Nitrogen fractionation in faeces: status quo and potential

Marcus Clauss & Jürgen Hummel

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75. Geburtstag Prof. Dr. Dr. h.c. Ernst Pfeffer, Bonn 2014
Apparent digestibility
Digestibility

\[
\frac{\text{Intake} - \text{Excretion}}{\text{Intake}}
\]
‘True’ digestibility

\[
\frac{(\text{Intake} - \text{Excretion})}{\text{Intake}}
\]

undigested diet remains
‘Apparent’ digestibility

\[
\frac{\text{Intake} - \text{Excretion}}{\text{Intake}}
\]

- undigested diet remains
- already metabolized ('metabolic') substance
‘Apparent’ digestibility

\[
\text{(Intake – Excretion) / Intake}
\]

- undigested diet remains
- already metabolized (‘metabolic’) substance
- endogenous substance
‘Apparent’ digestibility

\[
\frac{\text{Intake} - \text{Excretion}}{\text{Intake}}
\]

- undigested diet remains
- already metabolized (‘metabolic’) substance
- endogenous substance
- microbial substance
If there is endogenous/‘metabolic’ faecal excretion for a nutrient, its apparent digestibility increases with dietary concentration.
If there is endogenous/‘metabolic’ faecal excretion for a nutrient, its apparent digestibility increases with dietary concentration.
Apparent digestibility

If there is endogenous/‘metabolic’ faecal excretion for a nutrient, its apparent digestibility increases with dietary concentration.
Apparent digestibility

Carnivorous Mammals: Nutrient Digestibility and Energy Evaluation

Marcus Clauss, Helen Kleffner, and Ellen Kienzle
Estimating ‘true’ digestibility and endogenous losses by regression analysis

A Method to Estimate Digestible Energy in Horse Feed

Annette Zeyner and Ellen Kienzle


$r^2 = 0.857***$

DCP (% dry matter) vs. CP (% dry matter) graph with a correlation coefficient of $r^2 = 0.857***$.
Estimating ‘true’ digestibility and endogenous losses by regression analysis

A Method to Estimate Digestible Energy in Horse Feed

Annette Zeyner and Ellen Kienzle


$DCE = -2.72 + 0.917 \times CP$

$r^2 = 0.857^{***}$
Estimating ‘true’ digestibility and endogenous losses by regression analysis

A Method to Estimate Digestible Energy in Horse Feed

Annette Zeyner and Ellen Kienzle


\[ r^2 = 0.857^{***} \]

\[ \text{DCP} = -2.72 + 0.917 \times \text{CP} \]

endogenous losses per 100 g DMI
Estimating ‘true’ digestibility and endogenous losses by regression analysis

A Method to Estimate Digestible Energy in Horse Feed

Annette Zeyner and Ellen Kienzle


\[ r^2 = 0.857^{***} \]

\[ DCP = -2.72 + 0.917 \times CP \]

‘true’ digestibility
endogenous losses per 100 g DMI
Estimating ‘true’ digestibility and endogenous losses by regression analysis

The effect of very low food intake on digestive physiology and forage digestibility in horses

M. Clauss¹, K. Schiele², S. Ortmann³, J. Fritz², D. Codron¹, J. Hummel⁴ and E. Kienzle²


![Graph showing the relationship between rCP intake and rdCP intake. The graph includes data points for Hay 1 and Hay 2, with regression lines for each dietary component.]
Estimating ‘true’ digestibility and endogenous losses by regression analysis
Estimating ‘true’ digestibility and endogenous losses by regression analysis

The effect of very low food intake on digestive physiology and forage digestibility in horses

M. Clauss¹, K. Schiele², S. Ortmann³, J. Fritz², D. Codron¹, J. Hummel⁴ and E. Kienzle²


‘true’ digestibility – for a specific diet

endogenous losses per unit (metabolic) body mass – for a specific diet
Estimating ‘true’ digestibility and endogenous losses by regression analysis

The effect of very low food intake on digestive physiology and forage digestibility in horses

M. Clauss¹, K. Schiele², S. Ortmann³, J. Fritz², D. Codron¹, J. Hummel⁴ and E. Kienzle²


![](chart.png)

\[ y = -3.1x + 168 \]

\( R^2 = 0.92 \)
Estimating ‘true’ digestibility and endogenous losses by regression analysis

Is there a conceptual consensus how regression analysis is used to estimate tD and endogenous losses or is its use mainly determined by data availability?
Faecal nitrogen I
-
*simple ecological applications*

(Total faecal nitrogen = TFN)
Faecal nitrogen

Diet N ← undigested dietary N → Total faecal N → MFN → endogenous N → microbial N
TFN as a diet quality indicator

Diet N \rightarrow \text{Total faecal N} \leftrightarrow \text{endogenous N} \rightarrow \text{microbial N} \rightarrow \text{undigested dietary N} \rightarrow \text{MFN}
TFN as a diet quality indicator

Diet N $\uparrow$ $\leftrightarrow$ Total faecal N $\uparrow$

- undigested dietary N
- MFN
- endogenous N
- microbial N
TFN as a **diet quality** indicator

Diet N ↓ ← → Total faecal N ↓

- undigested dietary N
- MFN
- endogenous N
- microbial N
TFN as a diet quality indicator

Because of a statistical correlation, TFN is most often interpreted as an indicator of diet N.
TFN as a diet quality indicator

FECAL INDICES TO DIETARY QUALITY OF CERVIDS IN OLD-GROWTH FORESTS

DAVID M. LESLIE, JR.
EDWARD E. STARKEY

J. WILDL. MANAGE. 49(1):142–146
Facts From Feces: Nitrogen Still Measures Up as a Nutritional Index for Mammalian Herbivores

DAVID M. LESLIE, JR.,¹ United States Geological Survey, Oklahoma Cooperative Fish and Wildlife Research Unit and Department of Natural Resource Ecology and Management, Oklahoma State University, Stillwater, OK 74078-3051, USA
R. TERRY BOWYER, Department of Biological Sciences, 921 S 8th Avenue, Stop 8007, Idaho State University, Pocatello, ID 83209-8007, USA
JONATHAN A. JENKS, Department of Wildlife and Fisheries Sciences, South Dakota State University, Brookings, SD 57007, USA
TFN in seasonal datasets

Elk and deer diets in a coastal prairie-scrub Mosaic, California

PETER J. P. GOGAN AND REGINALD H. BARRETT

J. Range Manage. 48:327–335 July 1995
TFN in free-ranging ungulates

from Steuer et al. (revision submitted)
No easy solution for the fractionation of faecal nitrogen in captive wild herbivores: results of a pilot study

A. Schwarm¹,², M. Schweigert¹, S. Ortmann¹, J. Hummel³, G. P. J. Janssens⁴, W. J. Streich¹ and M. Clauss⁵

Faecal nitrogen II
- more elaborate ecological applications

(Total faecal nitrogen = TFN)
TFN as a diet quality indicator

Diet N ←→ Total faecal N

undigested dietary N

endogenous N

microbial N

MFN
TFN is a concentration!

Diet N  ←  Total faecal N

undigested dietary N  
endogenous N  
microbial N

MFN
TFN is a concentration!

Diet N $\rightarrow$ Total faecal N $\leftarrow$ other indigestible material

- undigested dietary N
- endogenous N
- MFN
- microbial N
TFN as a diet quality indicator

Diet N → Total faecal N

- undigested dietary N
- endogenous N
- MFN
- microbial N
- other indigestible material

Total faecal N → Diet N
TFN as a diet quality indicator

Diet N
- Easily fermentable carbohydrates
- Slowly fermenting fibre
- Indigestible fibre

Total faecal N
- Undigested dietary N
- Endogenous N
- Microbial N
- Other indigestible material
- MFN

Easily fermentable carbohydrates
Slowly fermenting fibre
Indigestible fibre
TFN as a diet quality indicator

Diet N
- Easily fermentable carbohydrates
- Slowly fermenting fibre
- Indigestible fibre

Total faecal N
- undigested dietary N
- endogenous N
- microbial N
- other indigestible material
- MFN

TFN as a diet quality indicator

Diet N
- Easily fermentable carbohydrates
- Slowly fermenting fibre
- Indigestible fibre

Total faecal N
- undigested dietary N
- endogenous N
- microbial N
- other indigestible material
- MFN
TFN as a diet quality indicator

Diet N \( \uparrow \) \( \rightarrow \) Total faecal N

Easily fermentable carbohydrates
Slowly fermenting fibre
Indigestible fibre

Undigested dietary N
Endogenous N
Microbial N

Other indigestible material
TFN as a diet quality indicator

Diet N ↑ → Total faecal N

Easily fermentable carbohydrates ↑
Slowly fermenting fibre
Indigestible fibre

Undigested dietary N
Endogenous N
Microbial N
Other indigestible material

MFN
TFN as a diet quality indicator

Diet N $\uparrow$ Total faecal N

Easily fermentable carbohydrates $\uparrow$
Slowly fermenting fibre
Indigestible fibre $\downarrow$

undigested dietary N
endogenous N
microbial N
other indigestible material

MFN
TFN as a **diet quality** indicator

**Diet N**
- Easily fermentable carbohydrates
- Slowly fermenting fibre
- Indigestible fibre

**Total faecal N**
- Undigested dietary N
- Endogenous N
- Microbial N
- Other indigestible material

MFN
TFN as a **diet quality** ↑ indicator

Diet N ↑ → Total faecal N

Easily fermentable carbohydrates ↑
Slowly fermenting fibre
Indigestible fibre ↓

Undigested dietary N
Endogenous N
Microbial N

Other indigestible material

MFN
TFN as a diet quality indicator

Diet N $\uparrow$ $\rightarrow$ Total faecal N $\leftarrow$ undigested dietary N $\downarrow$

Easily fermentable carbohydrates $\uparrow$
Slowly fermenting fibre $\downarrow$
Indigestible fibre $\downarrow$

MFN
endogenous N
microbial N
other indigestible material
TFN as a **diet quality** ↑ indicator

Diet N ↑ — Total faecal N

- **Easily fermentable carbohydrates** ↑
- **Slowly fermenting fibre** ↓
- **Indigestible fibre** ↓

- **undigested dietary N** ↓
- **endogenous N** ~
- **microbial N** ↑
- **other indigestible material** ↓

MFN
TFN as a diet quality indicator

Diet N $\uparrow$  Total faecal N

- Easily fermentable carbohydrates $\uparrow$
- Slowly fermenting fibre $\downarrow$
- Indigestible fibre $\downarrow$

\[
\text{Total faecal N} = \text{Diet N} - \text{Dietary N} - \text{Endogenous N} + \text{Microbial N} + \text{Other indigestible material}
\]
TFN as a diet quality indicator

Diet N ↑  Total faecal N ↑

Easily fermentable carbohydrates ↑
Slowly fermenting fibre ↓
Indigestible fibre ↓

undigested dietary N ↓
endogenous N ~
other indigestible material ↓

MFN ↑

microbial N ↑
TFN as a *diet quality* indicator

Diet N ↑  ←  Total faecal N ↑

Easily fermentable carbohydrates ↑
Slowly fermenting fibre ↓
Indigestible fibre ↓

undigested dietary N ↓
endogenous N ~
other indigestible material ↓

MFN ↑
microbial N ↑

*TFN summarizes processes that are related to the overall digestion of the diet.*
THE MEASUREMENT OF FEED INTAKE BY GRAZING CATTLE AND SHEEP

I. A METHOD OF CALCULATING THE DIGESTIBILITY OF PASTURE BASED ON THE NITROGEN CONTENT OF FÆCES DERIVED FROM THE PASTURE

By R. J. Lancaster, Ruakura Animal Research Station, Animal Research Division, Department of Agriculture

The N.Z. Journal of Science and Technology 1949
TFN as indicator of digestibility

Fecal Measures of Diet Quality in Wild and Domestic Ruminants

John D. Wehausen

J. Wildl. Manage. 59(4):816–823
TFN as indicator of digestibility

Relationship between fecal crude protein concentration and diet organic matter digestibility in cattle

M. Lukas*, K.-H. Südekum*, G. Rave†, K. Friedel‡, and A. Susenbeth*

TFN as indicator of digestibility
Prediction of the digestibility of the diet of horses: evaluation of faecal indices

P. Mésochina,* W. Martin-Rosset,† J.-L. Peyraud,‡ P. Duncan,§ D. Micot† and S. Boulot†

Faecal nitrogen III
-
a fundamental constraint

(Total faecal nitrogen = TFN)
ROLE OF TANNINS IN DEFENDING PLANTS AGAINST RUMINANTS: REDUCTION IN PROTEIN AVAILABILITY

C. T. Robbins
T. A. Hanley
A. E. Hagerman

O. Hjeljord
D. L. Baker
C. C. Schwartz
W. W. Mautz

TFN as indicator of digestibility
ROLE OF TANNINS IN DEFENDING PLANTS AGAINST RUMINANTS: REDUCTION IN PROTEIN AVAILABILITY

C. T. Robbins
T. A. Hanley
A. E. Hagerman

Ecology, 68(1), 1987, pp. 98–107

O. Hjeljord
D. L. Baker
C. C. Schwartz
W. W. Mautz

TFN and secondary plant compounds
Significance of diet type and diet quality for ecological diversity of African ungulates

DARYL CODRON*, JULIA A. LEE-THORP*, MATT SPONHEIMERS, JACQUI CODRON*, DARRYL DE RUITER† and JAMES S. BRINK***

76, 526–537

TFN in comparative datasets
Significance of diet type and diet quality for ecological diversity of African ungulates

DARYL CODRON*†, JULIA A. LEE-THORP*‡, MATT SPONHEIMER§, JACQUI CODRON*, DARRYL DE RUITER¶ and JAMES S. BRINK***

76, 526–537

TFN in comparative datasets
**TFN and secondary plant compounds**

**Faecal nitrogen, an index of diet quality in roe deer *Capreolus capreolus***?

Hélène Verheyden, Lise Aubry, Joël Merlet, Patrick Petibon, Béatrice Chauveau-Duriot, Nadine Guillon & Patrick Duncan

*Wildl. Biol. 17: 166-175 (2011)*

**Figure 2.** Relationship between dietary nitrogen (% DM) and faecal nitrogen (% DM) in wild roe deer; diets without significant levels of free condensed tannin (○) and diets with significant levels of free condensed tannin (●). The regression lines predicting

**Figure 3.** Relationship between dietary nitrogen (% DM) and faecal nitrogen (% DM) in tame roe deer fed with experimental diets; diets without significant levels of free condensed tannin (○) and diets with significant levels of free condensed tannin (●). The
TFN and secondary plant compounds

Estimating the digestibility of Sahelian roughages from faecal crude protein concentration of cattle and small ruminants

E. Schlecht¹ and A. Susenbeth²

However, if anti-nutritional dietary factors increase the concentration of faecal nitrogen from feed or endogenous origin, the approach might considerably overestimate diet digestibility.
Faecal nitrogen IV
- fractionation

(Total faecal nitrogen = TFN)
(Metabolic faecal nitrogen = MFN)
Analytical approaches

Total faecal N
Analytical approaches

Total faecal N

undigested dietary N

MFN
Analytical approaches

Total faecal N

undigested dietary N

MFN
Analytical approaches

Total faecal N

undigested dietary N → MFN ← regression analysis
Analytical approaches

Total faecal N

undigested dietary N

fibre-bound N

MFN

regression analysis
Analytical approaches

Total faecal N

undigested dietary N

MFN

regression analysis

fibre-bound N

NDF-N

ADF-N

Ultrasonic probe (ind.)

Lysozyme-Trypsin extract (ind.)
Analytical approaches

Total faecal N

- undigested dietary N
- MFN

Fibre-bound N
- NDF-N (‘undigested’)
- ADF-N (‘indigestible’)
- Ultrasonic probe (ind.)
- Lysozyme-Trypsin extract (ind.)

Regression analysis
Analytical approaches

Total faecal N

undigested dietary N

endogenous N

microbial N

MFN

regression analysis

fibre-bound N

NDF-N

ADF-N

Ultrasonic probe (ind.)

Lysozyme-Trypsin extract (ind.)
Analytical approaches

Total faecal N

- undigested dietary N
- MFN
- endogenous N
- microbial N

- fibre-bound N
  - NDF-N
  - ADF-N
  - Ultrasonic probe (ind.)
  - Lysozyme-Trypsin extract (ind.)

- microbial N marker

Regression analysis
Analytical approaches

Total faecal N

undigested dietary N

MFN

endogenous N

microbial N

fibre-bound N

NDF-N
ADF-N
Ultrasonic probe (ind.)
Lysozyme-Trypsin extract (ind.)

microbial N marker

Diaminopimelic acid (DAPA)
RNA extraction
Purines
Centrifugation
Microscopy

regression analysis
Some observations on the distribution and origin of nitrogen in sheep faeces
V. C. MASON

The digestion of bacterial mucopeptide constituents in the sheep
1. The metabolism of 2,6-diaminopimelic acid
2. The digestion of muramic acid
V. C. MASON and F. WHITE
V. C. MASON and G. MILNE

Partition of the nitrogen in sheep faeces with detergent solutions, and its application to the estimation of the true digestibility of dietary nitrogen and the excretion of non dietary faecal nitrogen
V. C. Mason and J. H. Frederiksen
Z. Tierphysiol., Tierernähr. u. Futtermittelkde. 41 (1979)
The quantitative importance of bacterial residues in the non-dietary faecal nitrogen of sheep

1. Methodology studies

2. Estimates of bacterial nitrogen in faecal material from 47 digestibility trials

V. C. Mason
Z. Tierphysiol., Tierernähr. u. Futtermittelkde. 41 (1979)
There is little evidence to link MFN to dietary constituents in larger-scale datasets (because of lack of data, not because of absence of link), although the logic appears sound.
Does MFN work – and does it provide more information than TFN?

(Total faecal nitrogen = TFN)
(Metabolic faecal nitrogen = MFN)
In Situ Neutral Detergent Insoluble Nitrogen as a Method for Measuring Forage Protein Degradability

R. A. Mass, G. P. Lardy², R. J. Grant, and T. J. Klopfenstein³


- Total N
- MN, Purine
- NDIN

![Graph showing undegraded intake protein, % of DM for different forage types.](image)
In situ in the rumen: good results

In Situ Neutral Detergent Insoluble Nitrogen as a Method for Measuring Forage Protein Degradability

R. A. Mass, G. P. Lardy, R. J. Grant, and T. J. Klopfenstein


![Graph showing the relationship between MN UIP, % of DM and NDIN UIP, % of DM with a linear regression line, equation Y = 0.71X + 0.74, and coefficient of determination r^2 = 0.97]
NITROGEN AND DIAMINOPIMELIC ACID IN DEER AND MOOSE FECES

DAVID M. LESLIE, JR.
JONATHAN A. JENKS
MARYELLEN CHILELLI
GERALD R. LAVIGNE,

_J. WILDL. MANAGE. 53(1):216–218_
Monitoring mule deer diet quality and intake with fecal indices

THOMAS P. HODGMAN, BRUCE B. DAVITT, AND JACK R. NELSON

JOURNAL OF RANGE MANAGEMENT 49(3), May 1996
TFN, MFN and other analytes in reaction to starch infusion

Factors influencing faecal nitrogen excretion in sheep
2. Carbohydrate fermentation in the caecum and large intestine
V. C. Mason, P. Kessank, J. C. Ononiwu and M. P. Narang

Tierphysiol., Tierernähr. u. Futtermittelkde. 45 (1981)
The effect of very low food intake on digestive physiology and forage digestibility in horses

M. Clauss¹, K. Schiele², S. Ortmann³, J. Fritz², D. Codron¹, J. Hummel⁴ and E. Kienzle²


<table>
<thead>
<tr>
<th>Diet</th>
<th>Intake level</th>
<th>FN</th>
<th>MFN% DM</th>
<th>MFN% FN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hay 1</td>
<td>ad libitum</td>
<td>1.27 ± 0.08abA</td>
<td>0.56 ± 0.13aA</td>
<td>43.3 ± 8.3aA</td>
</tr>
<tr>
<td></td>
<td>75</td>
<td>1.38 ± 0.06b</td>
<td>0.66 ± 0.04a</td>
<td>47.7 ± 3.6a</td>
</tr>
<tr>
<td></td>
<td>55</td>
<td>1.33 ± 0.06b</td>
<td>0.69 ± 0.04a</td>
<td>51.7 ± 2.1a</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>1.15 ± 0.11a</td>
<td>0.49 ± 0.07a</td>
<td>42.7 ± 5.7a</td>
</tr>
<tr>
<td>Hay 2</td>
<td>ad libitum</td>
<td>1.03 ± 0.07abB</td>
<td>0.46 ± 0.11abB</td>
<td>44.1 ± 8.1abB</td>
</tr>
<tr>
<td></td>
<td>75</td>
<td>1.01 ± 0.03a</td>
<td>0.42 ± 0.06a</td>
<td>41.6 ± 4.8a</td>
</tr>
<tr>
<td></td>
<td>55</td>
<td>0.99 ± 0.08a</td>
<td>0.37 ± 0.10a</td>
<td>37.1 ± 7.7a</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>1.01 ± 0.07a</td>
<td>0.38 ± 0.06a</td>
<td>37.7 ± 4.7a</td>
</tr>
</tbody>
</table>
Habitat quality and the decline of an African elephant population: Implications for conservation

Armin H.W. Seydack*, Cobri Vermeulen and Johan Huisamen
MFN in relation to faecal VFA

Studies on digestive physiology and feed digestibilities in captive Indian rhinoceros (Rhinoceros unicornis)

M. Clauss¹, C. Polster¹, E. Kienzle¹, H. Wiesner², K. Baumgartner³, F. von Houwald⁴, S. Ortmann⁵, W. J. Streich⁵ and E.S. Dierenfeld⁶


![Graph showing the relationship between endogenous faecal protein and total faecal VFA (mmol/l).]
MFN in relation to dietary N

The influence of dietary tannin supplementation on digestive performance in captive black rhinoceroses (*Diceros bicornis*)

M. Clauss¹, J. C. Castell², E. Kienzle², E. S. Dierenfeld³, E. J. Flach⁴, O. Behlert⁵, S. Ortmann⁶, W. J. Streich⁶, J. Hummel⁵,⁷ and J.-M. Hatt¹

TFN/MFN – fibre digestibility

Comparing FN and the in vitro gas production of faecal fibre (inverse of digestibility achieved by the animal).

from Steuer et al. (in prep.)
Comparing FN and the in vitro gas production of faecal fibre (inverse of digestibility achieved by the animal).

from Steuer et al. (in prep.)
Foregut vs. Hindgut Fermentation

from Stevens & Hume (1995)
Foregut vs. Hindgut Fermentation

Lower bacterial nitrogen losses in the faeces?

from Stevens & Hume (1995)
Foregut vs. Hindgut Fermentation

Lower bacterial nitrogen losses in the faeces?

Higher bacterial nitrogen losses in the faeces?

from Stevens & Hume (1995)
Foregut vs. Hindgut Fermentation

Lower bacterial nitrogen losses in the faeces?

Lower bacterial nitrogen losses in hard faeces in coprophagic hindgut fermenters due to bacterial accumulation in caecotrophs?

from Stevens & Hume (1995)
Foregut vs. Hindgut Fermentation

Lower bacterial nitrogen losses in the faeces?

Higher bacterial nitrogen losses in the faeces?

Concentration in faeces vs. total excretion

from Stevens & Hume (1995)
No easy solution for the fractionation of faecal nitrogen in captive wild herbivores: results of a pilot study


No easy solution for the fractionation of faecal nitrogen in captive wild herbivores: results of a pilot study

A. Schwarm¹,², M. Schweigert¹, S. Ortmann¹, J. Hummel³, G. P. J. Janssens⁴, W. J. Streich¹ and M. Clauss⁵

TFN in zoo animals

No easy solution for the fractionation of faecal nitrogen in captive wild herbivores: results of a pilot study

A. Schwarm\textsuperscript{1,2}, M. Schweigert\textsuperscript{1}, S. Ortmann\textsuperscript{1}, J. Hummel\textsuperscript{3}, G. P. J. Janssens\textsuperscript{4}, W. J. Streich\textsuperscript{1} and M. Clauss\textsuperscript{5}


from Hesta et al. (2003)
MFN in zoo animals

No easy solution for the fractionation of faecal nitrogen in captive wild herbivores: results of a pilot study

A. Schwarm¹,², M. Schweigert¹, S. Ortmann¹, J. Hummel³, G. P. J. Janssens⁴, W. J. Streich¹ and M. Clauss⁵

No easy solution for the fractionation of faecal nitrogen in captive wild herbivores: results of a pilot study

A. Schwarm1,2, M. Schweigert1, S. Ortmann1, J. Hummel3, G. P. J. Janssens4, W. J. Streich1 and M. Clauss5


MFN in zoo animals
No easy solution for the fractionation of faecal nitrogen in captive wild herbivores: results of a pilot study

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from Hesta et al. (2003)
TFN – MFN relationship: no influence of digestion type ...

No easy solution for the fractionation of faecal nitrogen in captive wild herbivores: results of a pilot study

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TFN – MFN relationship: no influence of digestion type ... except the most basic
TFN – MFN relationship: no influence of digestion type ... except the most basic

No easy solution for the fractionation of faecal nitrogen in captive wild herbivores: results of a pilot study

A. Schwarm¹, M. Schweigert¹, S. Ortmann¹, J. Hummel³, G. P. J. Janssens⁴, W. J. Streich¹ and M. Clauss⁵


from Hesta et al. (2003)
TFN – MFN relationship: no influence of digestion type

from Steuer et al. (revision submitted)
TFN – MFN relationship: no influence of digestion type

from Steuer et al. (revision submitted)
TFN/MFN on grass hay

![Graph showing the faecal N (% OM) for various animals with TFN and MFN compared.](image)

from Steuer et al. (revision submitted)
TFN/MFN on grass hay

from Steuer et al. (revision submitted)
MFN not better as indicator of digestibility

Relationship between fecal crude protein concentration and diet organic matter digestibility in cattle

M. Lukas*, K.-H. Südekum*3,4, G. Rave†, K. Friedel‡, and A. Susenbeth*

MFN not better as indicator of digestibility

Relationship between fecal crude protein concentration and diet organic matter digestibility in cattle

M. Lukas*2, K.-H. Südekum*3,4, G. Rave†, K. Friedel‡, and A. Susenbeth*


The OM digestibility was more closely related to CP than to ADSCP in fecal OM, resulting in higher coefficients of determination ($R^2$) and lower residual SD of the respective equations for the variable CP than for ADSCP.
Does MFN work – and does it provide more information than TFN – in the presence of secondary compound?

(Total faecal nitrogen = TFN)
(Metabolic faecal nitrogen = MFN)
Faecal N and secondary compounds

Fecal nitrogen and 2,6-diaminopimelic acid as indices to dietary nitrogen in white-tailed deer

Robert G. Osborn and Tim F. Ginnett

TFN is influenced by diet

<table>
<thead>
<tr>
<th>GLM</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body mass</td>
<td>8.09</td>
<td>0.012</td>
</tr>
<tr>
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<td>8.55</td>
<td>0.010</td>
</tr>
</tbody>
</table>

from Steuer et al. (revision submitted)
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<td>0.010</td>
</tr>
<tr>
<td>%grass</td>
<td>4.51</td>
<td>0.051</td>
</tr>
</tbody>
</table>

from Steuer et al. (revision submitted)
MFN is less influenced by diet

<table>
<thead>
<tr>
<th>Feature</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body mass</td>
<td>14.2</td>
<td>0.002</td>
</tr>
<tr>
<td>Digestion type (Rum vs. HF)</td>
<td>10.3</td>
<td>0.006</td>
</tr>
<tr>
<td>%grass</td>
<td>0.1</td>
<td>0.711</td>
</tr>
</tbody>
</table>

from Steuer et al. (revision submitted)
A failed attempt to quantify ‘endogenous’ faecal N in herbivores
Analytical approaches

Total faecal N

- undigested dietary N
- MFN
- endogenous N
- microbial N

- fibre-bound N
  - NDF-N
  - ADF-N
  - Ultrasonic probe (ind.)
  - Lysozyme-Trypsin extract (ind.)

- microbial N marker
  - Diaminopimelic acid (DAPA)
  - RNA extraction
  - Purines
  - Centrifugation
  - Microscopy

Regression analysis
Analytical approaches

Total faecal N

- undigested dietary N
- endogenous N
- microbial N

fibre-bound N
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- ADF-N
- Ultrasonic probe (ind.)
- Lysozyme-Trypsin extract (ind.)

vertebrate N marker
- Diaminopimelic acid (DAPA)
- RNA extraction
- Purines
- Centrifugation
- Microscopy

MFN

regression analysis
Analytical approaches

Total faecal N

undigested dietary N

endogenous N

fibre-bound N
NDF-N
ADF-N
Ultrasonic probe (ind.)
Lysozyme-Trypsin extract (ind.)

vertebrate N marker
(SDS difference?)

MFN

microbial N

microbial N marker
Diaminopimelic acid (DAPA)
RNA extraction
Purines
Centrifugation
Microscopy

regression analysis
Analytical approaches

Total faecal N

- undigested dietary N
- MFN
- endogenous N
- microbial N
- fibre-bound N
- vertebrate N marker
- microbial N marker

Analytical approaches include:
- Total faecal N
- fibre-bound N
  - NDF(SDS)-N
- undigested dietary N
- vertebrate N marker
- microbial N marker
- endogenous N
- MFN

Regression analysis is used to:
- Analyse relationships between variables.
Prebiotics affect nutrient digestibility but not faecal ammonia in dogs fed increased dietary protein levels

M. Hesta*, W. Roosen, G. P. J. Janssens, S. Millet and R. De Wilde

*British Journal of Nutrition (2003), 90, 1007–1014
**No easy solution for the fractionation of faecal nitrogen in captive wild herbivores: results of a pilot study**

A. Schwarm¹,², M. Schweigert¹, S. Ortmann¹, J. Hummel³, G. P. J. Janssens⁴, W. J. Streich¹ and M. Clauss⁵


Table 1 Mean (± SD) proportion of forage N (=NDF<sub>SDS</sub>N) and metabolic faecal N (MFN = Faecal N – NDF<sub>SDS</sub>N) in faecal nitrogen (FN) in the faeces of plains viscachas (*Lagostomus maximus*). Additionally, the different N fractions are given in % of FN, including the supposedly N<sub>Bacteria</sub> (=NDF<sub>withoutSDS</sub>N – NDF<sub>SDS</sub>N) and N<sub>Animal</sub> (=MFN – N<sub>Bacteria</sub>) (see Methods for details). From Besselmann (2005)

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Grass hay only</td>
<td>45 ± 4</td>
<td>55 ± 4</td>
<td>19 ± 4</td>
<td>36 ± 7</td>
</tr>
<tr>
<td>Concentrates</td>
<td>30 ± 7</td>
<td>70 ± 7</td>
<td>12 ± 3</td>
<td>58 ± 9</td>
</tr>
</tbody>
</table>
... but generally unplausible results

No easy solution for the fractionation of faecal nitrogen in captive wild herbivores: results of a pilot study

A. Schwarm\textsuperscript{1,2}, M. Schweigert\textsuperscript{1}, S. Ortmann\textsuperscript{1}, J. Hummel\textsuperscript{3}, G. P. J. Janssens\textsuperscript{4}, W. J. Streich\textsuperscript{1} and M. Clauss\textsuperscript{5}


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<tbody>
<tr>
<td>Coprophagous hindgut fermenter</td>
<td>3.06\textsuperscript{a} ± 0.75</td>
<td>0.57\textsuperscript{a} ± 0.16</td>
<td>2.49 ± 0.79</td>
<td>20\textsuperscript{a} ± 7</td>
<td>80\textsuperscript{a} ± 7</td>
<td>21\textsuperscript{a} ± 6</td>
<td>59 ± 9</td>
</tr>
<tr>
<td>Non-coprophagous hindgut fermenter</td>
<td>2.78\textsuperscript{ab} ± 1.02</td>
<td>0.67\textsuperscript{b} ± 0.32</td>
<td>2.11 ± 0.78</td>
<td>24\textsuperscript{ab} ± 6</td>
<td>75\textsuperscript{b} ± 6</td>
<td>12\textsuperscript{b} ± 3</td>
<td>63 ± 8</td>
</tr>
<tr>
<td>Ruminant foregut fermenter</td>
<td>3.07\textsuperscript{ab} ± 1.11</td>
<td>0.86\textsuperscript{b} ± 0.28</td>
<td>2.21 ± 0.91</td>
<td>29\textsuperscript{b} ± 4</td>
<td>71\textsuperscript{b} ± 4</td>
<td>11\textsuperscript{b} ± 3</td>
<td>61 ± 4</td>
</tr>
<tr>
<td>Non-ruminant foregut fermenter</td>
<td>3.89\textsuperscript{b} ± 1.93</td>
<td>0.73\textsuperscript{b} ± 0.27</td>
<td>3.15 ± 1.84</td>
<td>22\textsuperscript{b} ± 9</td>
<td>78\textsuperscript{b} ± 9</td>
<td>12\textsuperscript{b} ± 2</td>
<td>66 ± 8</td>
</tr>
<tr>
<td>Non-coprophagous hindgut fermenter (no hyrax, primates)</td>
<td>2.53 ± 1.14</td>
<td>0.65 ± 0.38</td>
<td>1.88 ± 0.82</td>
<td>26 ± 6</td>
<td>74 ± 6</td>
<td>12 ± 4</td>
<td>62 ± 8</td>
</tr>
<tr>
<td>Non-ruminant foregut fermenter (no primates, sloth)</td>
<td>2.33 ± 0.62</td>
<td>0.66 ± 0.18</td>
<td>1.68 ± 0.45</td>
<td>28 ± 3</td>
<td>72 ± 3</td>
<td>12 ± 1</td>
<td>60 ± 3</td>
</tr>
<tr>
<td>Non-coprophagous hindgut fermenter primates</td>
<td>3.33\textsuperscript{a} ± 0.33</td>
<td>0.71 ± 0.20</td>
<td>2.63 ± 0.37</td>
<td>21 ± 7</td>
<td>79 ± 7</td>
<td>13\textsuperscript{a} ± 2</td>
<td>66 ± 5</td>
</tr>
<tr>
<td>Non-ruminant foregut fermenter primates</td>
<td>5.75\textsuperscript{c} ± 1.05</td>
<td>0.83 ± 0.41</td>
<td>4.92 ± 1.18</td>
<td>15 ± 8</td>
<td>85 ± 8</td>
<td>11\textsuperscript{b} ± 4</td>
<td>74 ± 7</td>
</tr>
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</table>
Applying MFN in an ecological context

(Metabolic faecal nitrogen = MFN)
An old question:

Do larger herbivores ingest lower-quality diets, and are they physiologically equipped for a ‘better’ digestion of such diets?
Hypothesis building

from Steuer et al. (revision submitted)
Larger size endows higher digestive efficiency ...

from Steuer et al. (revision submitted)
... or body size has no effect on digestibility

from Steuer et al. (revision submitted)
Body size does not affect diet selection ...

from Steuer et al. (revision submitted)
... or larger animals eat lower quality diets

from Steuer et al. (revision submitted)
... or larger animals eat lower quality diets

from Steuer et al. (revision submitted)
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Conclusions
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- Total faecal nitrogen (TFN) is often used in ecology, but sometimes not with a functional understanding.
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- TFN reflects diet digestibility, but this is affected by plant secondary compounds (PSC).
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Conclusions

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• Simple assays to separate microbial and endogenous N have failed so far.
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• Simple assays to separate microbial and endogenous N have failed so far.
• Herbivore digestive strategies are linked to digestibility and hence TFN or MFN, but not to differences in the MFN-TFN relationship.
• MFN appears superior to TFN in situations of heterogenous diets (incl. PSC).
thank you
for your attention