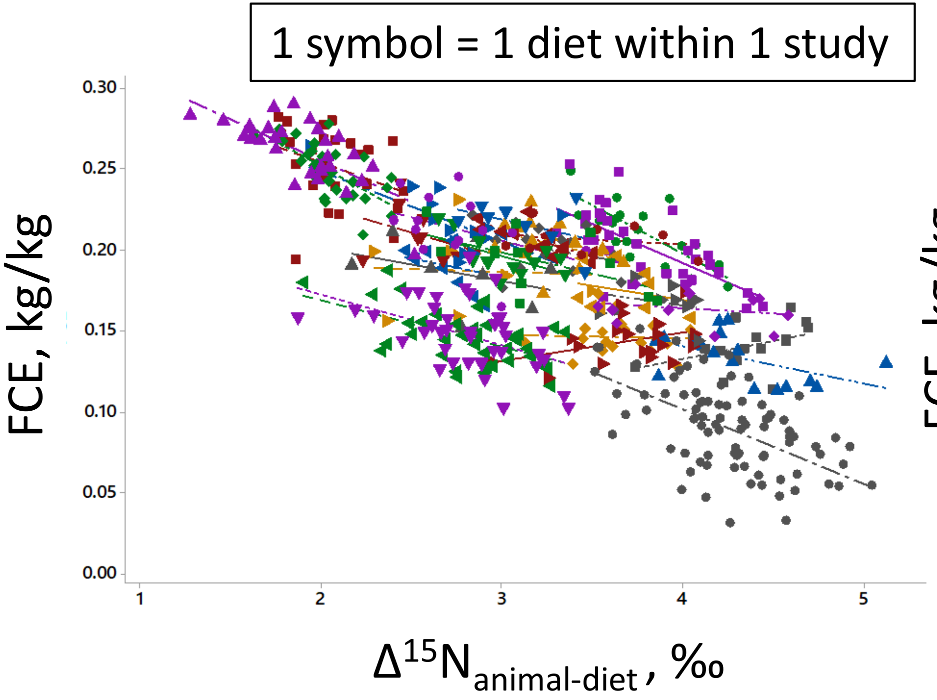
RESULTS

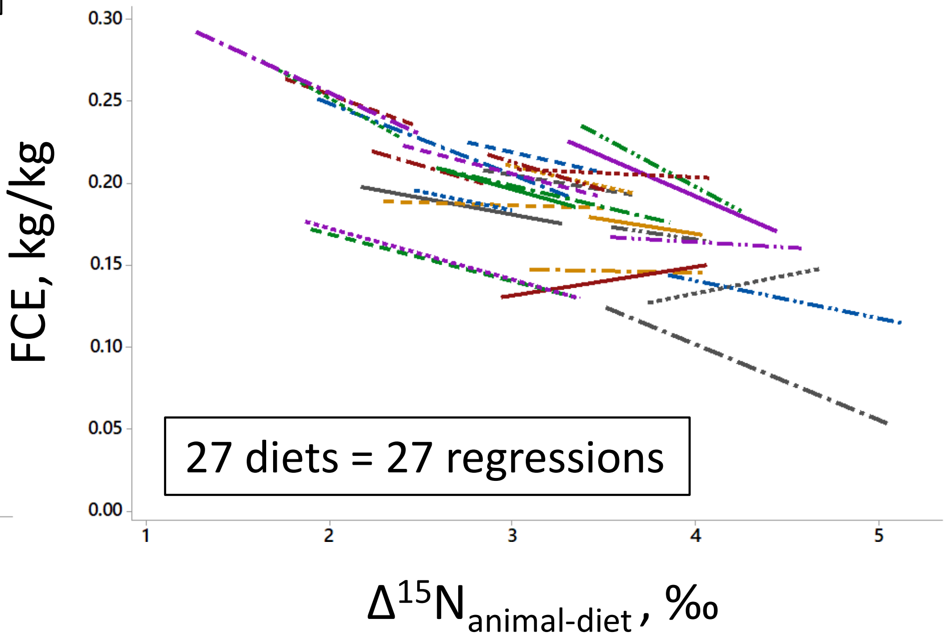


OVERALL RELATIONSHIP BETWEEN FCE & $\Delta^{15}N$



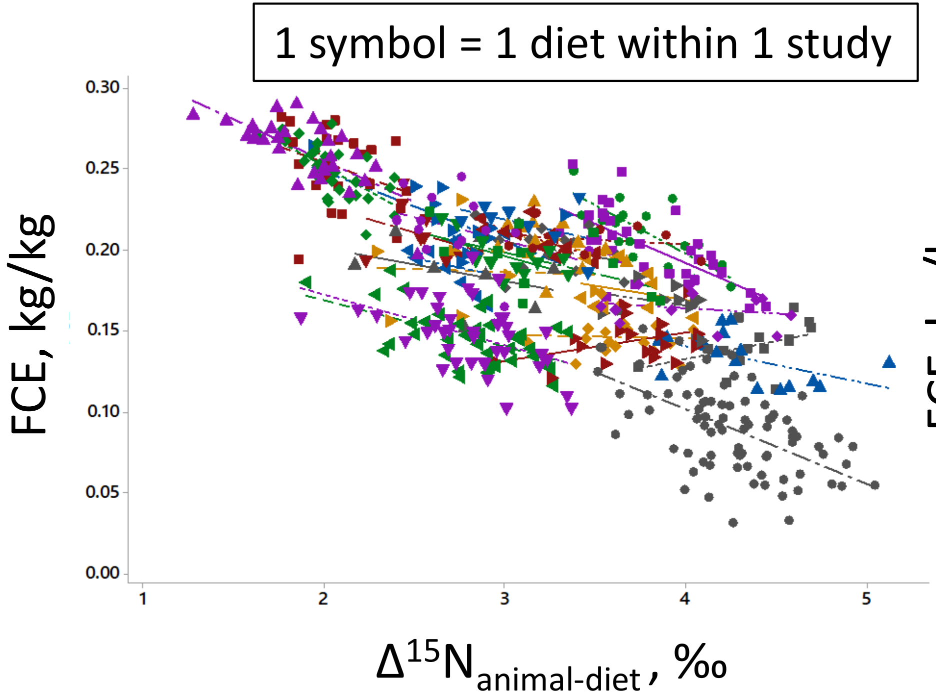
WITHIN-DIET RELATIONSHIP BETWEEN FCE & $\Delta^{15}N$
(MIXED-EFFECT MODEL)

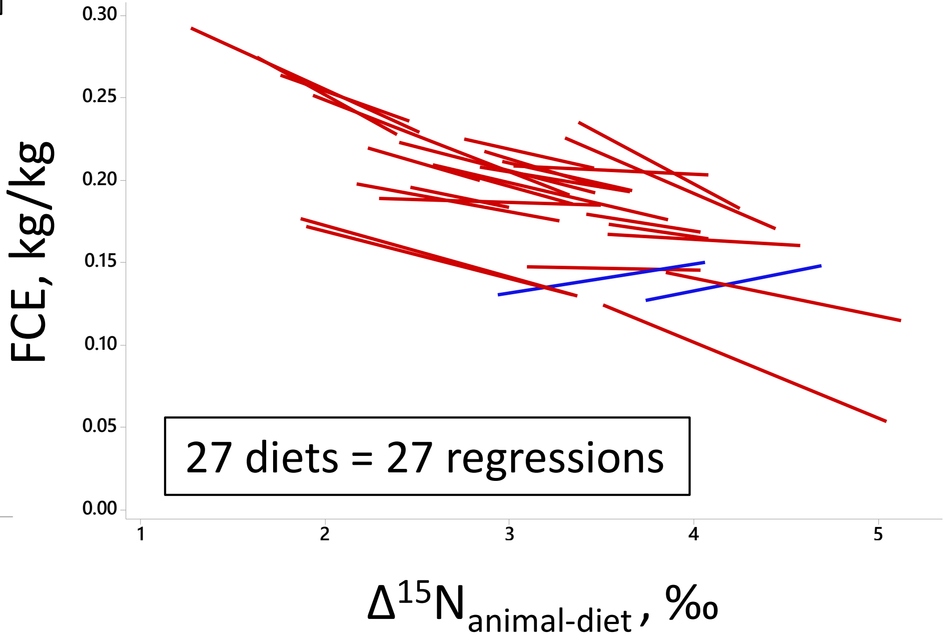




WITHIN-DIET RELATIONSHIP BETWEEN FCE & $\Delta^{15}N$

(MIXED-EFFECT MODEL)





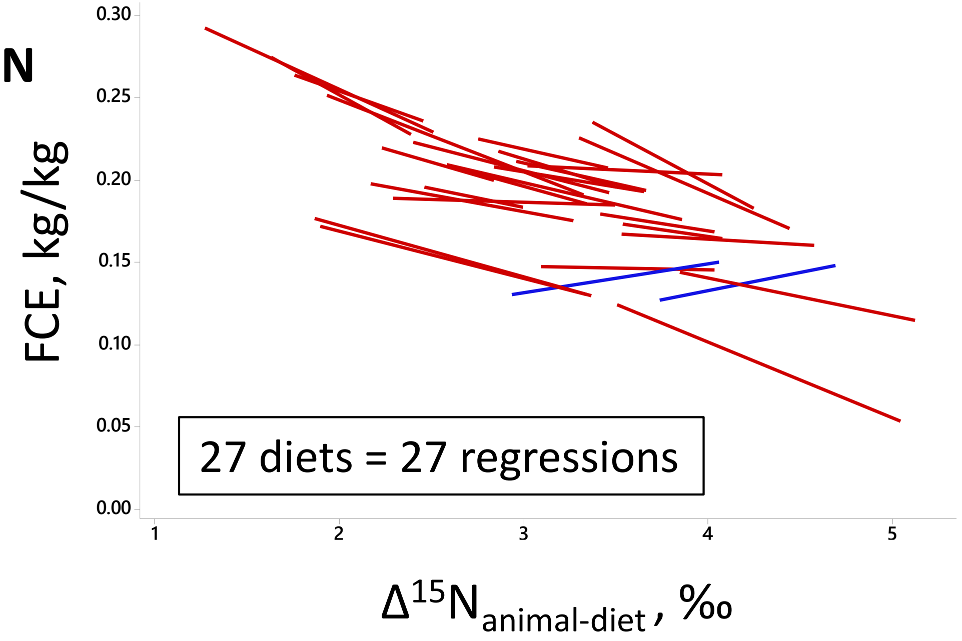
WITHIN-DIET RELATIONSHIP BETWEEN FCE & $\Delta^{15}N$ (MIXED-EFFECT MODEL)

Average within-diet regression

FCE = $0.28^{*}(\pm 0.02)$ **– $0.032^{**}(\pm 0.004) \times \Delta^{15}N$**

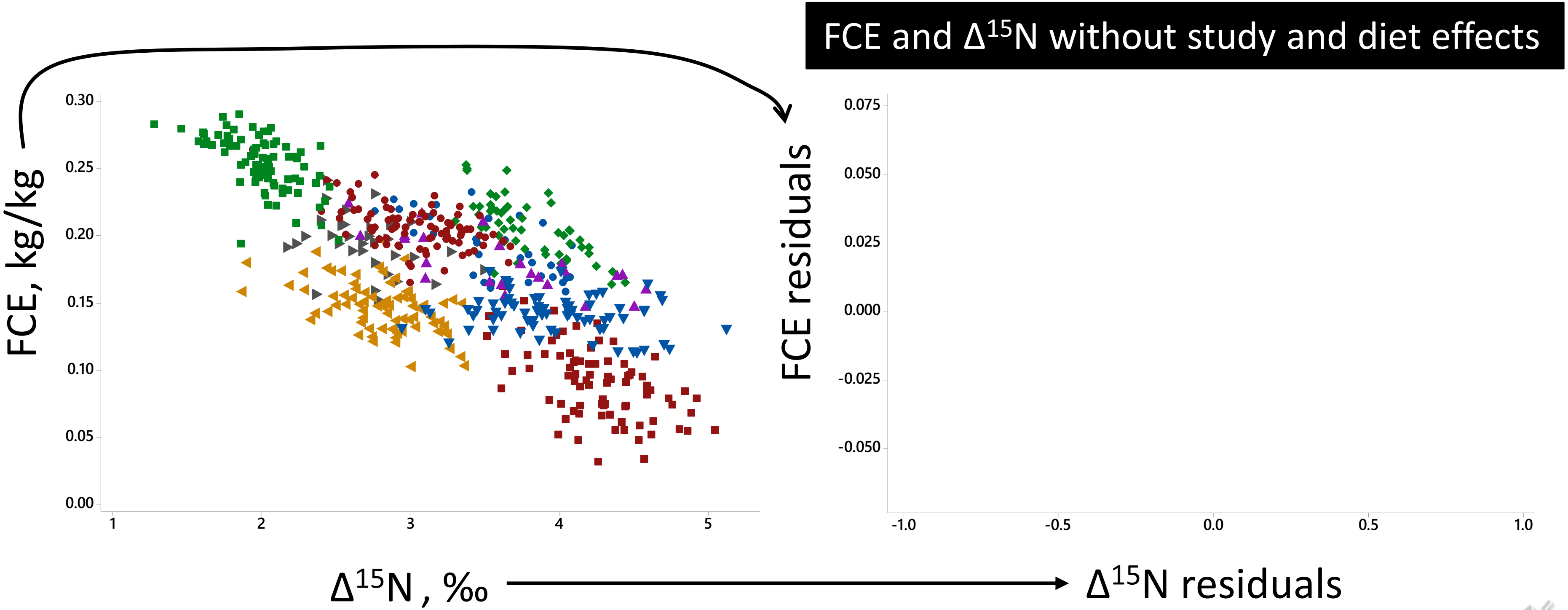
RSE = 0.017 kg/kg

The error is still compatible with the identification of extreme FCE young bulls!



WITHIN-DIET RELATIONSHIP BETWEEN FCE & $\Delta^{15}N$

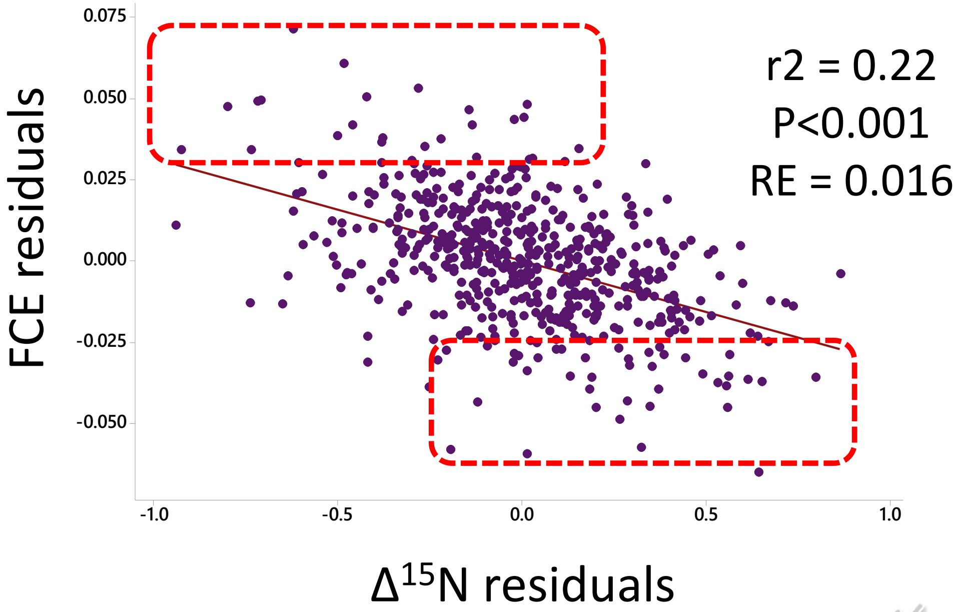
(SIMPLE REGRESSION FROM RESIDUALS)



WITHIN-DIET RELATIONSHIP BETWEEN FCE & $\Delta^{15}N$

(SIMPLE REGRESSION FROM RESIDUALS)

FCE and $\Delta^{15}N$ without study and diet effects

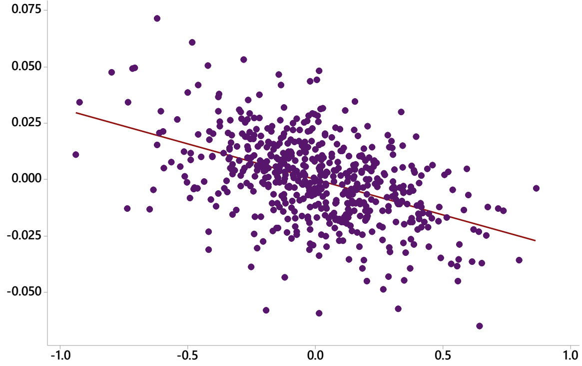


WITHIN-DIET RELATIONSHIP BETWEEN PERFORMANCES AND $\Delta^{15}N$

(SIMPLE REGRESSION FROM RESIDUALS)

FCE

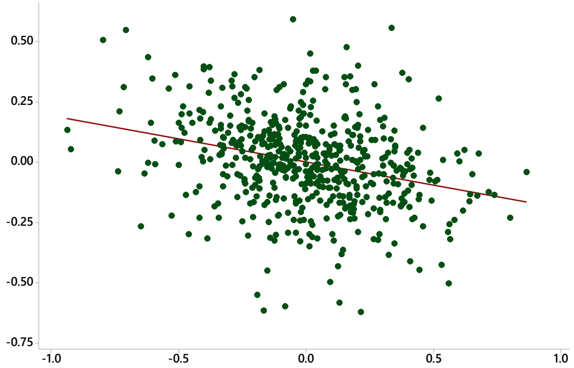
r2 = 0.22***



$\Delta^{15}N$ residuals

ADG

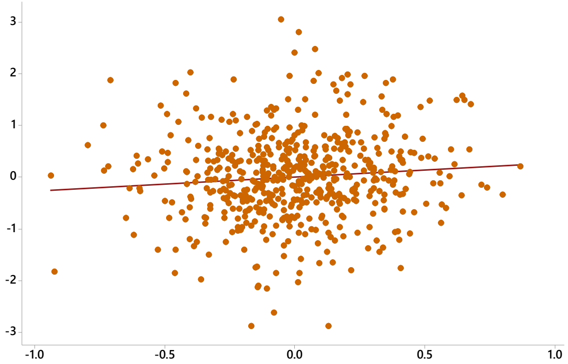
r2 = 0.08***



$\Delta^{15}N$ residuals

DMI

r2 = 0.01*



$\Delta^{15}N$ residuals

FCE ~ ^{15}N (r2 = 0.22)
FCE ~ ADG (r2 = 0.44)

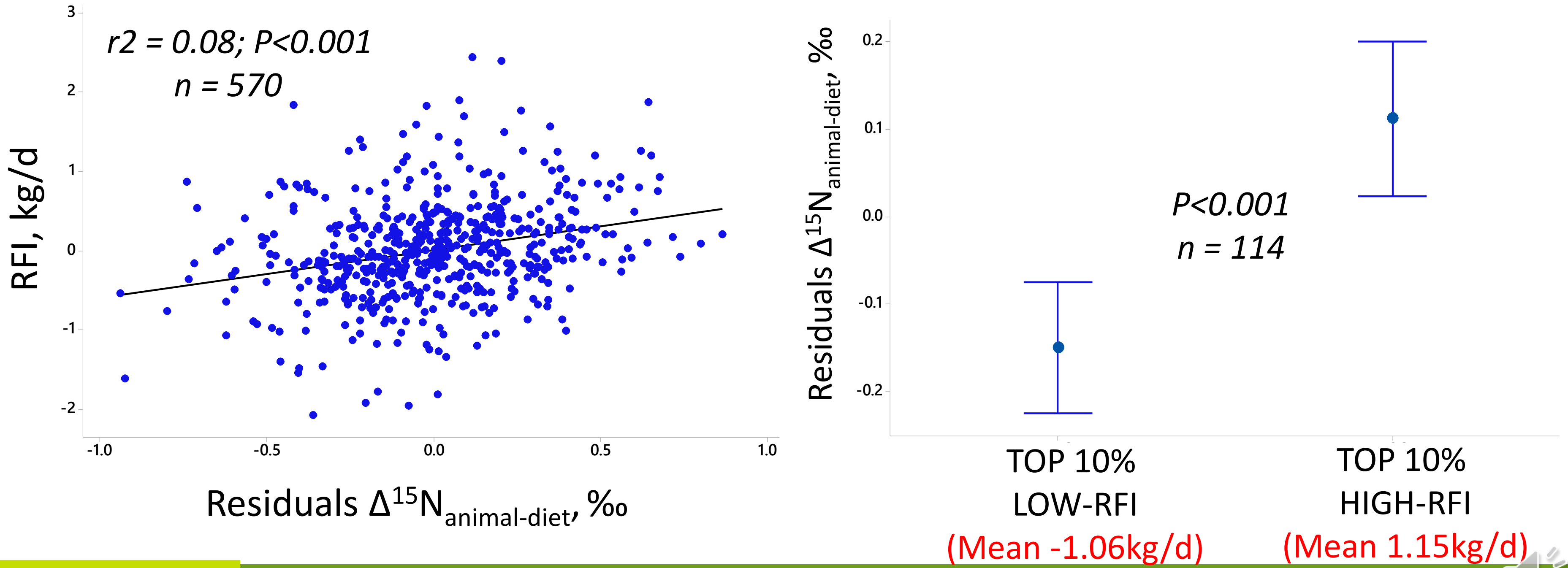
If we combine both predictors: FCE ~ ADG + ^{15}N (r2 = 0.52)

.....but need to be validated

POTENTIAL OF $\Delta^{15}N$ TO REFLECT RFI VARIATION

WHOLE POPULATION

EXTREME RFI ANIMALS



CONCLUSIONS

- We confirmed the potential of $\Delta^{15}N$ to reflect between-animal variation in feed conversion efficiency and residual feed intake
- Most efficient beef cattle (10% highest FCE and 10% lowest RFI) had lower 15N abundance in their proteins than their less efficient counterparts
- More research is needed to validate this biomaker in practical conditions and to assess genetic correlations with feed efficiency

ACKNOWLEDGEMENTS

I Ortigues-Marty

C Martin

I Morel

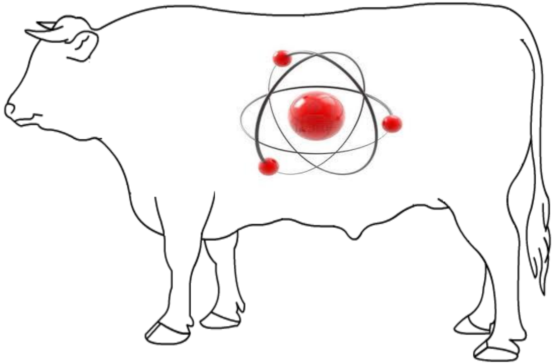
R Dewhurst

Céline Chantelauze
(irms analysis)

Public funds SmartCow

Private funds APIS-GENE Investir Innover Valoriser ADISSEO A Bluestar Company

THANK YOU FOR YOUR ATTENTION



SmartCow
an integrated infrastructure for increased research capability and innovation in the European cattle sector

www.smartcow.eu

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The SmartCow project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°730924