Nitrogen fractionation in faeces: status quo and potential

Marcus Clauss & Jürgen Hummel

Clinic for Zoo Animals, Exotic Pets and Wildlife, Vetsuisse Faculty, University of Zurich, Switzerland
Department of Animal Sciences, Ruminant Nutrition, Georg-August-University of Göttingen, Germany

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

University of Zurich[UZH]

Clinic of Zoo Animals, Exotic Pets and Wildlife

Georg-August-Universität Göttingen

Apparent digestibility

Digestibility

(Intake – Excretion) / Intake

‘True’ digestibility

(Intake – Excretion) / Intake

undigested diet remains

‘Apparent’ digestibility

(Intake – Excretion) / Intake

undigested diet remains

already metabolized (‘metabolic’) substance

‘Apparent’ digestibility

(Intake – Excretion) / Intake

undigested diet remains

already metabolized (‘metabolic’) substance

endogenous substance

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microbial substance

‘Apparent’ digestibility

(Intake – Excretion) / Intake

undigested diet remains

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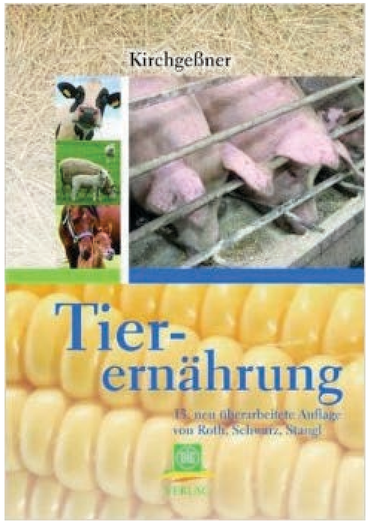
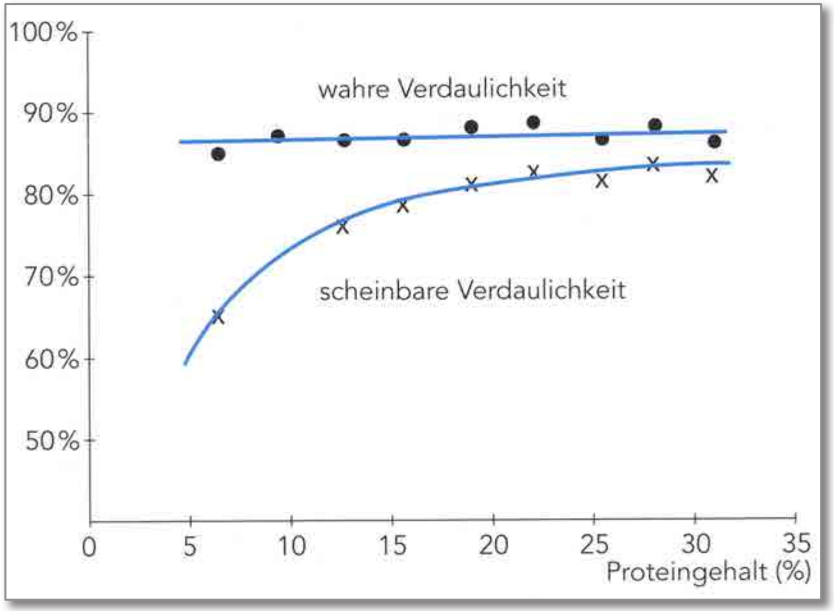
endogenous substance

microbial substance

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

Apparent digestibility





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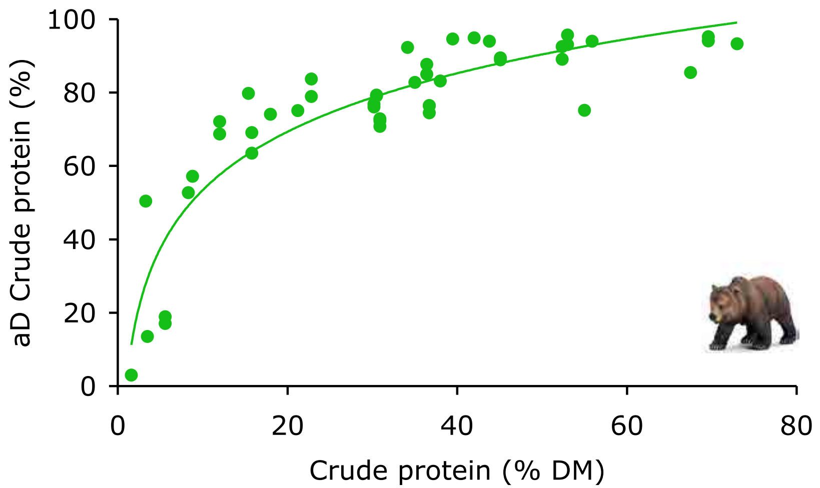
Apparent digestibility

Carnivorous Mammals: Nutrient Digestibility and Energy Evaluation

Marcus Clauss,[1*] Helen Kleffner,[2] and Ellen Kienzle[2]

Zoo Biology 29 : 687–704 (2010)



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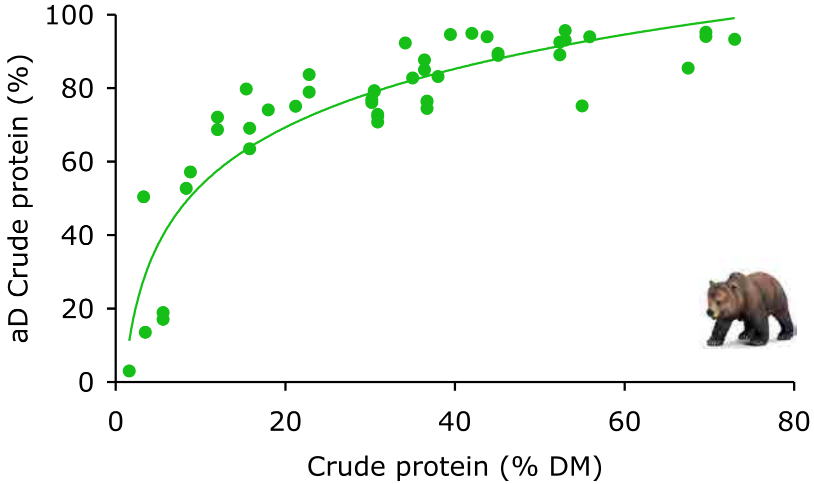
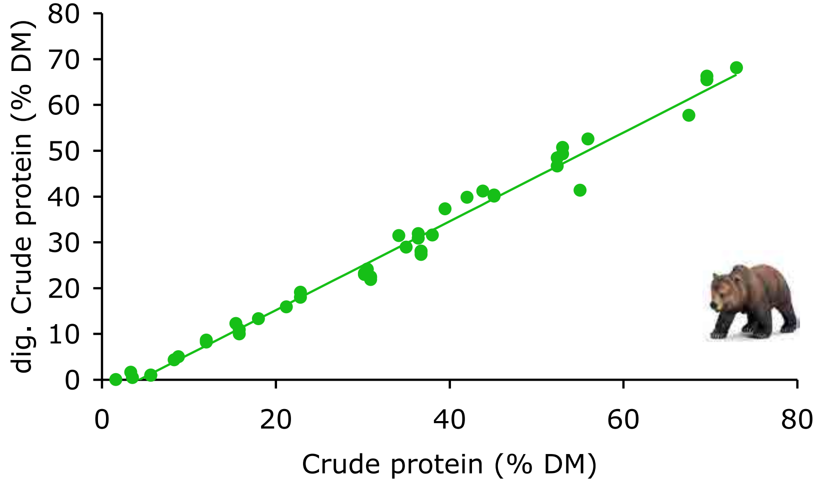


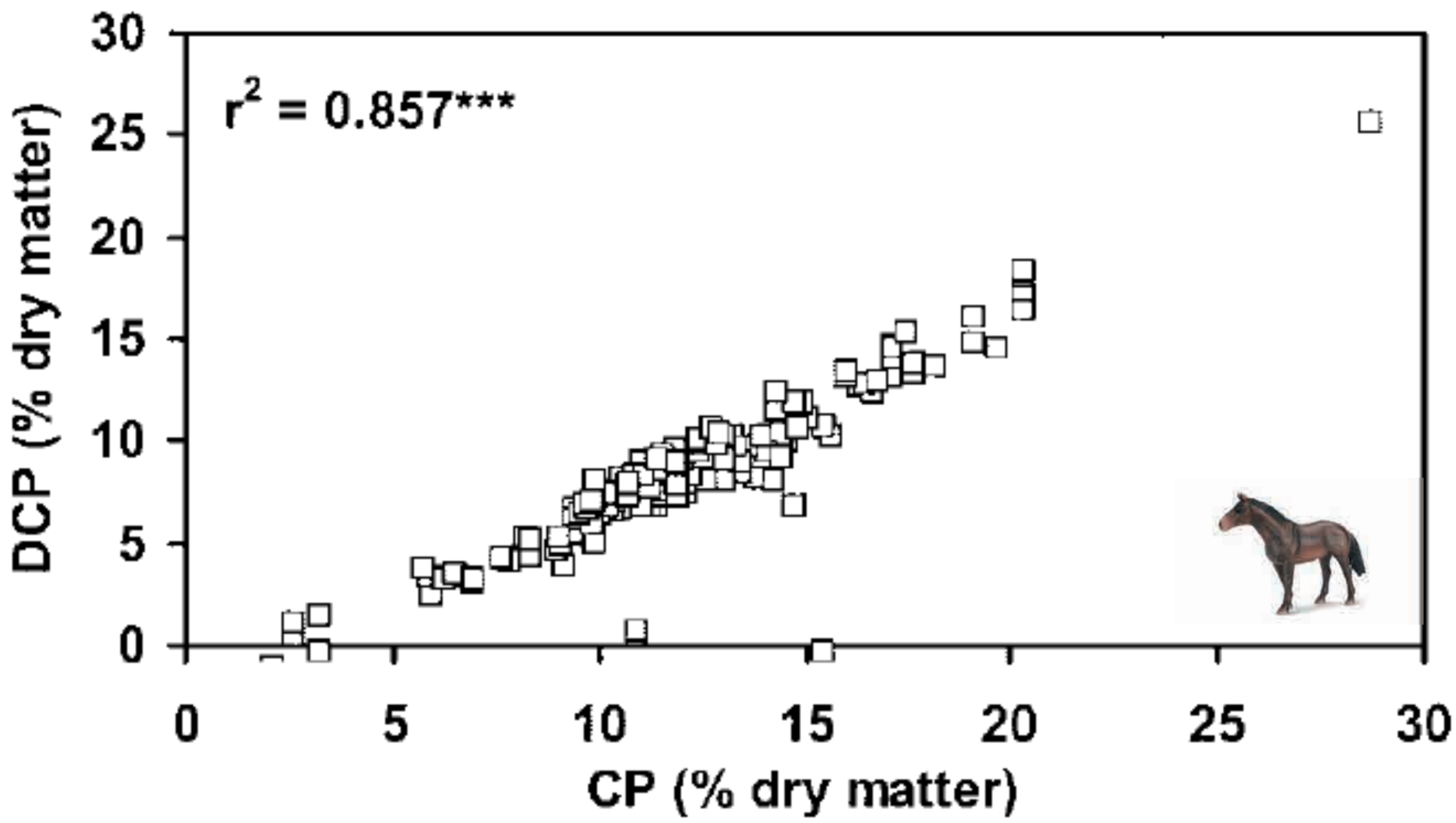


Estimating ‘true’ digestibility and endogenous losses by regression analysis

A Method to Estimate Digestible Energy in Horse Feed[1]

Annette Zeyner[2] and Ellen Kienzle*

J. Nutr. 132: 1771S–1773S, 2002.



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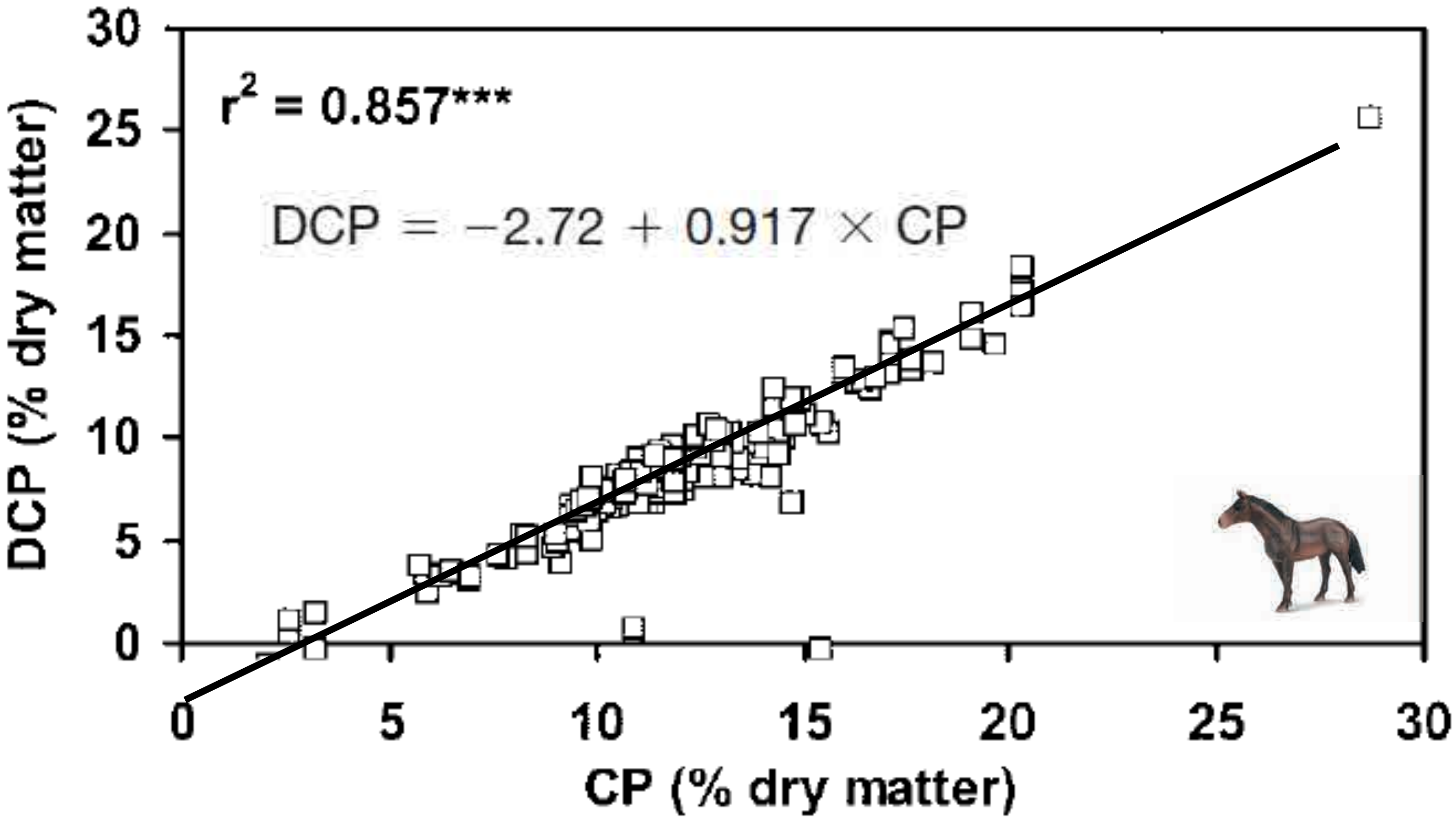

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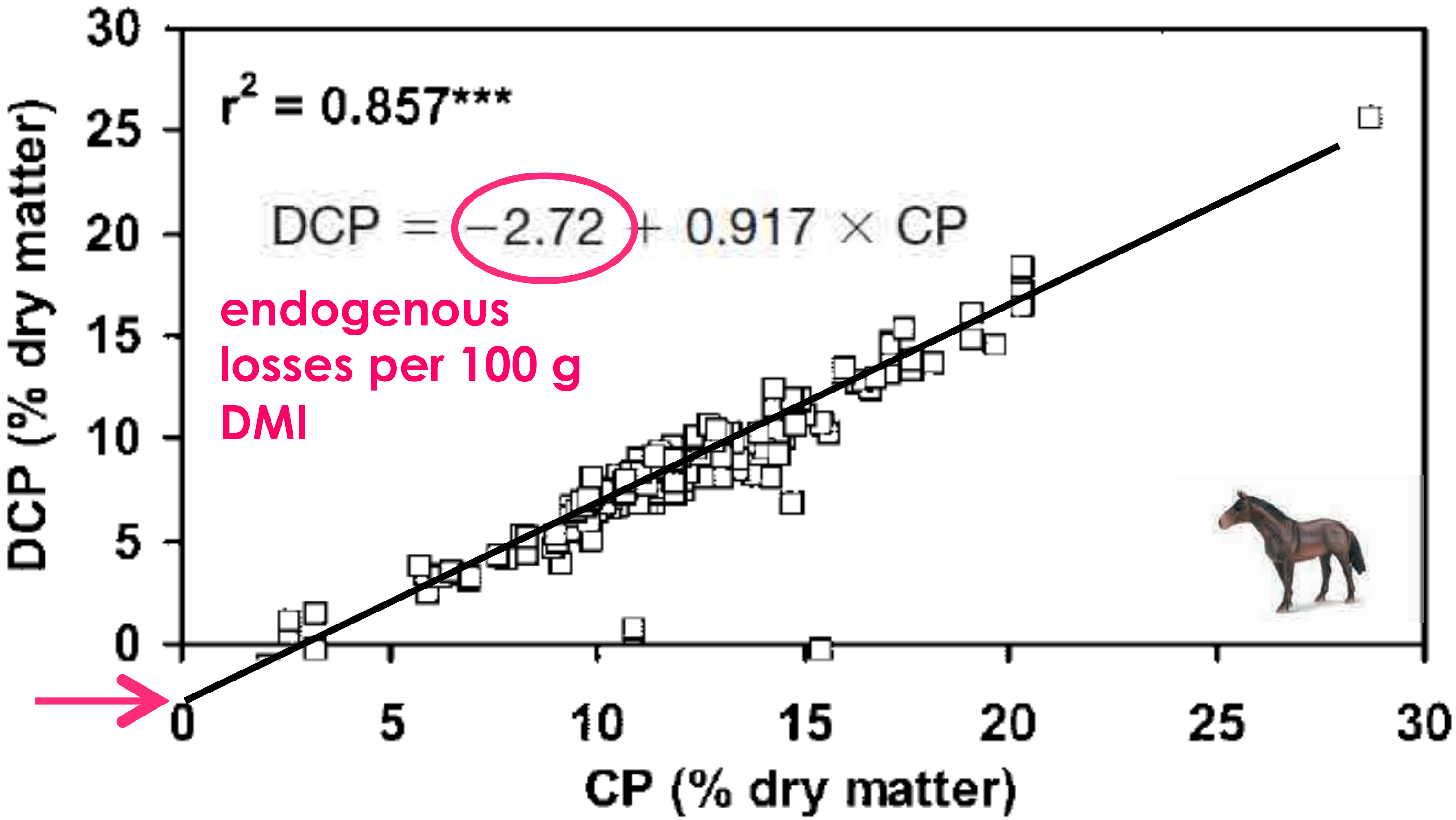

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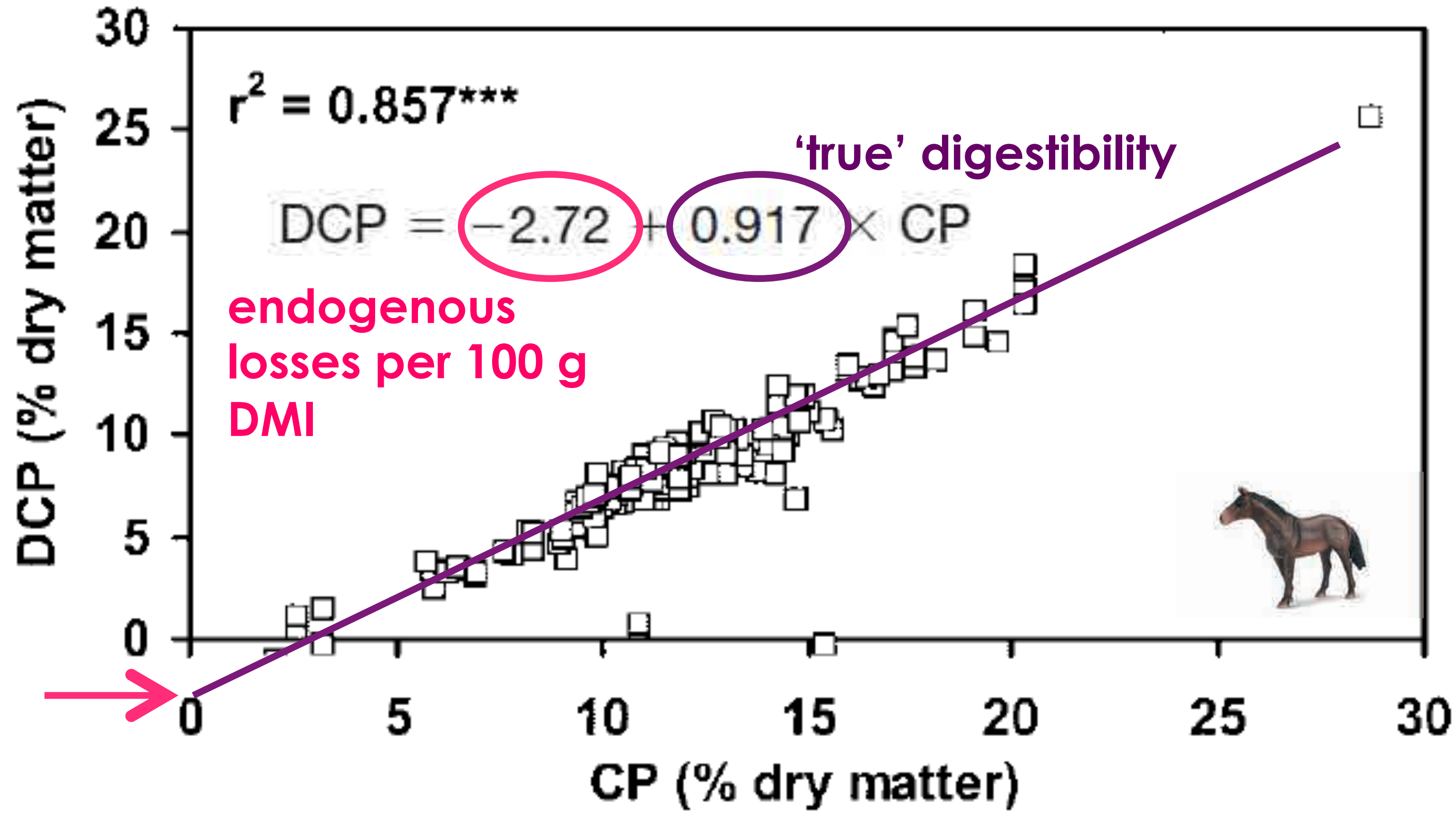
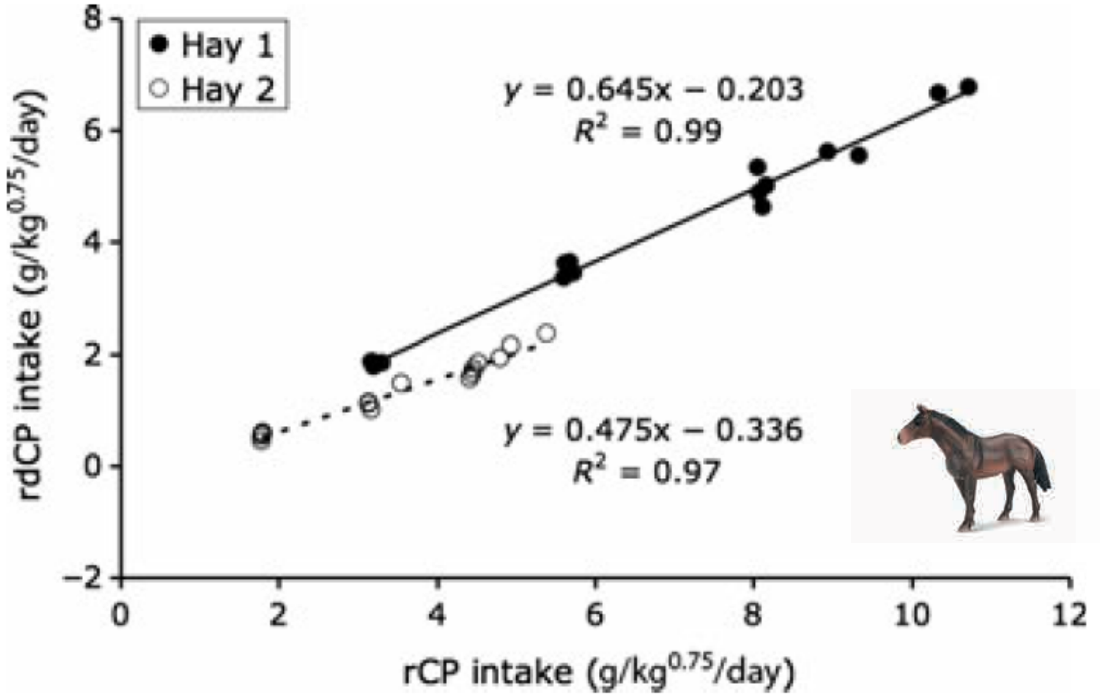


Estimating 'true' digestibility and endogenous losses by regression analysis

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

M. Clauss[1], K. Schiele[2], S. Ortmann[3], J. Fritz[2], D. Codron[1], J. Hummel[4] and E. Kienzle[2]

Journal of Animal Physiology and Animal Nutrition **98** (2014) 107–118



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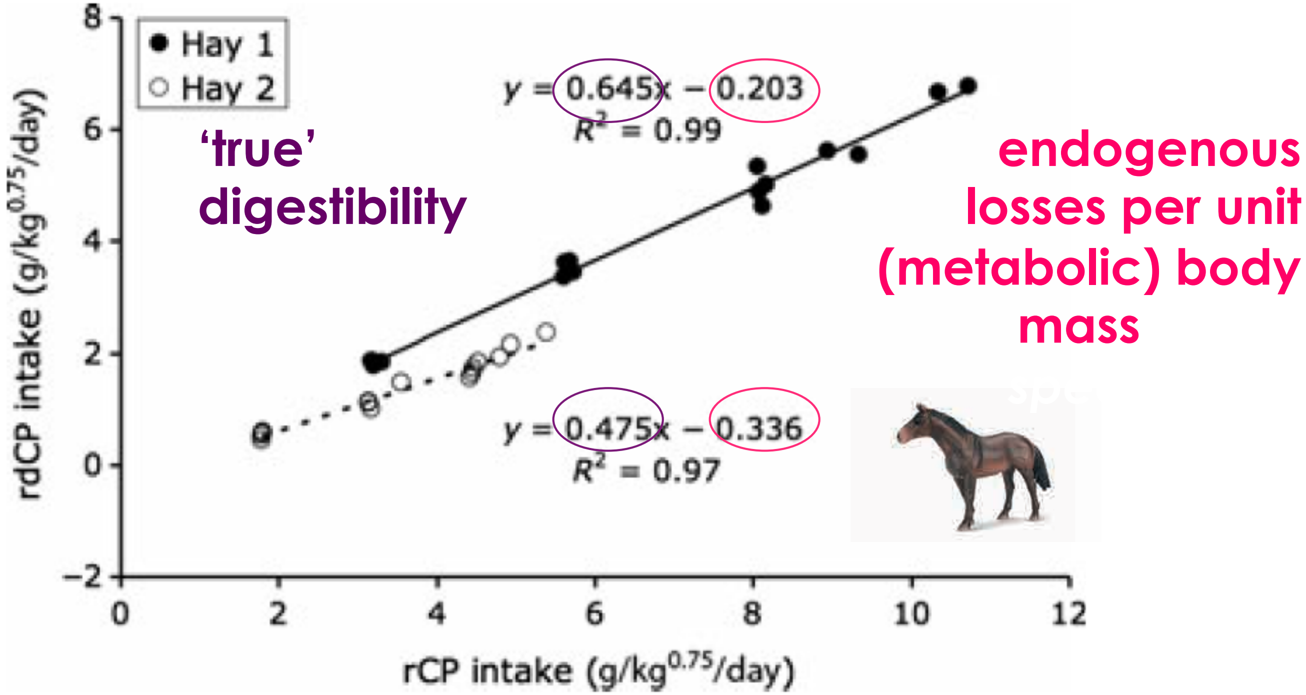

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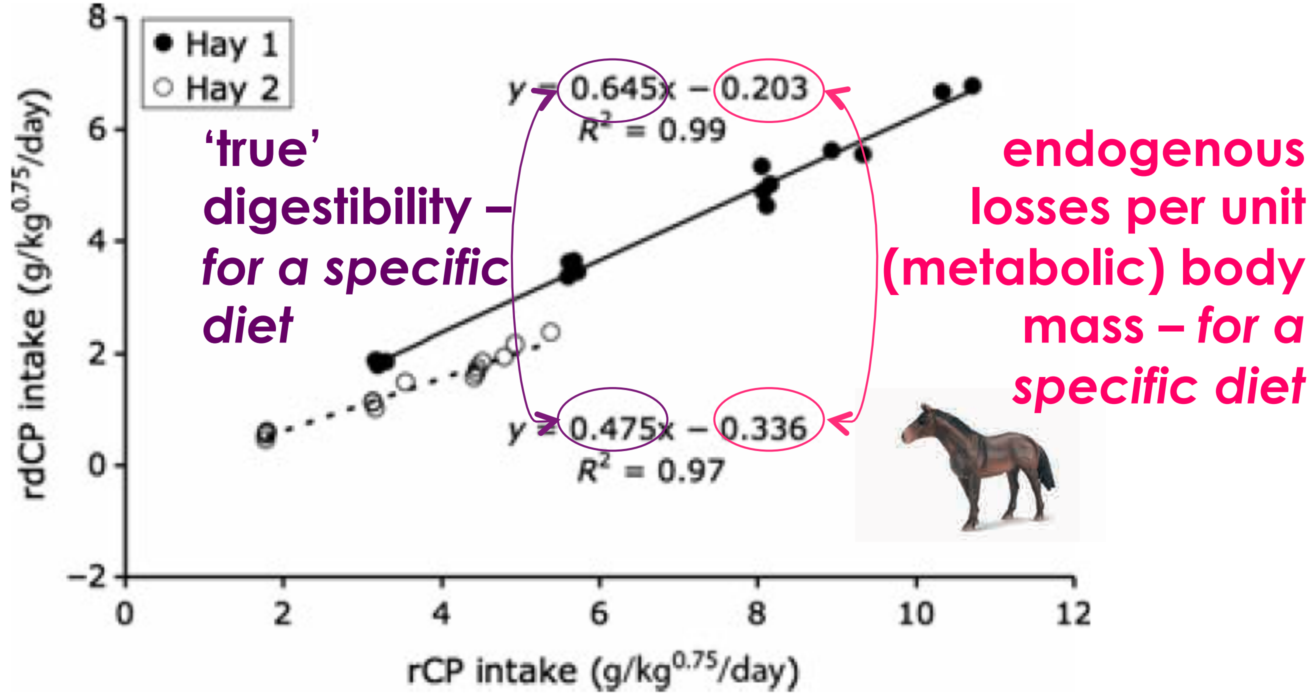

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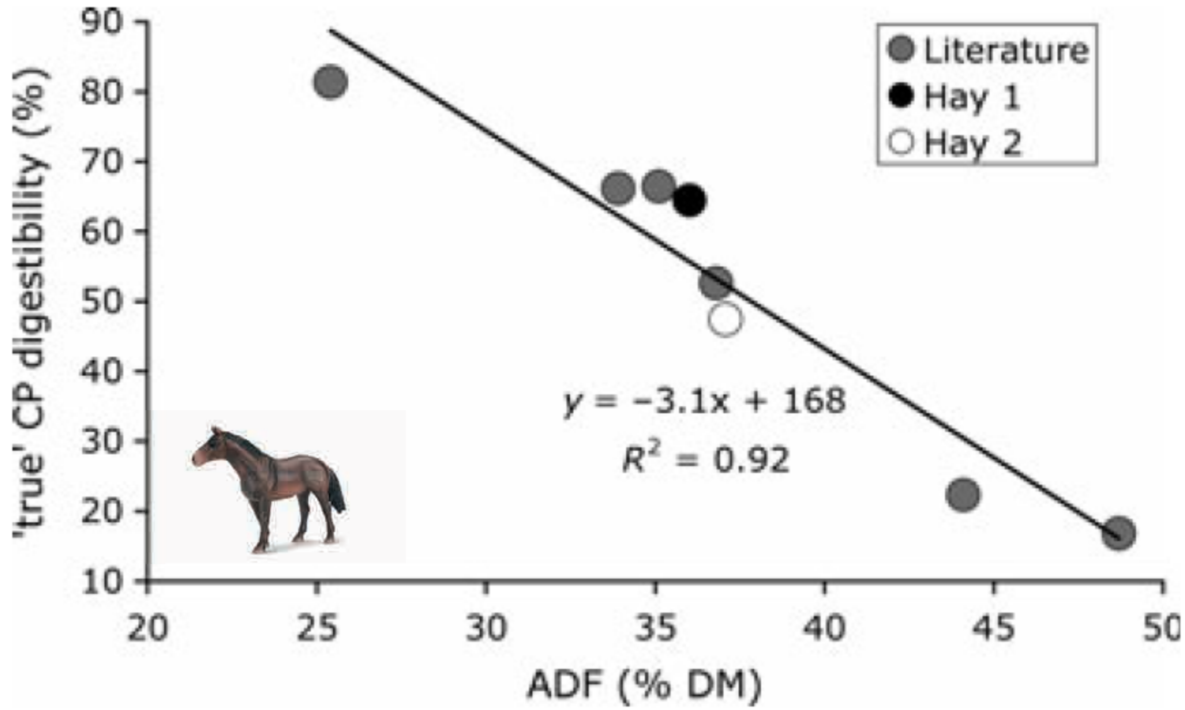


Estimating ‘true’ digestibility and endogenous losses by regression analysis

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 ⟷ Total faecal N

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

Diet N ↑ ⟷ Total faecal N ↑

undigested dietary N

MFN

endogenous N

microbial N

TFN as a **diet quality** ↓ indicator

Diet N ↓ ⟷ Total faecal N ↓

undigested dietary N → Total faecal N

MFN → Total faecal N

endogenous N → MFN

microbial N → MFN

TFN as a **diet quality** ↓ indicator

Diet N ↓ ⟷ Total faecal N ↓

undigested dietary N → Total faecal N

MFN → Total faecal N

endogenous N → MFN

microbial N → MFN

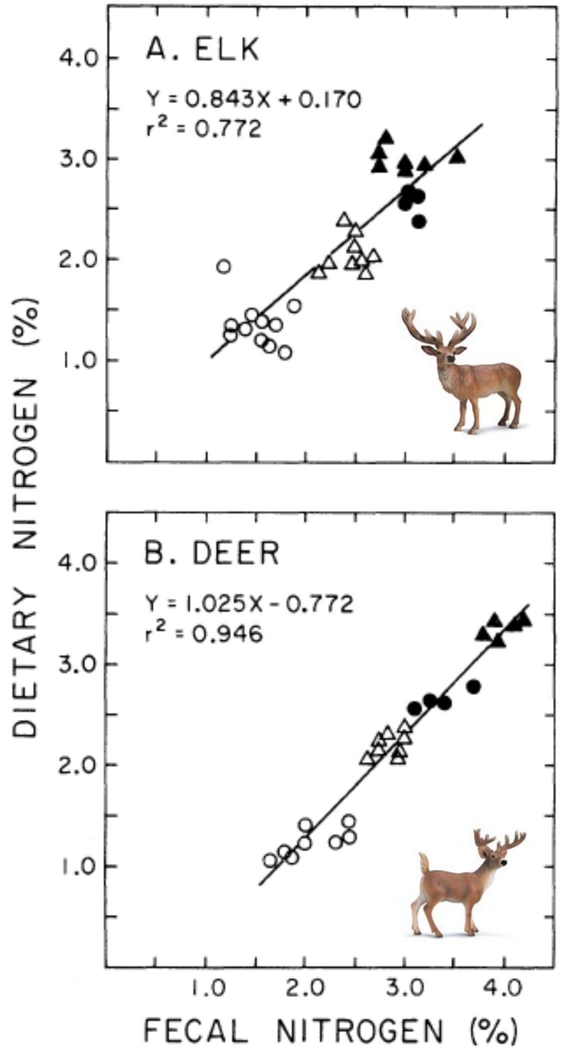
Because of a statistical correlation, TFN is most often interpreted as an indicator of diet N.

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



TFN in free-ranging populations

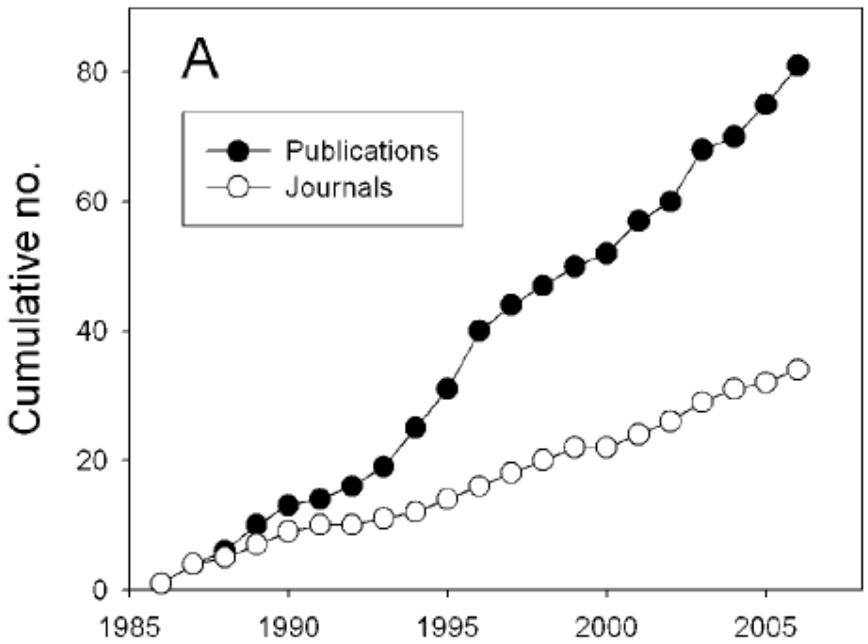
Tools and Technology Article JOURNAL OF WILDLIFE MANAGEMENT 72(6):1420–1433; 2008

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*

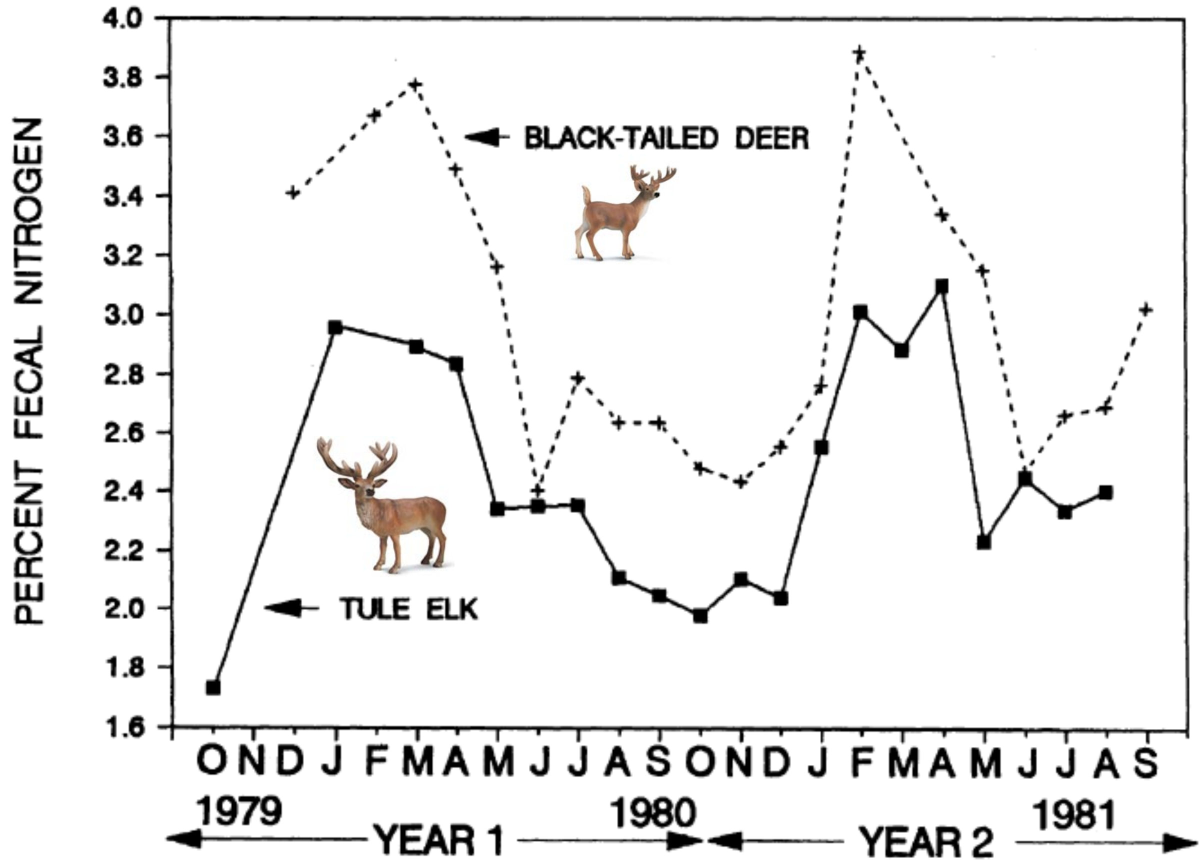


TFN in seasonal datasets

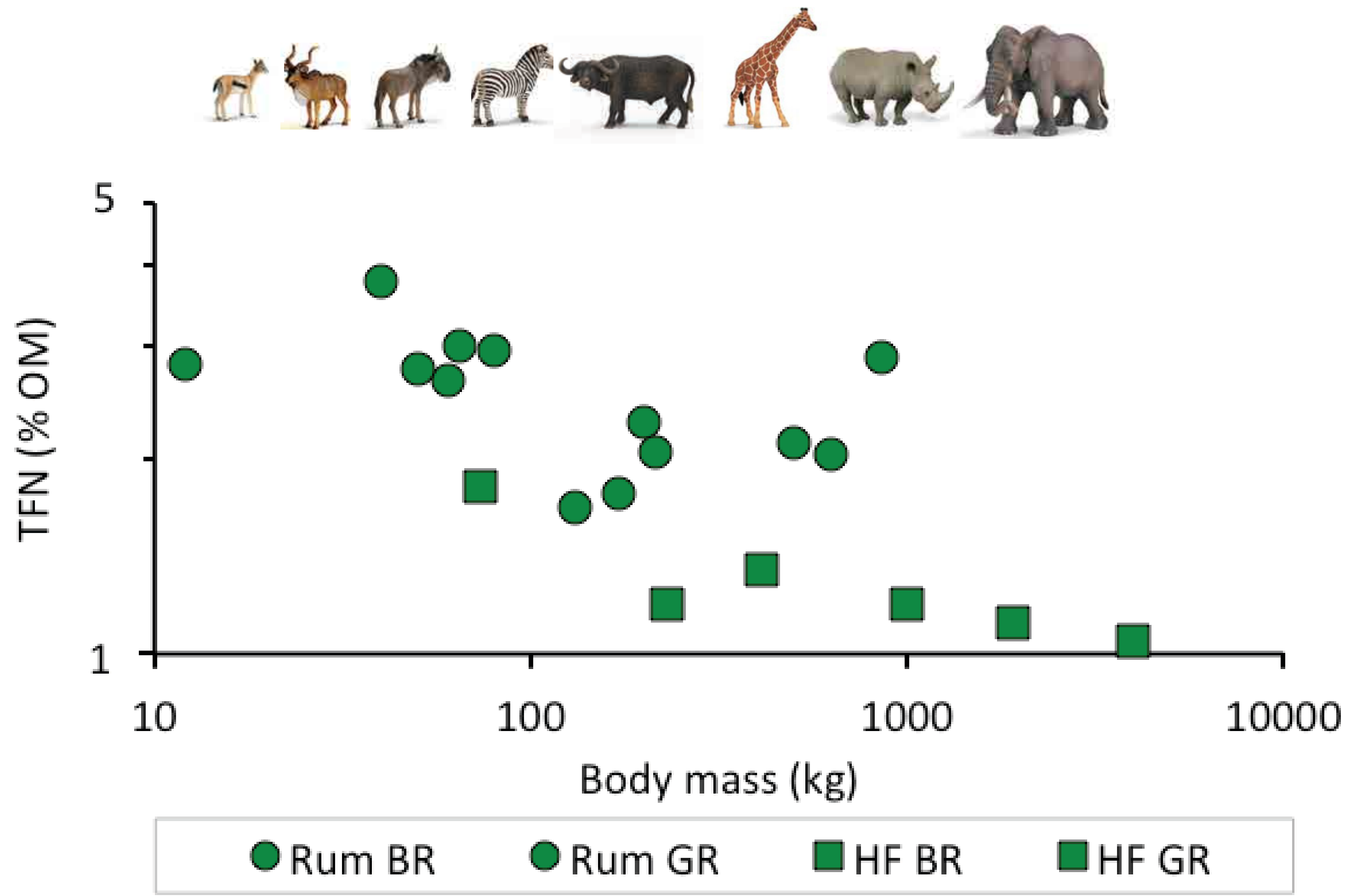
Elk and deer diets in a coastal prairie-scrub Mosaic, California

PETER J. P. GOGAN AND REGINALD H. BARRETT

J. Range Manage.
48:327–335 July 1995



TFN in free-ranging ungulates



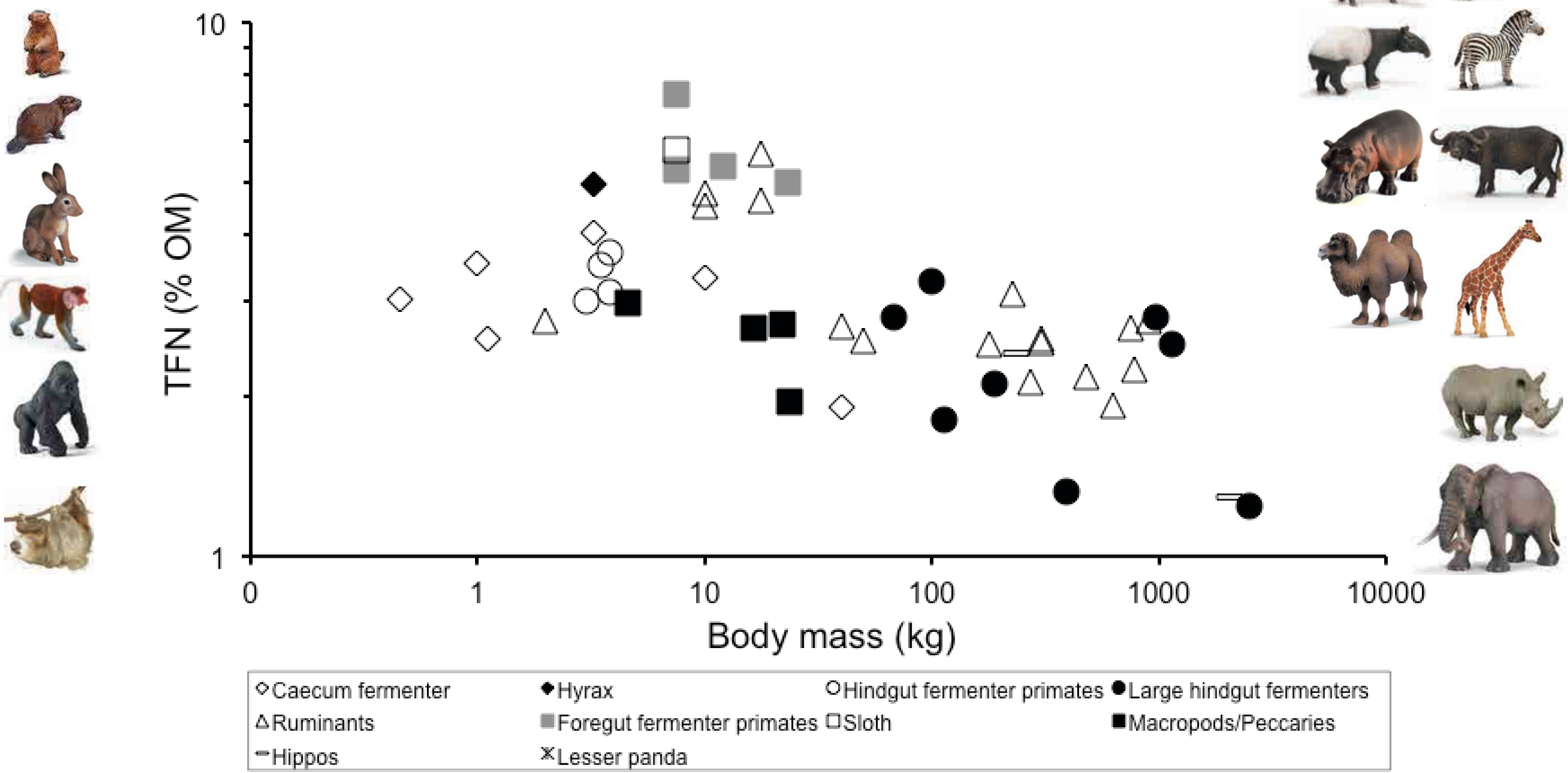
from Steuer et al. (revision submitted)

TFN in zoo animals

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

A. Schwarm[1,2], M. Schweigert[1], S. Ortmann[1], J. Hummel[3], G. P. J. Janssens[4], W. J. Streich[1] and M. Clauss[5]

Journal of Animal Physiology and Animal Nutrition **93** (2009) 596–605



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

MFN

endogenous N

microbial N

TFN is a concentration!

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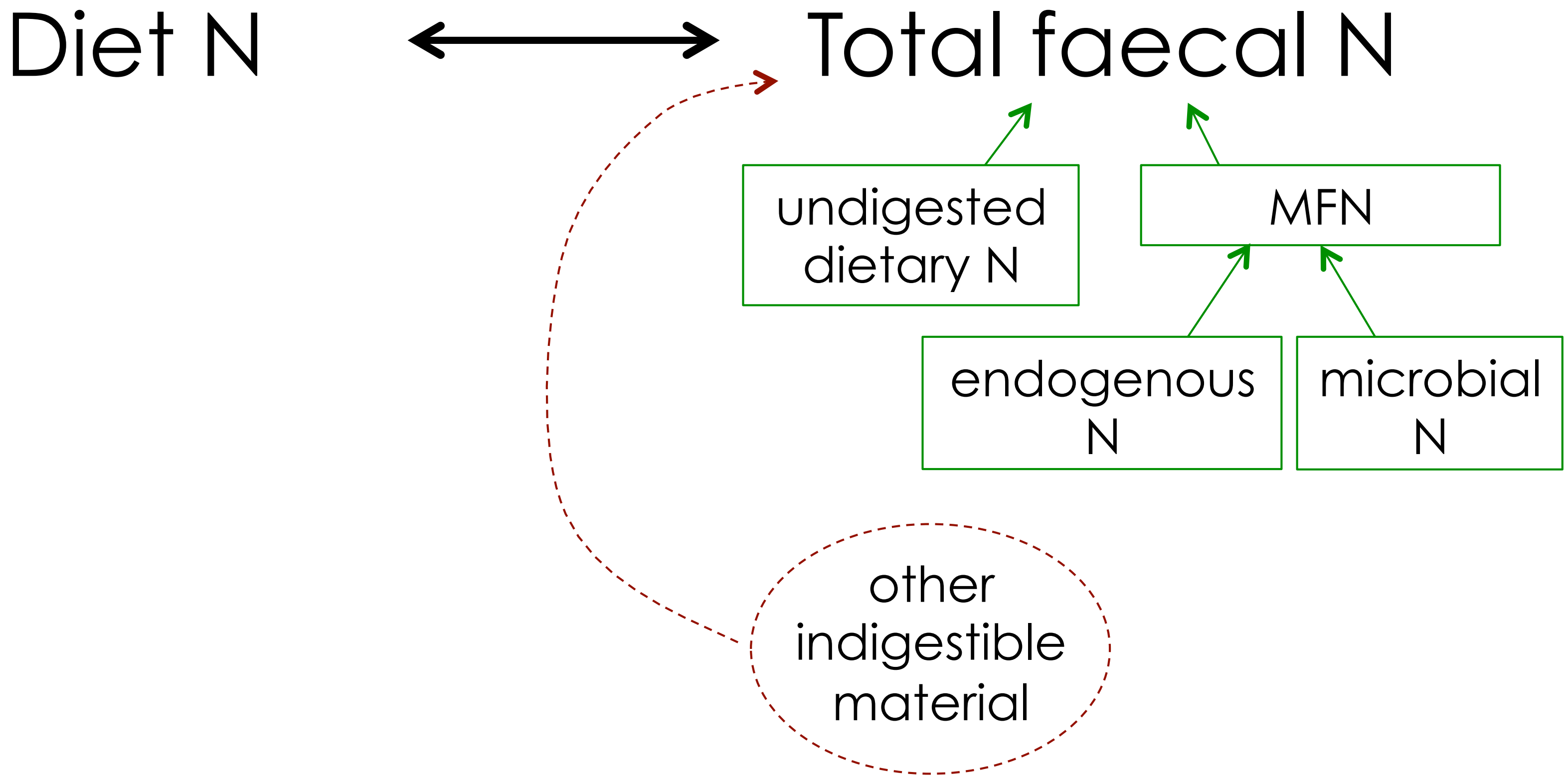
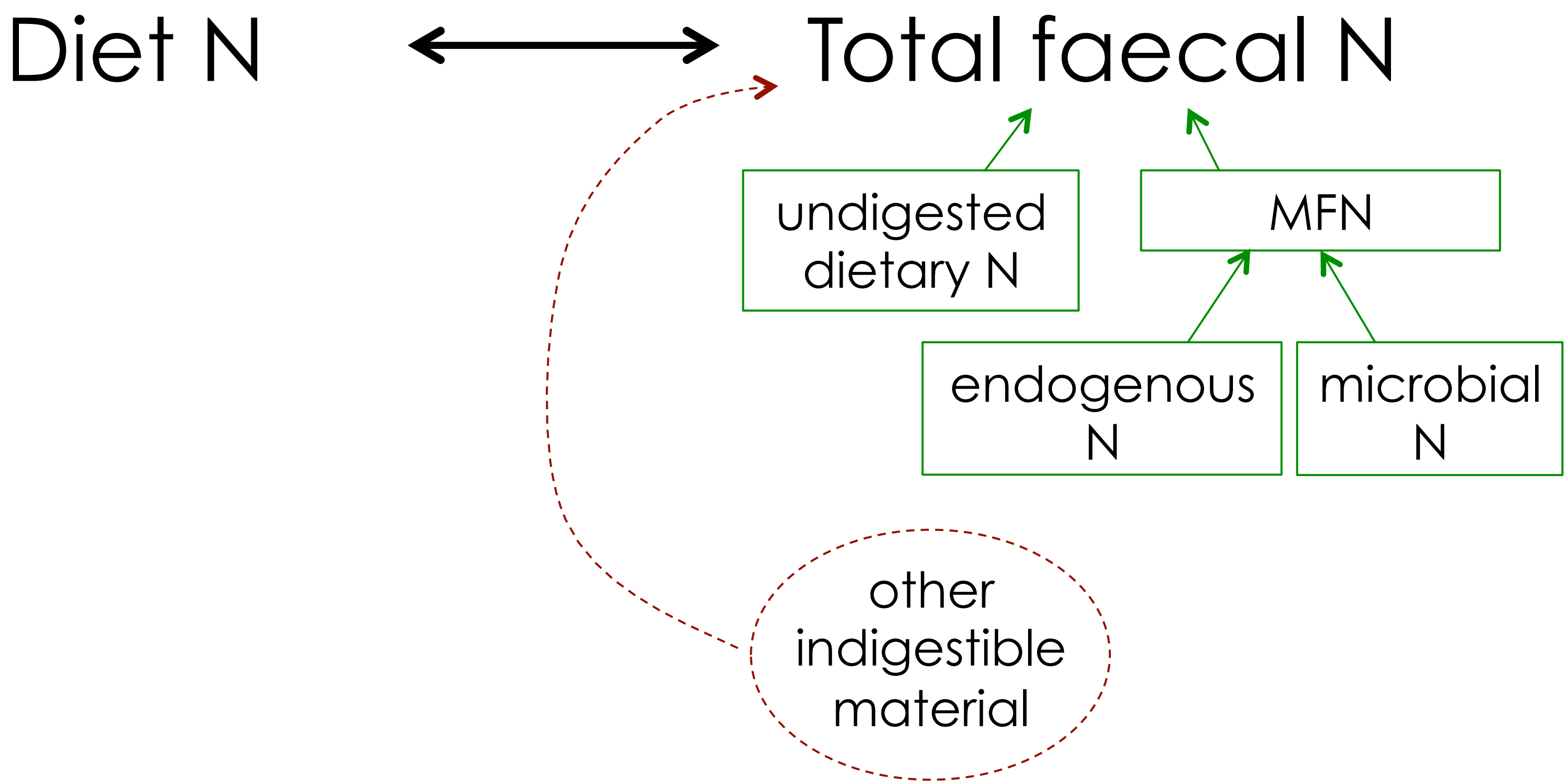


TFN as a diet quality indicator



TFN as a diet quality indicator

Diet N ↔ Total faecal N

Easily fermentable carbohydrates

Slowly fermenting fibre

Indigestible fibre

undigested dietary N

MFN

endogenous N

microbial N

other indigestible material

TFN as a **diet quality** ↑ indicator

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↓ undigested dietary N

MFN ↑

~ endogenous N

microbial N ↑

other ↓ indigestible material

TFN summarizes processes that are related to the overall digestion of the diet.

TFN as indicator of digestibility

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

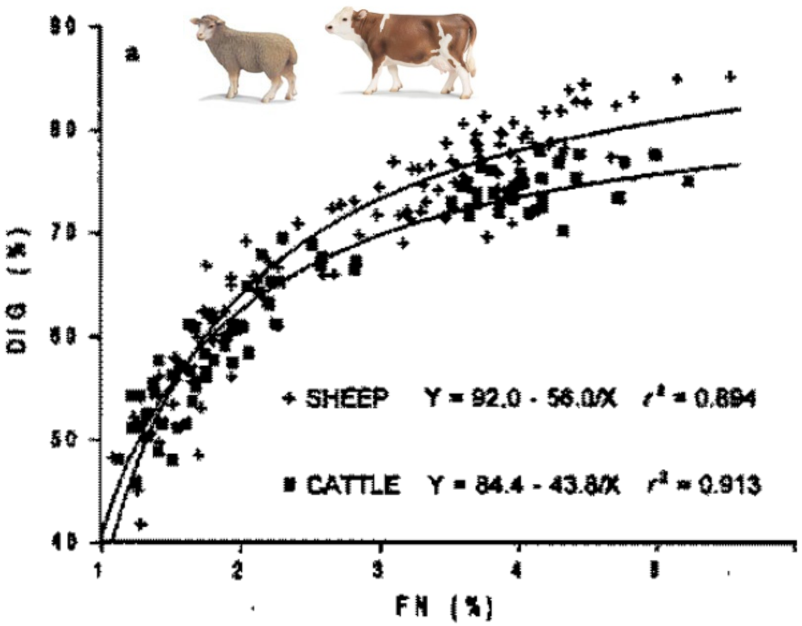
THE N.Z. JOURNAL OF SCIENCE AND TECHNOLOGY 1949

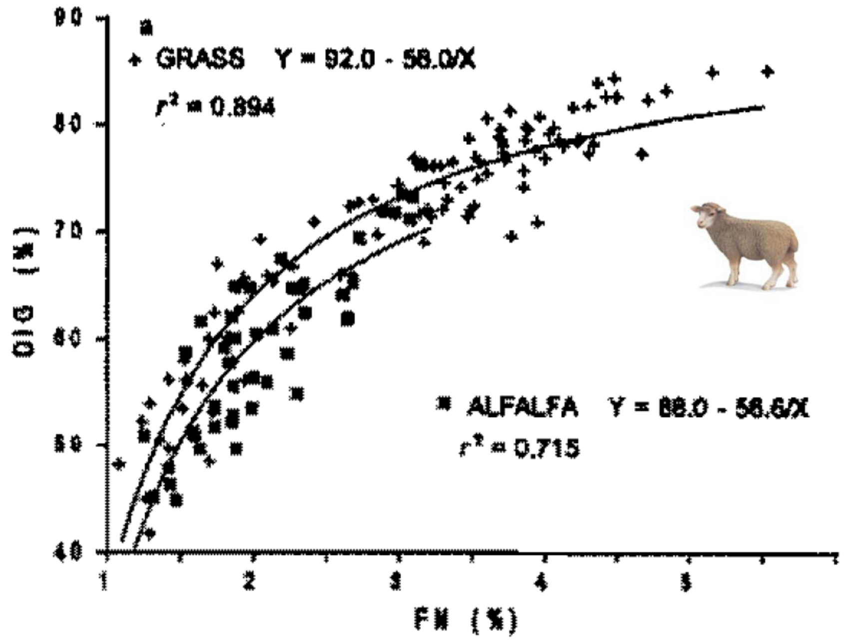
TFN as indicator of digestibility

FECAL MEASURES OF DIET QUALITY IN WILD AND DOMESTIC RUMINANTS

JOHN D. WEHAUSEN

J. WILDL. MANAGE. 59(4):816–823



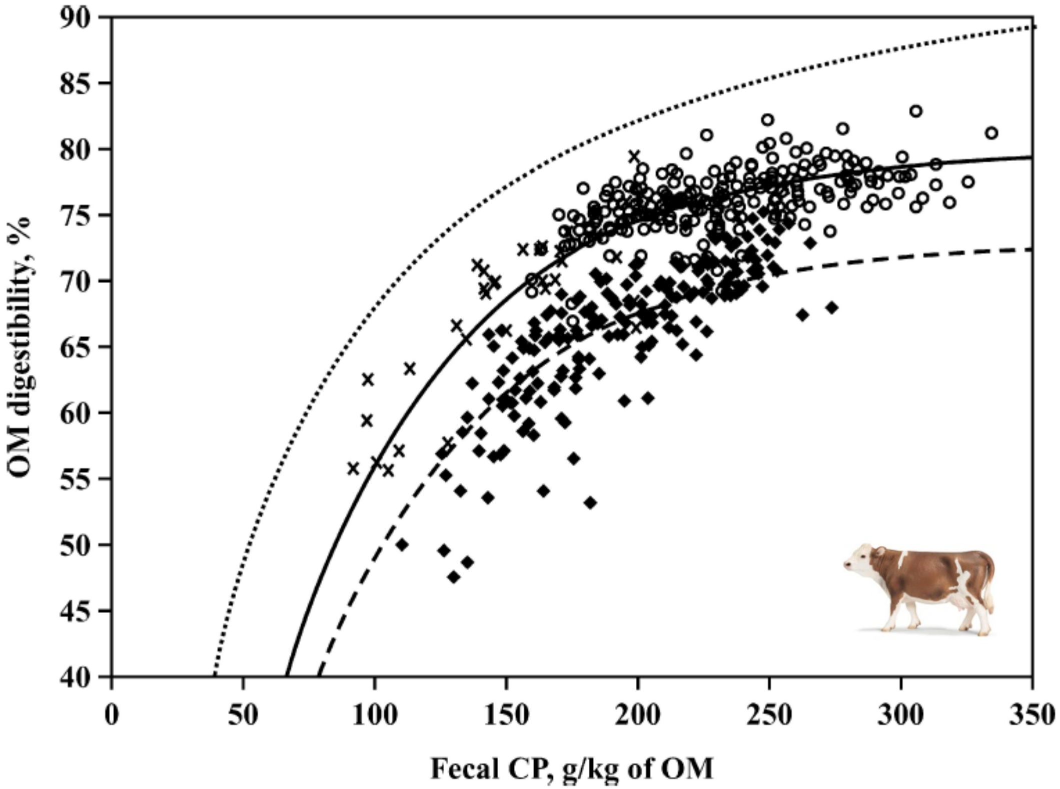


TFN as indicator of digestibility

Relationship between fecal crude protein concentration and diet organic matter digestibility in cattle[1]

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

J. Anim. Sci. 2005. 83:1332–1344

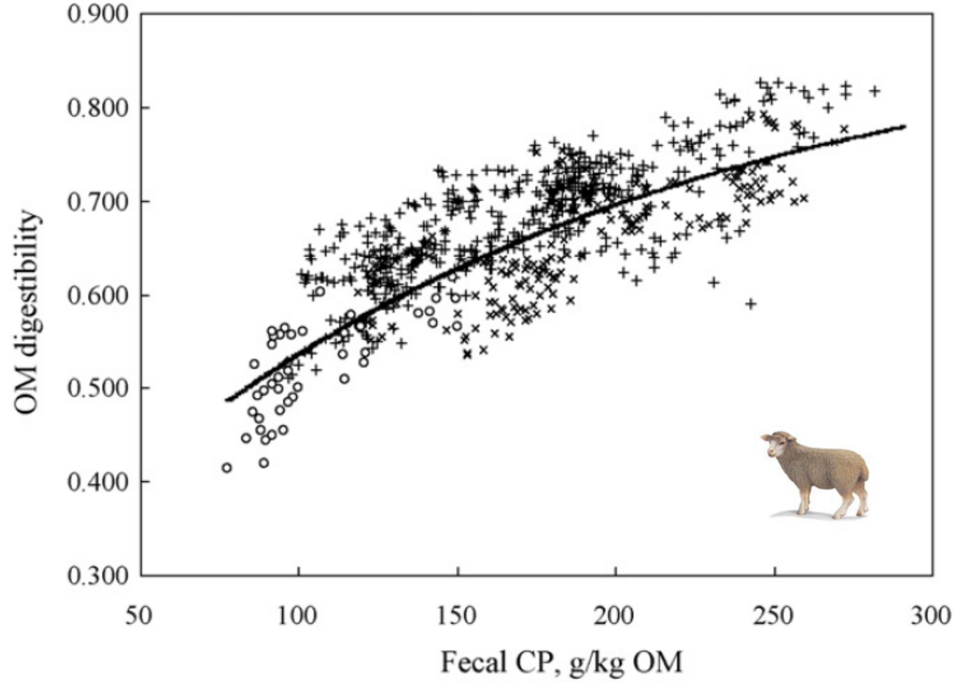


TFN as indicator of digestibility

Fecal crude protein content as an estimate for the digestibility of forage in grazing sheep

C.J. Wang[a,d], B.M. Tas[a], T. Glindemann[a], G. Rave[b], L. Schmidt[c], F. Weißbach[c], A. Susenbeth[a,*]

Animal Feed Science and Technology 149 (2009) 199–208

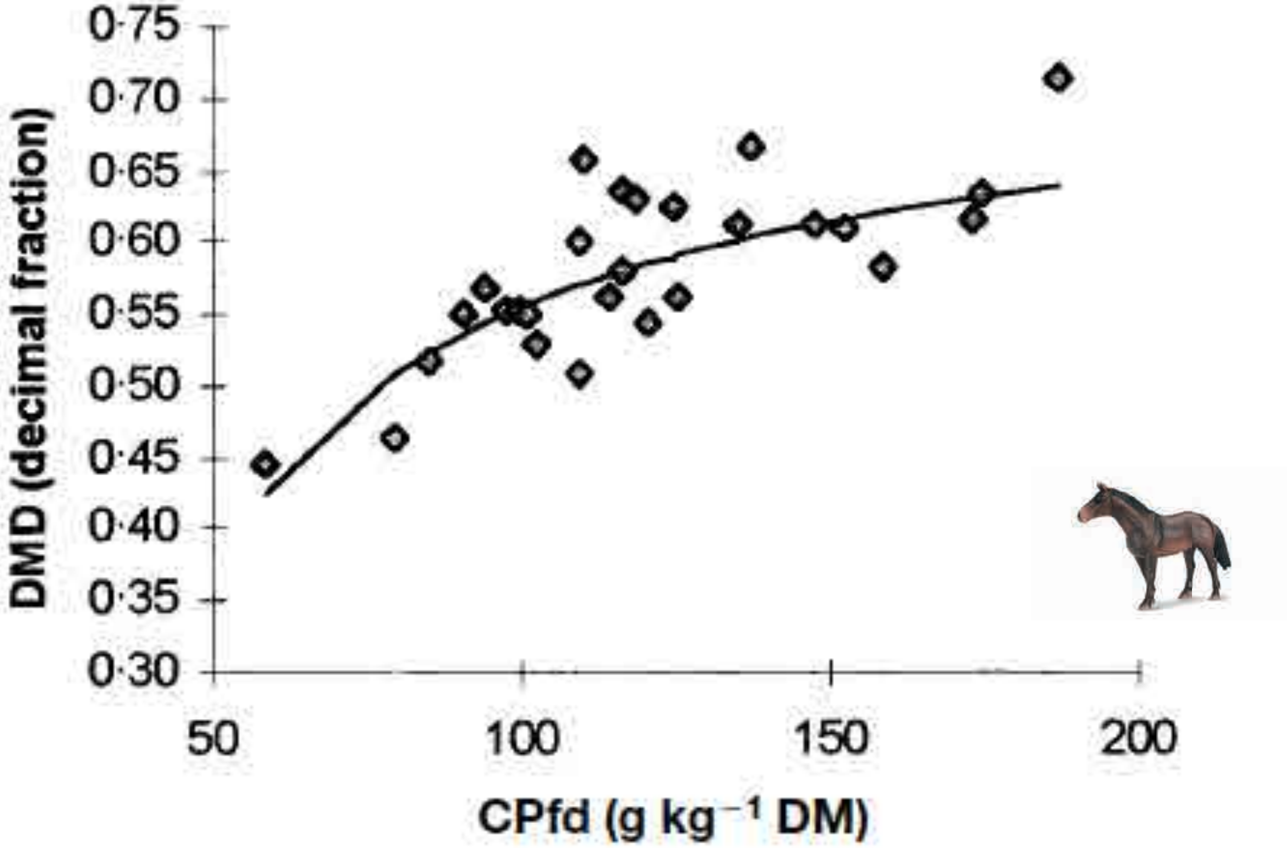


TFN as indicator of digestibility

Prediction of the digestibility of the diet of horses: evaluation of faecal indices

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

Grass and Forage Science, **53**, 189–196 1998



Faecal nitrogen III

-

a fundamental constraint

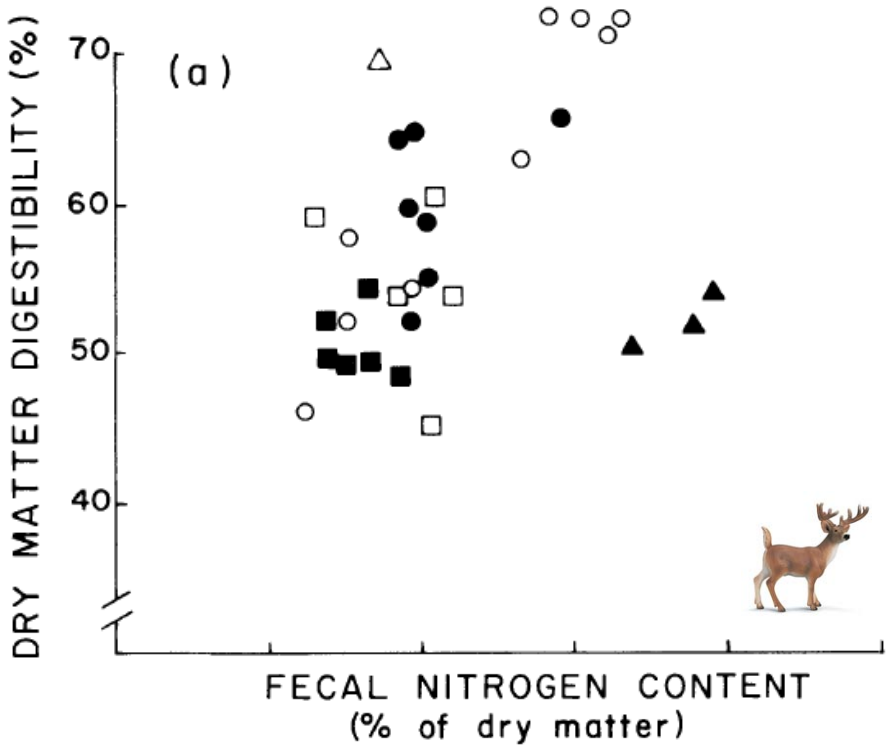
(Total faecal nitrogen = TFN)

TFN as indicator of digestibility

ROLE OF TANNINS IN DEFENDING PLANTS AGAINST RUMINANTS: REDUCTION IN PROTEIN AVAILABILITY[1]

C. T. ROBBINS
T. A. HANLEY
A. E. HAGERMAN
O. HJELJORD
D. L. BAKER
C. C. SCHWARTZ
W. W. MAUTZ

Ecology, 68(1), 1987, pp. 98–107



TFN and **secondary plant compounds**

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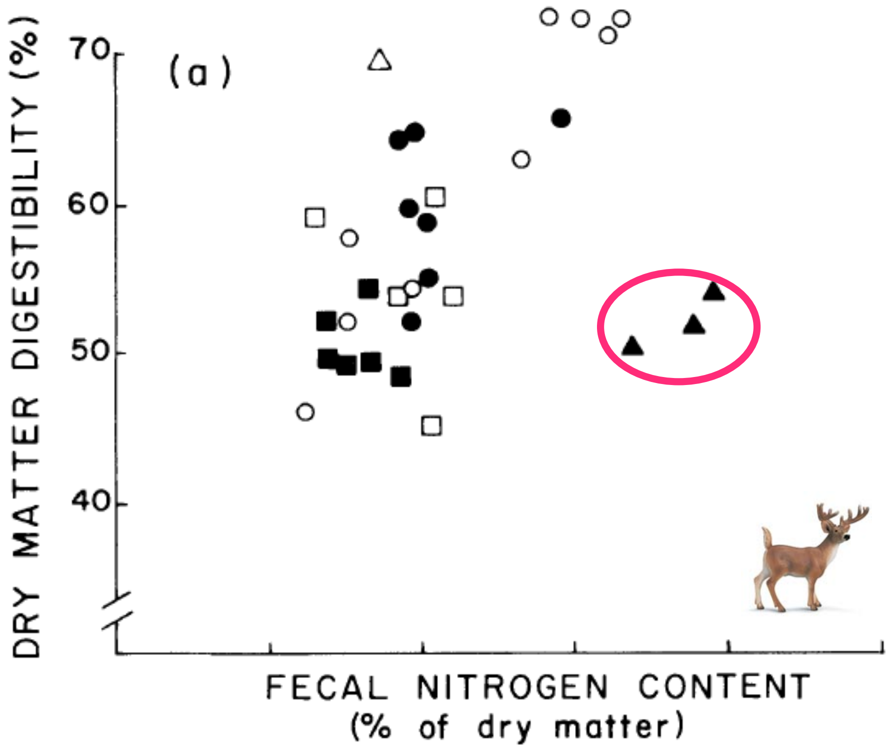
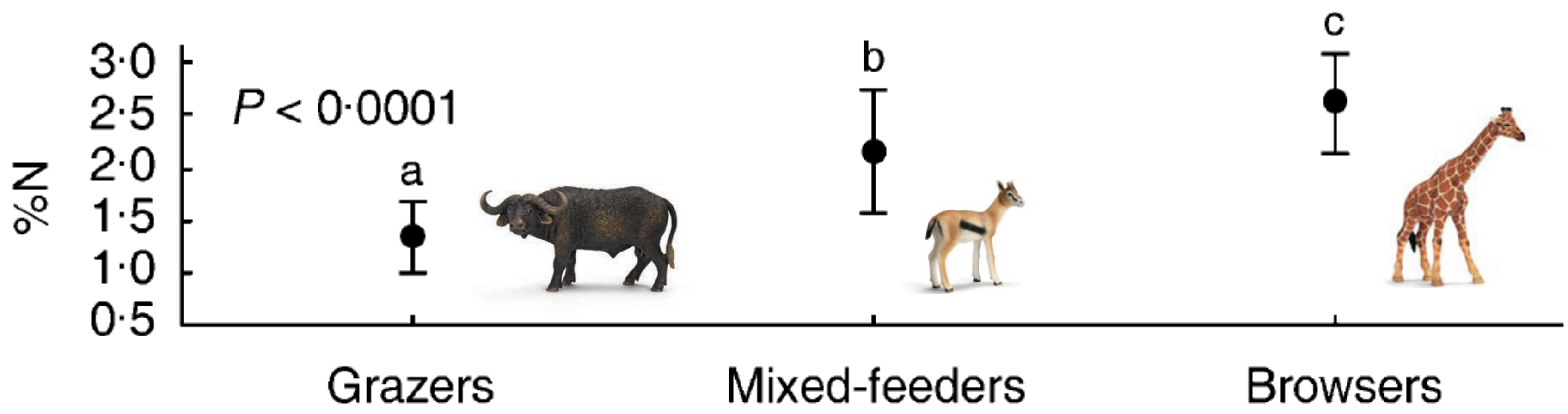


TFN in comparative datasets

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†**

Journal of Animal Ecology 2007
76, 526–537



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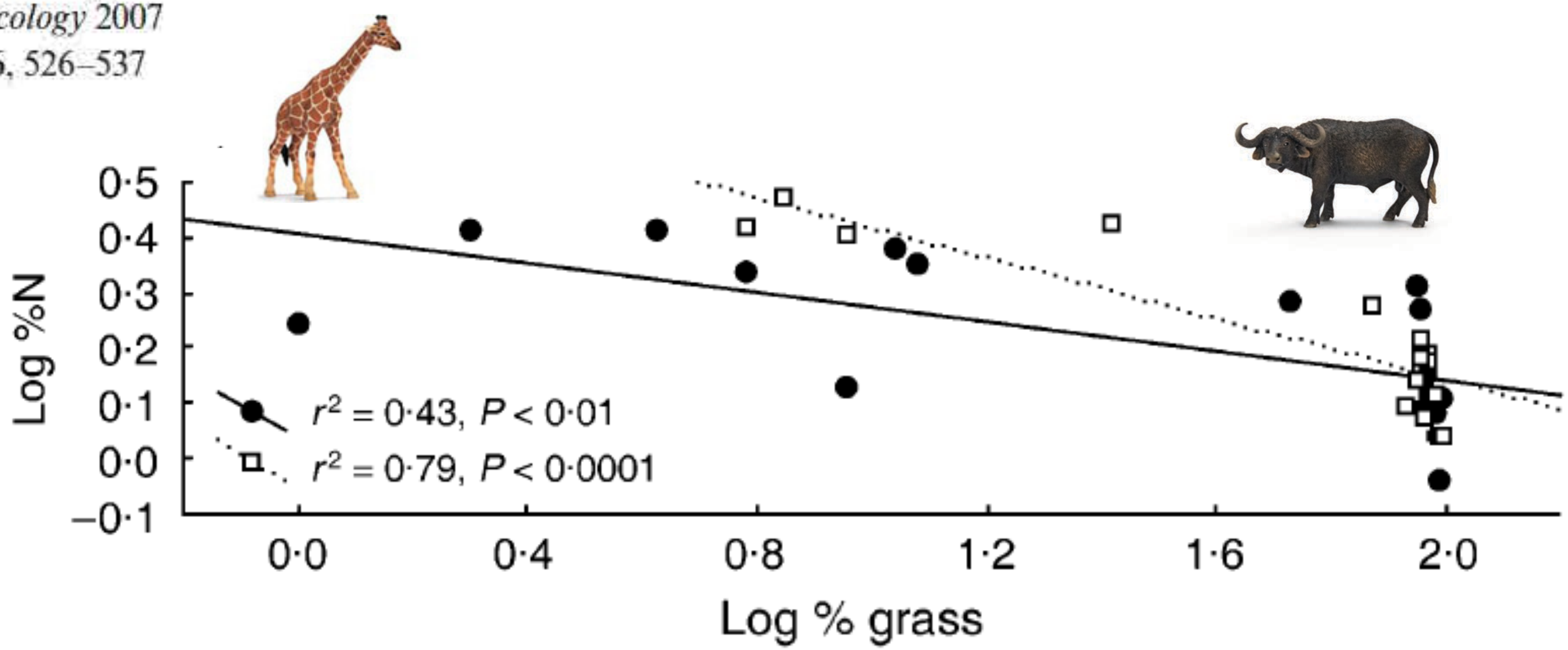
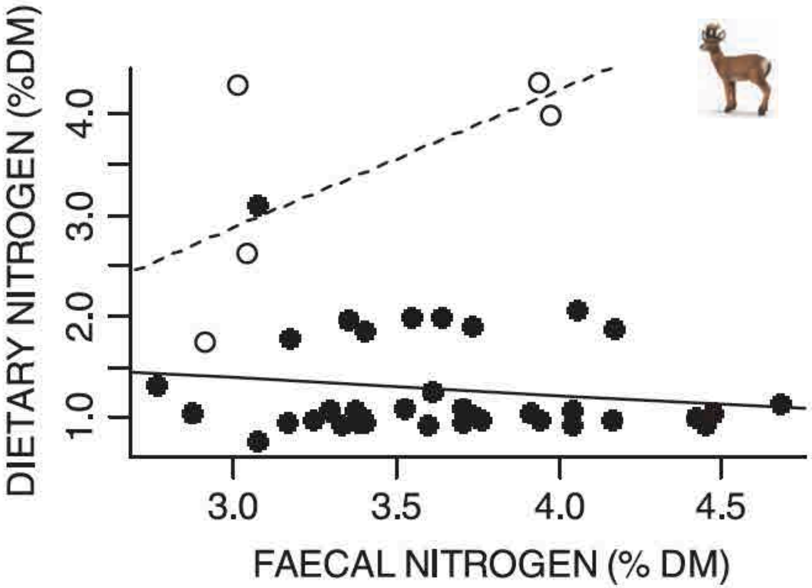


TFN and secondary plant compounds

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)



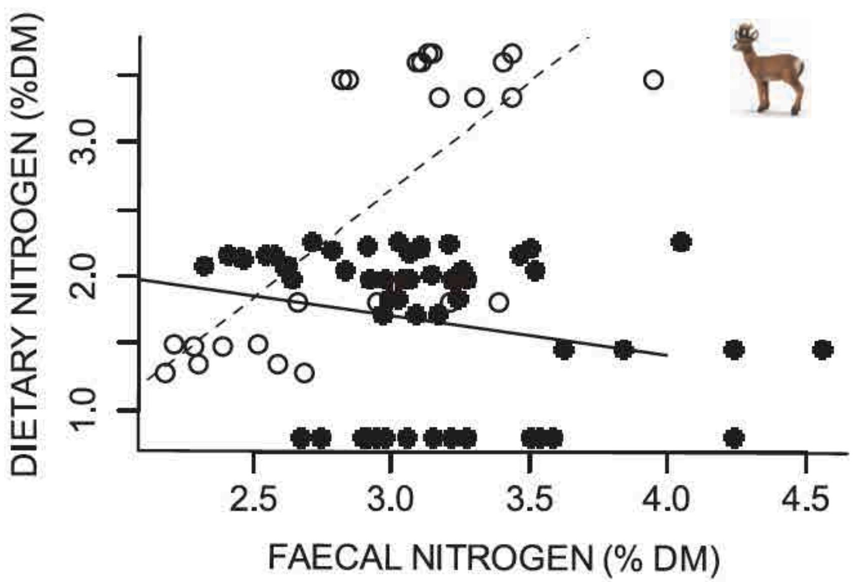


Figure 2. Relationship between dietary nitrogen (% DM) and faecal nitrogen (% DM) in wild roe deer; diets without significant levels of free condensed tannin (○) and diets with significant levels of free condensed tannin (●). The regression lines predicting

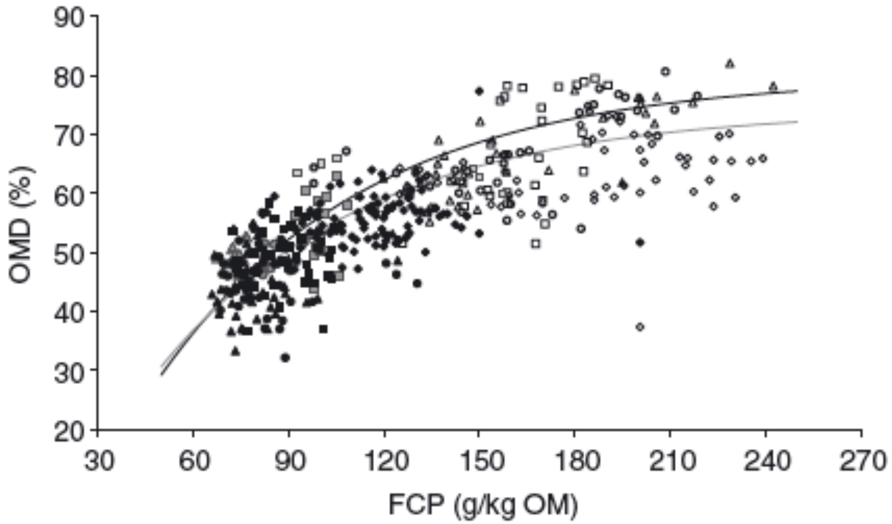
Figure 3. Relationship between dietary nitrogen (% DM) and faecal nitrogen (% DM) in tame roe deer fed with experimental diets; diets without significant levels of free condensed tannin (○) and diets with significant levels of free condensed tannin (●). The

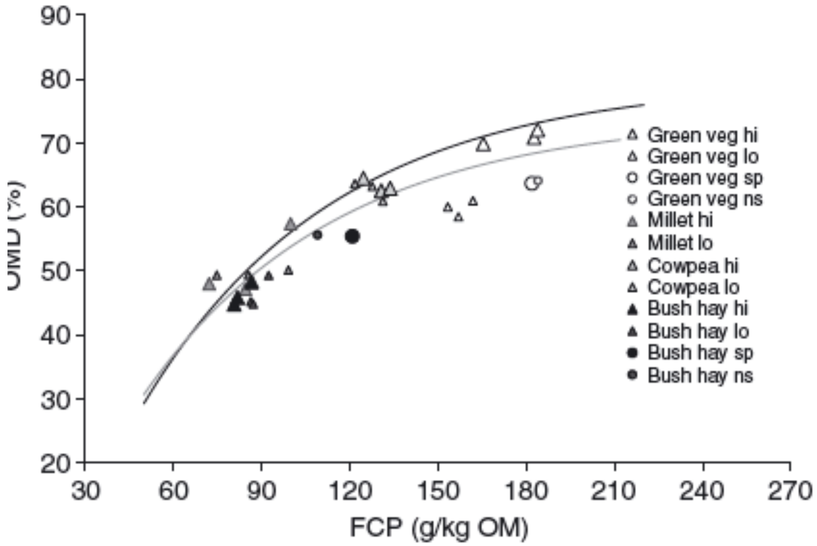
TFN and secondary plant compounds

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

E. Schlecht[1] and A. Susenbeth[2]

Journal of Animal Physiology and Animal Nutrition **90** (2006) 369–379





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

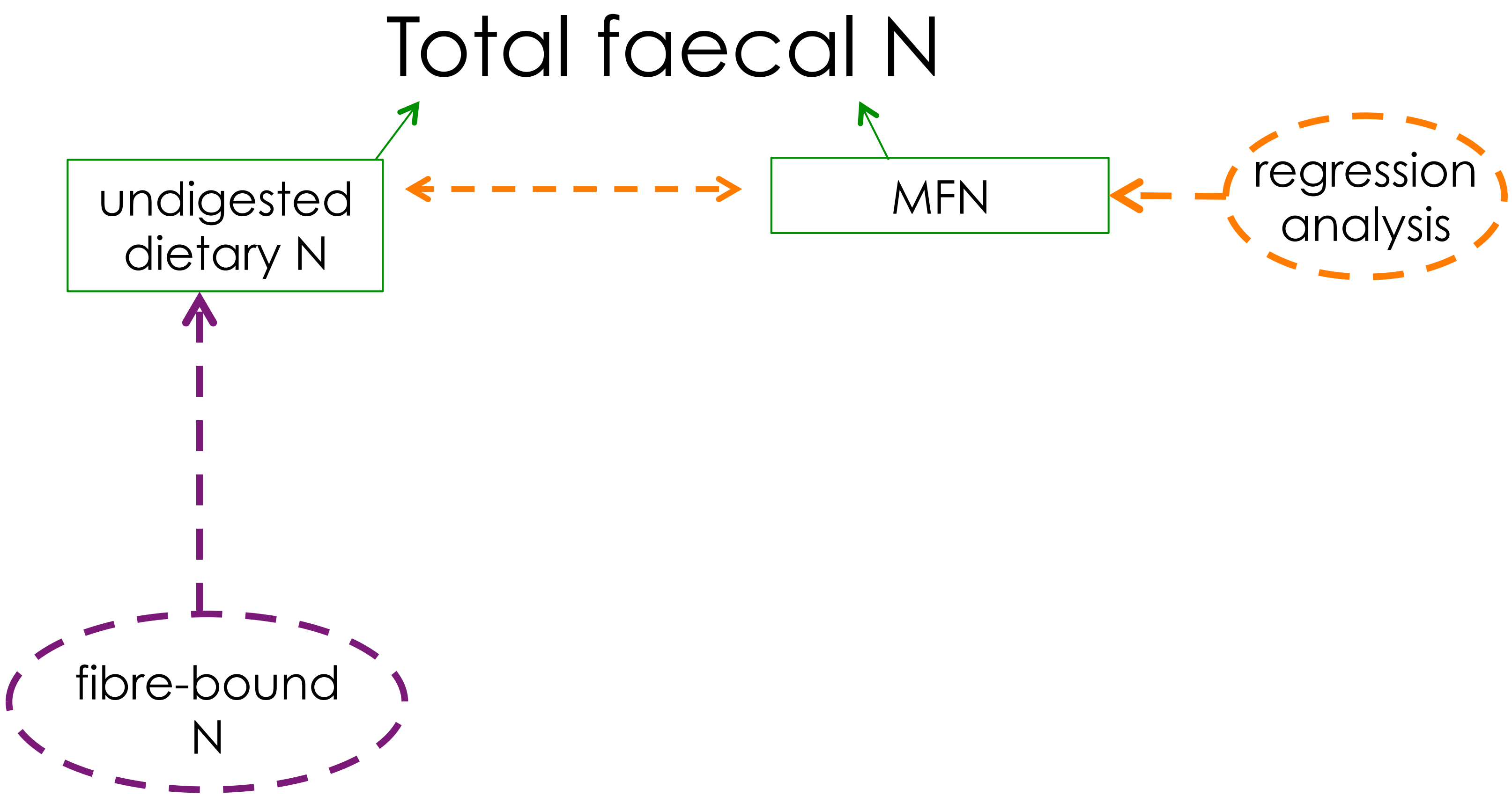
Total faecal N

undigested dietary N

MFN

regression analysis

Analytical approaches



Analytical approaches

Total faecal N

undigested dietary N

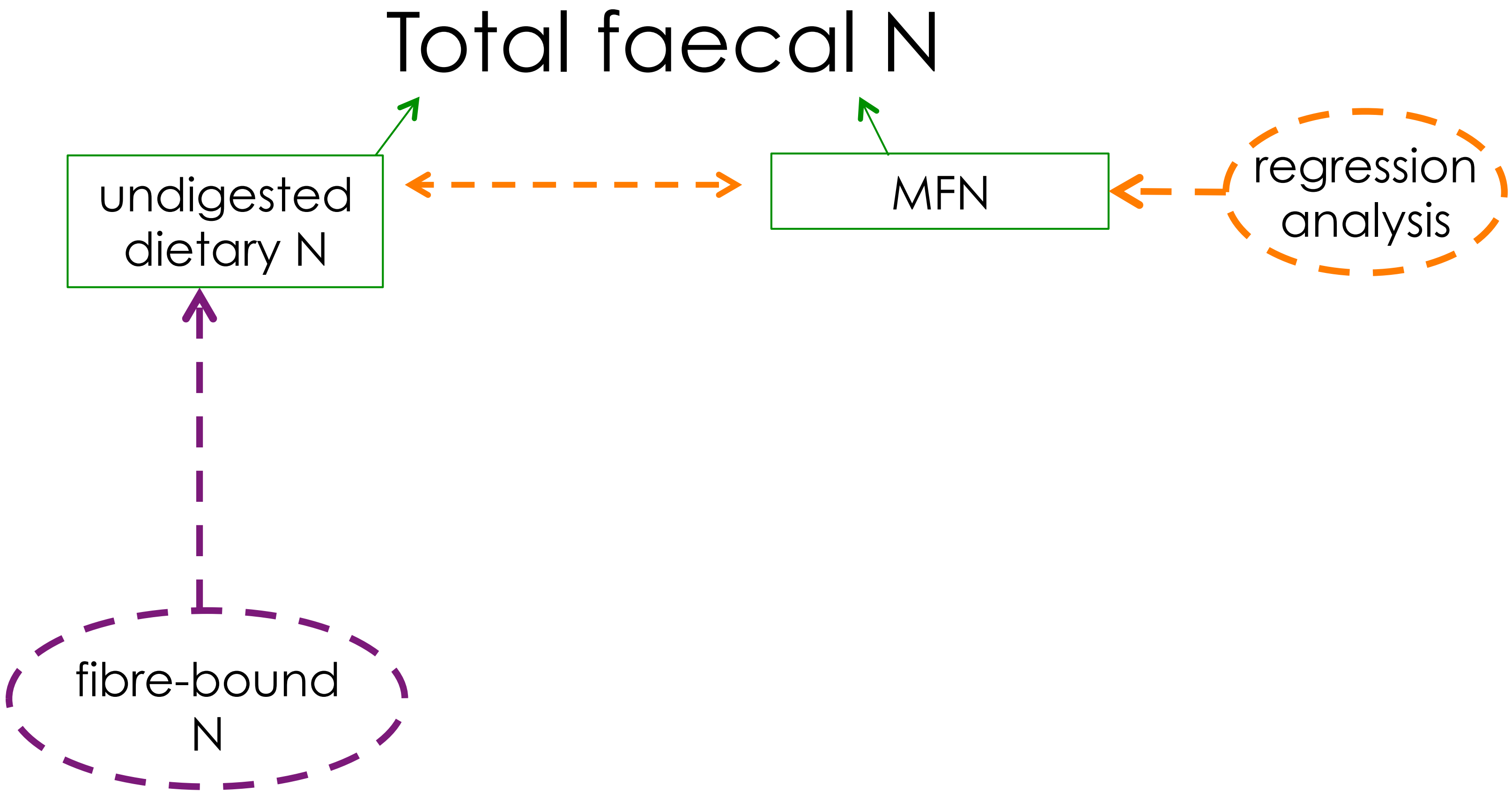
MFN

regression analysis

fibre-bound N

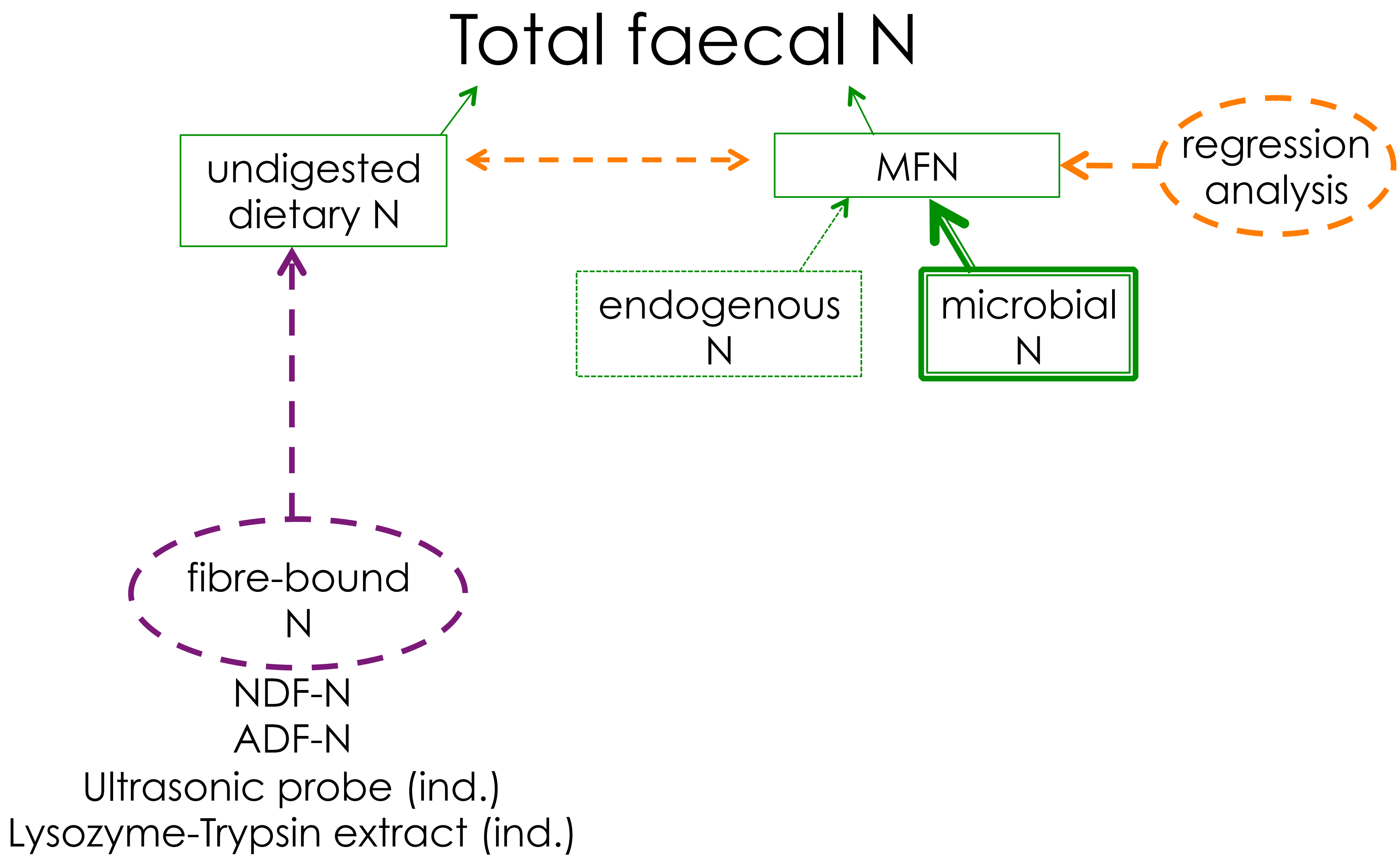
NDF-N
ADF-N
Ultrasonic probe (ind.)
Lysozyme-Trypsin extract (ind.)

Analytical approaches

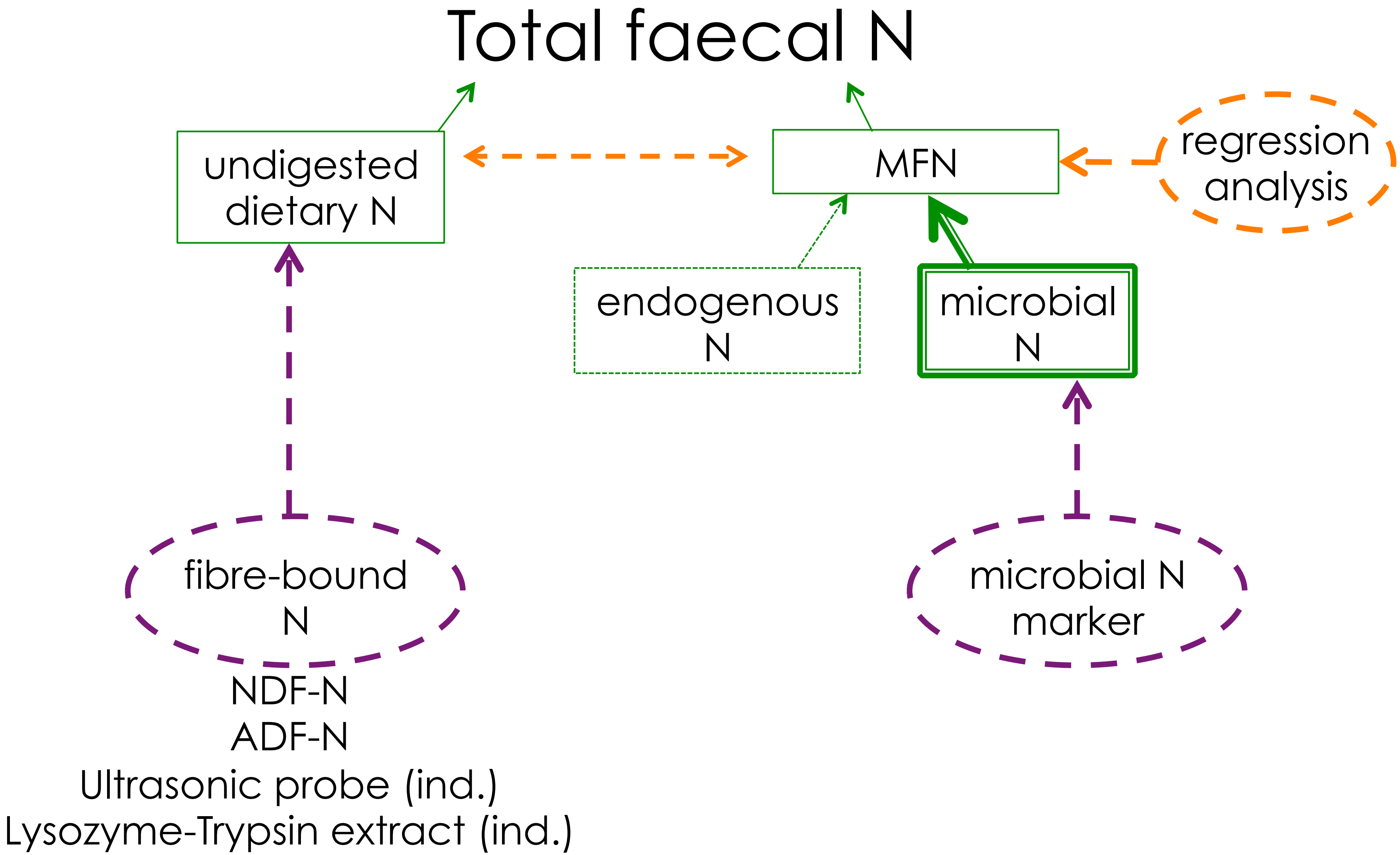


NDF-N ('undigested')
ADF-N ('indigestible')
Ultrasonic probe (ind.)
Lysozyme-Trypsin extract (ind.)

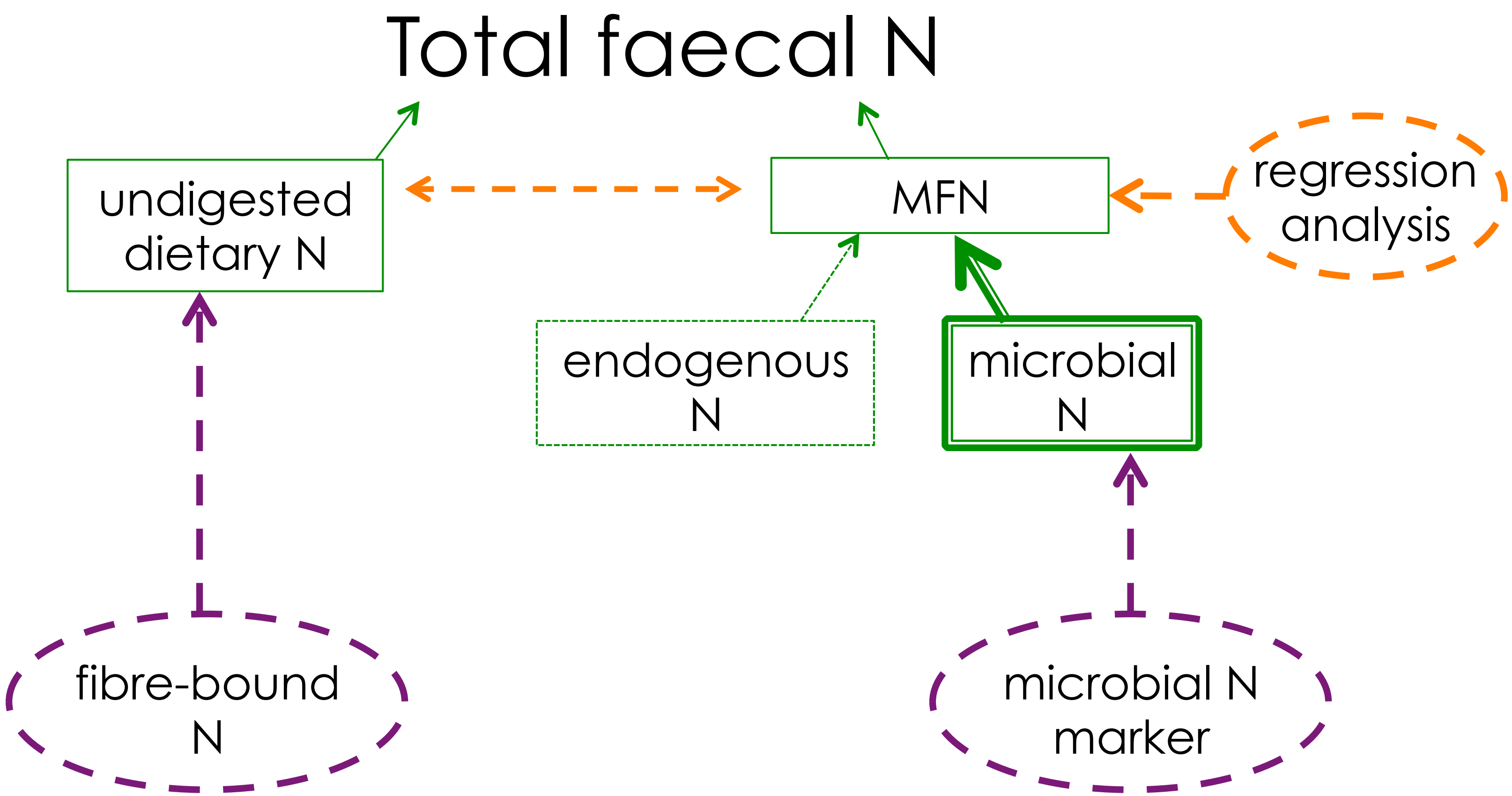
Analytical approaches



Analytical approaches



Analytical approaches



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

Diaminopimelic acid (DAPA)
RNA extraction
Purines
Centrifugation
Microscopy

MFN – method Mason

Some observations on the distribution and origin of nitrogen in sheep faeces

V. C. MASON

J. agric. Sci., Camb. (1969), **73**, 99–111

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

J. agric. Sci., Camb. (1971), **77**, 91–98

V. C. MASON AND G. MILNE

J. agric. Sci., Camb. (1971), **77**, 99–101

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., Tierernährg. u. Futtermittelkde. 41 (1979).

MFN – method Mason

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., Tierernährg. u. Futtermittelkde. 41 (1979).

MFN – method Mason

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V. C. MASON

Z. Tierphysiol., Tierernährg. u. Futtermittelkde. 41 (1979).

There is little evidence to link MFN to dietary consituents 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?

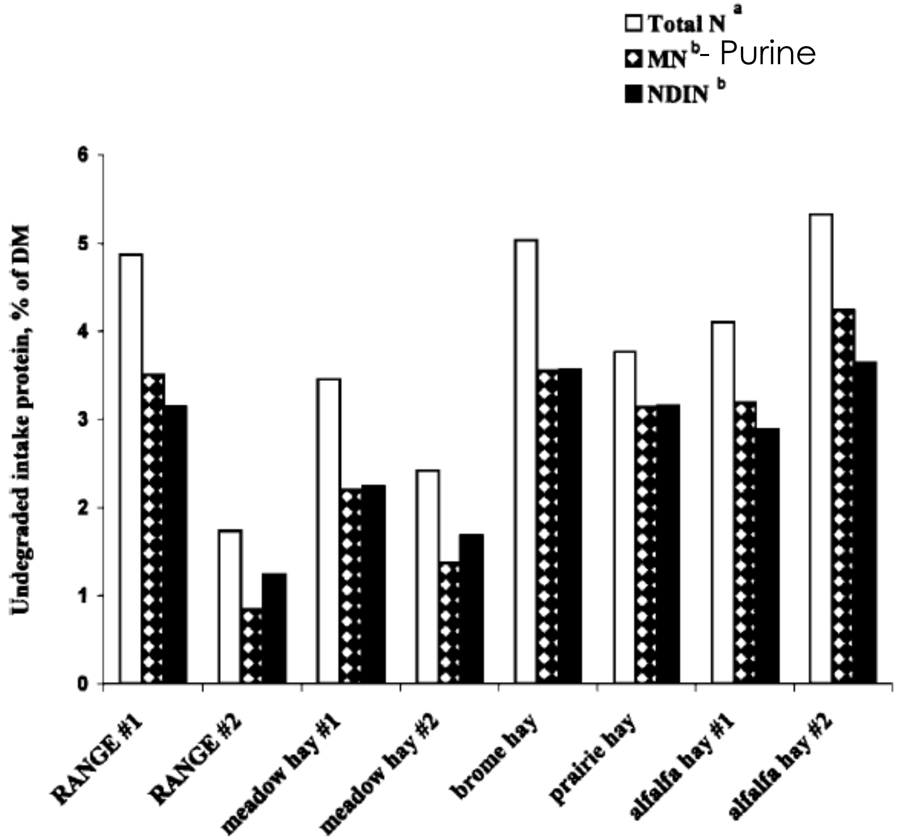
(Total faecal nitrogen = TFN)
(Metabolic faecal nitrogen = MFN)

In situ in the rumen: good results

In Situ Neutral Detergent Insoluble Nitrogen as a Method for Measuring Forage Protein Degradability[1]

R. A. Mass, G. P. Lardy[2], R. J. Grant, and T. J. Klopfenstein[3]

J. Anim. Sci. 1999. 77:1565–1571



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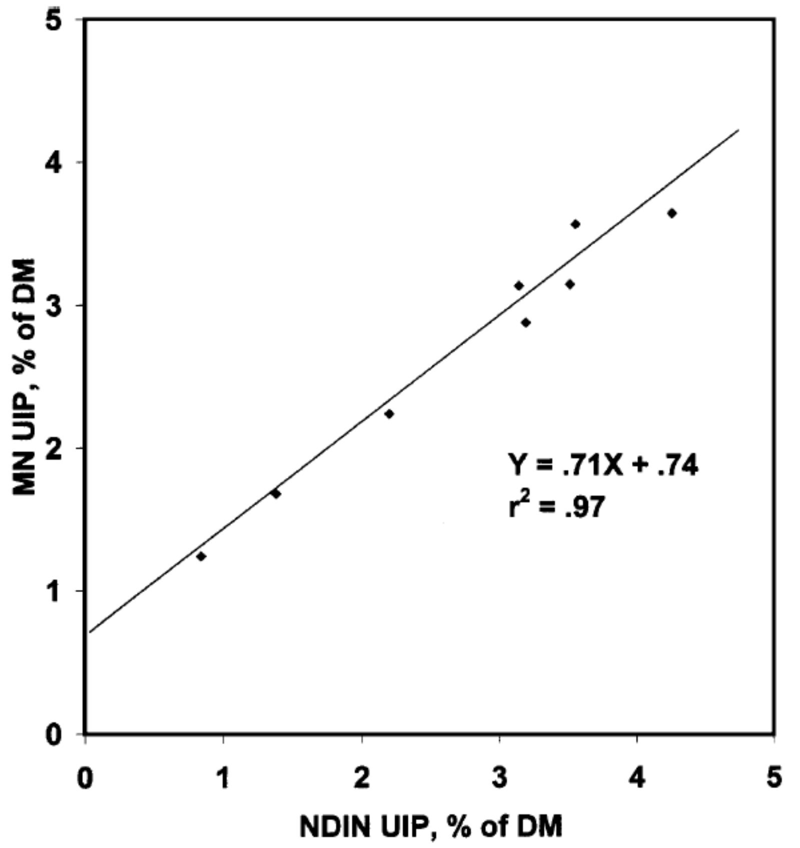
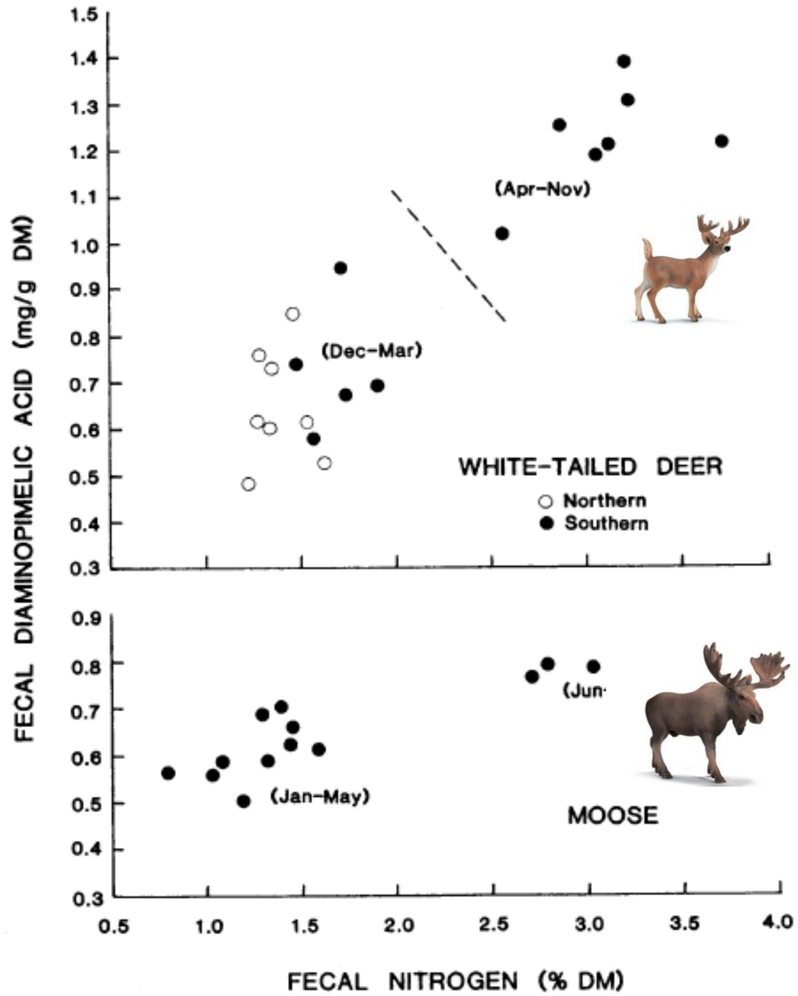


TFN - DAPA

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

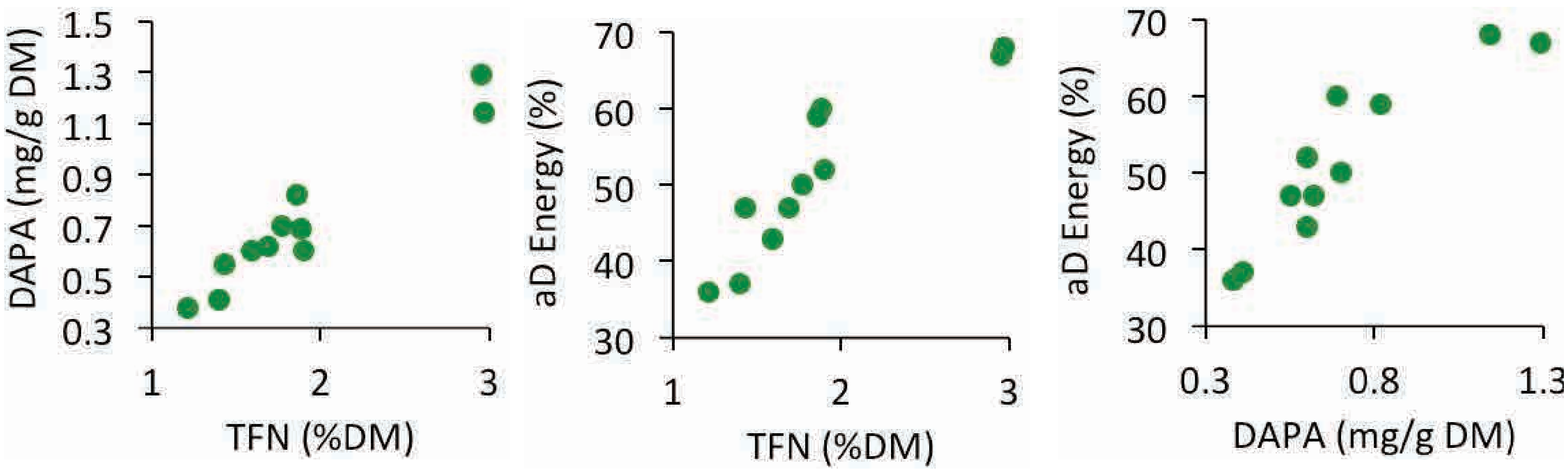


TFN/DAPA – energy digestibility

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



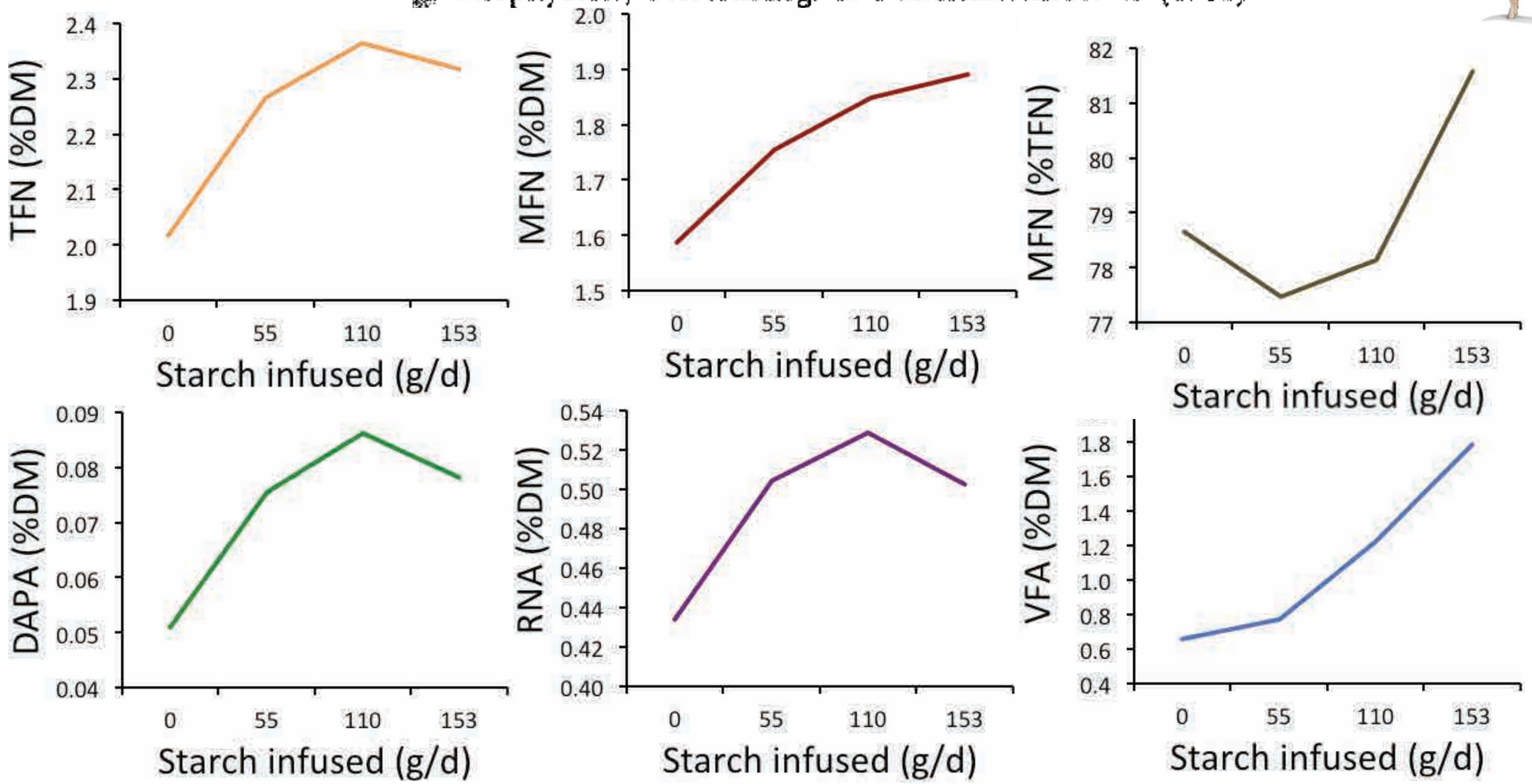
TFN, MFN and other analytes in reaction to starch infusion

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

Z. Tierphysiol., Tierernährg. u. Futtermittelkde. 45 (1981)



TFN and MFN at different diet quality and intake levels

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

M. Clauss[1], K. Schiele[2], S. Ortmann[3], J. Fritz[2], D. Codron[1], J. Hummel[4] and E. Kienzle[2]

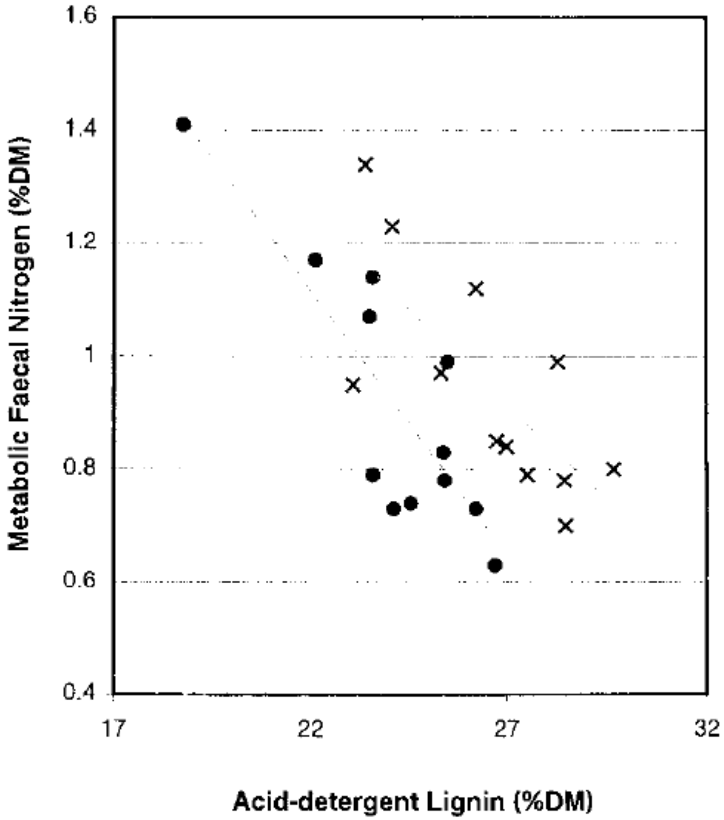
Journal of Animal Physiology and Animal Nutrition **98** (2014) 107–118

Diet	Intake level	FN	MFN% DM	MFN% FN
Hay 1	*ad libitum*	1.27 ± 0.08[abA]	0.56 ± 0.13[aA]	43.3 ± 8.3[aA]
	75	1.38 ± 0.06[b]	0.66 ± 0.04[a]	47.7 ± 3.6[a]
	55	1.33 ± 0.06[b]	0.69 ± 0.04[a]	51.7 ± 2.1[a]
	30	1.15 ± 0.11[a]	0.49 ± 0.07[a]	42.7 ± 5.7[a]
Hay 2	*ad libitum*	1.03 ± 0.07[aB]	0.46 ± 0.11[aB]	44.1 ± 8.1[aB]
	75	1.01 ± 0.03[a]	0.42 ± 0.06[a]	41.6 ± 4.8[a]
	55	0.99 ± 0.08[a]	0.37 ± 0.10[a]	37.1 ± 7.7[a]
	30	1.01 ± 0.07[a]	0.38 ± 0.06[a]	37.7 ± 4.7[a]

MFN and faecal ADL

Habitat quality and the decline of an African elephant population: Implications for conservation S.Afr. J. Wildl. Res. 2000, 30(1)

Armin H.W. Seydack*, Cobri Vermeulen and Johan Huisamen

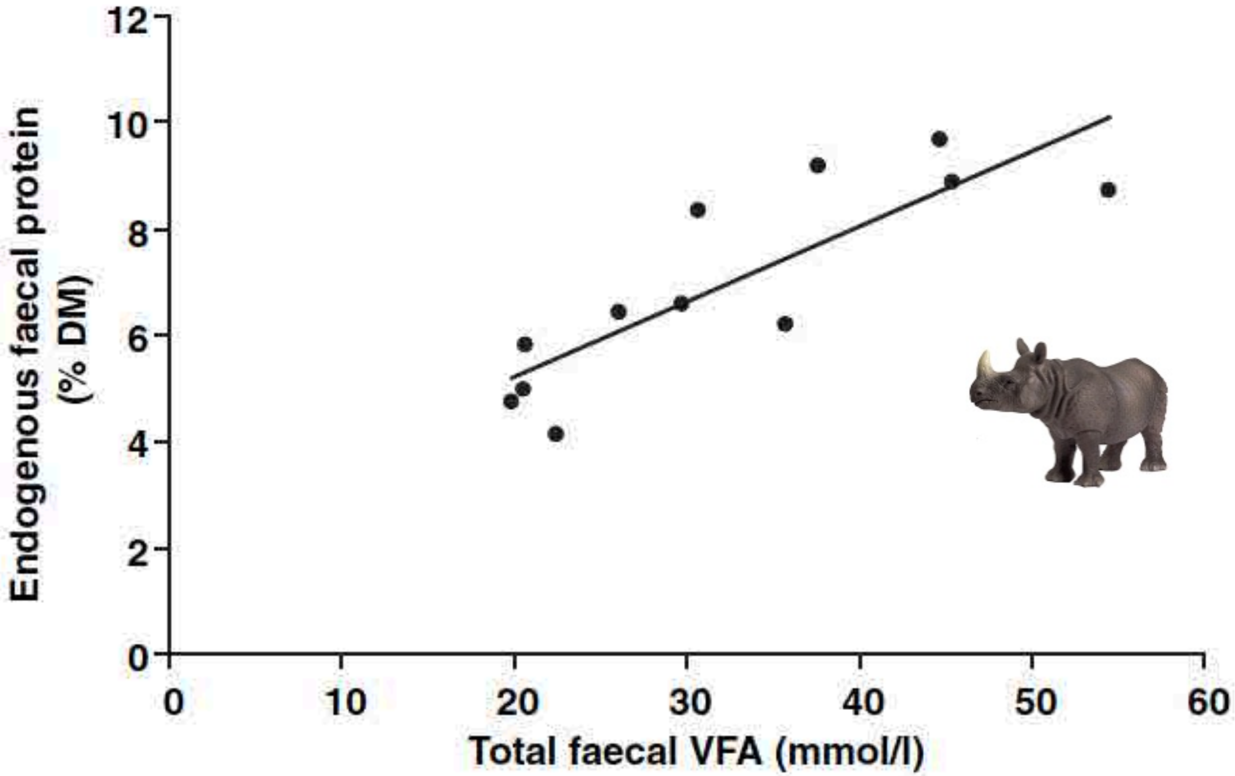


MFN in relation to faecal VFA

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

M. Clauss[1], C. Polster[1], E. Kienzle[1], H. Wiesner[2], K. Baumgartner[3], F. von Houwald[4], S. Ortmann[5], W. J. Streich[5] and E.S. Dierenfeld[6]

Journal of Animal Physiology and Animal Nutrition **89** (2005) 229–237

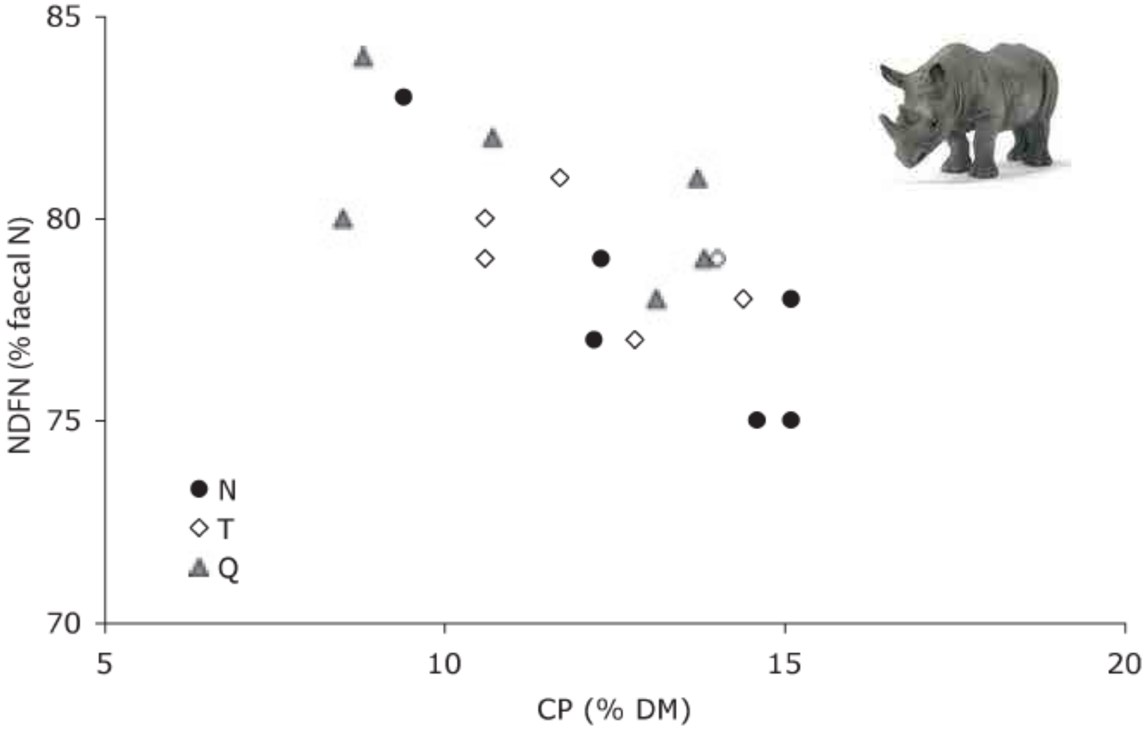


MFN in relation to dietary N

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

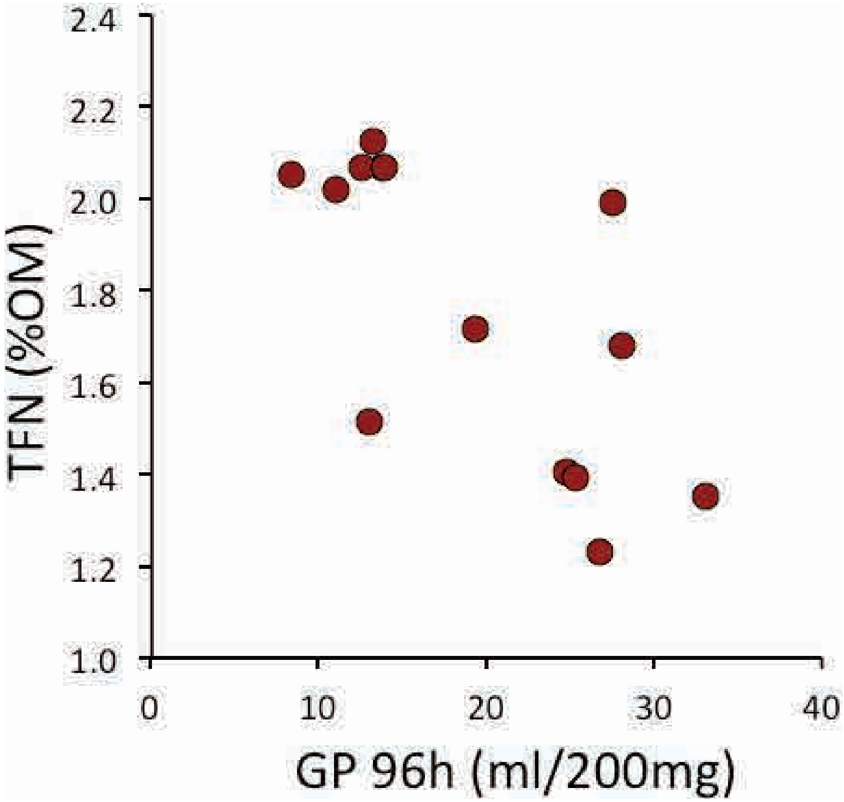
M. Clauss[1], J. C. Castell[2], E. Kienzle[2], E. S. Dierenfeld[3], E. J. Flach[4], O. Behlert[5], S. Ortmann[6], W. J. Streich[6], J. Hummel[5,7] and J.-M. Hatt[1]

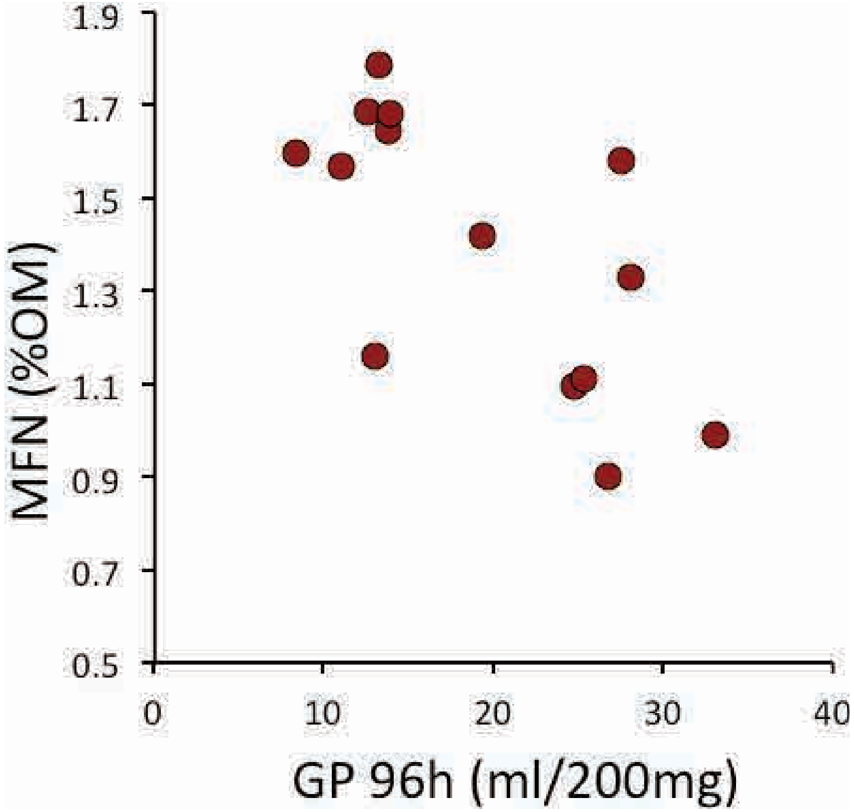
Journal of Animal Physiology and Animal Nutrition **91** (2007) 449–458



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.)

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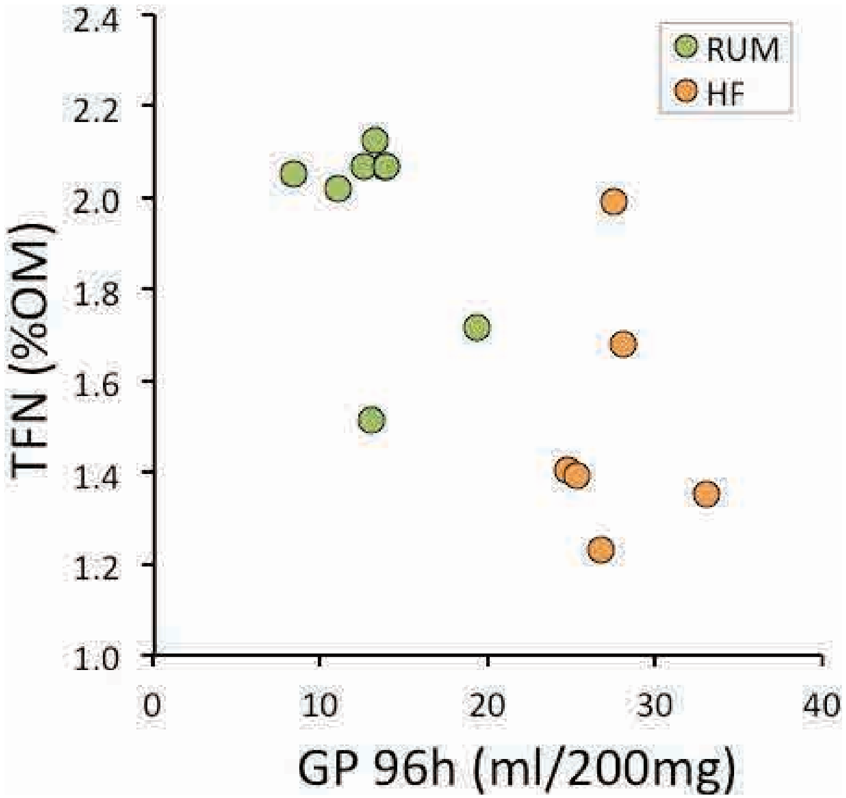
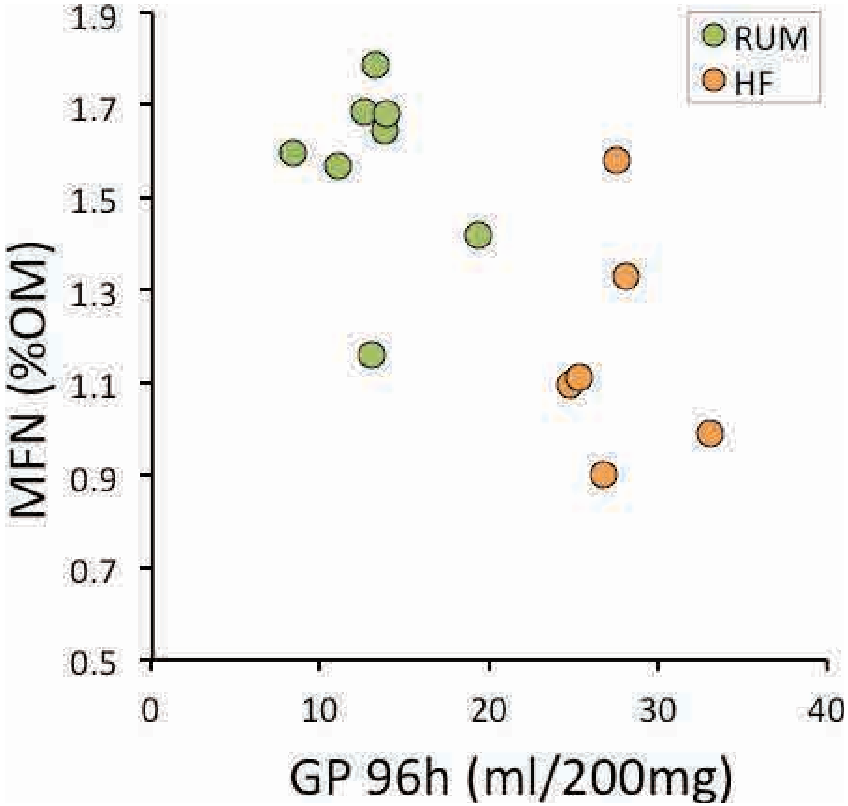
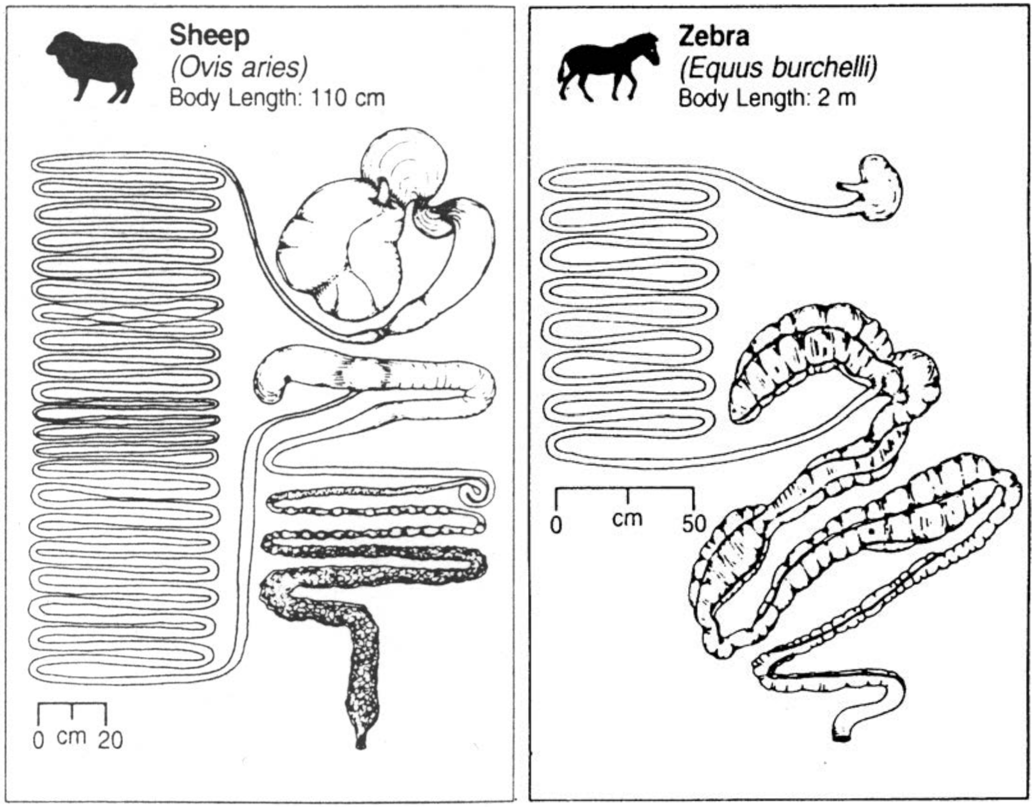




from Steuer et al. (in prep.)

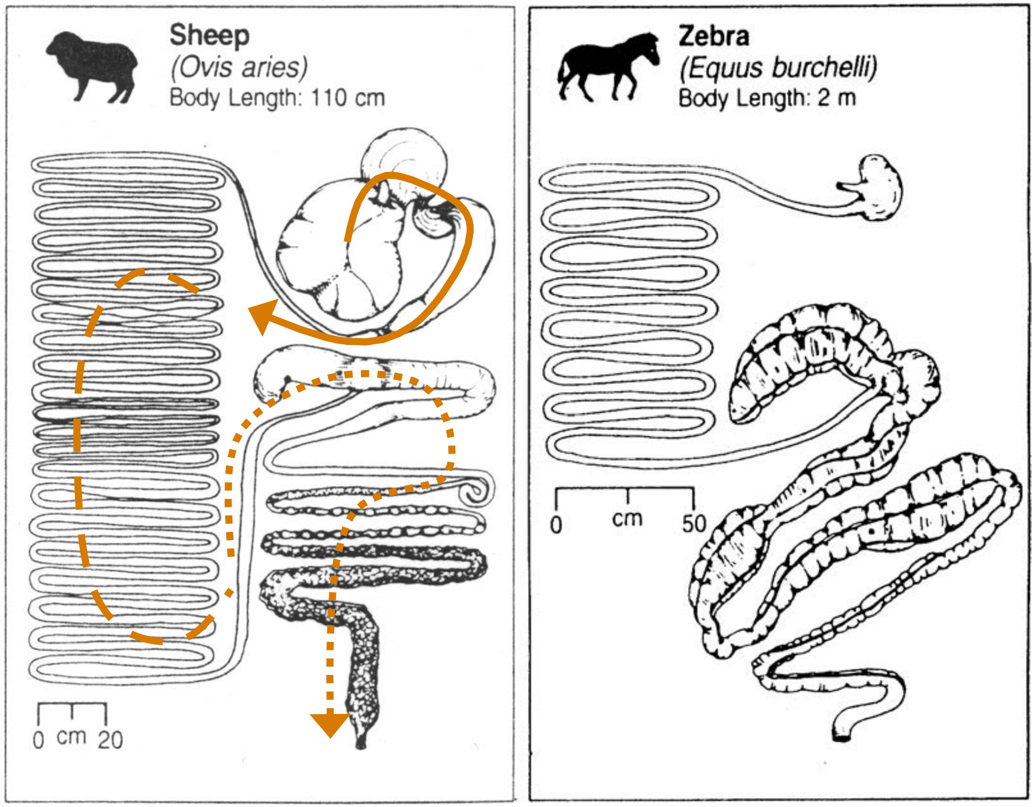
Foregut vs. Hindgut Fermentation



from Stevens & Hume (1995)

Foregut vs. Hindgut Fermentation

Lower bacterial nitrogen losses in the faeces?



from Stevens & Hume (1995)

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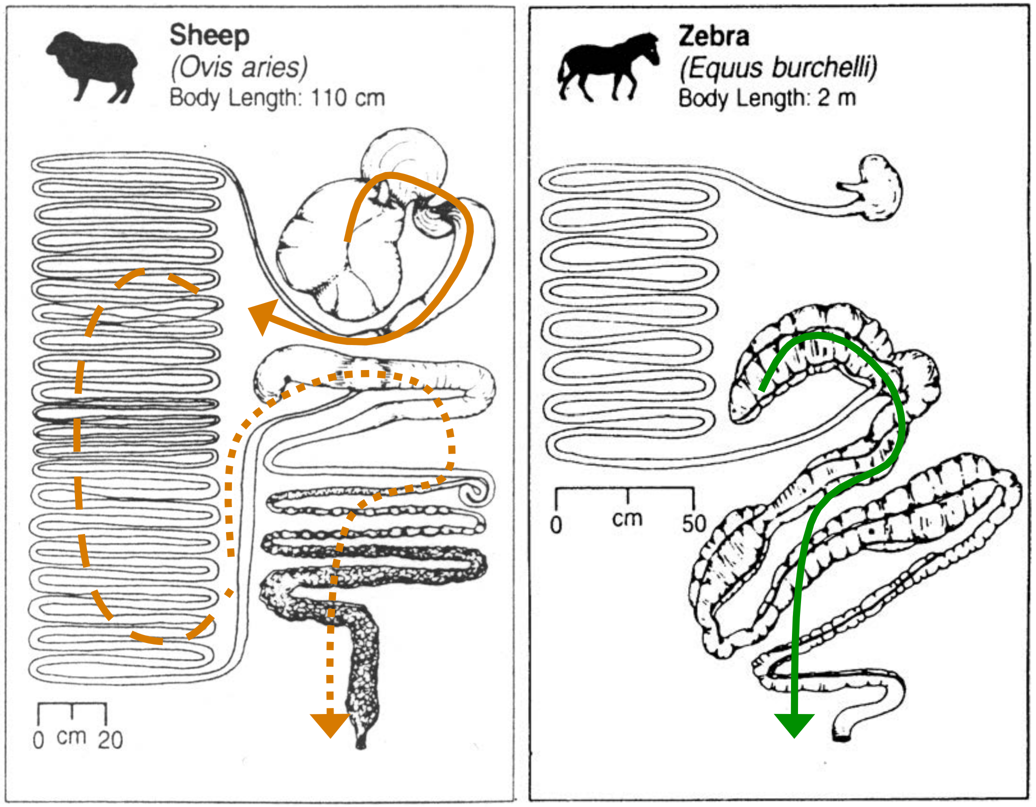
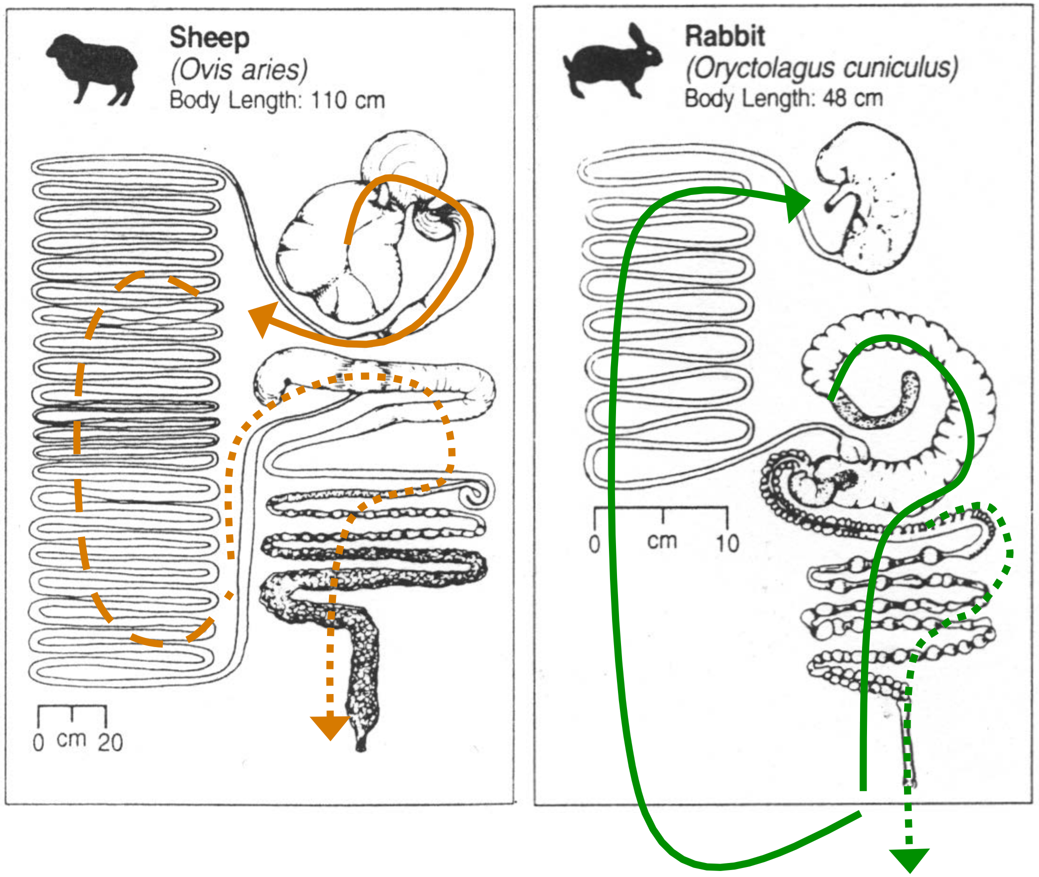


Higher bacterial nitrogen losses in the faeces?

from Stevens & Hume (1995)

Foregut vs. Hindgut Fermentation

Lower bacterial nitrogen losses in the faeces?

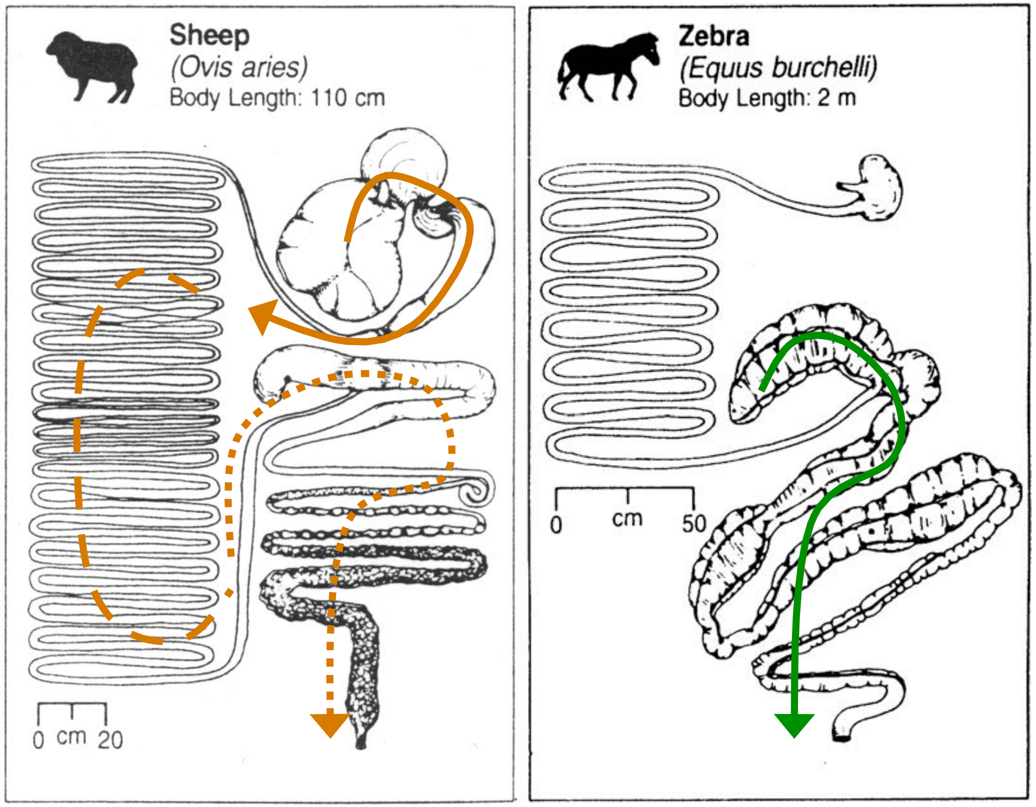


Lower bacterial nitrogen losses in hard faeces in coprophagic hindgut fermenters due to bacterial accumulation in caecotrophs?

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

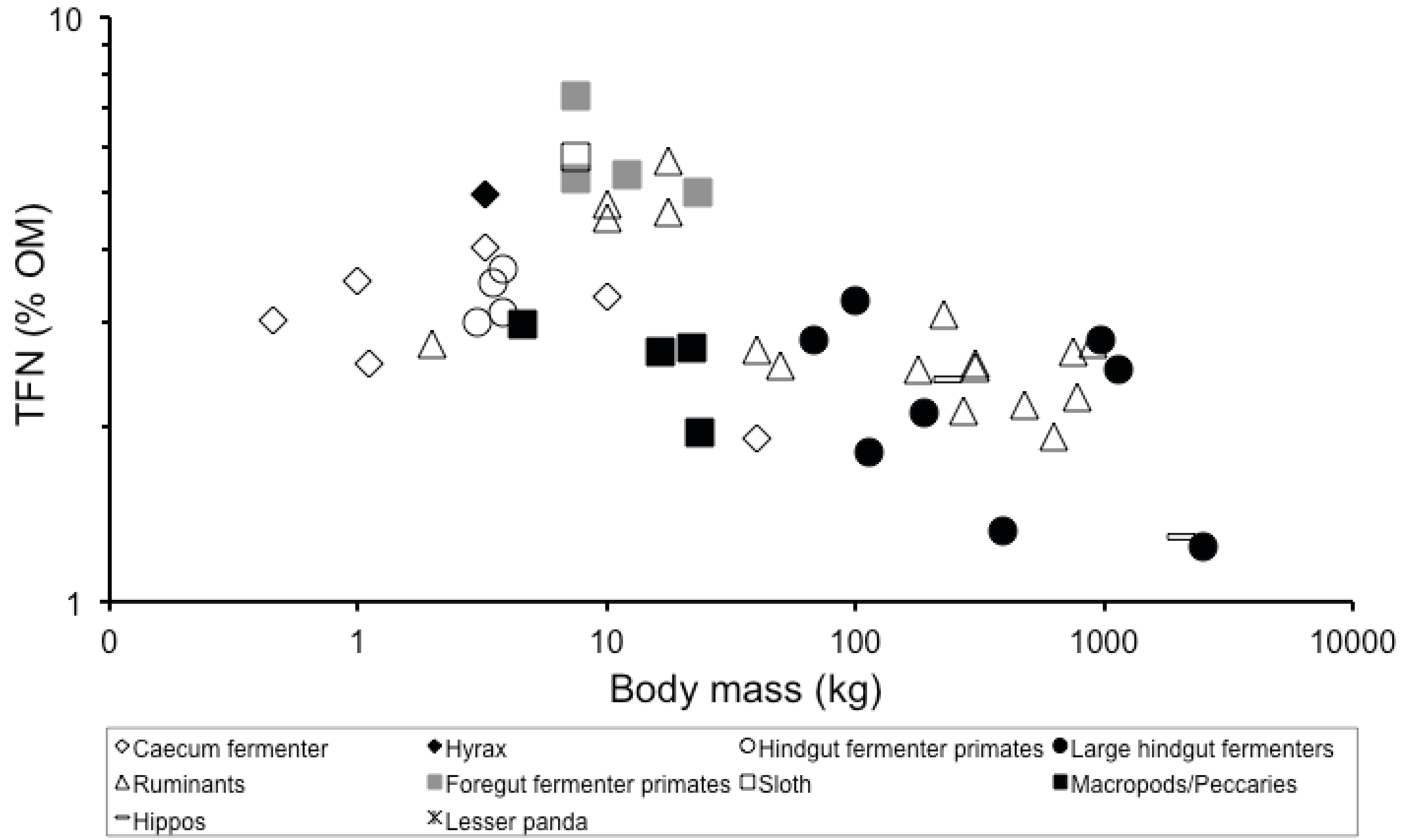
from Stevens & Hume (1995)

TFN in zoo animals

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

A. Schwarm[1,2], M. Schweigert[1], S. Ortmann[1], J. Hummel[3], G. P. J. Janssens[4], W. J. Streich[1] and M. Clauss[5]

Journal of Animal Physiology and Animal Nutrition **93** (2009) 596–605



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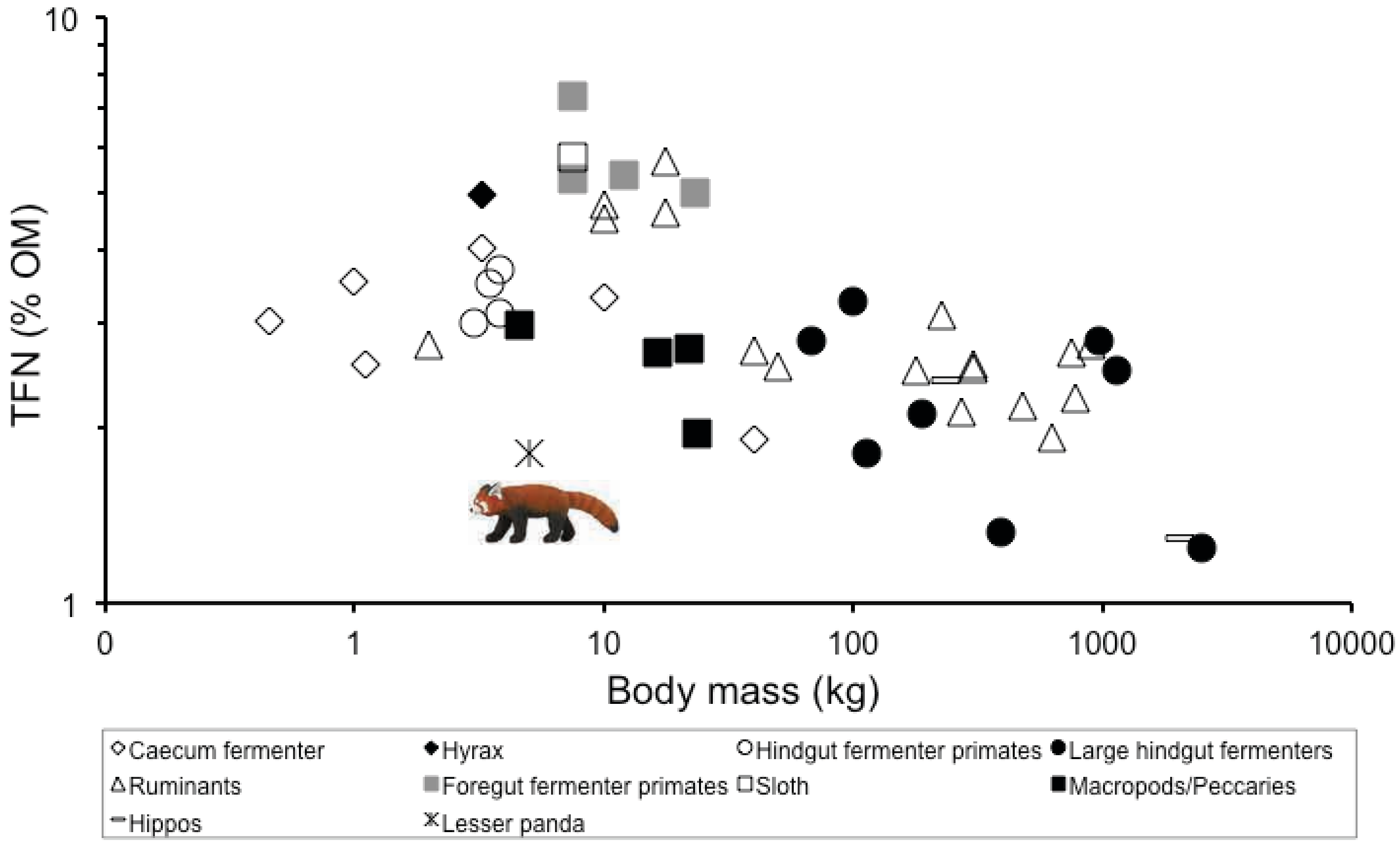

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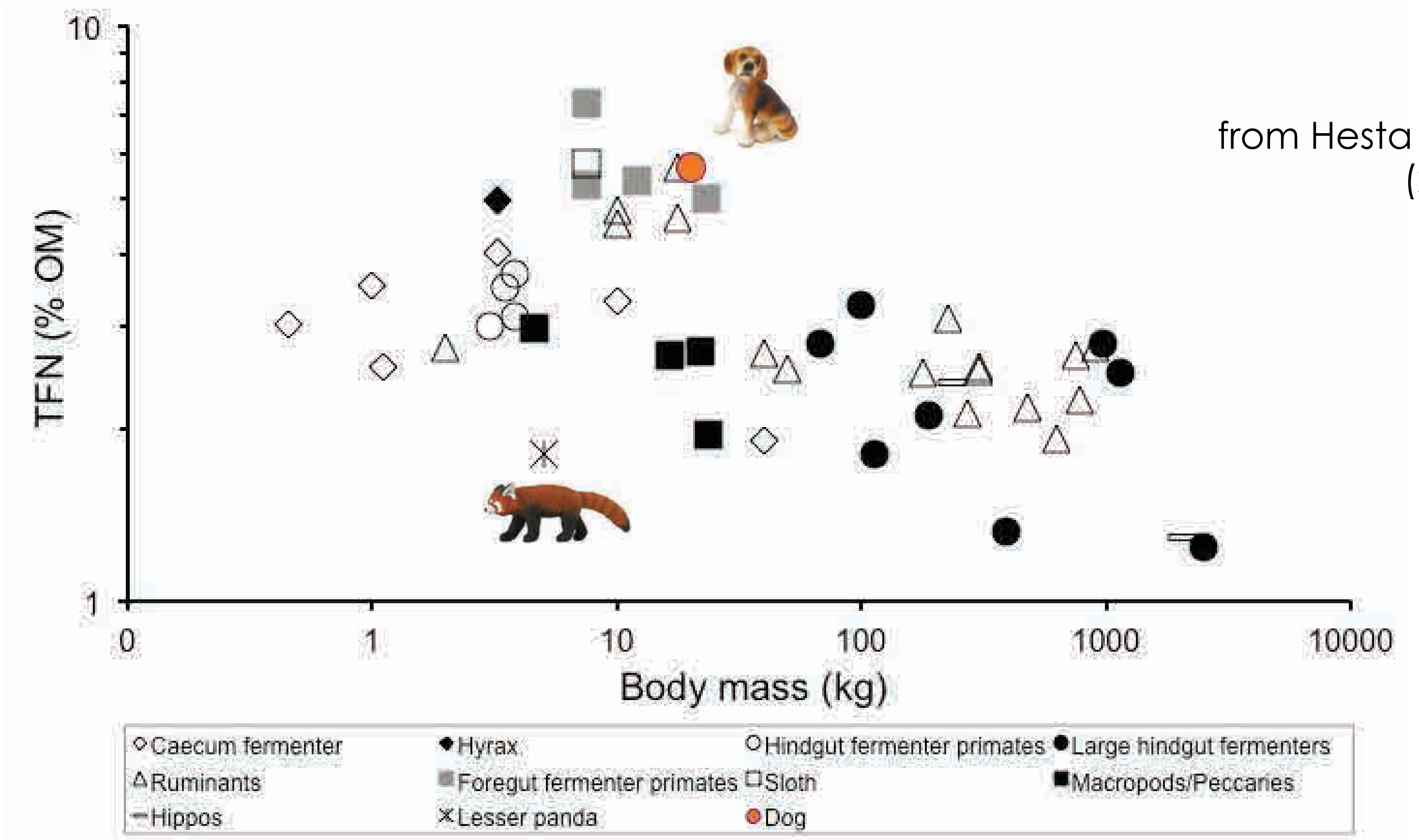

from Hesta et al. (2003)

MFN in zoo animals

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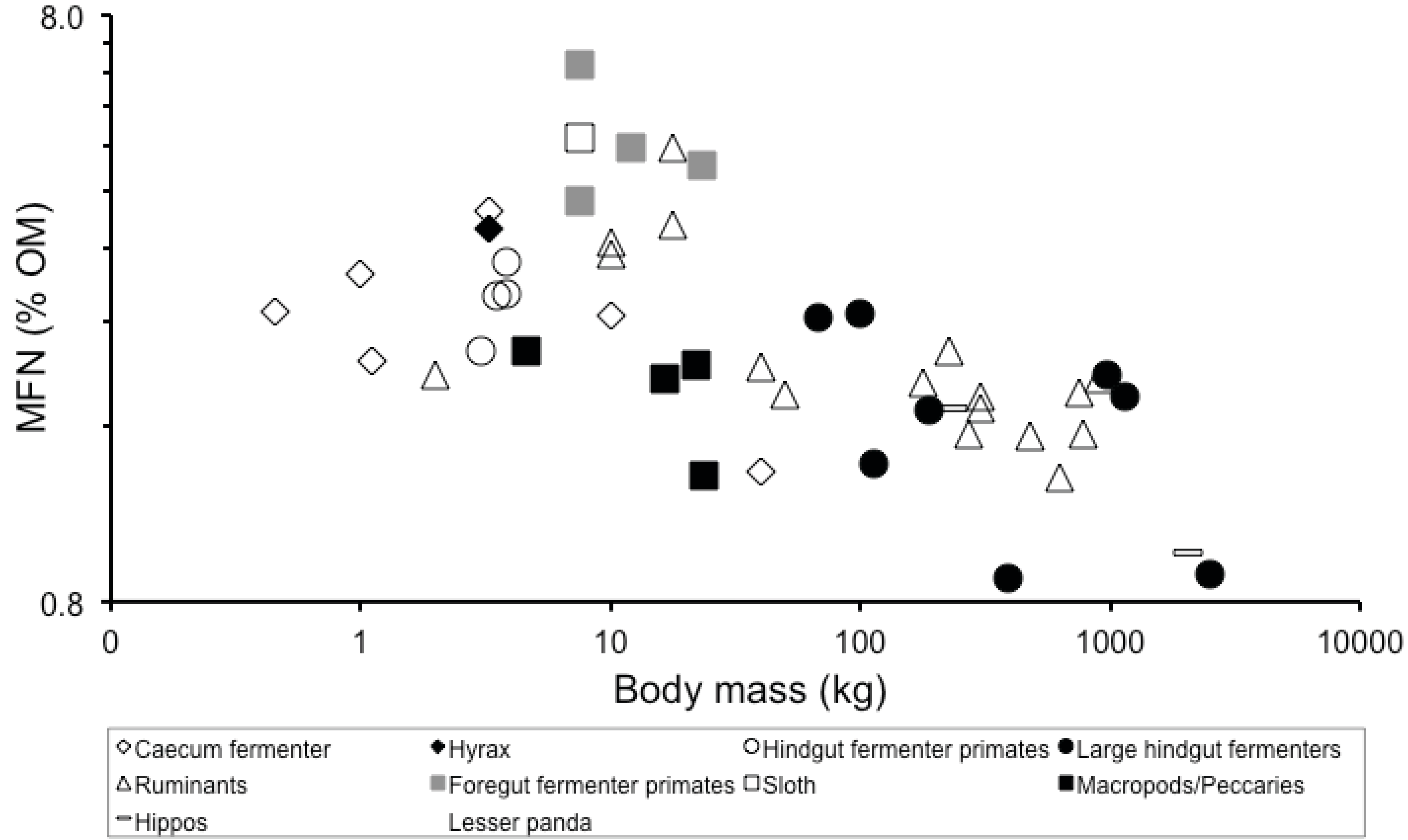

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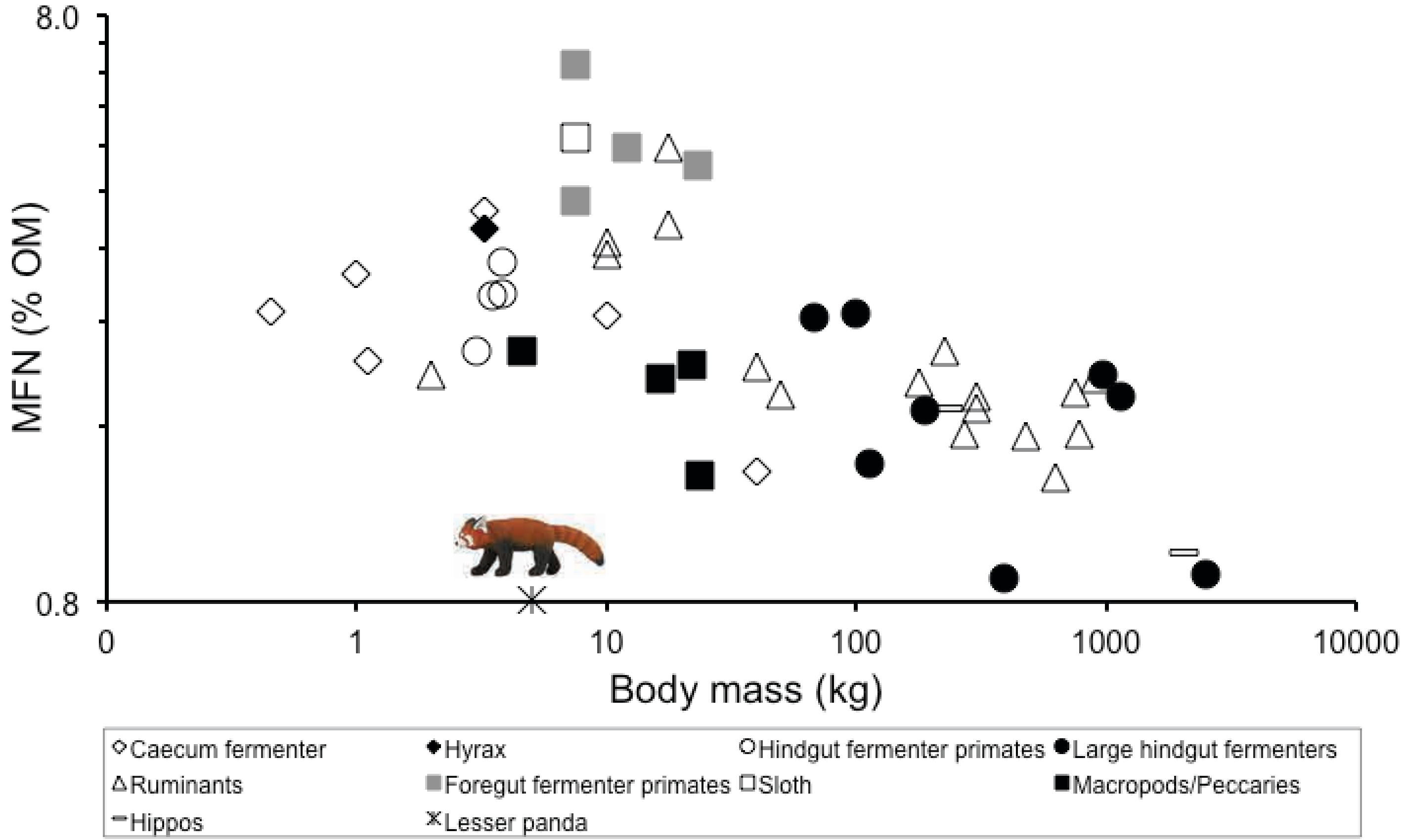

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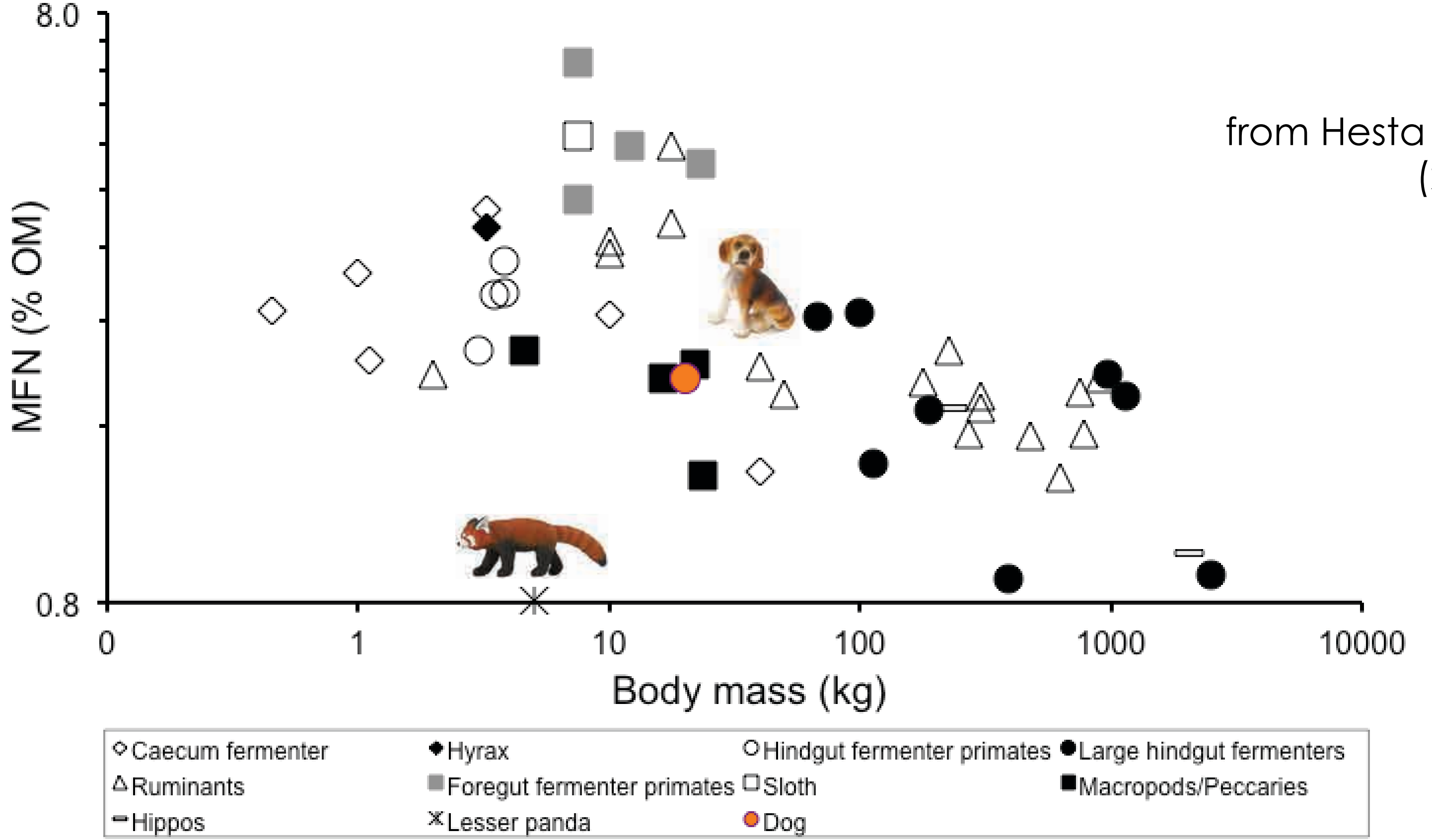

TFN – MFN relationship: no influence of digestion type ...

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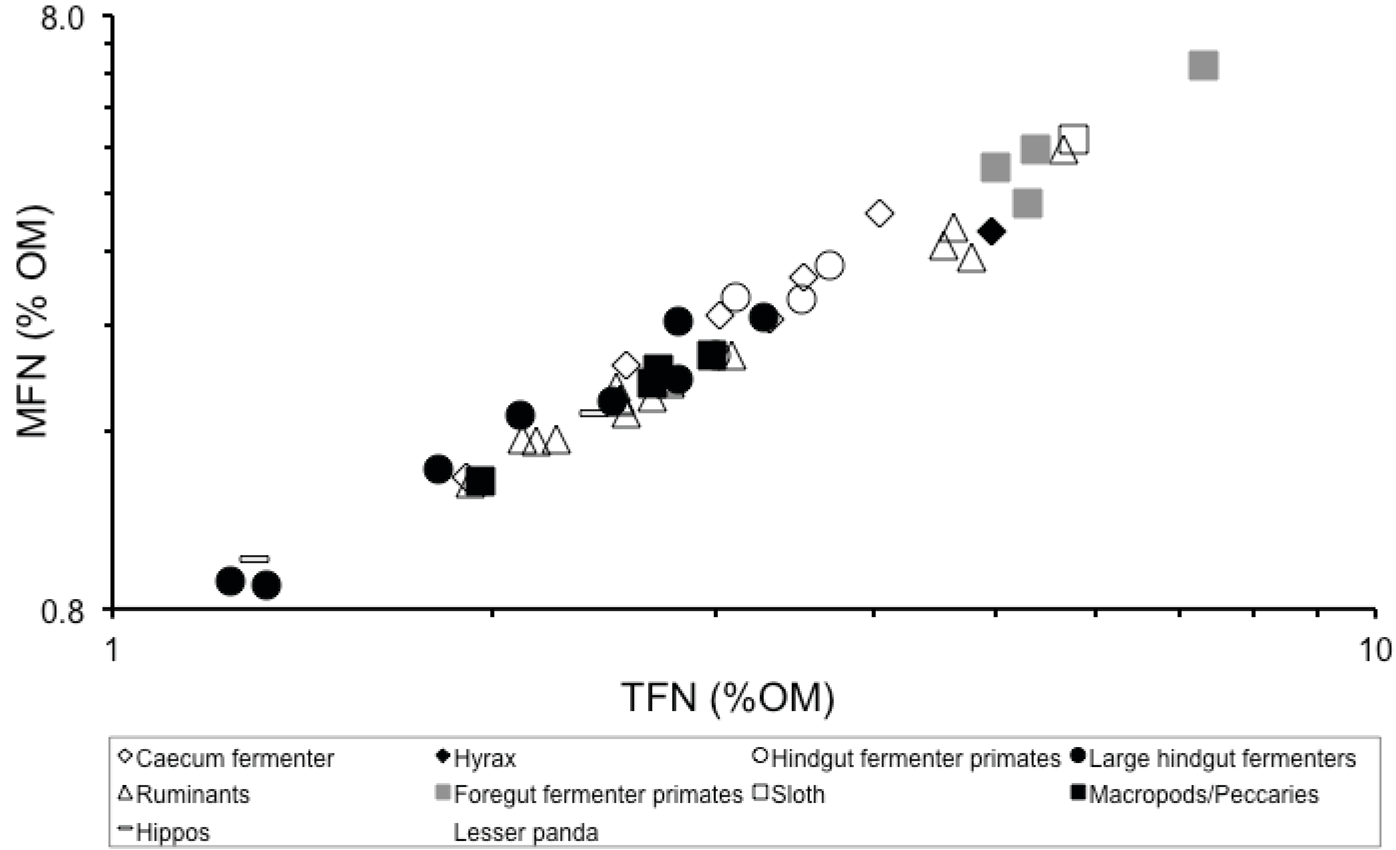

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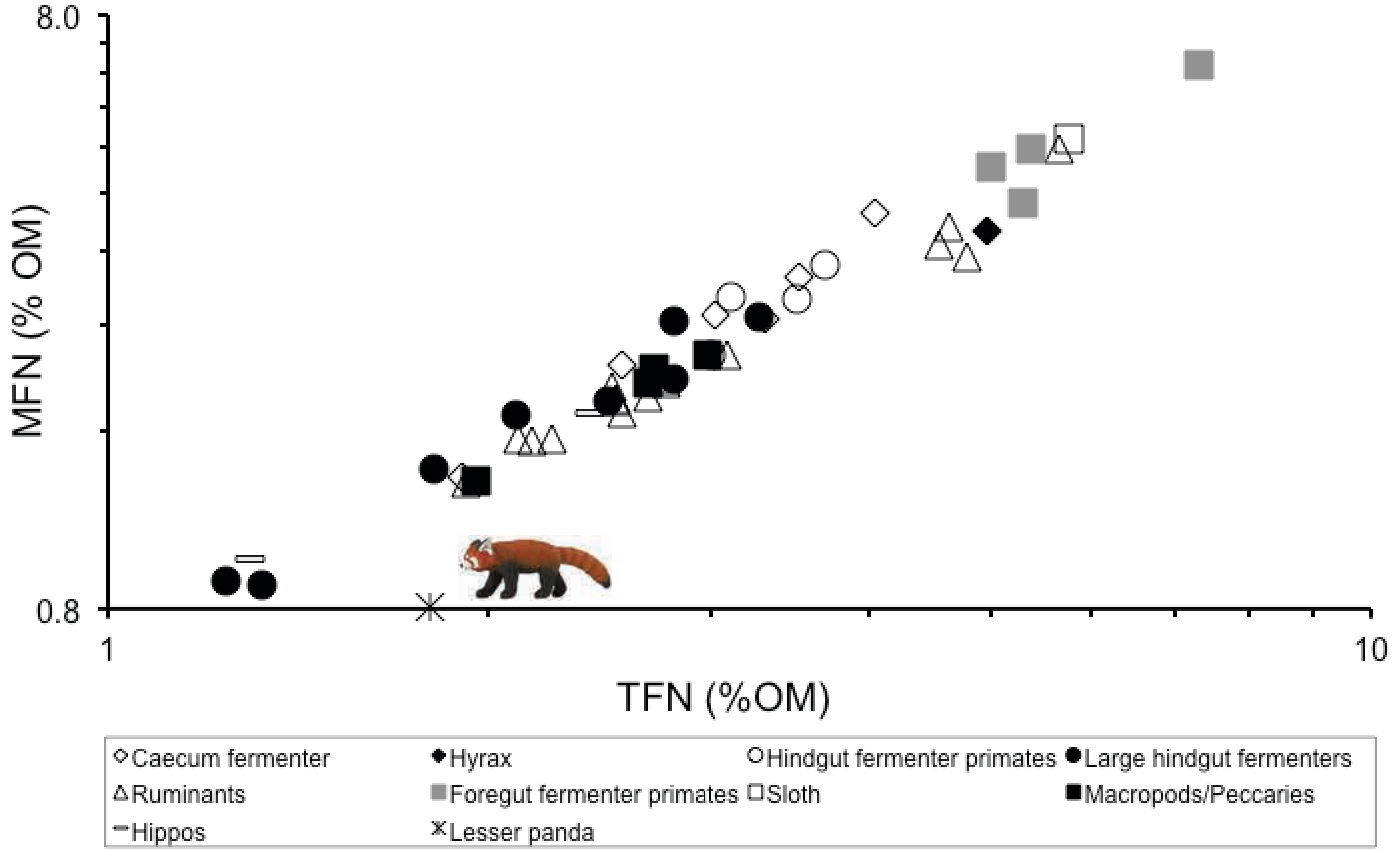

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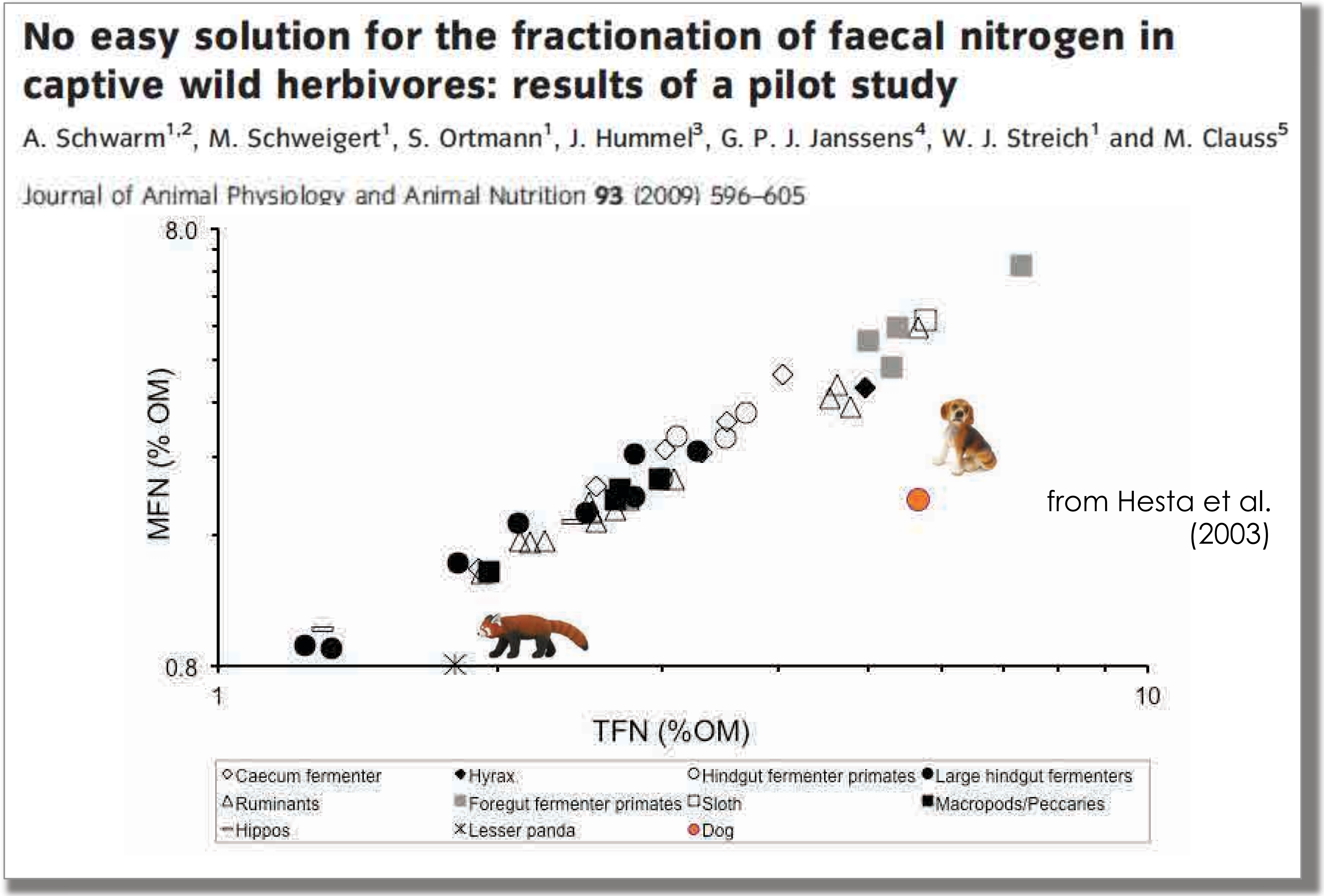

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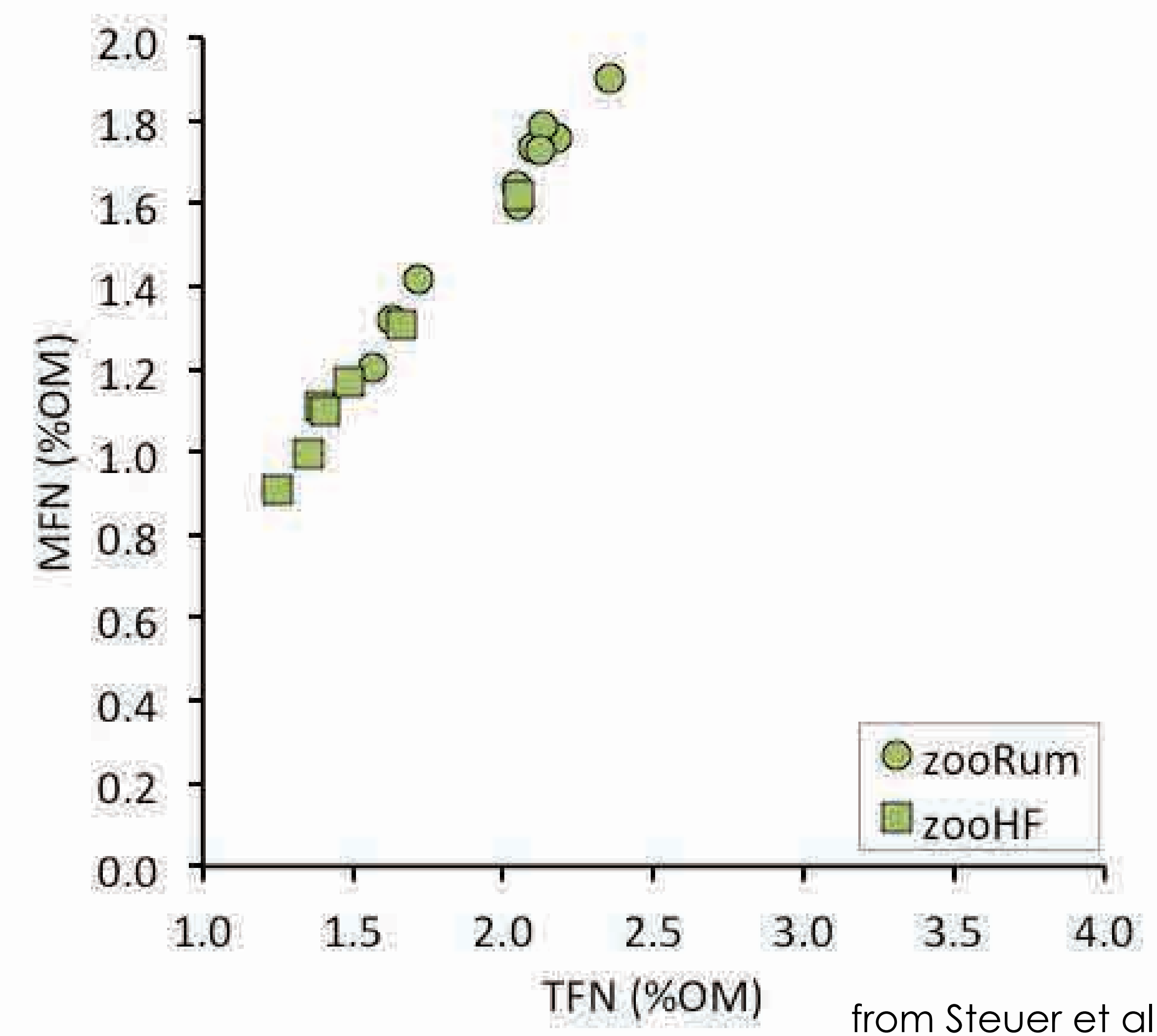
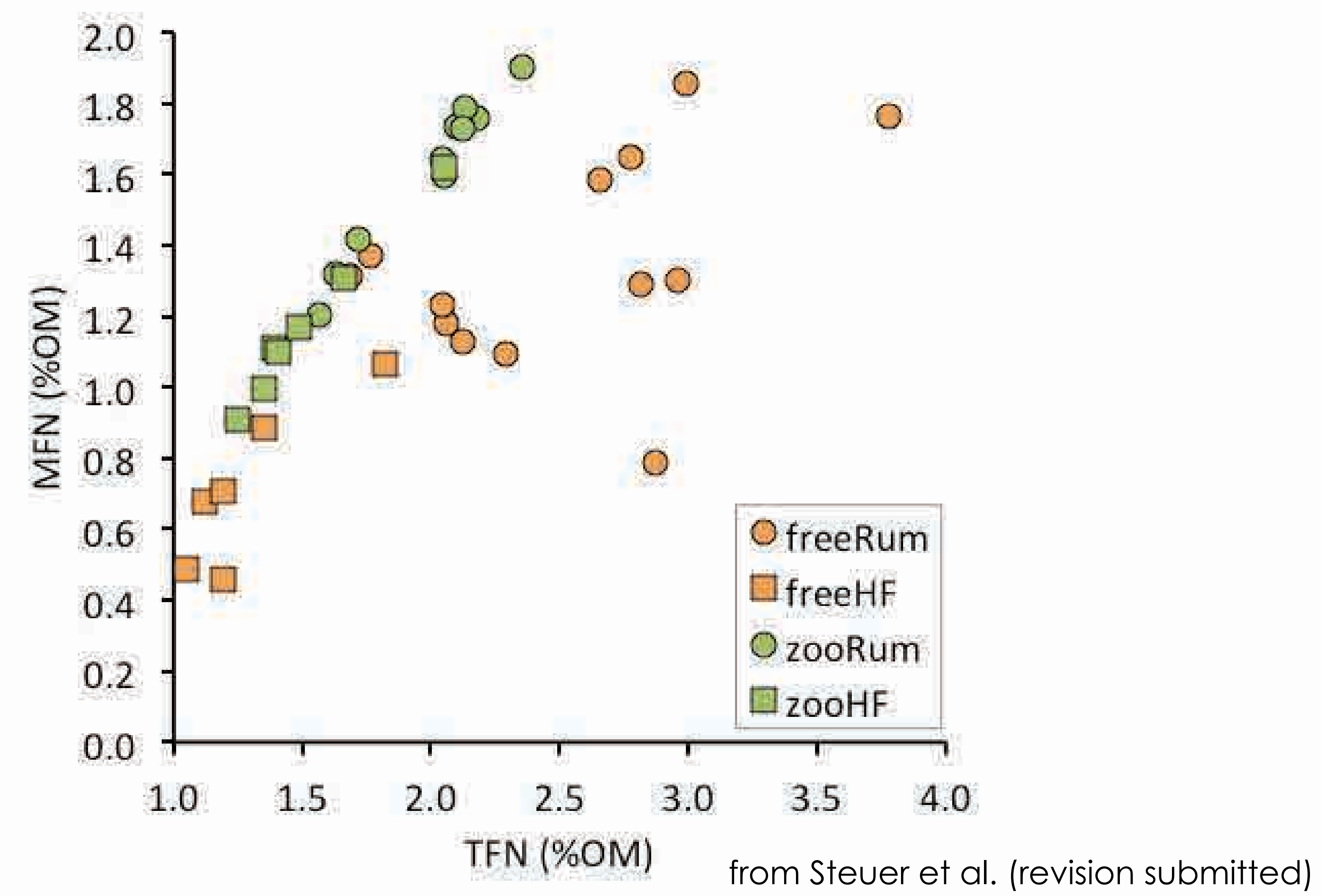


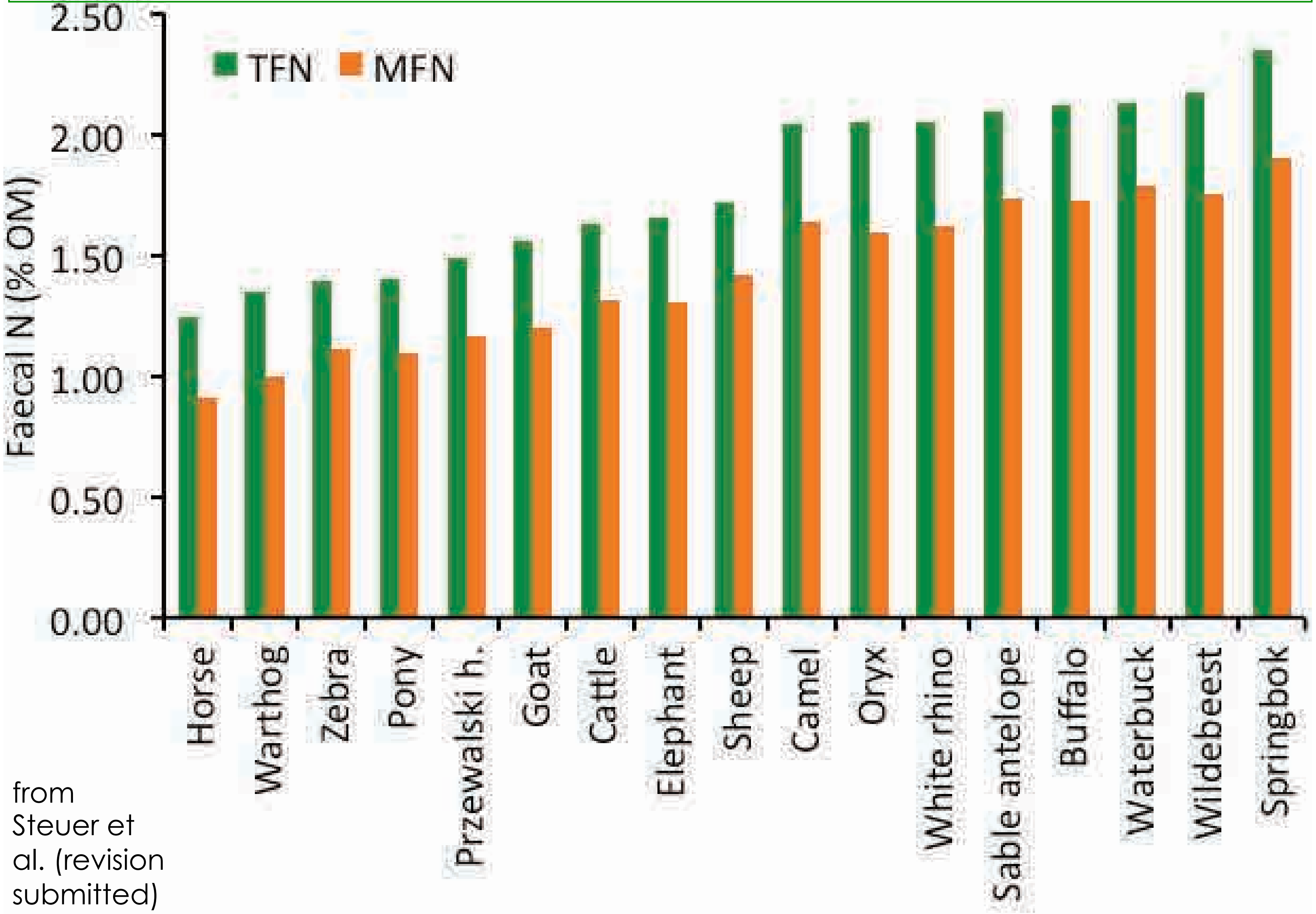
from Steuer et al. (revision submitted)

TFN – MFN relationship: no influence of digestion type



from Steuer et al. (revision submitted)

TFN/MFN on grass hay



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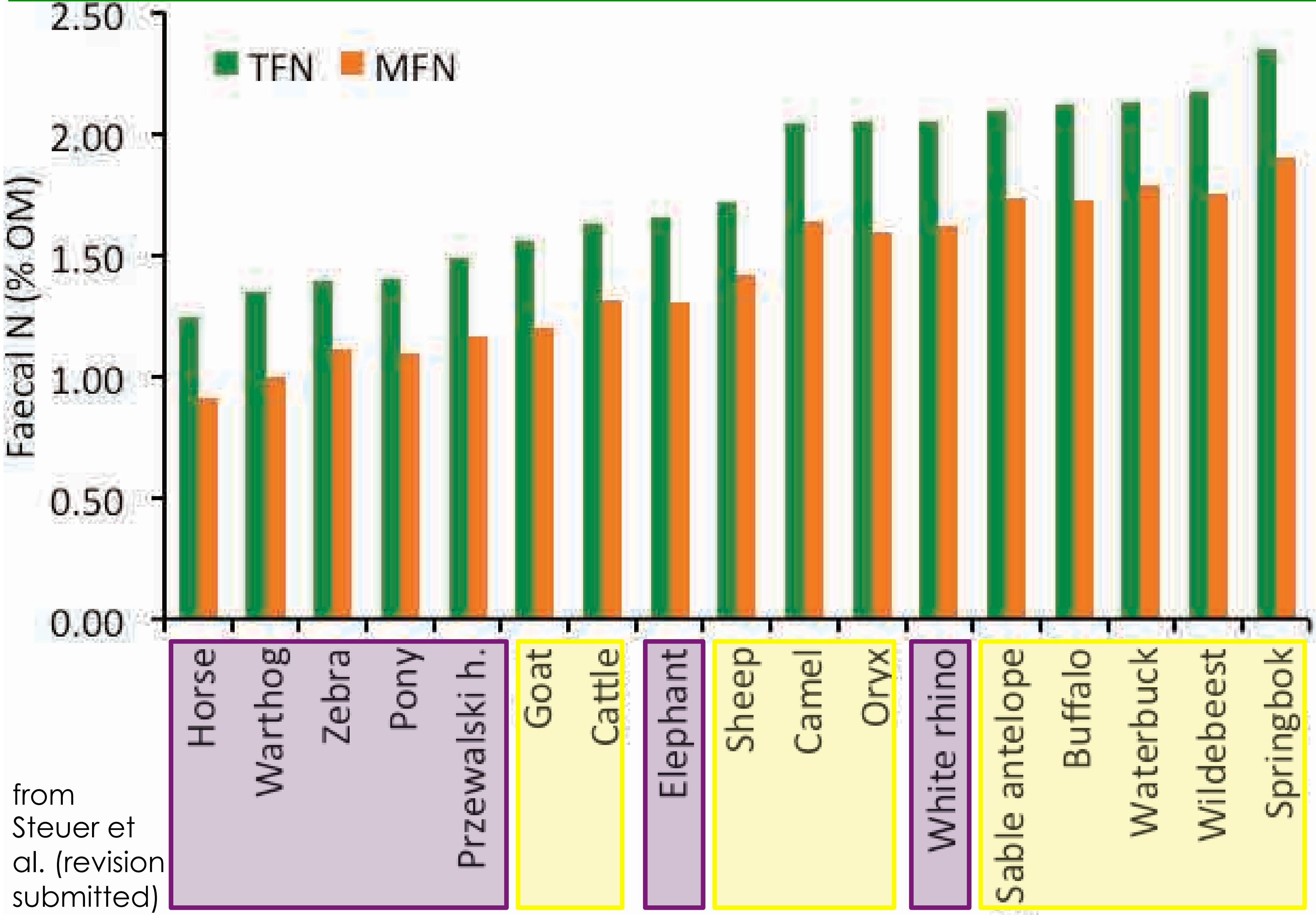


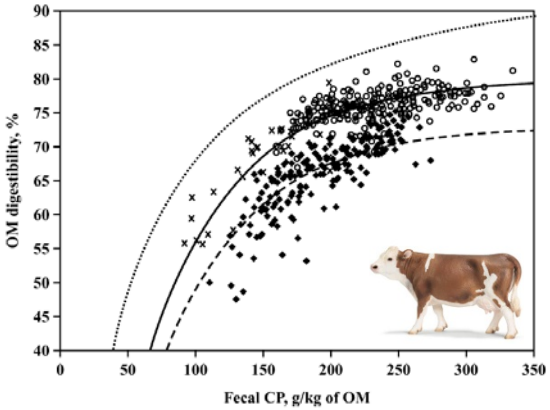
from Steuer et al. (revision submitted)

MFN not better as indicator of digestibility

Relationship between fecal crude protein concentration and diet organic matter digestibility in cattle[1]

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

J. Anim. Sci. 2005. 83:1332–1344



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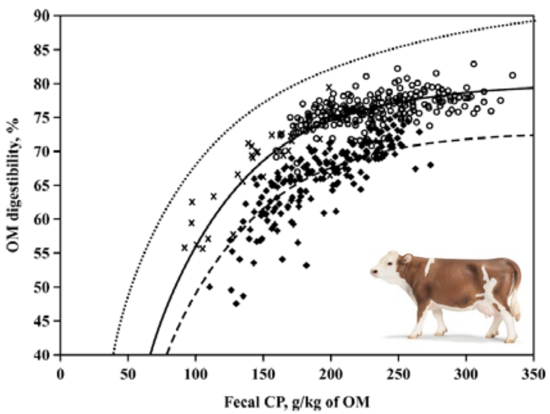


MFN

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?

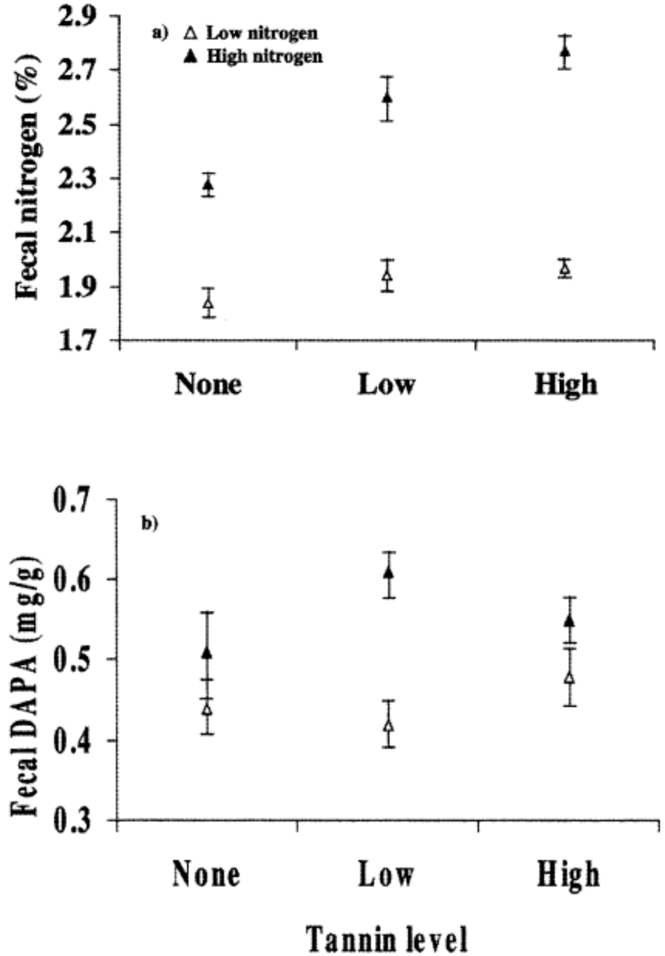
(Total faecal nitrogen = TFN)
(Metabolic faecal nitrogen = MFN)

Faecal N and secondary compounds

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

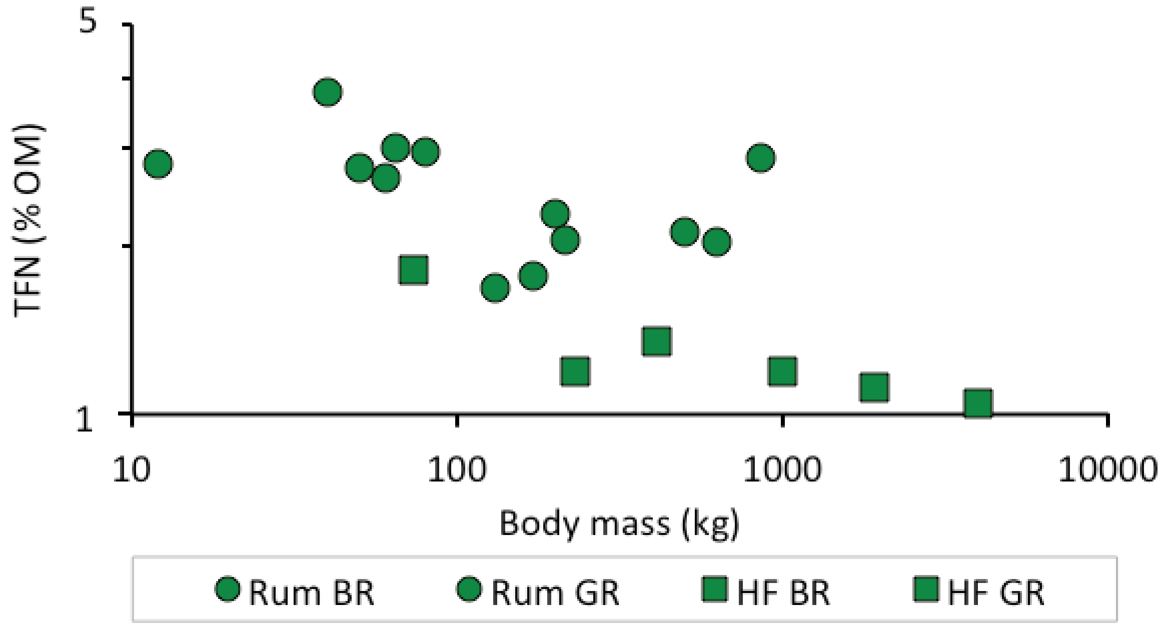
Robert G. Osborn and Tim F. Ginnett

Wildlife Society Bulletin 2001, 29(4):1131–1139



TFN is influenced by diet

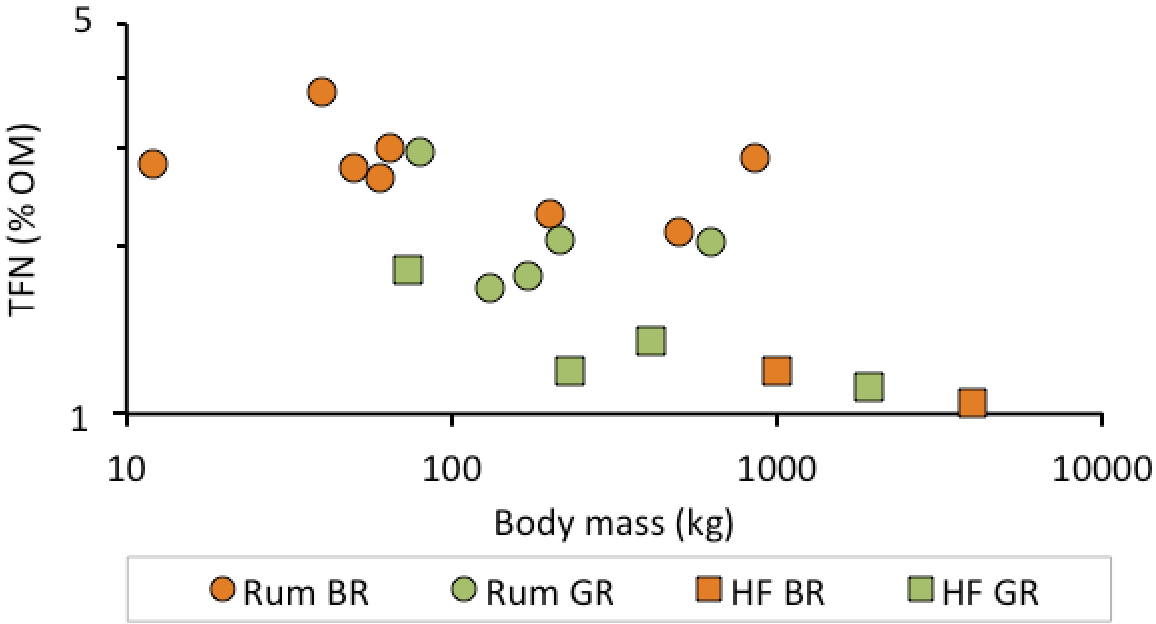
GLM	F	p
Body mass	8.09	0.012
Digestion type (Rum vs. HF)	8.55	0.010



from Steuer et al. (revision submitted)

TFN is influenced by diet

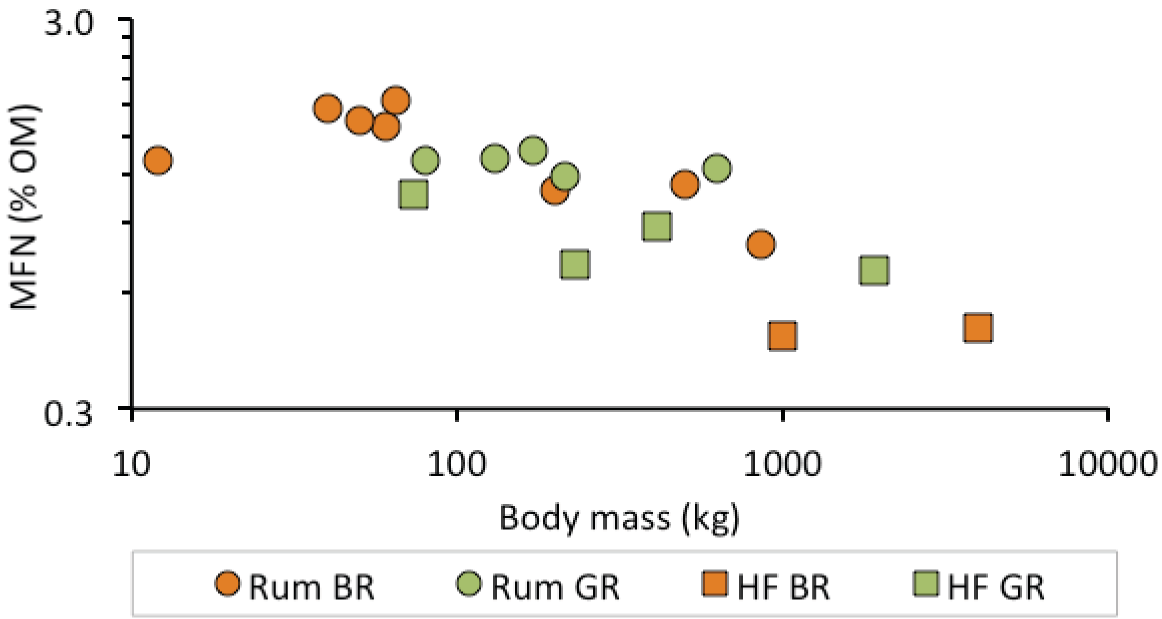
GLM	F	p
Body mass	8.09	0.012
Digestion type (Rum vs. HF)	8.55	0.010
%grass	4.51	0.051



from Steuer et al. (revision submitted)

MFN is less influenced by diet

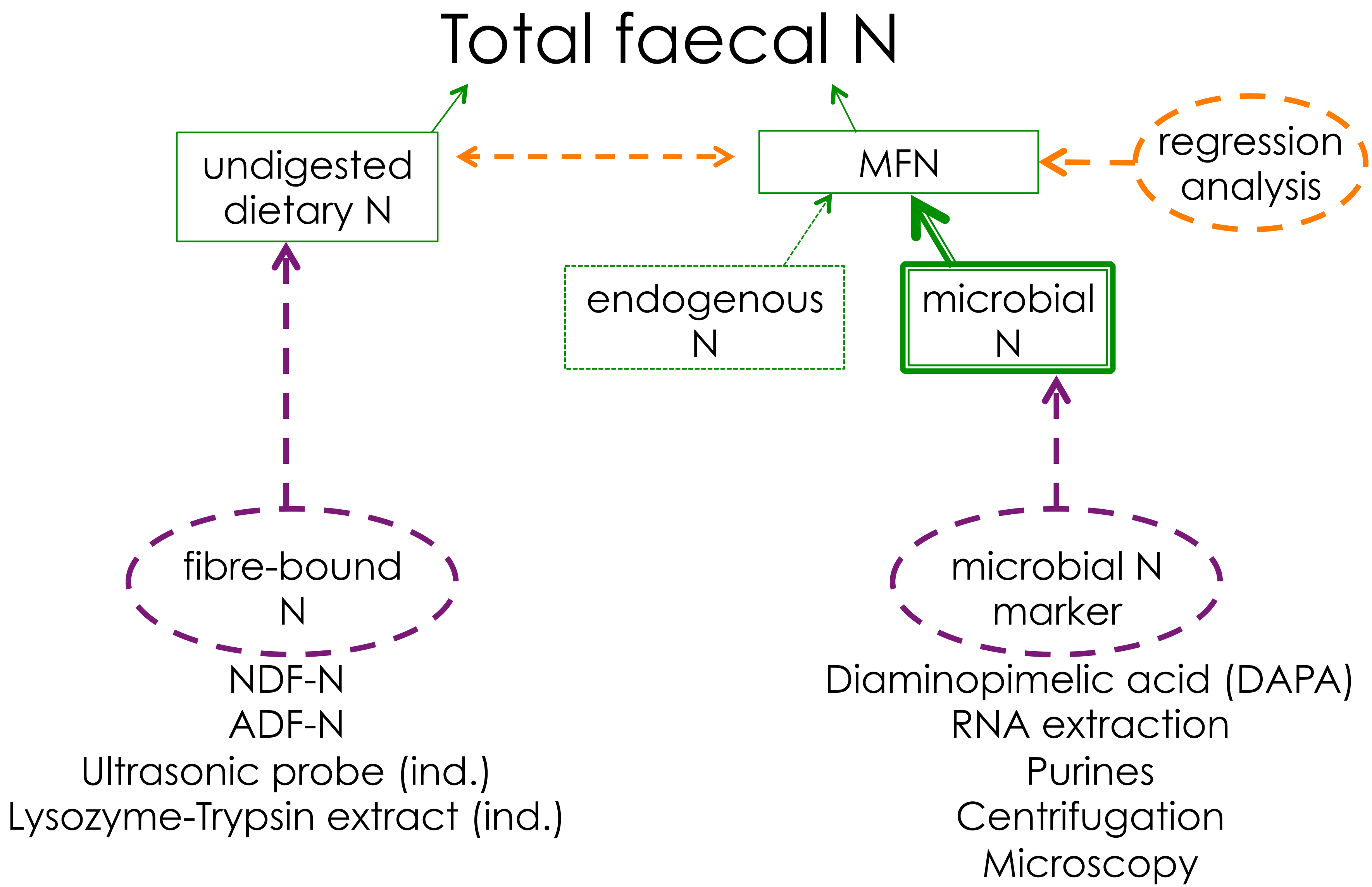
GLM	F	p
Body mass	14.2	0.002
Digestion type (Rum vs. HF)	10.3	0.006
%grass	0.1	0.711



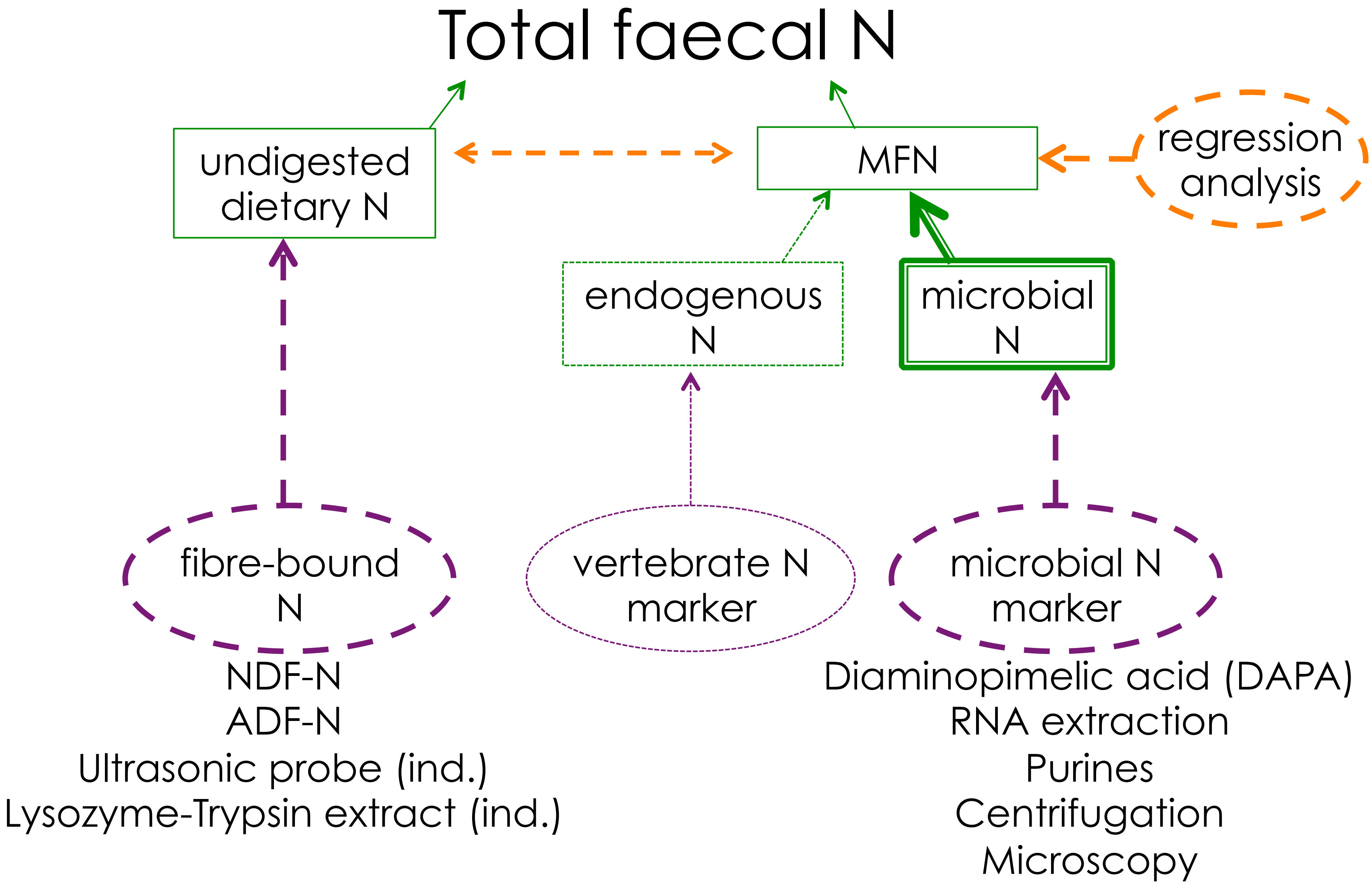
from Steuer et al. (revision submitted)

A failed attempt to quantify 'endogenous' faecal N in herbivores

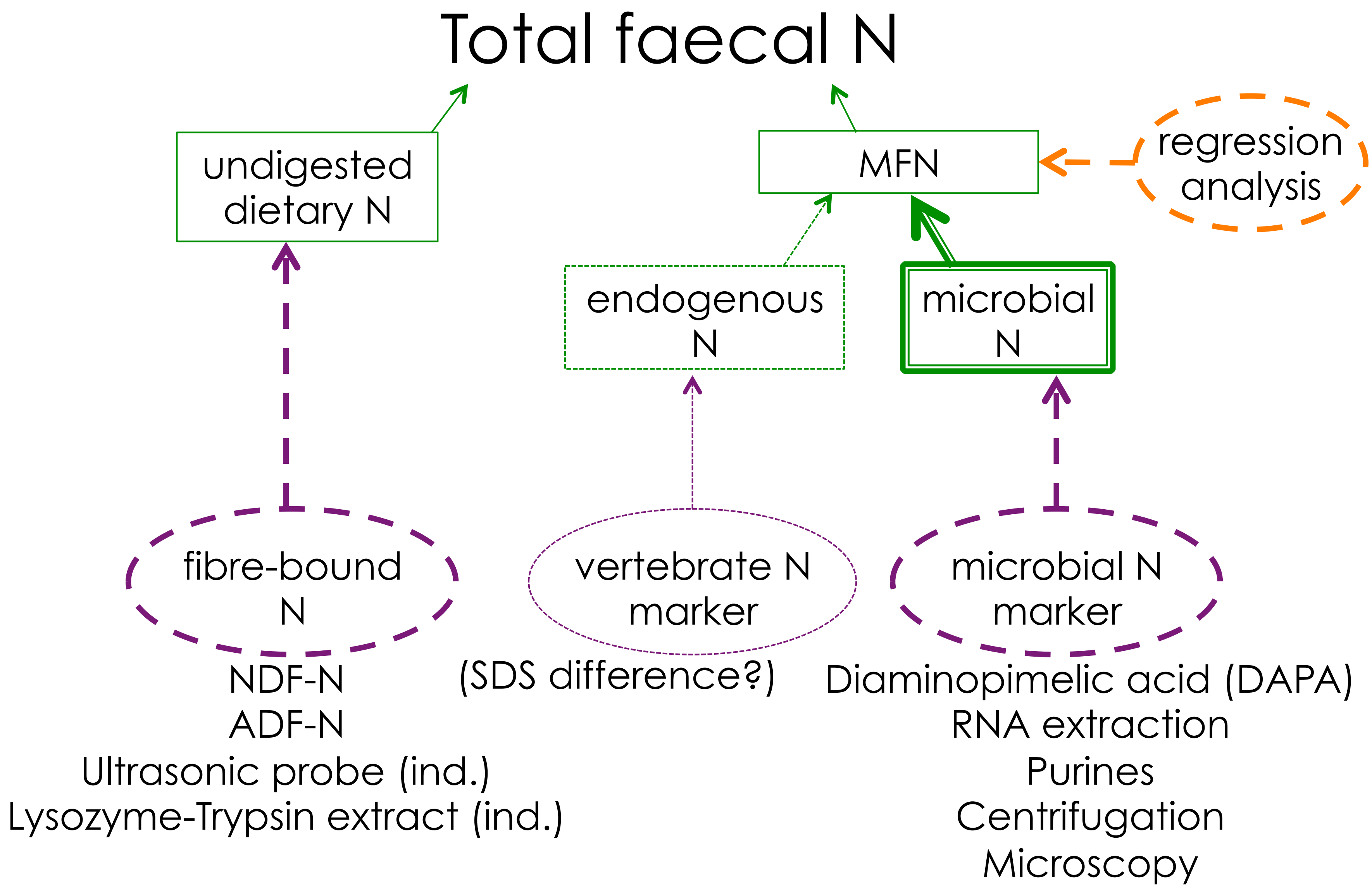
Analytical approaches



Analytical approaches



Analytical approaches



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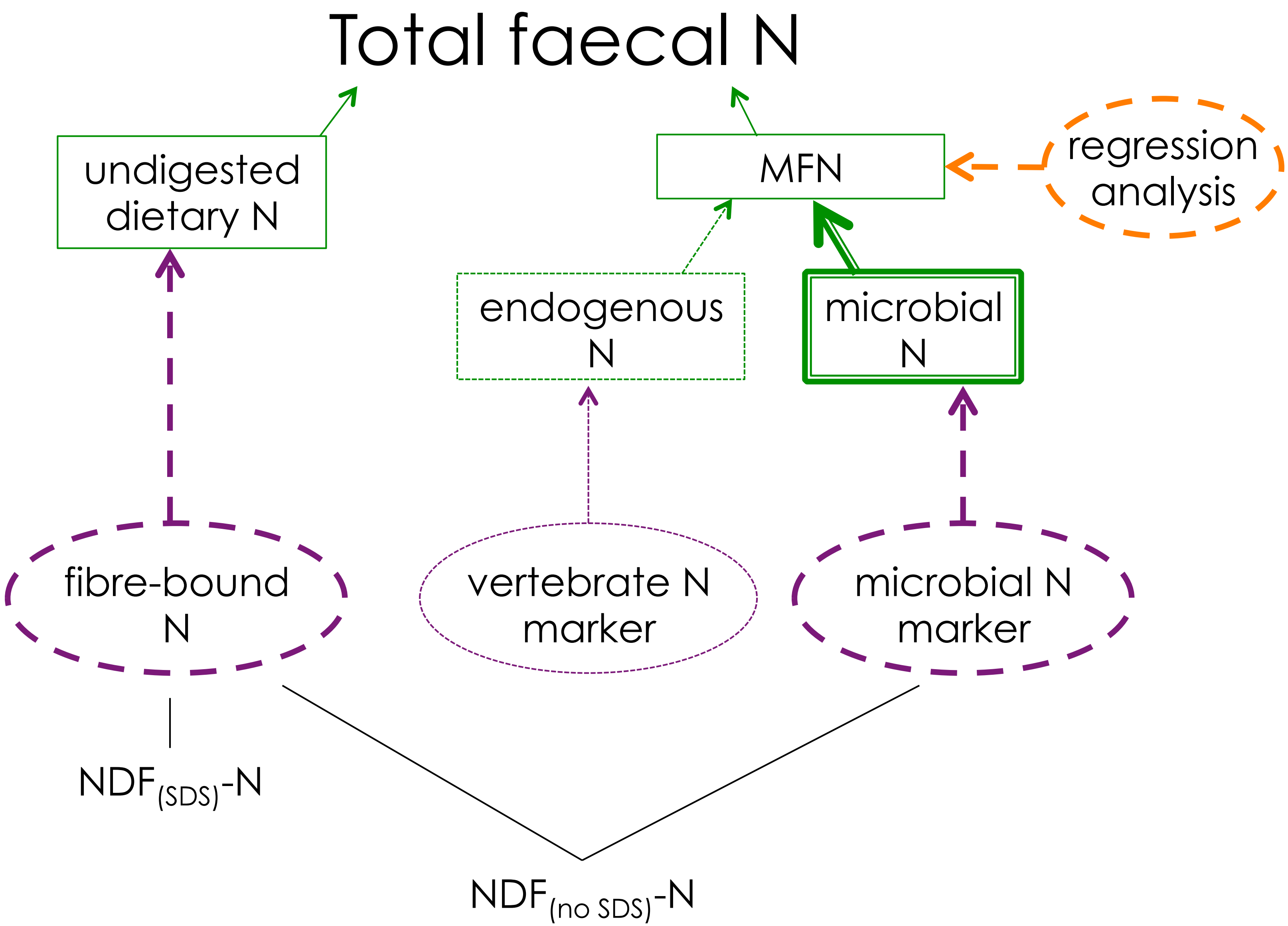

Used in a dog study

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

Pilot result ...

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

A. Schwarm[1,2], M. Schweigert[1], S. Ortmann[1], J. Hummel[3], G. P. J. Janssens[4], W. J. Streich[1] and M. Clauss[5]

Journal of Animal Physiology and Animal Nutrition **93** (2009) 596–605

Table 1 Mean (± SD) proportion of forage N (=$NDF_{SDS}N$) and metabolic faecal N (MFN = Faecal N − $NDF_{SDS}N$) 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 $N_{Bacteria}$ (=$NDF_{withoutSDS}N$ − $NDF_{SDS}N$) and N_{Animal} (=MFN − $N_{Bacteria}$) (see *Methods* for details). From Besselmann (2005)

Diet	Forage N (% FN)	MFN (% FN)	Bact. N (% FN)	Anim. N (% FN)
Grass hay only	45 ± 4	55 ± 4	19 ± 4	36 ± 7
Concentrates	30 ± 7	70 ± 7	12 ± 3	58 ± 9

... but generally unplausible results

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Digestive group	FN (% OM)	Forage N (% OM)	MFN (% OM)	Forage N (% FN)	MFN (% FN)	Bact. N (% FN)	Anim. N (% FN)
Coprophageous hindgut fermenter	$3.06^{a} \pm 0.75$	$0.57^{a} \pm 0.16$	2.49 ± 0.79	$20^{a} \pm 7$	$80^{a} \pm 7$	$21^{a} \pm 6$	59 ± 9
Non-coprophageous hindgut fermenter	$2.78^{ab} \pm 1.02$	$0.67^{ab} \pm 0.32$	2.11 ± 0.78	$24^{ab} \pm 6$	$75^{ab} \pm 6$	$12^{b} \pm 3$	63 ± 8
Ruminant foregut fermenter	$3.07^{ab} \pm 1.11$	$0.86^{b} \pm 0.28$	2.21 ± 0.91	$29^{b} \pm 4$	$71^{b} \pm 4$	$11^{b} \pm 3$	61 ± 4
Non-ruminant foregut fermenter	$3.89^{b} \pm 1.93$	$0.73^{ab} \pm 0.27$	3.15 ± 1.84	$22^{ab} \pm 9$	$78^{ab} \pm 9$	$12^{b} \pm 2$	66 ± 8
Non-coprophageous hindgut fermenter (no hyrax, primates)	2.53 ± 1.14	0.65 ± 0.38	1.88 ± 0.82	26 ± 6	74 ± 6	12 ± 4	62 ± 8
Non-ruminant foregut fermenter (no primates, sloth)	2.33 ± 0.62	0.66 ± 0.18	1.68 ± 0.45	28 ± 3	72 ± 3	12 ± 1	60 ± 3
Non-coprophageous hindgut fermenter primates	$3.33^{a} \pm 0.33$	0.71 ± 0.20	2.63 ± 0.37	21 ± 7	79 ± 7	$13^{a} \pm 2$	66 ± 5
Non-ruminant foregut fermenter primates	$5.75^{b} \pm 1.05$	0.83 ± 0.41	4.92 ± 1.18	15 ± 8	85 ± 8	$11^{b} \pm 4$	74 ± 7

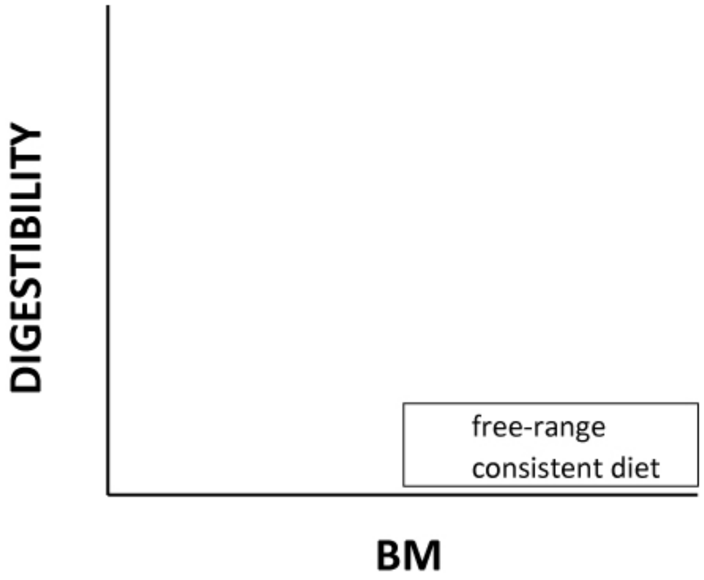
Applying MFN in an ecological context

(Metabolic faecal nitrogen = MFN)

An old question:

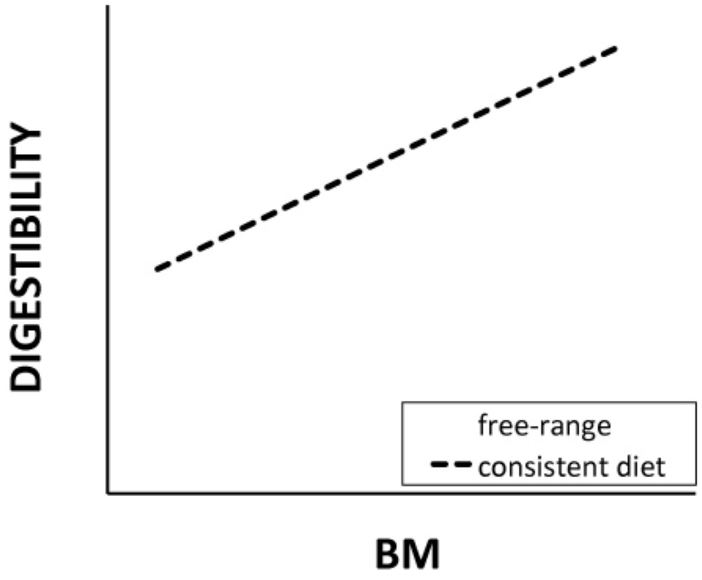
Do larger herbivores ingest lower-quality diets, and are they physiologically equipped for a 'better' digestion of such diets?

Hypothesis building



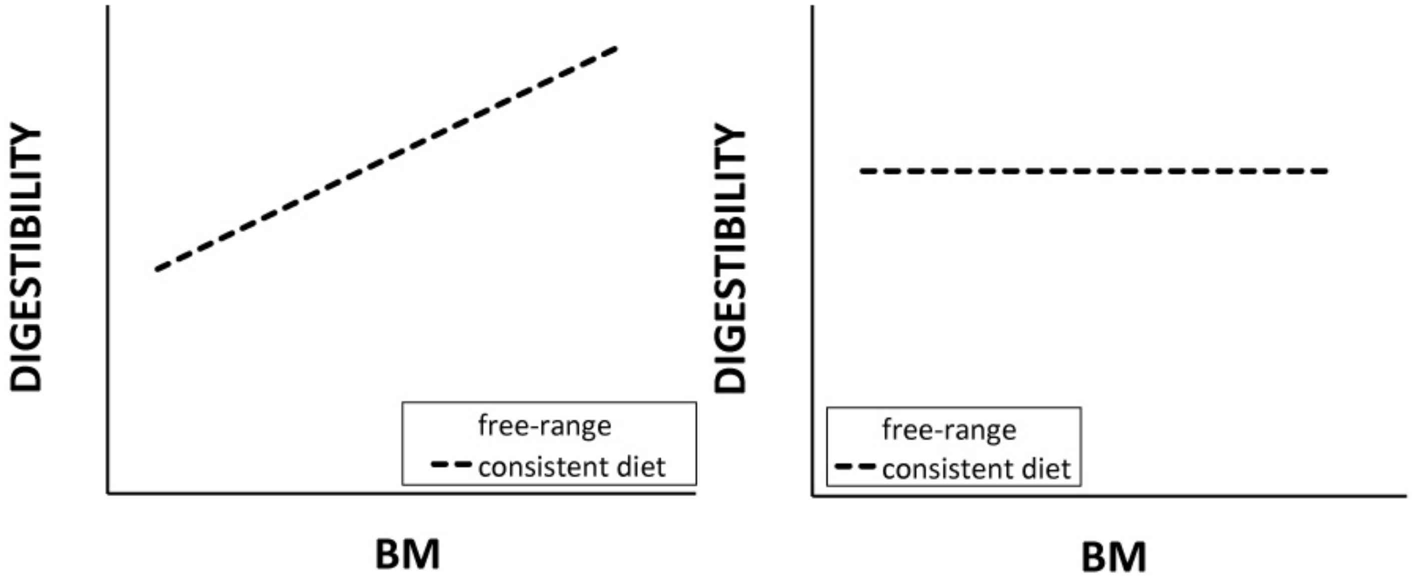
from Steuer et al. (revision submitted)

Larger size endows higher digestive efficiency ...



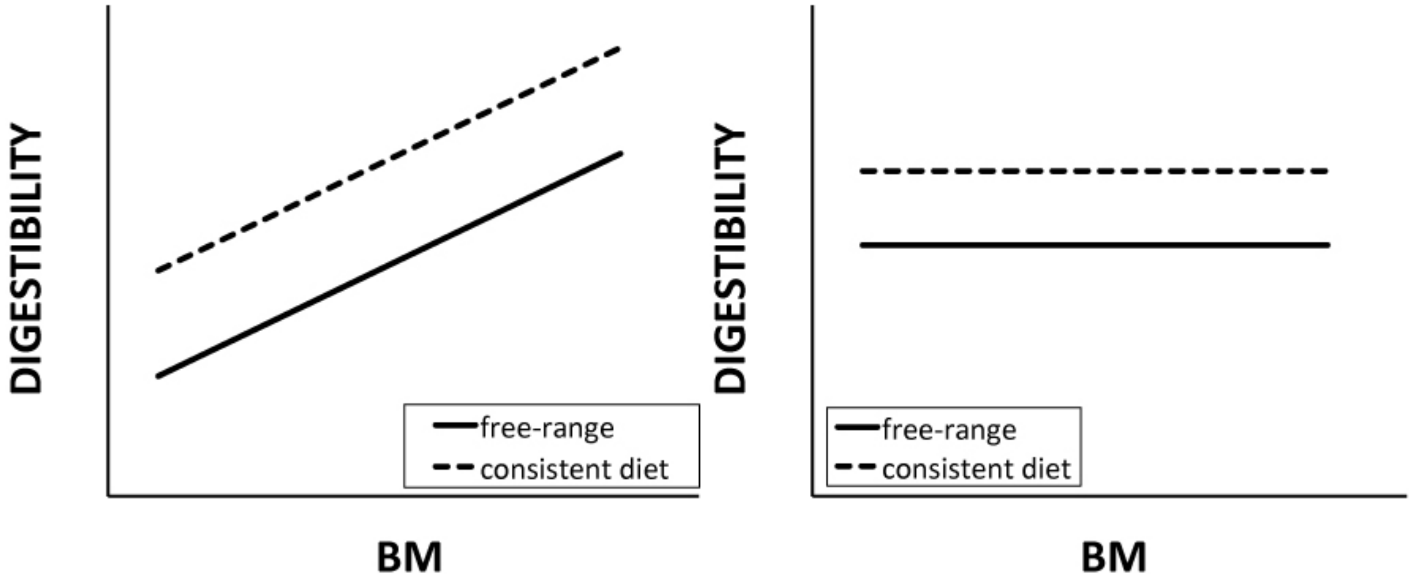
from Steuer et al. (revision submitted)

... or body size has no effect on digestibility



from Steuer et al. (revision submitted)

Body size does not affect diet selection ...



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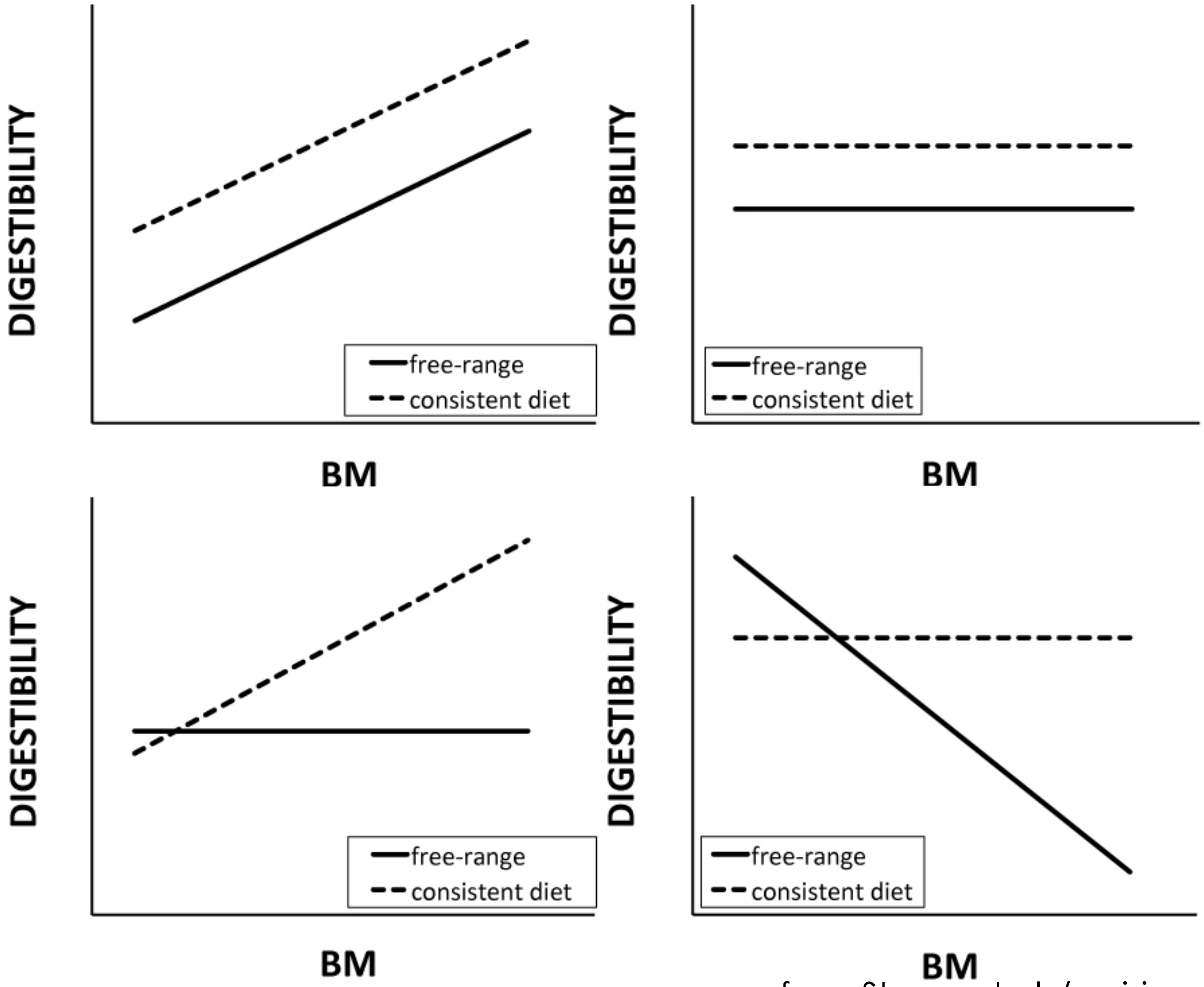
... or larger animals eat lower quality diets



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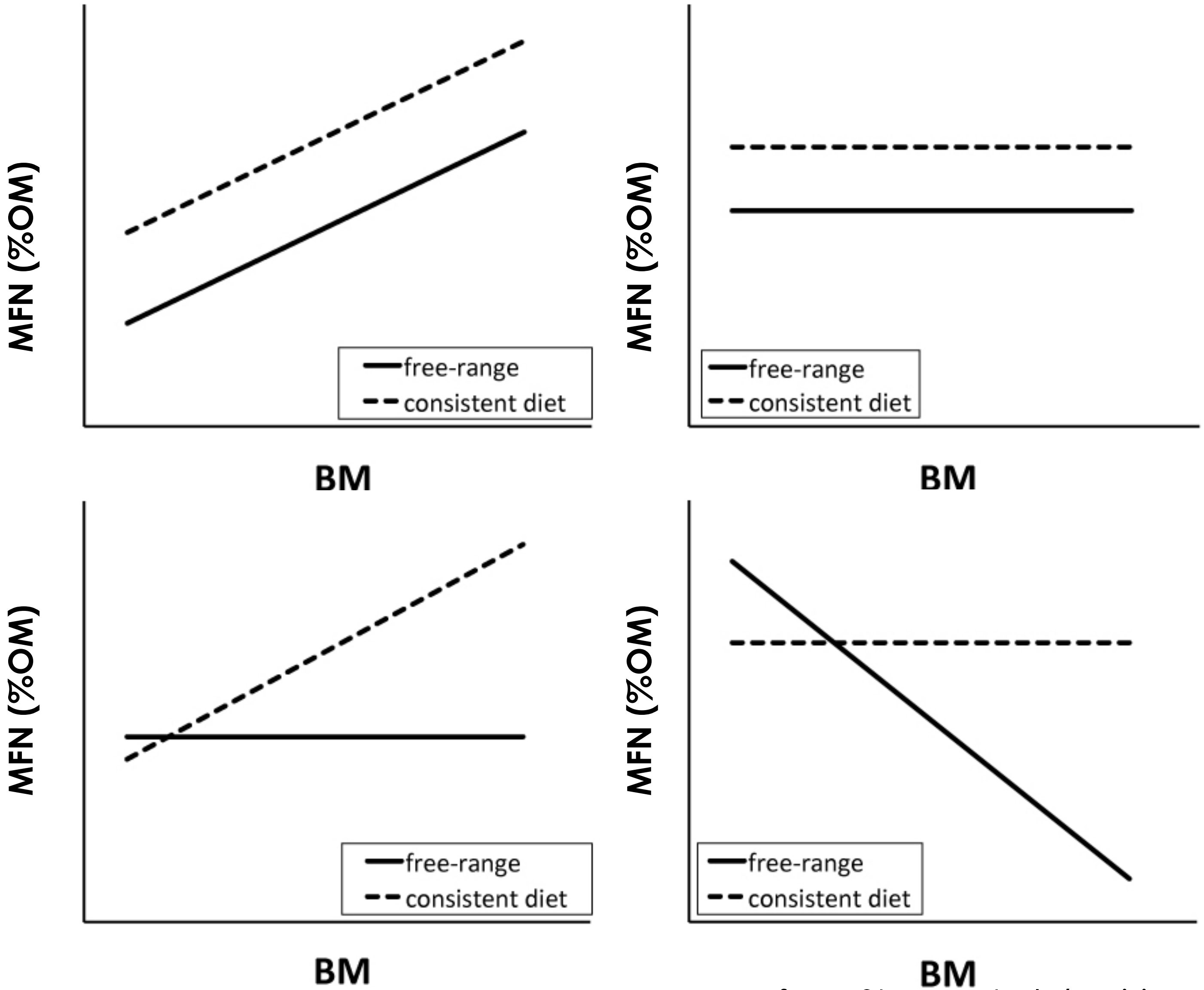

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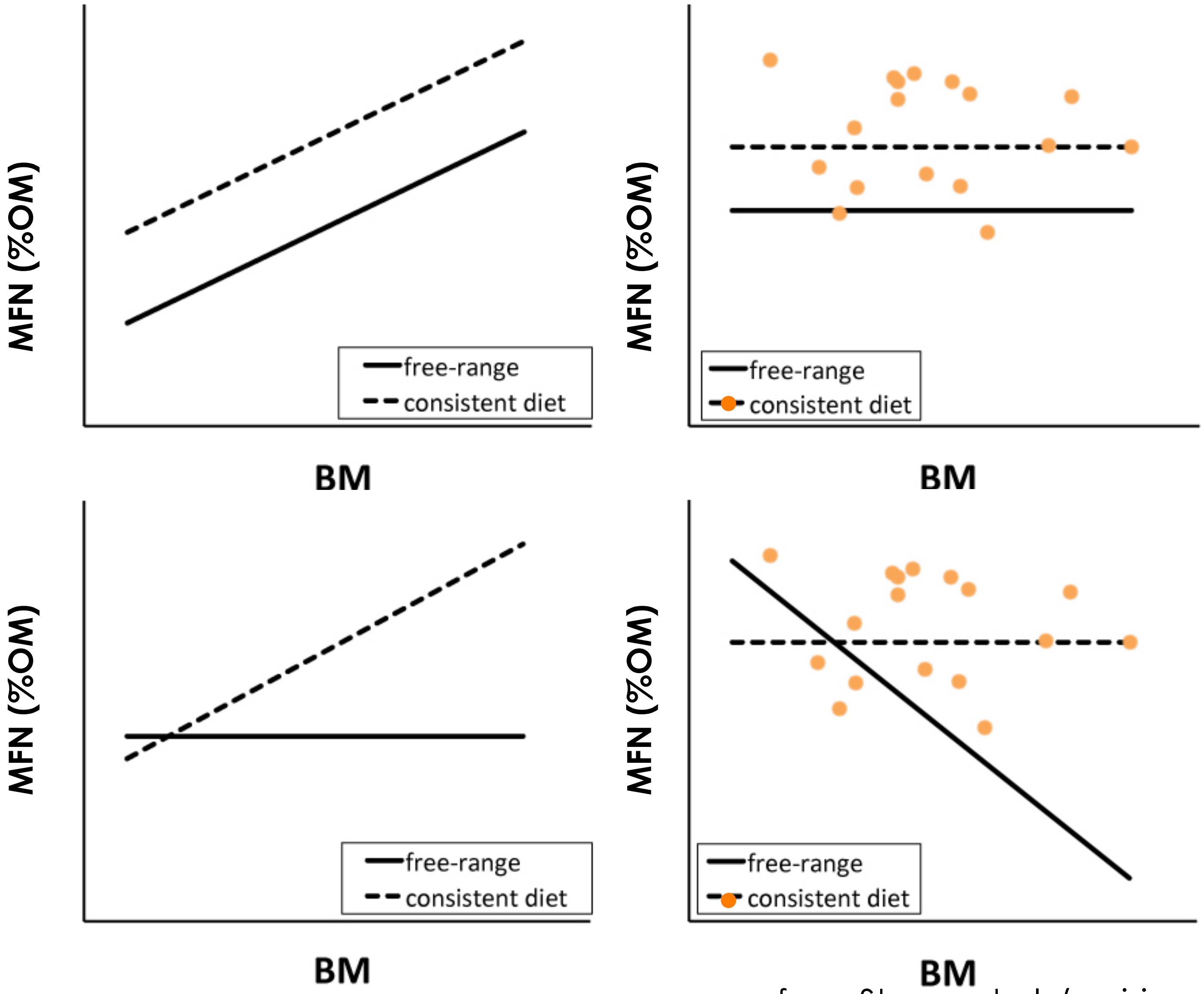

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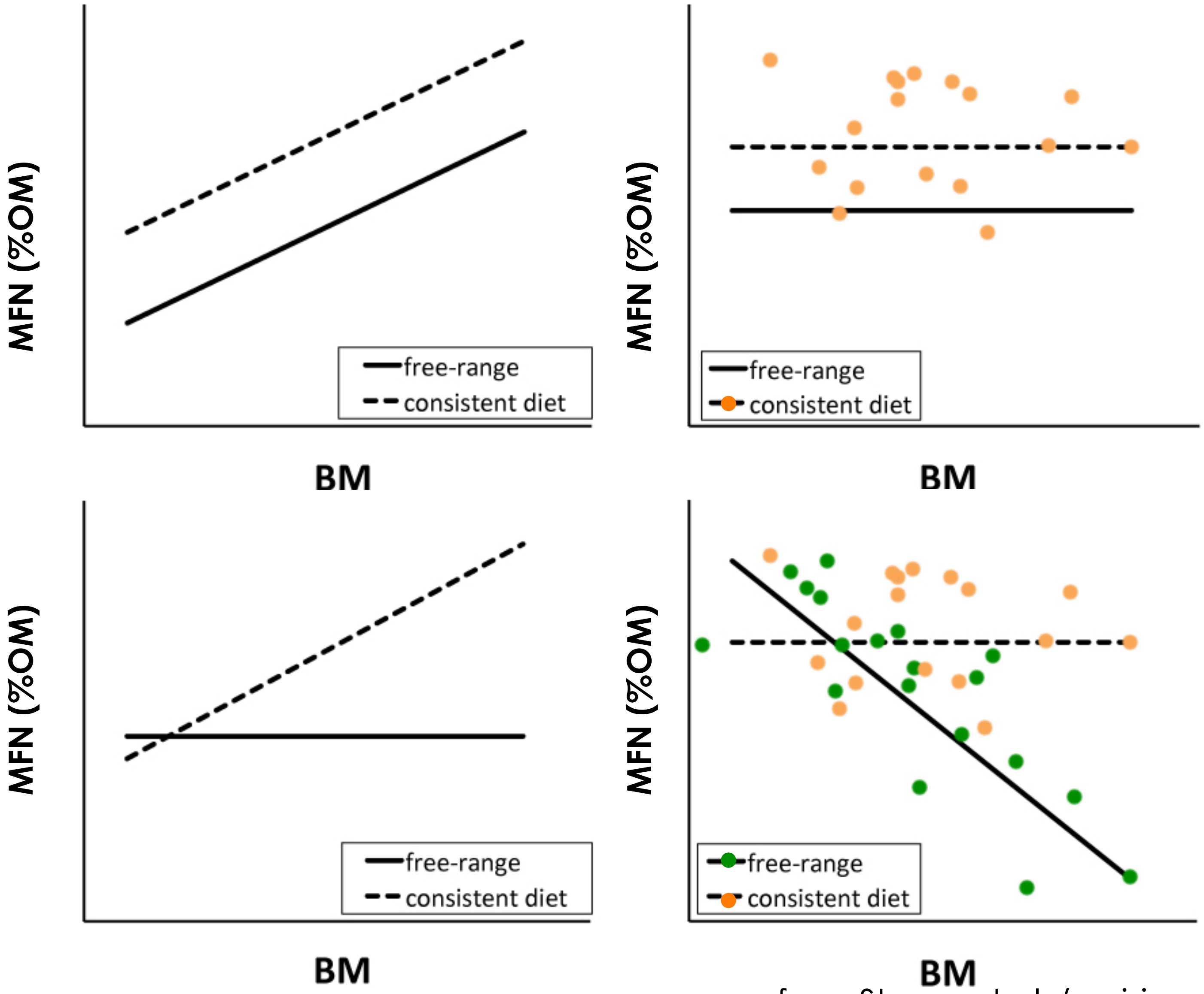

from Steuer et al. (revision submitted)

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- MFN appears superior to TFN in situations of heterogenous diets (incl. PSC).

thank you
for your attention