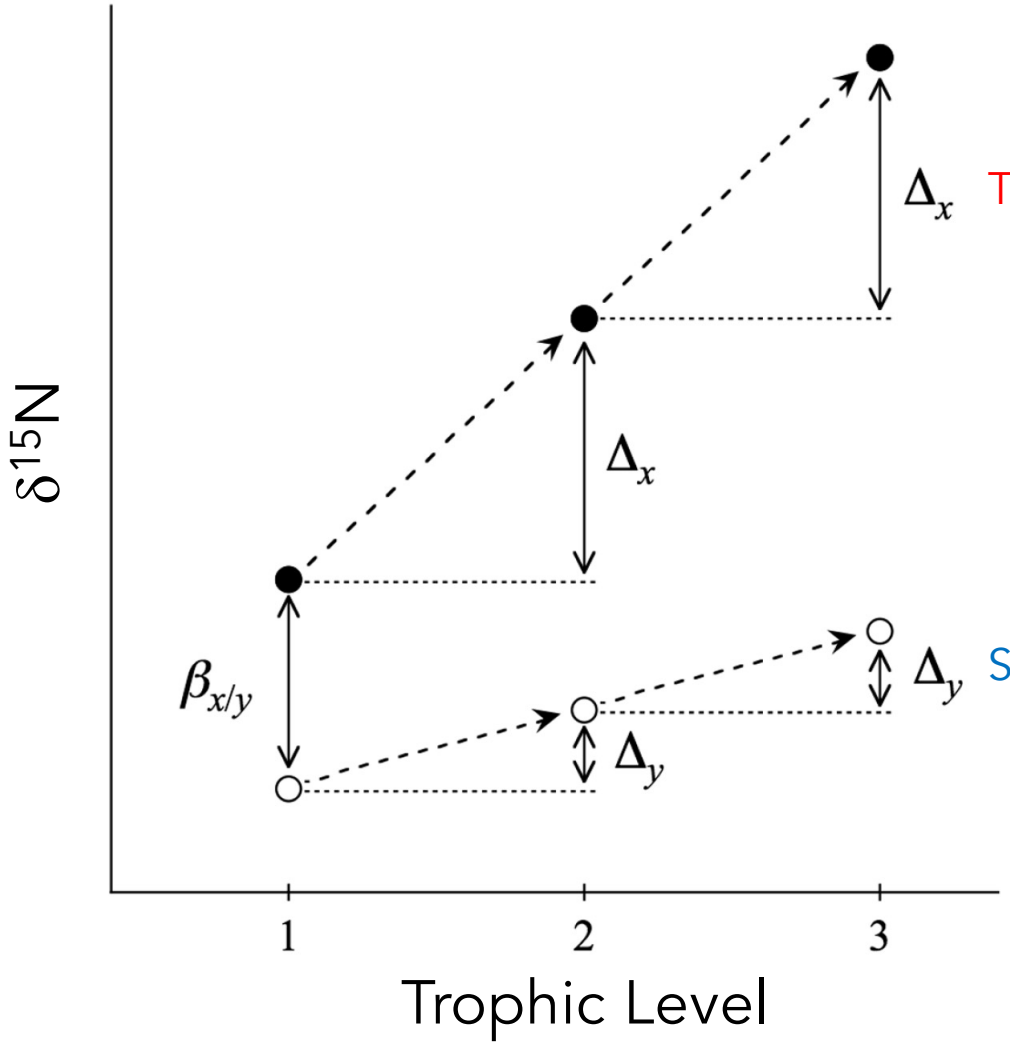
Using AA $\delta^{15}N$ to Estimate Trophic Level

$$TP_{\text{Trophic-Source}} = \frac{\delta^{15}N_{\text{Trophic}} - \delta^{15}N_{\text{Source}} + \beta_{\text{Trophic-Source}}}{TDF_{\text{Trophic-Source}}} + 1$$



Trophic Amino Acid

Source Amino Acid

$\beta_{x/y}$ = TL_1 (primary producer)

$\delta^{15}N_{\text{Trophic}} - \delta^{15}N_{\text{Source}}$

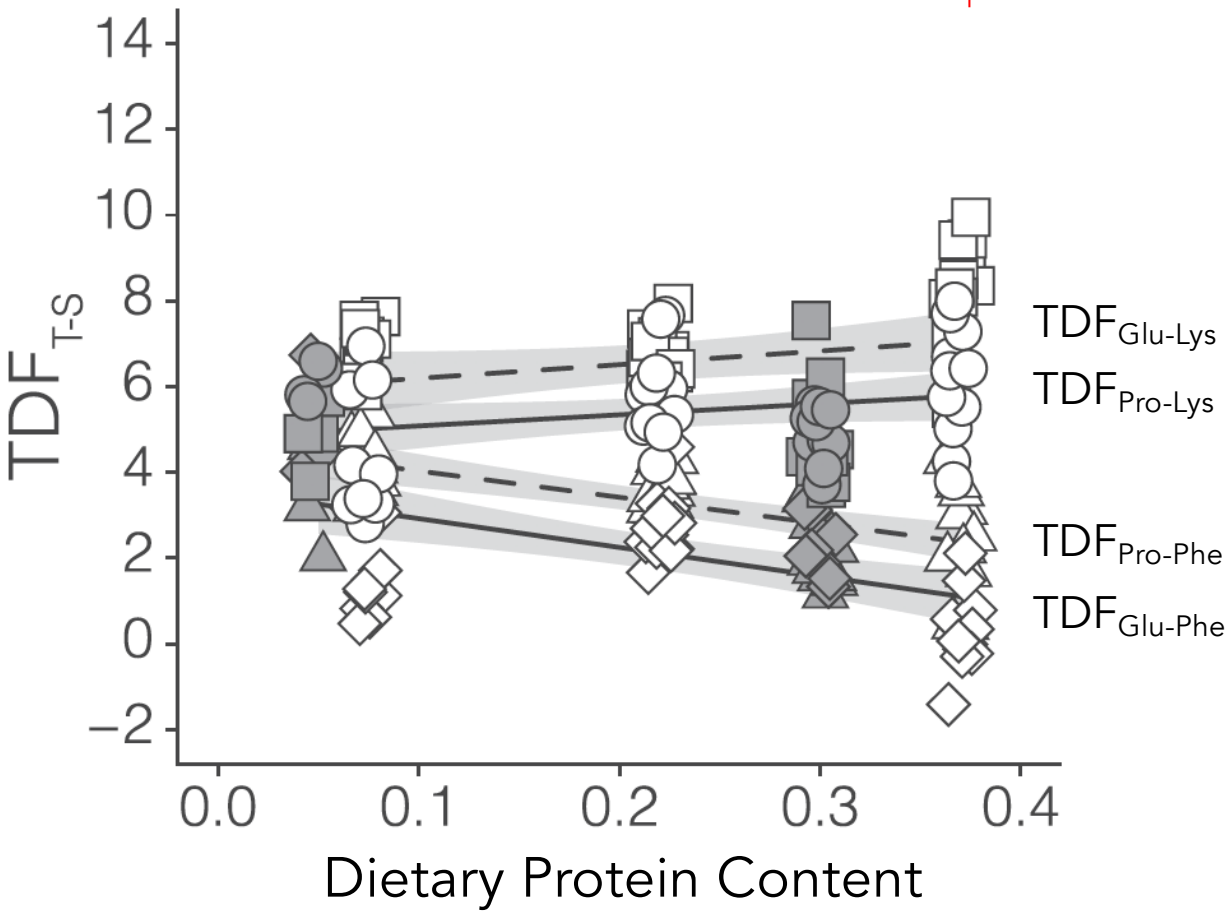
TDF: $\Delta_x - \Delta_y$

β and TDF are trophic-source pair specific

Chikaraishi et al. 2009

Dietary Protein Content Impacts $TDF_{Trophic\text{-}Source}$

$$TP = \frac{\delta^{15}N_{Trophic} - \delta^{15}N_{Source} + \beta_{Trophic\text{-}Source}}{TDF_{Trophic\text{-}Source}} + 1$$



Mus musculus

4 Diets: Low to High Protein
One Dietary Protein Source

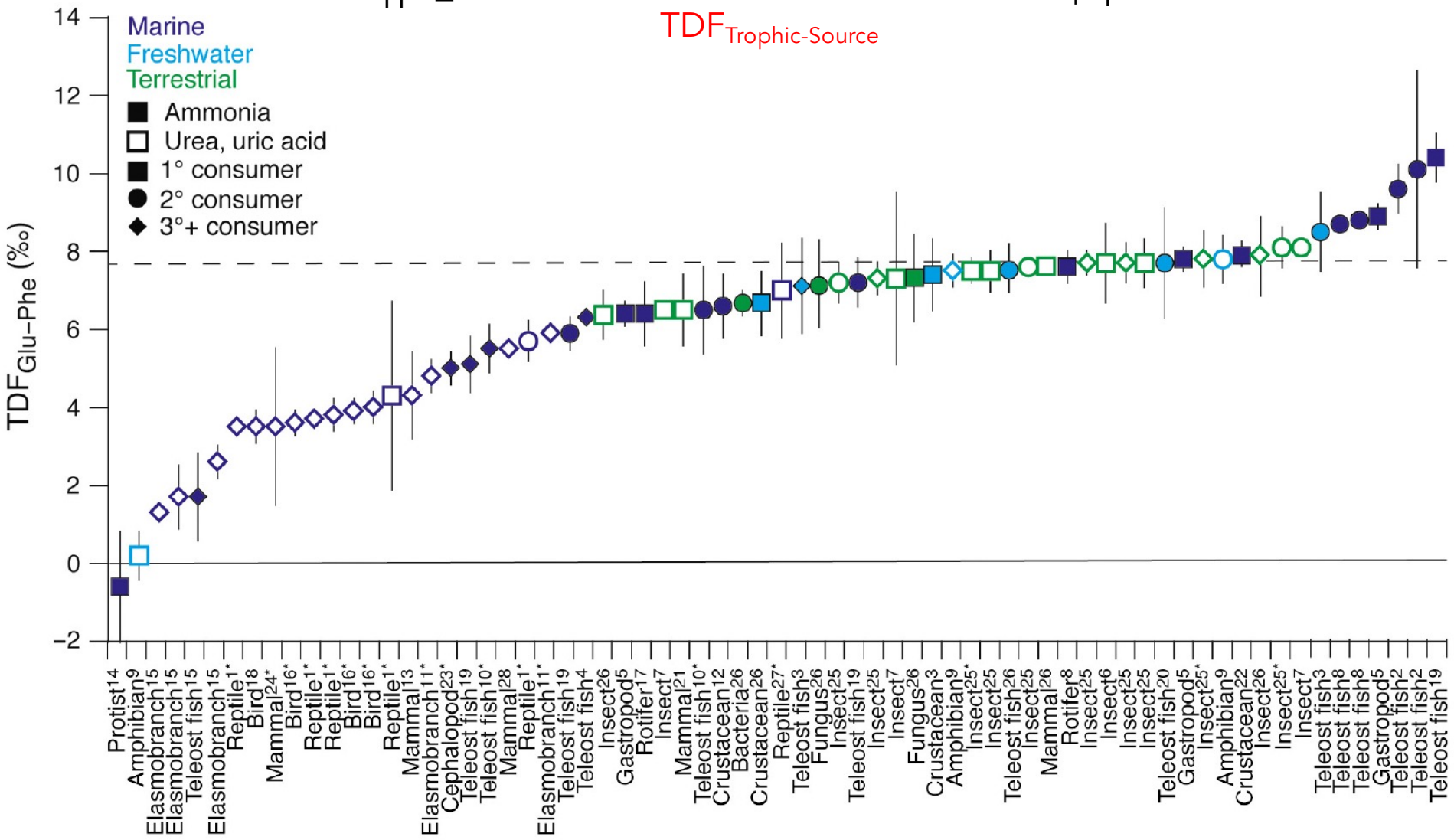
Dr. John Whiteman

Some trophic-source pairs (Pro-Lys) show little change with [dietary protein], while others (Glu-Phe) show a significant decrease.

Whiteman et al. 2021

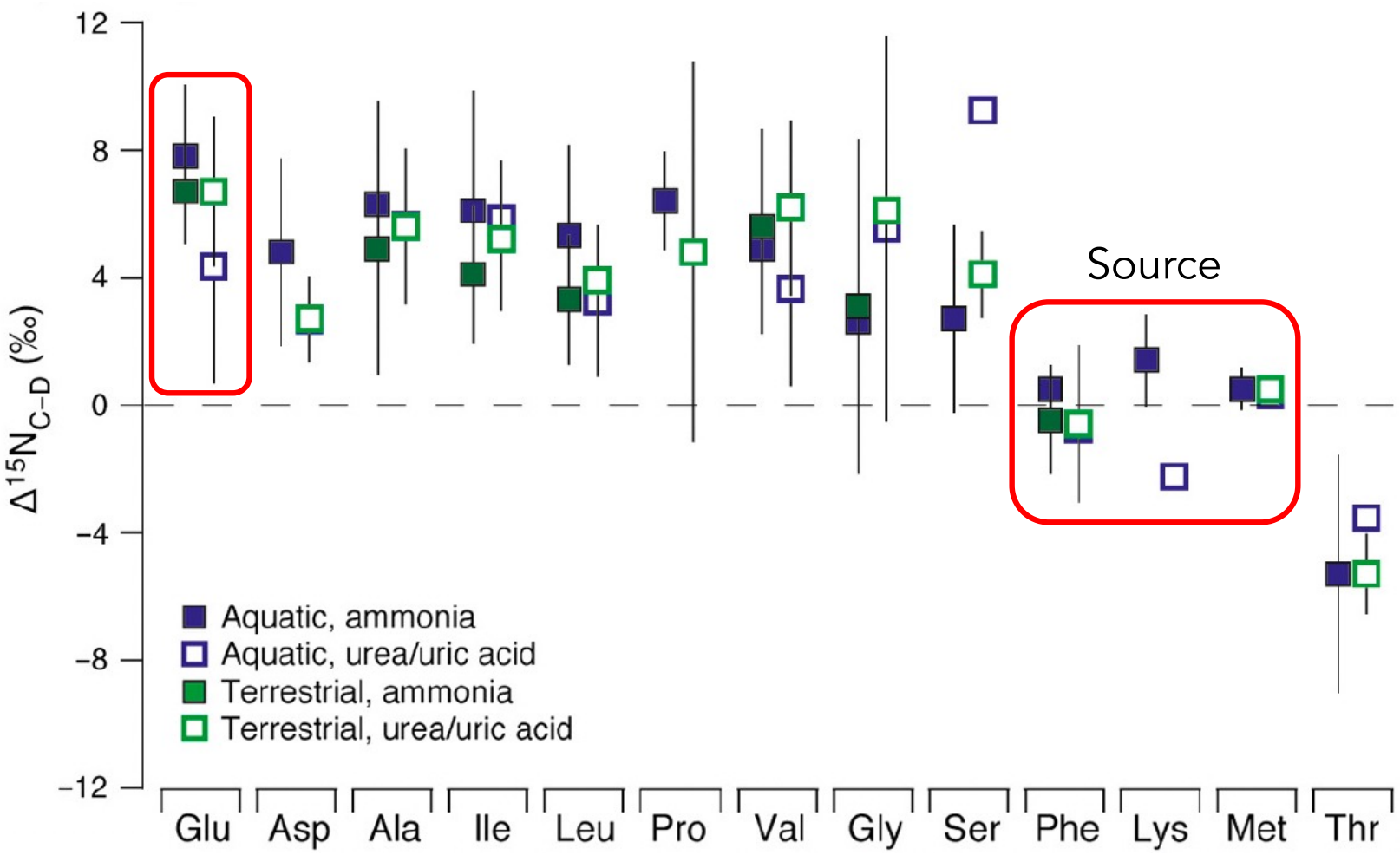
Variation in $TDF_{Glu\text{-}Phe}$

$$TP = \frac{\delta^{15}N_{Trophic} - \delta^{15}N_{Source} + \beta_{Trophic\text{-}Source}}{TDF_{Trophic\text{-}Source}} + 1$$



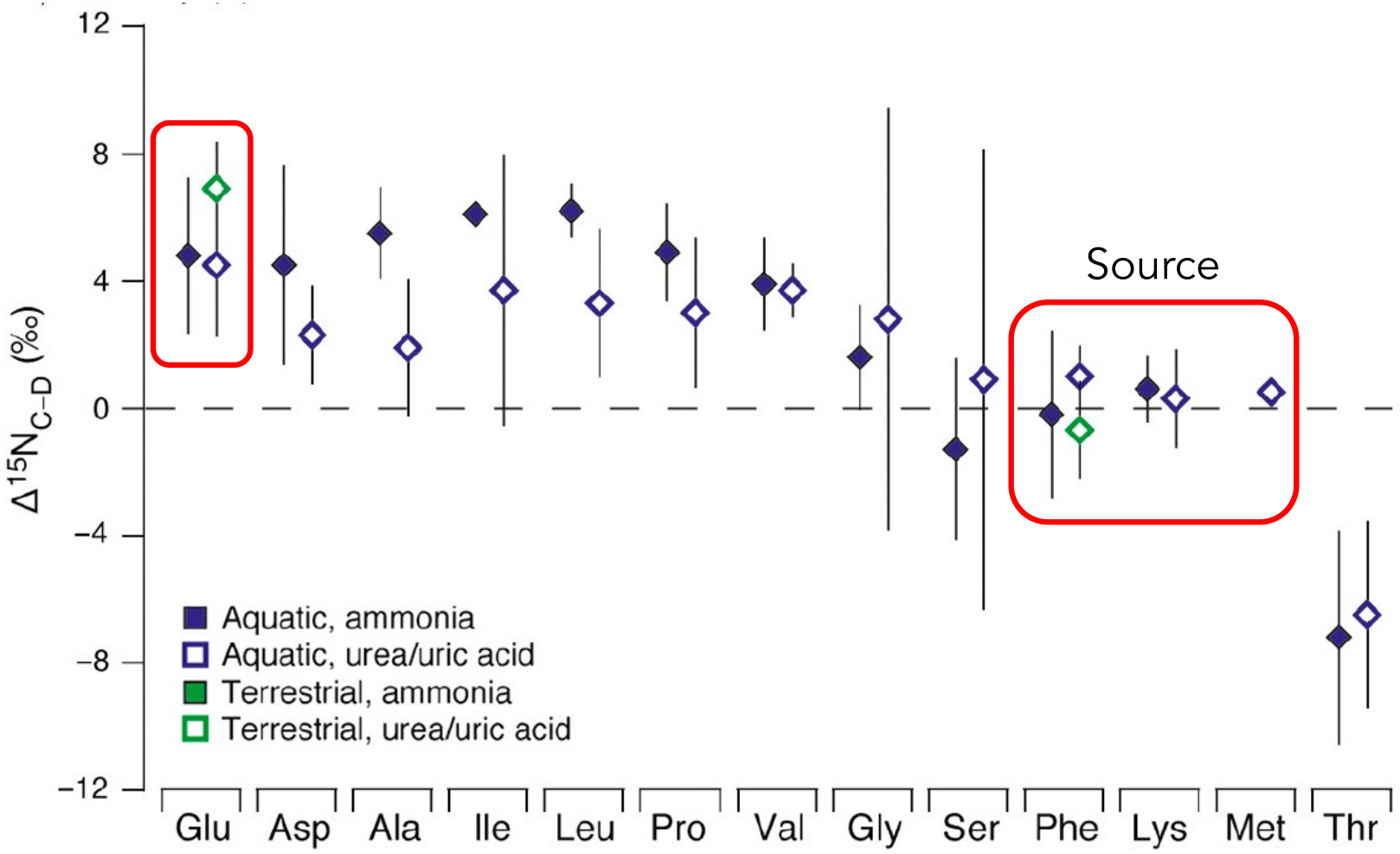
McMahon and McCarthy 2016

Consumer–Diet $\Delta^{15}N$: Primary Consumers

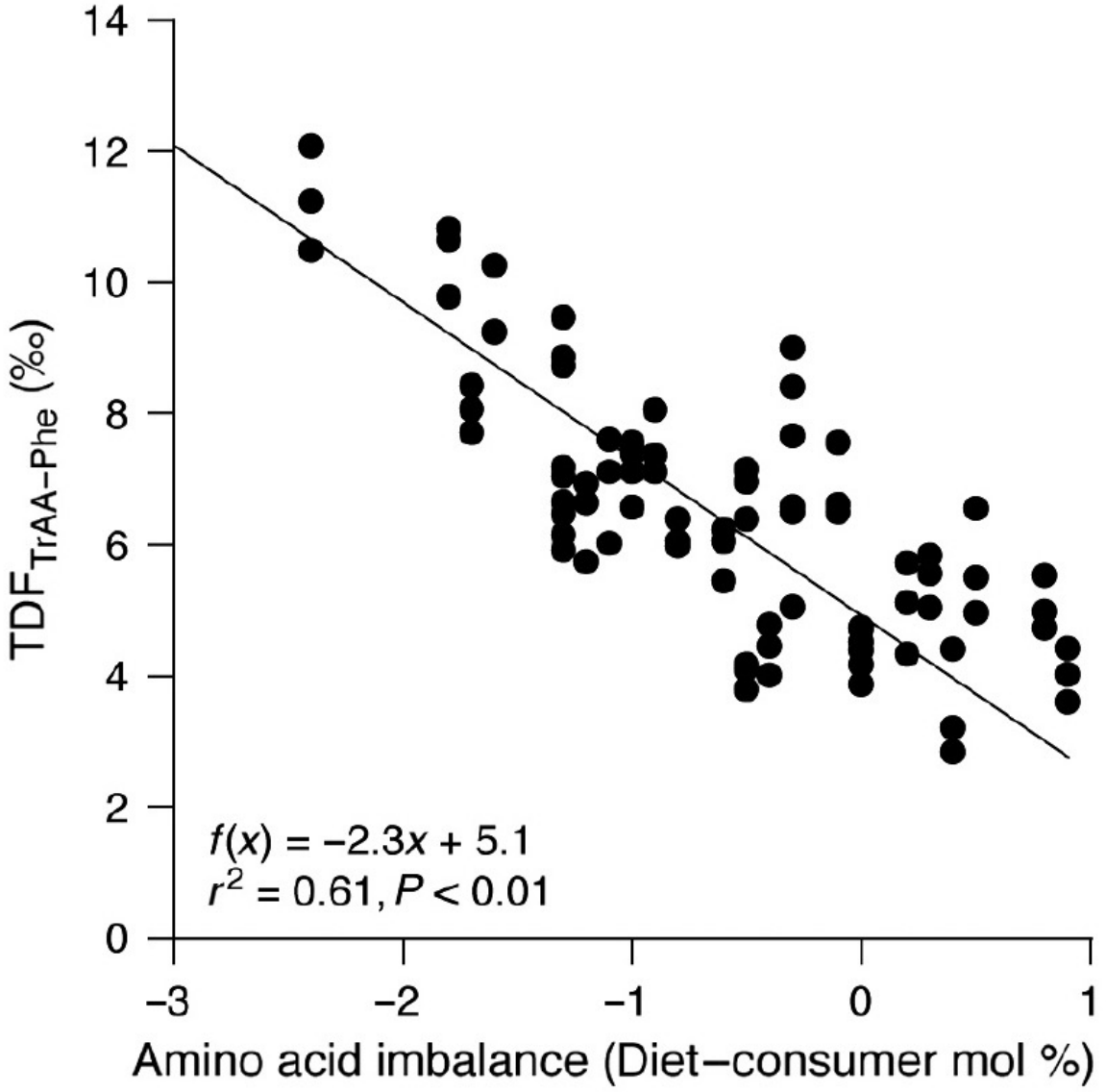


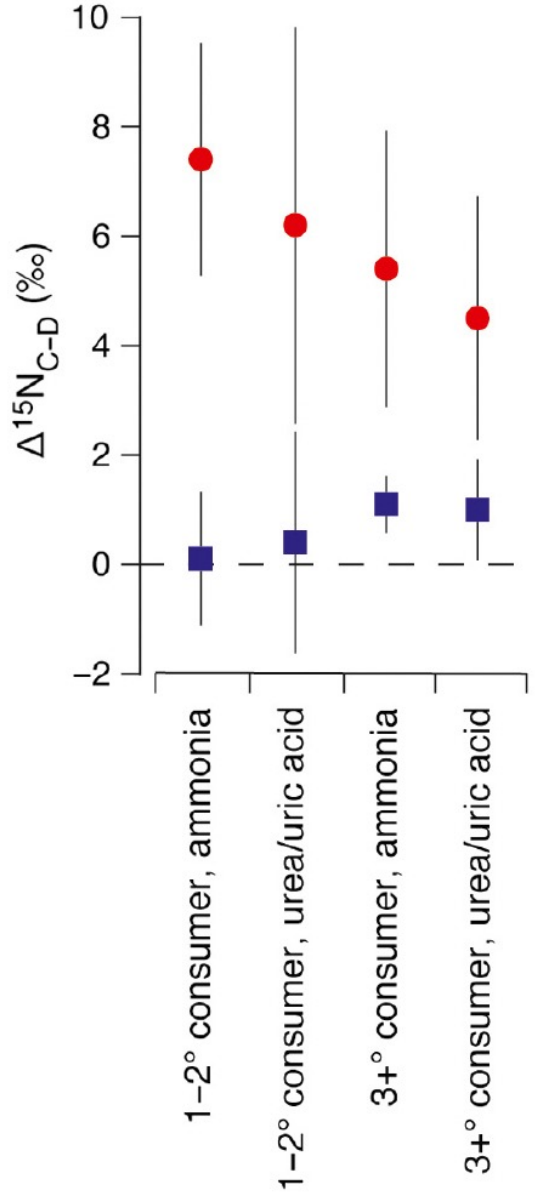
McMahon and McCarthy 2016

Consumer–Diet $\Delta^{15}N$: Tertiary Consumers

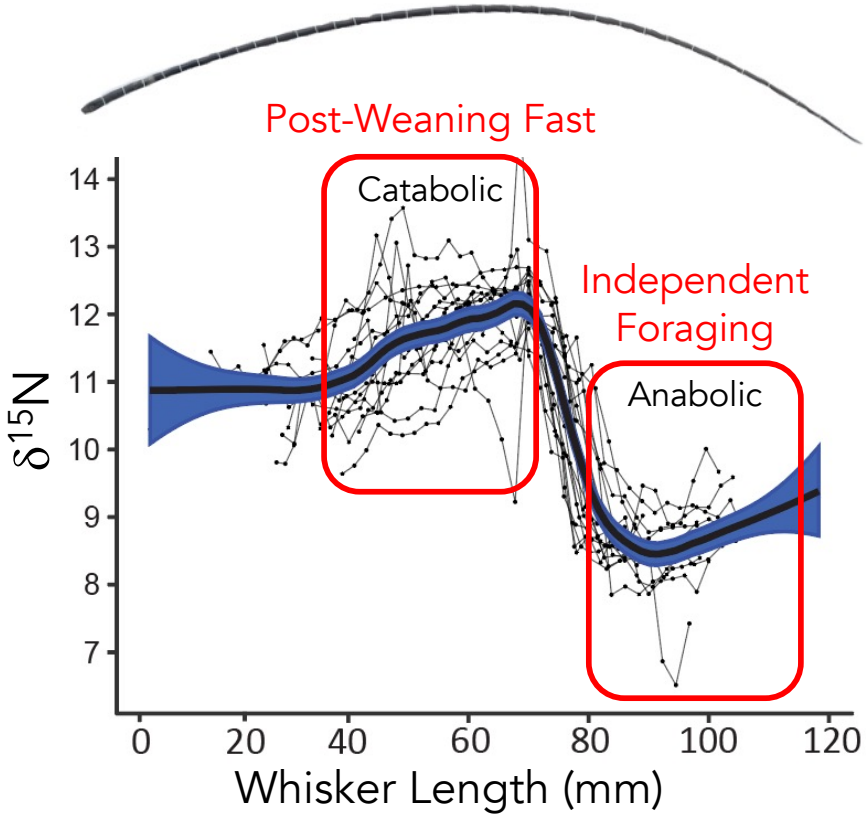


Diet Quality and Excretion Mode Matter





Patterns in Amino Acid $\delta^{15}N$: Proxy for Nitrogen Balance?



Lubcker

de Bruyn

Whiteman

Marion Island, South Africa

Mirounga leonina

Lubcker et al. 2016, 2017

$\delta^{15}N$ Values of Many Amino Acids are Higher During Fasting

$\delta^{15}N$

30
25
20
15
10
5
0
-5

*

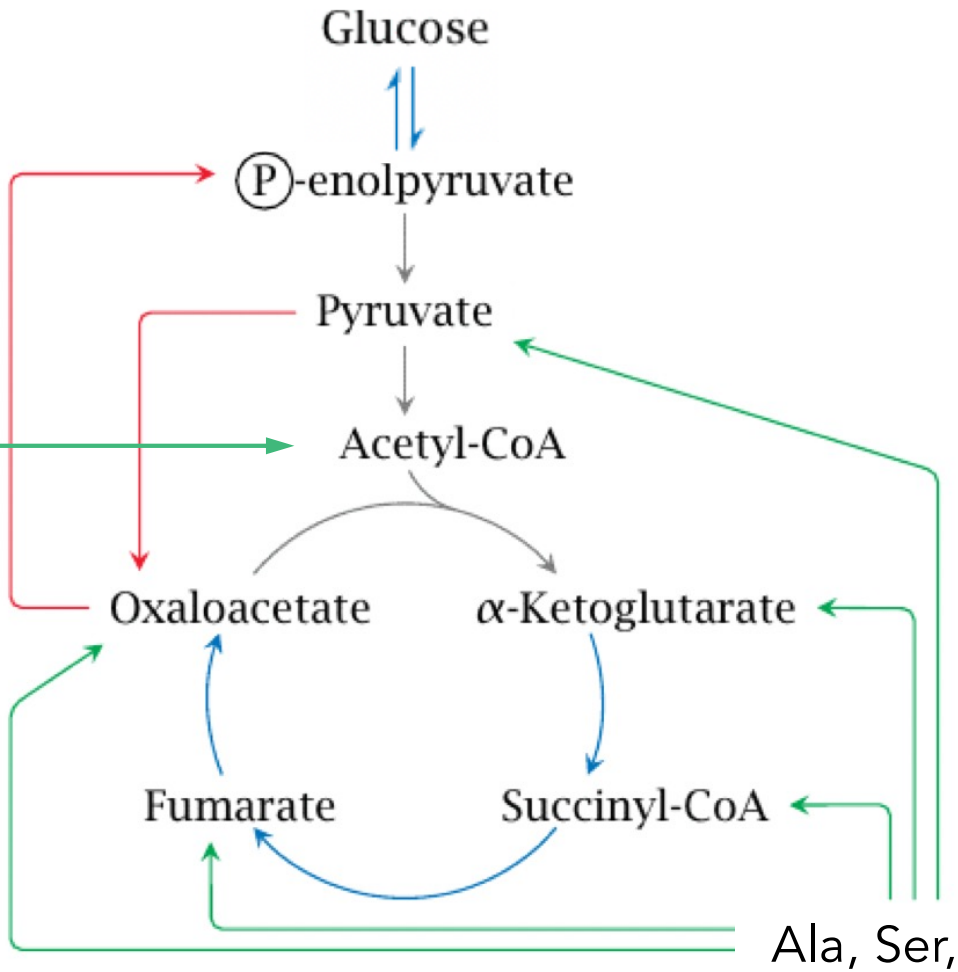
Fasting (endogenous)
Independent (exogenous)

Ala Asp Glu Ile Leu Val Pro Gly Ser Phe Lys Tyr

Amino Acid

Lubcker et al. 2020

Gluconeogenesis: A Critical Pathway



Lys
(ketogenic)

^{15}N-AAs

(plasma)

Ala, Ser, Gly,
Glu, Pro, Asp
Phe, Tyr
(glucogenic)

^{14}N-Urea

(pee)

+

δ^{15}N

–

Alanine $\delta^{15}N$ is Lower During Fasting

$\delta^{15}N$

30
25
20
15
10
5
0
-5

*

Fasting (endogenous)
Independent (exogenous)

Ala Asp Glu Ile Leu Val Pro Gly Ser Phe Lys Tyr

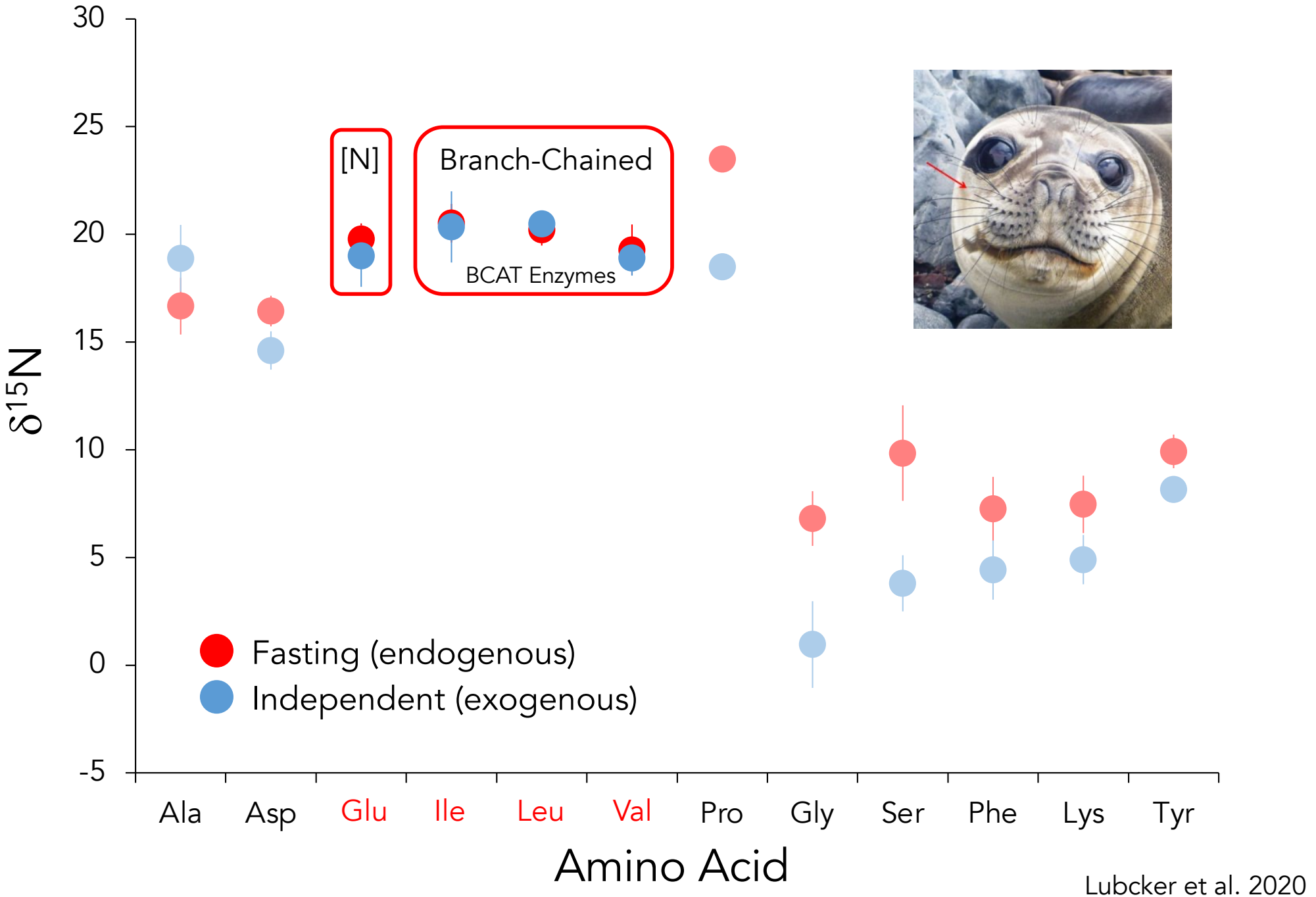
Amino Acid

Lubcker et al. 2020

Glucose - Alanine (Cahill) Cycle

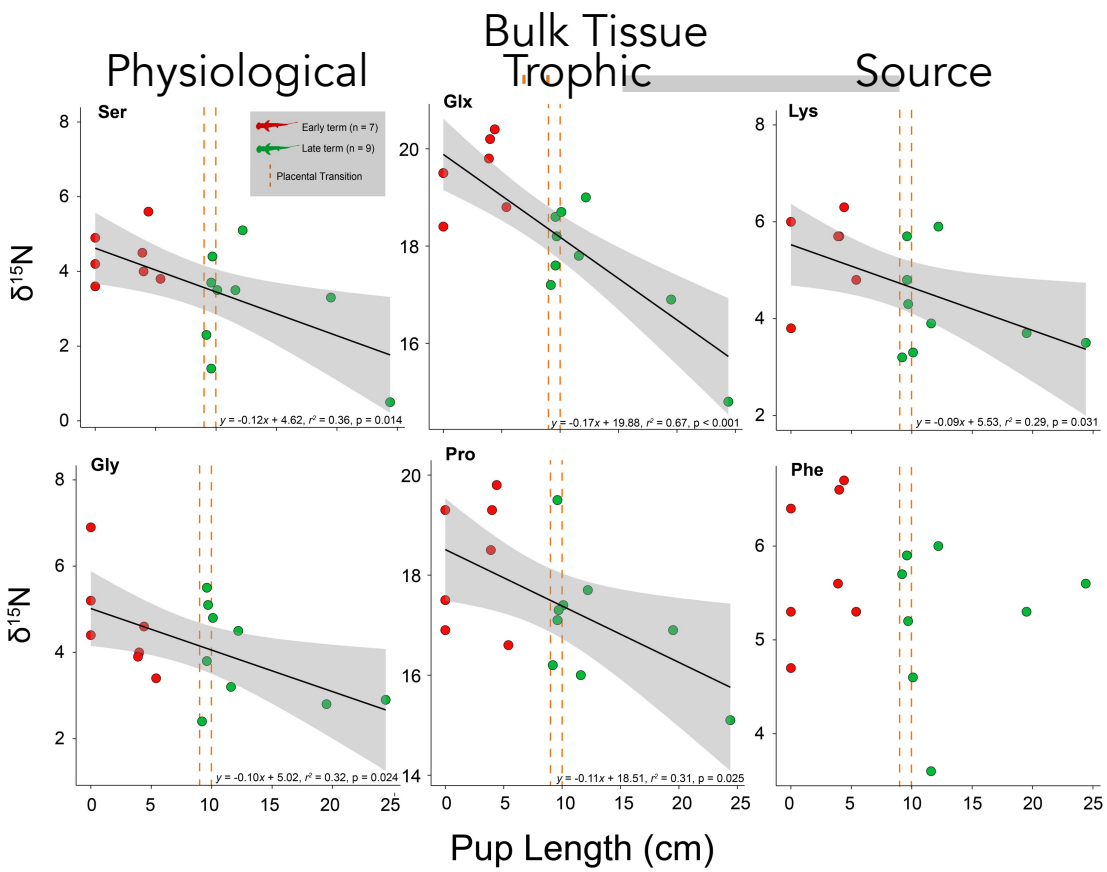
Interorgan cycle that transports nitrogen from skeletal muscle to the liver using alanine as a carrier during nutritional stress (i.e., fasting).

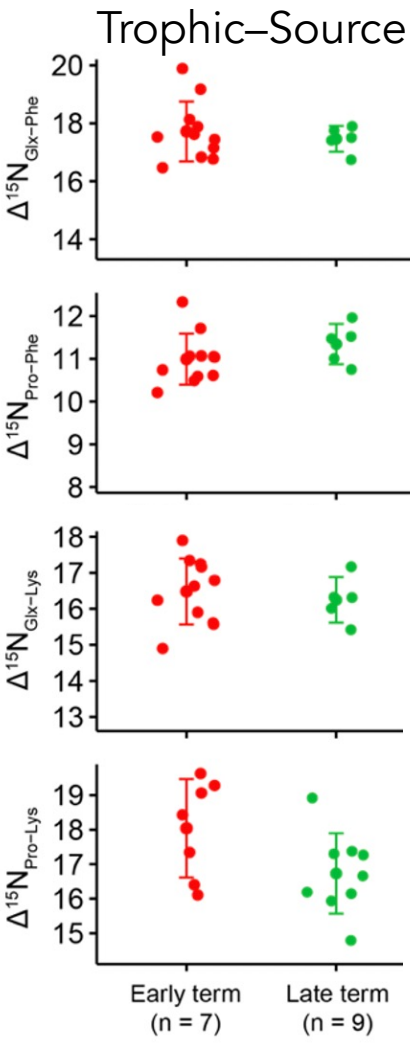
No Change in Branch-Chained AAs and Glutamic Acid $\delta^{15}N$



Lubcker et al. 2020

Reproduction and Nitrogen Balance?





Sphyrna tiburo

Matritrophic Viviparity

Dr. Oliver Shipley

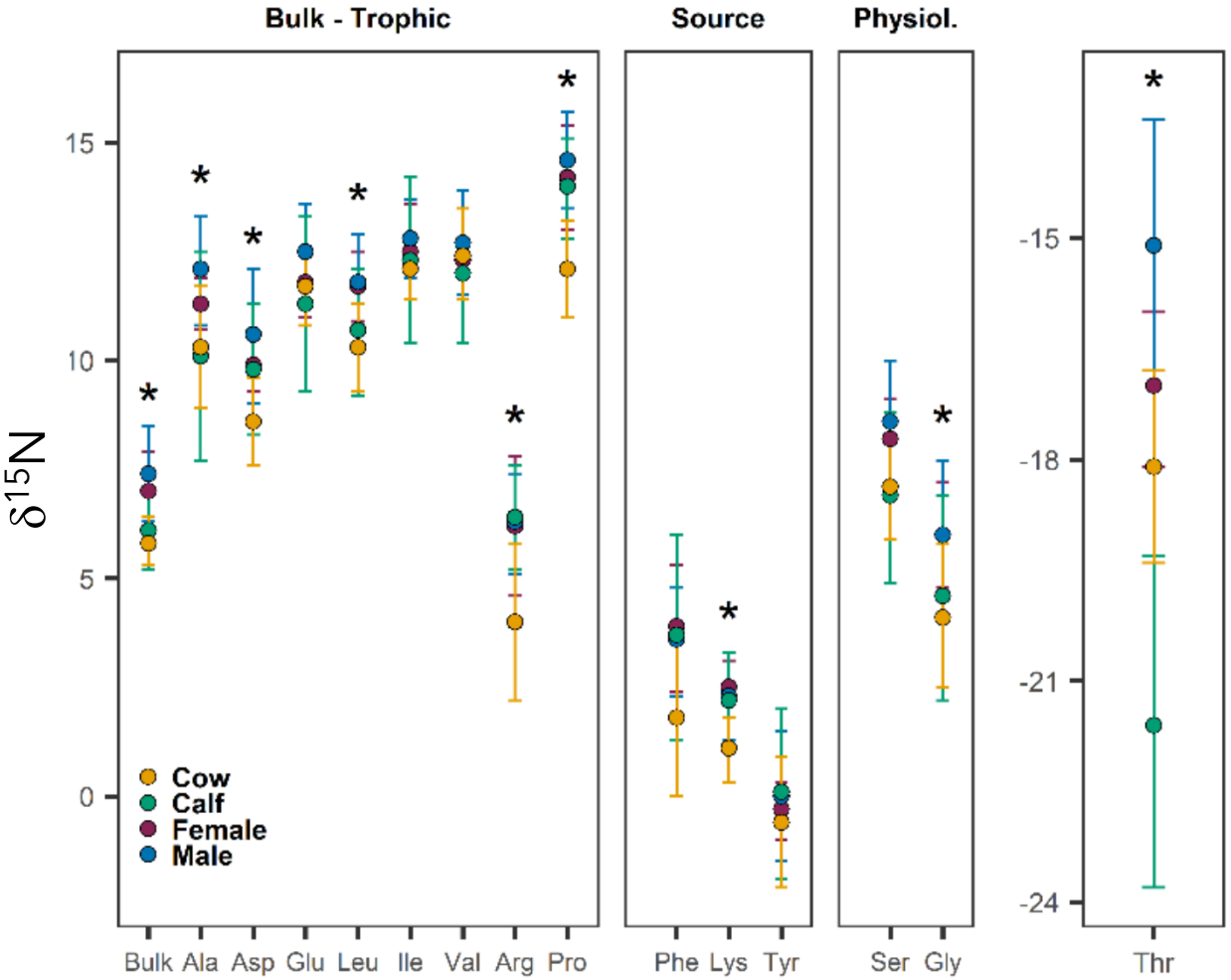
Significant (3-5‰) decreases in $\delta^{15}N$ from early (yolk) to late (placenta) term pregnancy in nearly all AAs (except Phe)

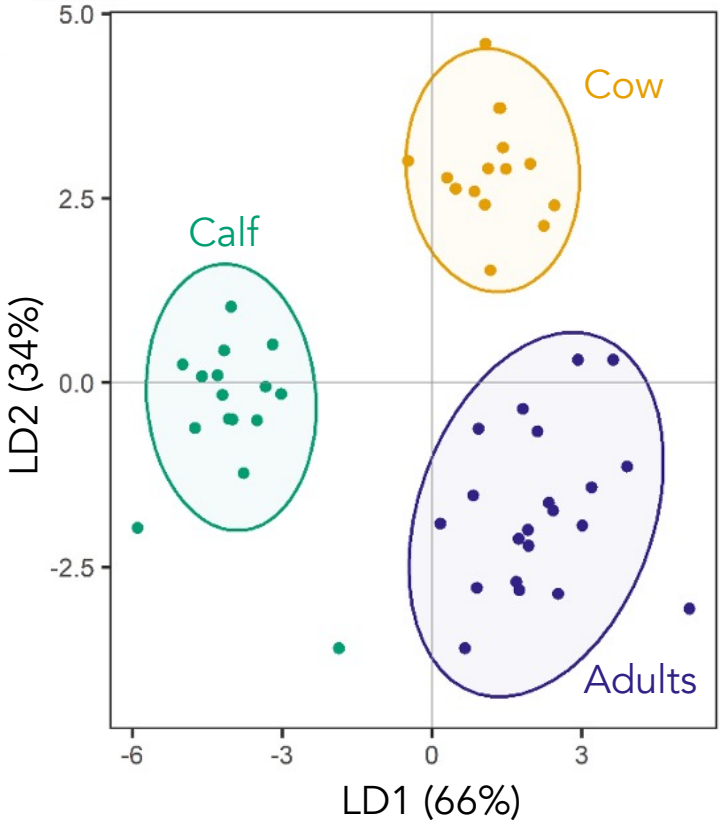
Preliminary results suggest either (1) protein sparing (decrease in $\Delta^{15}N_{consumer\text{-}diet}$), and/or (2) nitrogen ($^{14}N$ urea) recycled for reproduction.

Developing a Pregnancy Test for a Whale

Dr. Geraldine Busquets Vass

Eubalaena australis





Take Home Message(s): Amino Acid $\delta^{15}N$

For $\delta^{15}N$, amino acids are classified as source and trophic depending on their involvement in the central metabolic nitrogen pool.

$\delta^{15}N$ analysis of source amino acids (Phe/Lys) provides a way of assessing baseline (primary producer) $\delta^{15}N$ composition that is sensitive to environmental conditions by analyzing consumer tissues.

Comparison of trophic and source amino acids can provide an estimate of trophic position that only requires a single consumer tissue sample.

Amino acid $\delta^{15}N$ is also a promising tool to study animal eco-physiology, specifically processes that impact nitrogen balance (reproduction).

At present, too few exist data to robustly assess taxon- and ecosystem-related variation in primary producer β and AA-specific trophic discrimination factors* (especially true for terrestrial and freshwater aquatic ecosystems).

*IMO