Isotopic natural abundance as biomarkers of between-animal variation in feed efficiency in ruminants

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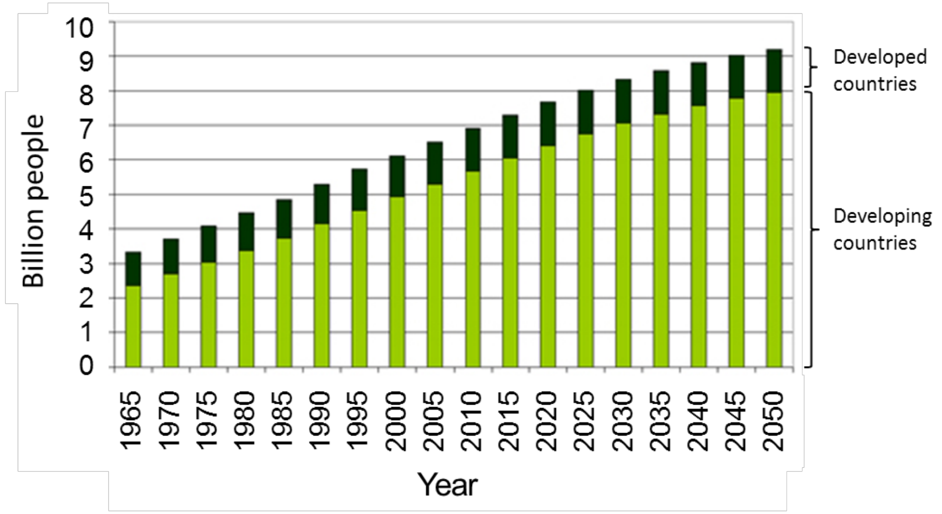
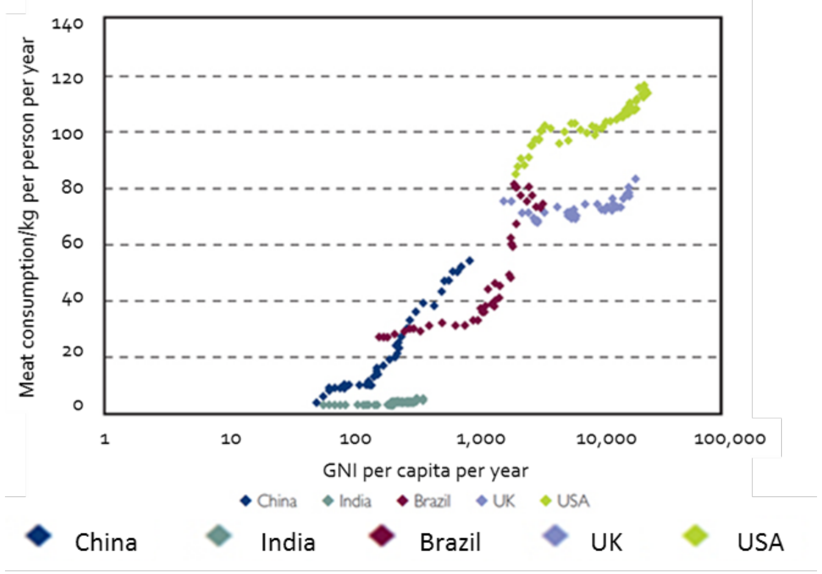


Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2007)



Source: FAOSTAT; World Bank

- Today ruminants consume 30% of crops grown globally and occupy another 30% of global land mass (Thornton, 2010)

Need to improve production efficiency on currently available land area and resources to minimise environmental impact

Feed Conversion Efficiency (FCE)

kg gain/ kg DMI

Residual Feed Intake (RFI)

Actual – expected intake for maintenance and growth over a set period

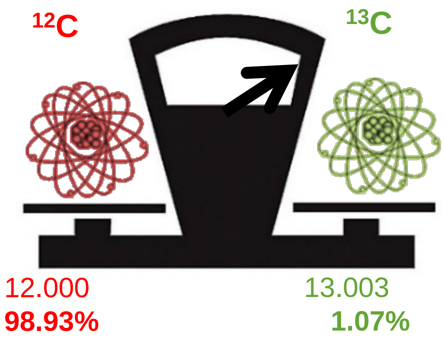
- independent of BW and weight gain
- moderately heritable trait (h^2 = 0.29-0.46)

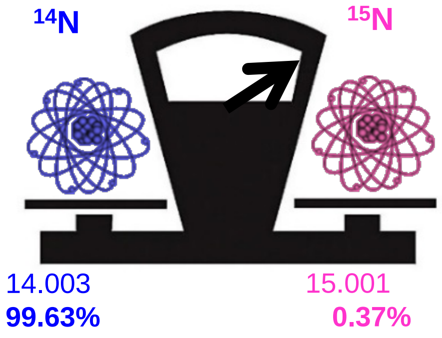
- Variable efficiency to assimilate nutrients between individuals
- Expensive and difficult to measure in farming conditions

Objective

Explore natural abundance of ^{15}N and ^{13}C and isotopic fractionation as biomarkers of individual feed efficiency in cattle fed forage-based diets

Natural abundance of isotopes





- Calculated as the ratio of heavier isotope to lighter isotope, compared to a reference standard:
  - $^{13}C/^{12}C$
  - $^{15}N/^{14}N$

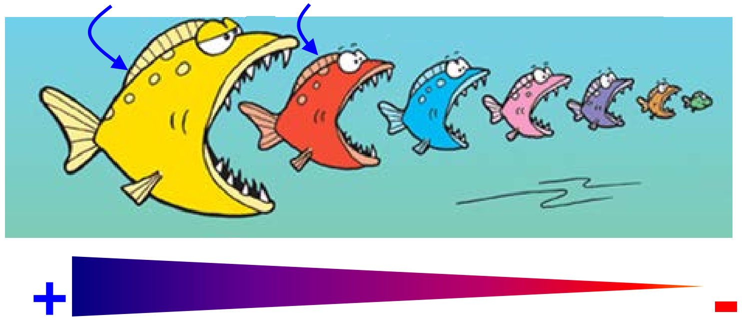
- Lighter isotopes tend to form weaker bonds and react faster than heavier isotopes (Macko et al., 1984)
  - Abundance of stable isotopes varies between chemical species = **fractionation** (Gannes et al., 1998)

Isotopic N fractionation : $\Delta^{15}N_{(animal\text{-}diet)} = \delta^{15}N_{animal} - \delta^{15}N_{diet}$

^{15}NAnimal - ^{15}Ndiet

Variable efficiency

$^{15}N_{predator} - ^{15}N_{prey}$ = " $^{15}N = 3.4‰ \pm X$



+ ^{15}N (‰) -

- **Digestion**

Rumen bacterial protein synthesis

Transaminases and deaminases prefer $^{14}N\text{-}NH_3$ *vs* $^{15}N\text{-}NH_3$

Wattiaux and Reed, 1995

- **Metabolism**

Hepatic amino acid (AA) catabolism

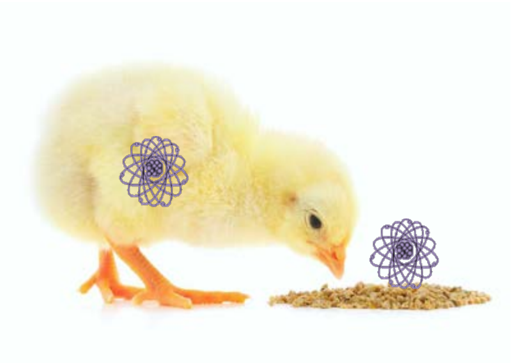
Transaminases and deaminases prefer ^{14}N-AA *vs* ^{15}N-AA

Macko et al., 1986

Enrichment of ^{15}N in the animal

Carbon enrichment is thought to be subjected to the same isotopic discrimination

EFFICIENT

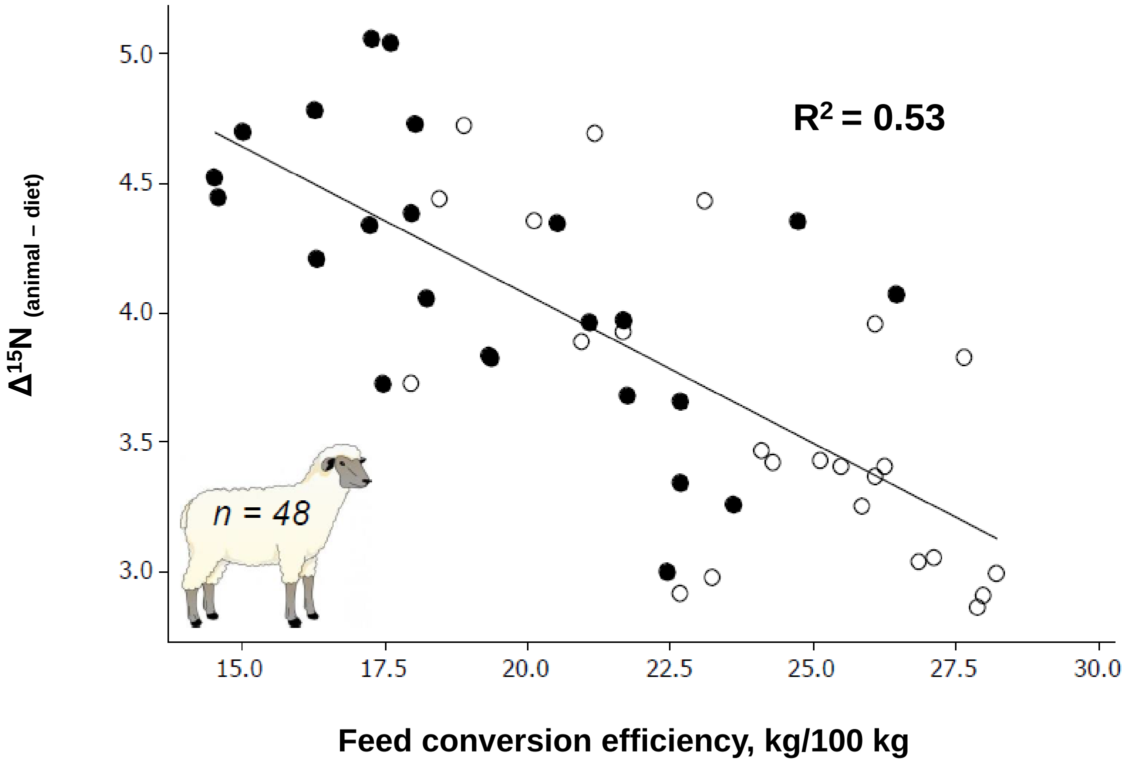


^{15}N animal H ^{15}N diet

INEFFICIENT

^{15}N animal > ^{15}N diet

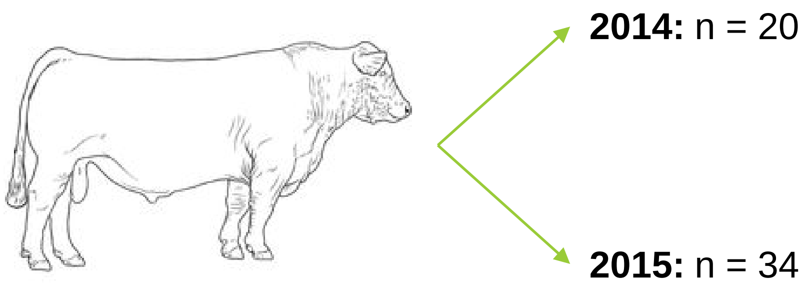
^{15}N urine < ^{15}N diet



- Diet: Dehydrated Lucerne pellet supplemented with Low (100 g) or high (400 g) barley for 75 d pre-slaughter

Cantalapiedra-Hijar et al., 2016

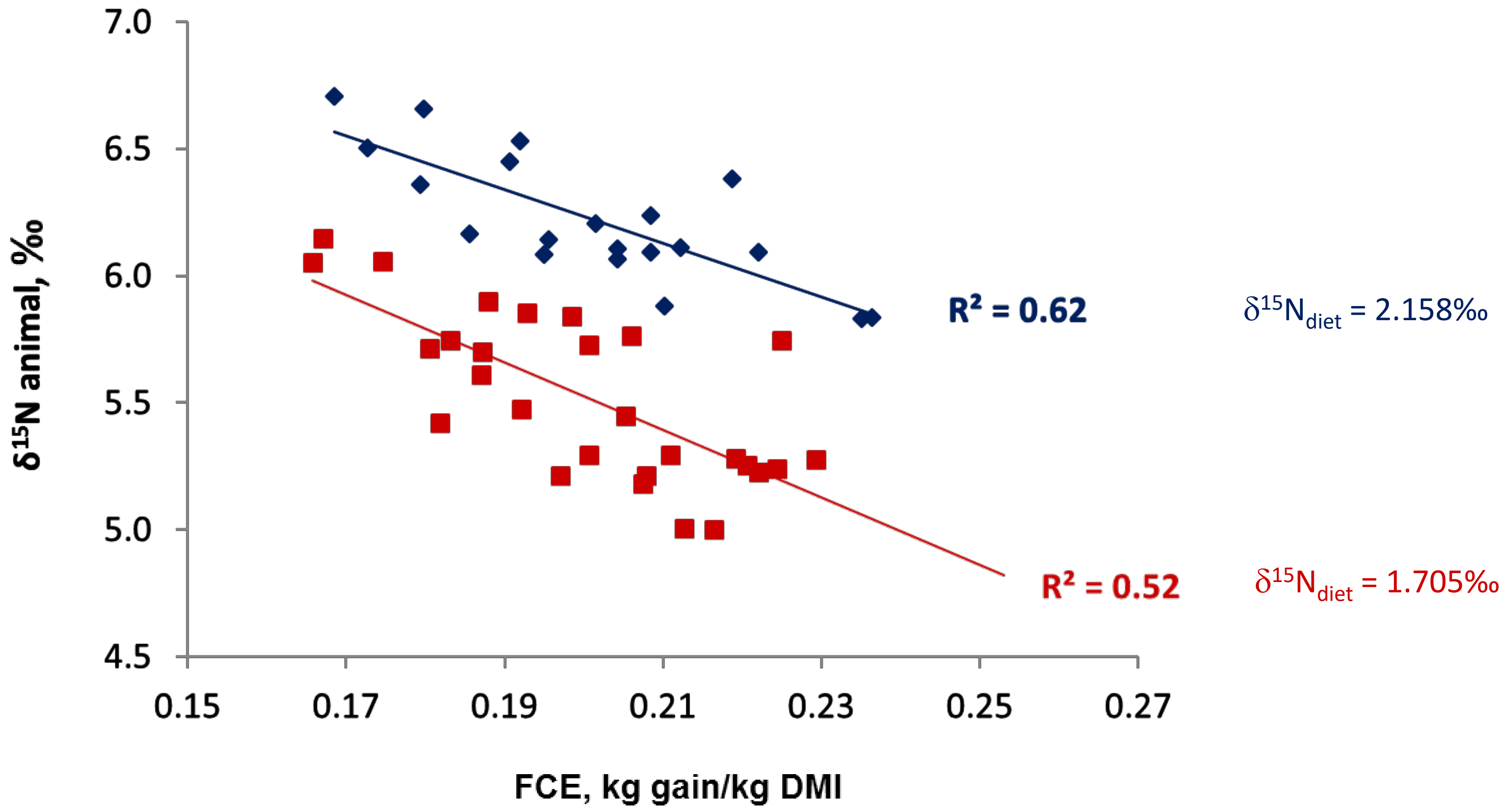
Can isotopic natural abundance be used as a biomarker of between-animal variation in feed efficiency?



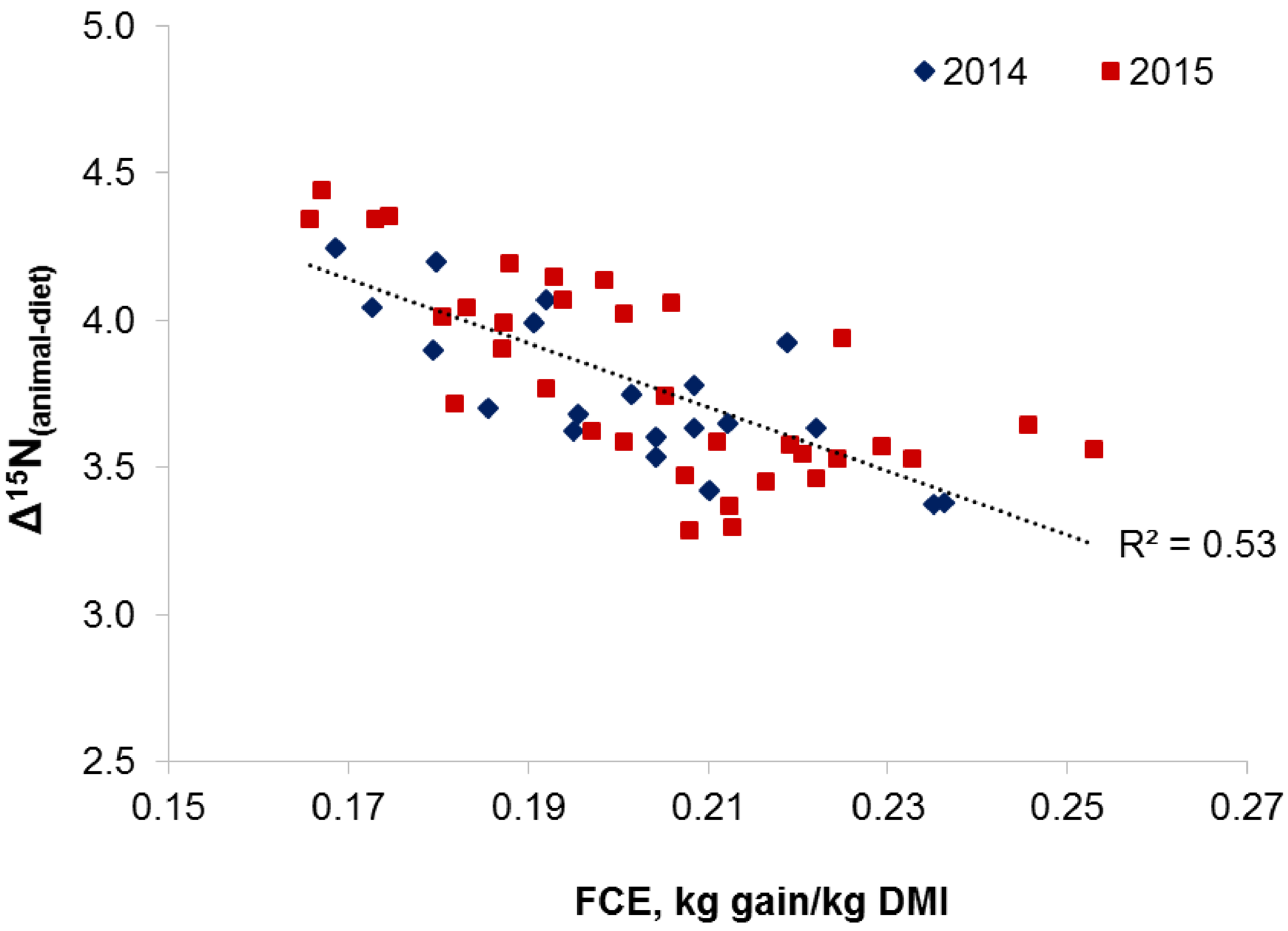
54 Charolais bulls

- Diet of 67% forage: 33% grain
- Tested for RFI and FCE at 8-10 months of age for 112 days
- Plasma was collected at the end of the RFI test
- Natural abundance of ^{15}N and ^{13}C in plasma proteins was determined using a continuous flow isotope ratio measurement mass spectrometer following total combustion in an elemental analyzer (EA-irms)
- Regression analysis was used to determine the relationship between isotope abundance and feed efficiency indices

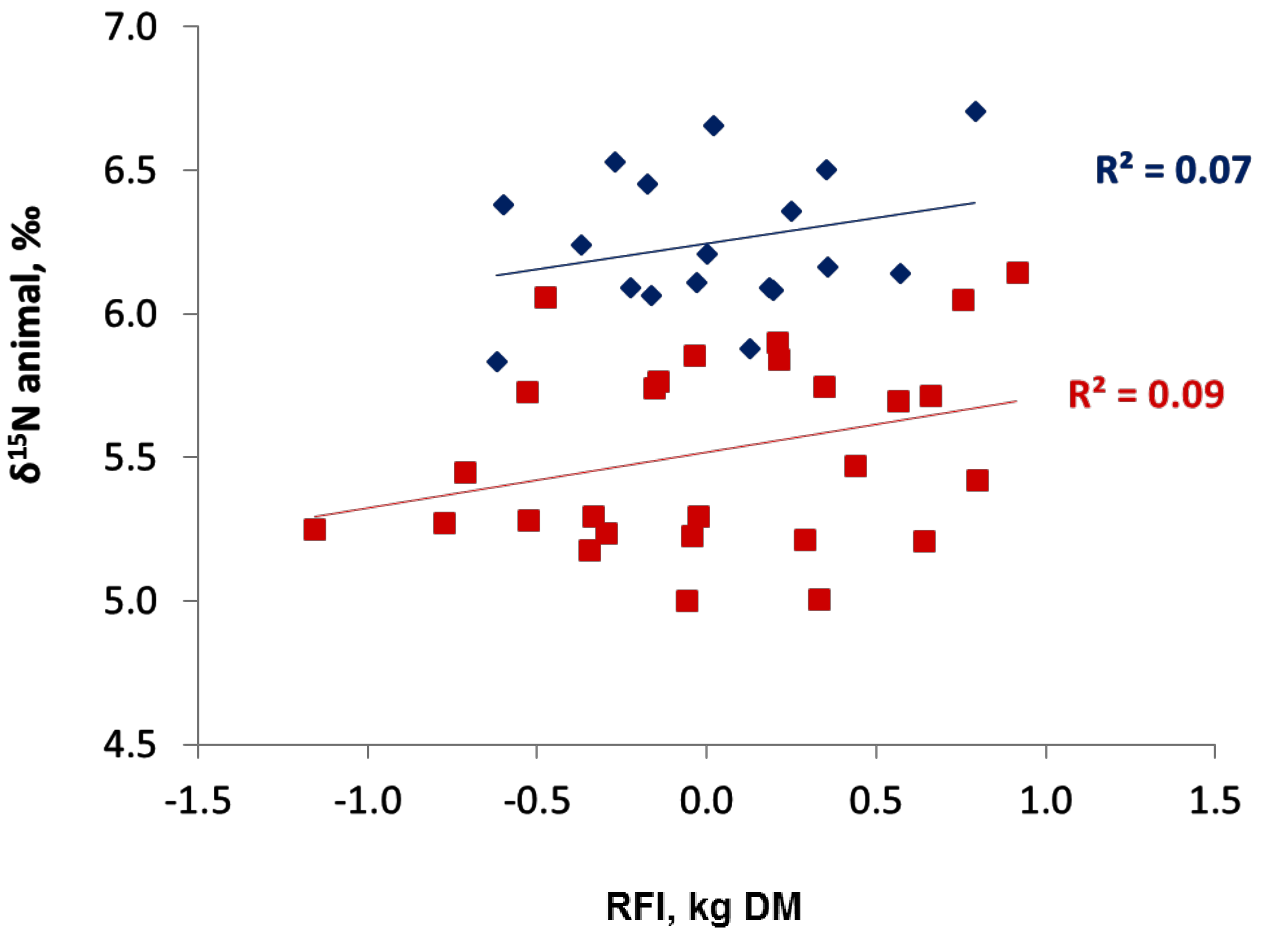
FCE correlates with $\delta^{15}N$ when diet is unknown



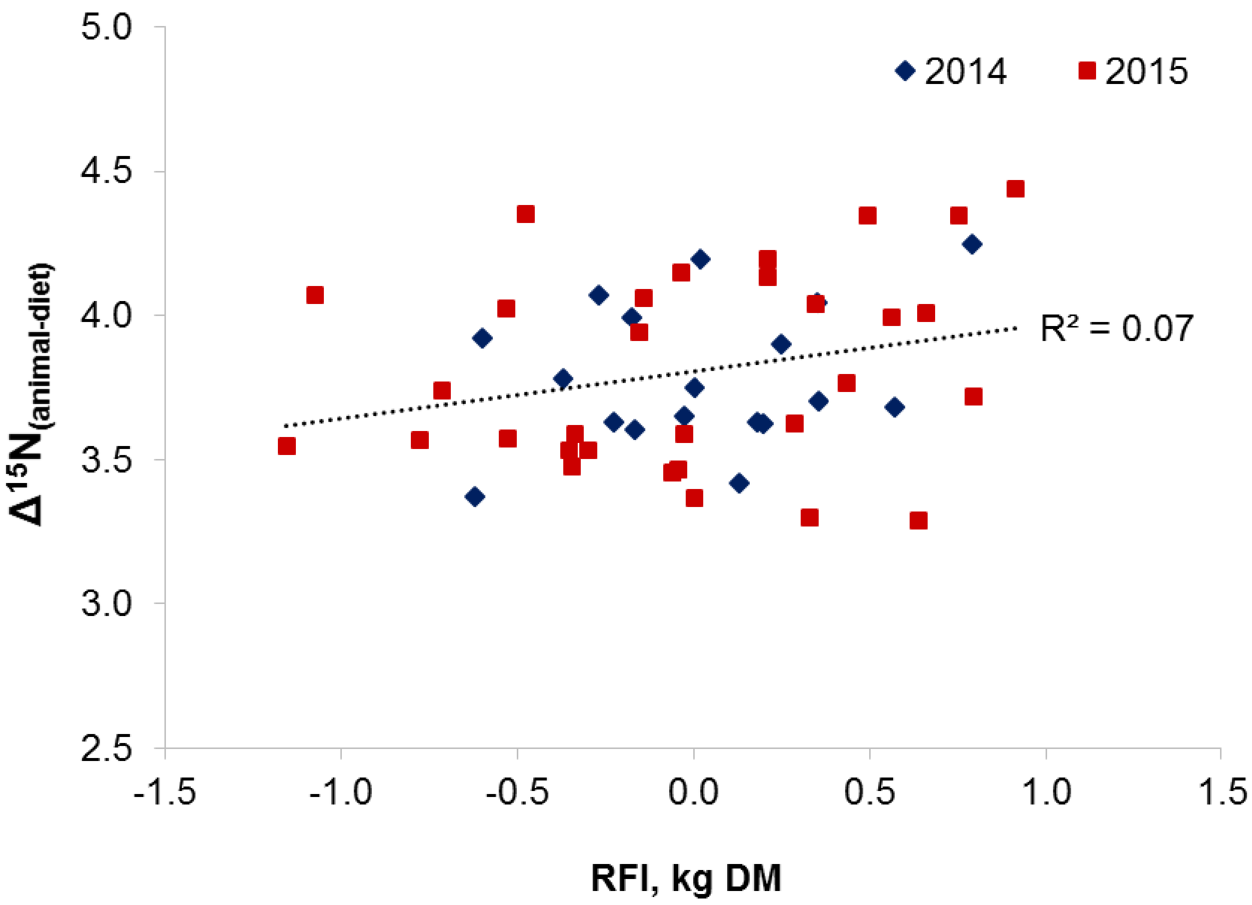
Isotopic N fractionation facilitates ranking of individual FCE across different years



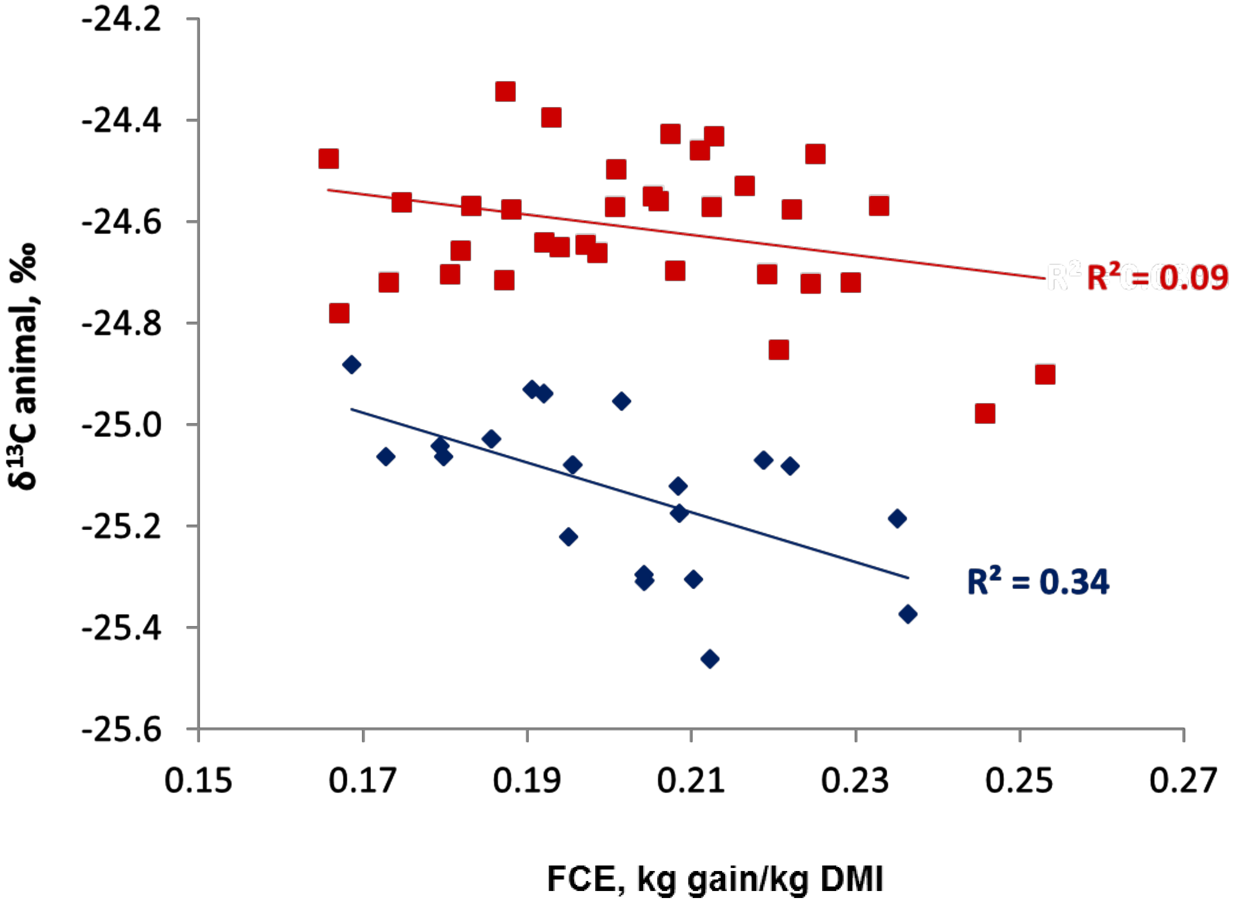
… yet no correlation was observed between RFI and δ15N natural abundance



… Or with isotopic N fractionation



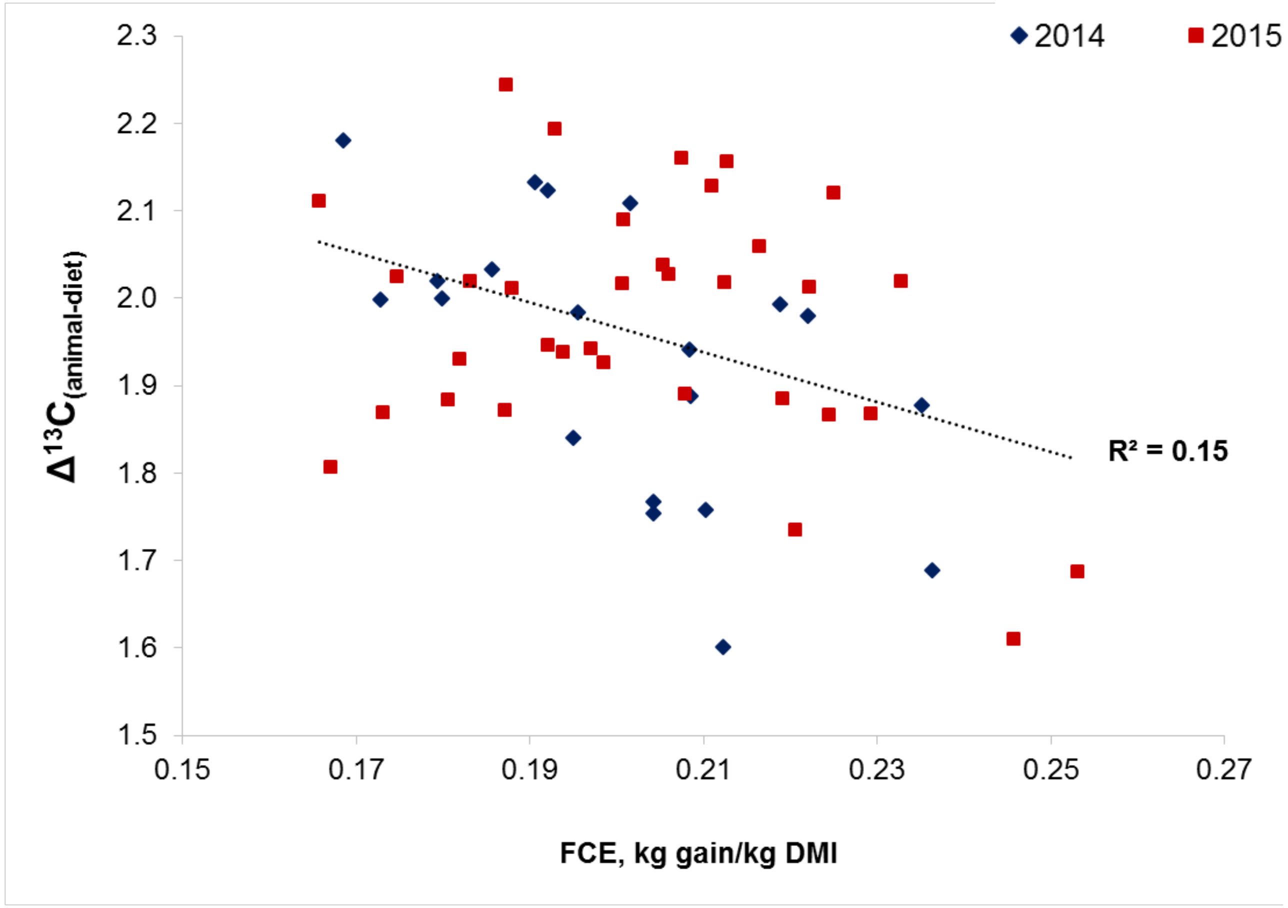
Variable correlation between FCE and δ13C natural abundance



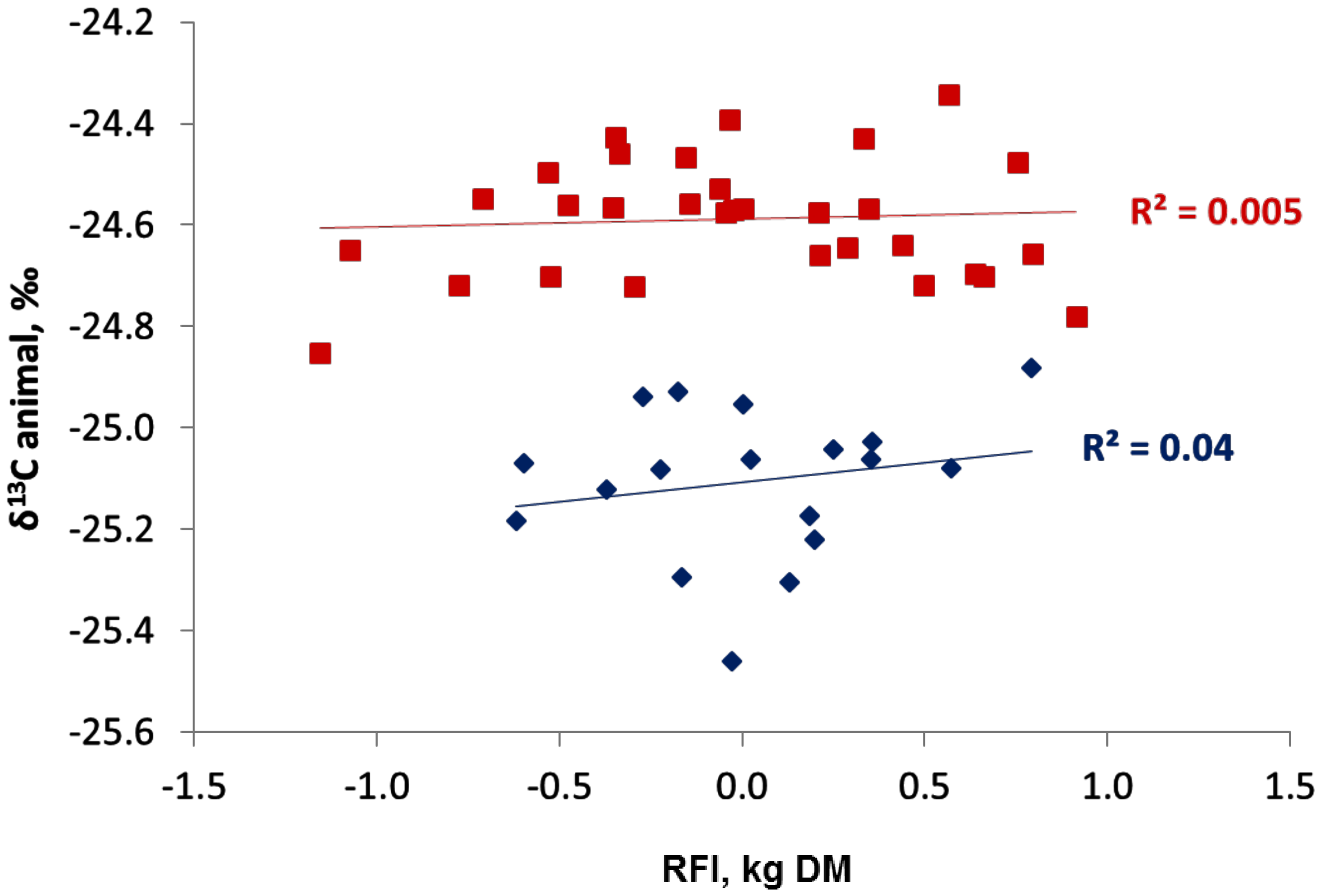
$\delta^{13}C_{diet}$ = -27.06‰

$\delta^{13}C_{diet}$ = -26.59‰

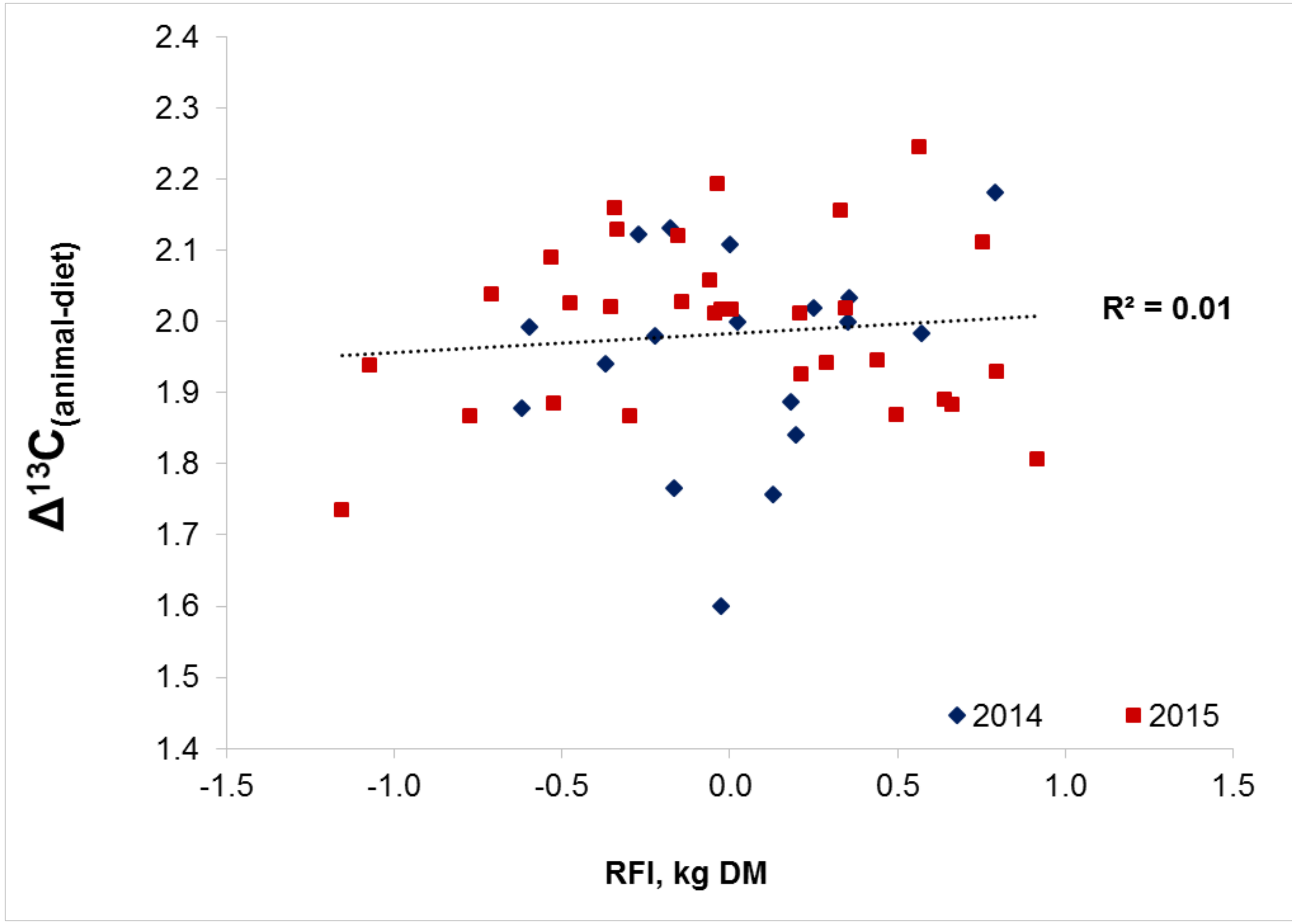
Correcting for diet [$\Delta^{13}C_{(animal\text{-}diet)}$] did not strengthen the correlation



Nor was a correlation observed with RFI



… and similarly, no correlation between $\Delta^{13}C_{(animal\text{-}diet)}$ and RFI was observed



Conclusion

- The relationship between $\delta^{15}N$ or $\Delta^{15}N_{(animal\text{-}diet)}$ in plasma proteins and feed conversion efficiency indicates their potential as a biomarker of between-animal variations of feed efficiency, when diet is either unknown or known.

- $\delta^{15}N$ or $\Delta^{15}N_{(animal\text{-}diet)}$ is not a strong predictor of RFI in ruminants

- The lack of relationship between $\delta^{13}C$ or $\Delta^{13}C_{(animal\text{-}diet)}$ suggests it may not be a suitable biomarker for feed efficiency (FCE or RFI) in ruminants

Thank you
Questions?

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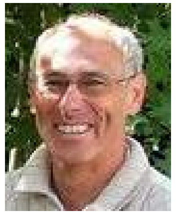

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