



# Diet quality and food intake in herbivores: an example of traditional concepts and 'easy' research

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*Clinic for Zoo Animals, Exotic Pets and Wildlife, Vetsuisse Faculty, University of Zurich, Switzerland*

*Wildlife Digestive Physiology Course Vienna 2013*



University of Zurich  
Vetsuisse Faculty



Clinic  
of Zoo Animals, Exotic Pets and Wildlife



*try this at home*



# How to generate new knowledge

1. Find an old hypothesis or formulate a new one ... which seems critical to you
2. Identify measures how to test the hypothesis
3. Test it
4. Arrive at a new hypothesis



# Old hypothesis: voluntary food intake



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2. Feeds vary in energy (and nutrient) content
3. Animals compensate differences in energy (and nutrient) content by adjusting the amount of food eaten (voluntary food intake)
4. ***“if diet quality gets lower, the animal simply eats more”***





Do you believe it?

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***“if diet quality gets lower, the animal simply eats more”***

## The Effects of Caloric Dilution on Meal Patterns and Food Intake of Ponies

JANE E. LAUT, KATHERINE A. HOUP<sup>1</sup>, HAROLD F. HINTZ  
AND T. RICHARD HOUP

*Physiology & Behavior*, Vol 35, pp 549-554

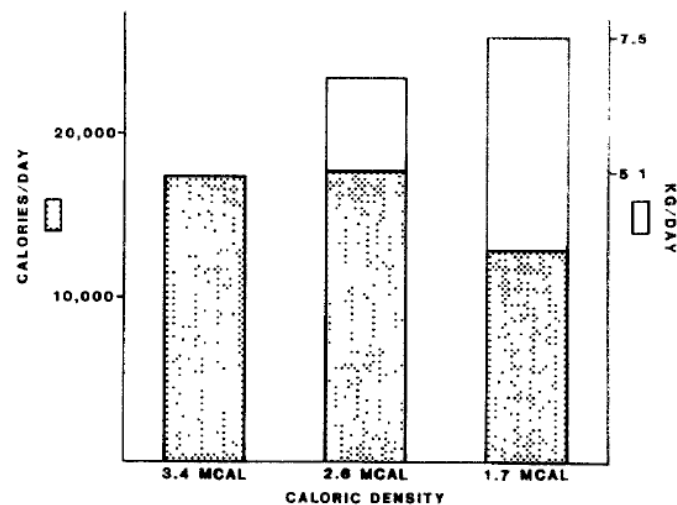


FIG 1. The intake of ponies on 3 diets varying in caloric density. The total height of the column indicates the mean weight of feed eaten per day (left ordinate). The dark portion of the column indicates the mean calories consumed per day (right ordinate).



Why not believe it?



# Why not believe it?

## 1. Common sense/experience





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2. Does a test with grains/pelleted feeds tell you anything about real life?



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1. Common sense/experience



2. Does a test with grains/pelleted feeds tell you anything about real life?

**=> We want a test with real forages!**



# Looking for measurements



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3. What is the expectation?



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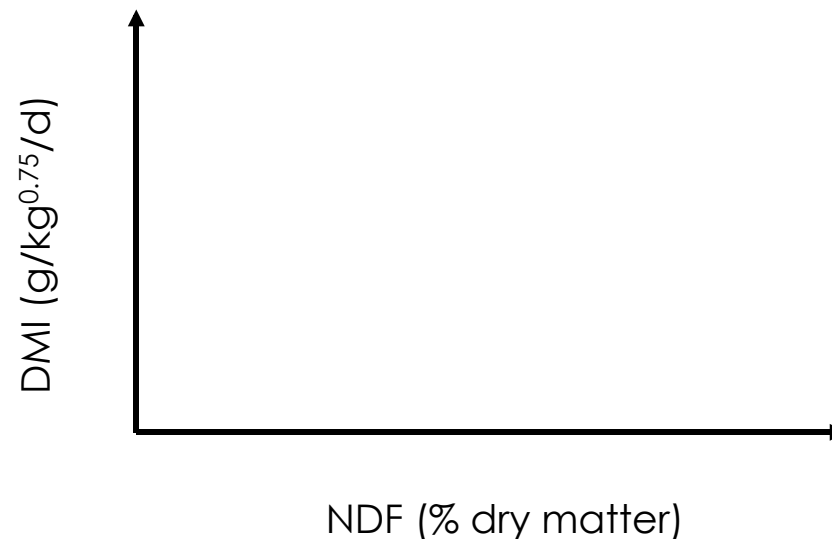
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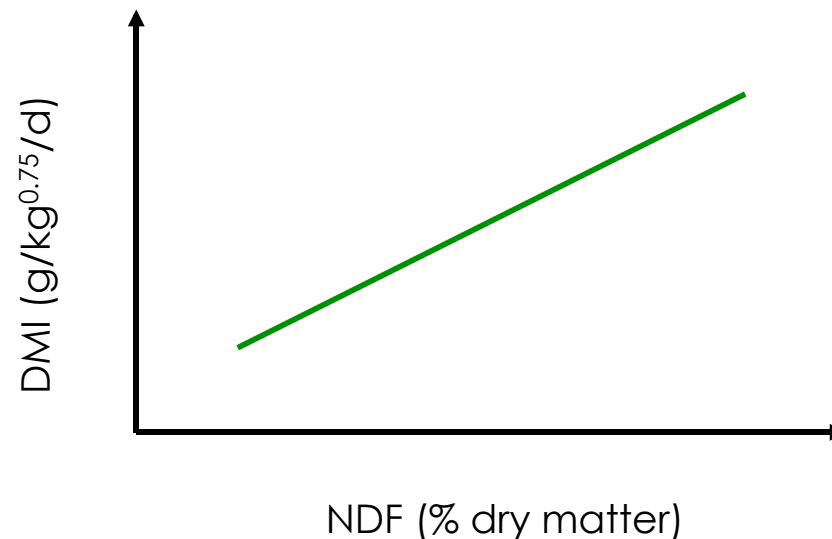
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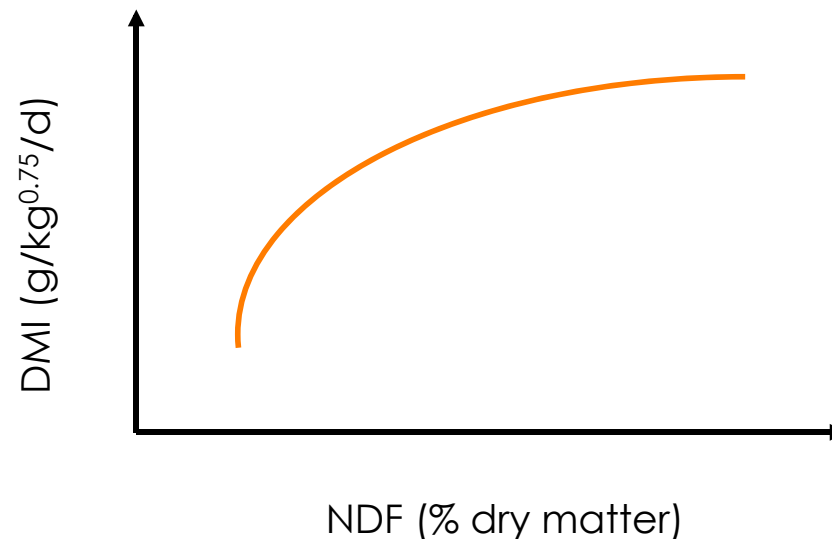
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# Data in sheep

## SYMPOSIUM ON FACTORS INFLUENCING THE VOLUNTARY INTAKE OF HERBAGE BY RUMINANTS: VOLUNTARY INTAKE IN RELATION TO CHEMICAL COMPOSITION AND DIGESTIBILITY<sup>1</sup>

P. J. VAN SOEST

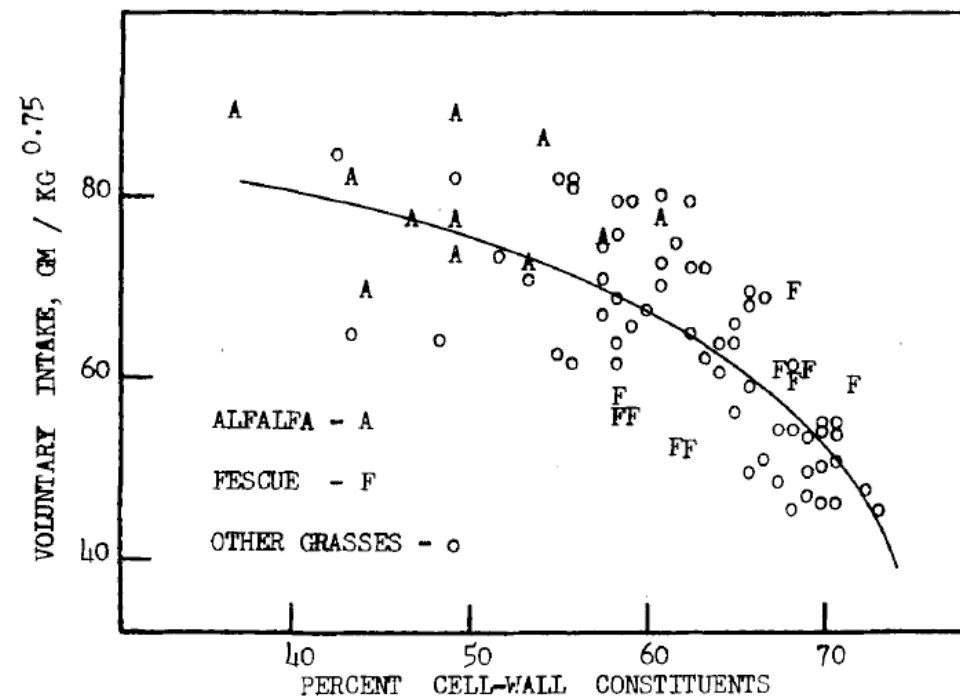


Figure 2. Relationship between voluntary intake and cell-wall constituents of 83 forages from West Virginia. Regression equation:  $Y = 110.4 - 1716/(100 - X)$ .





## Why not believe it?

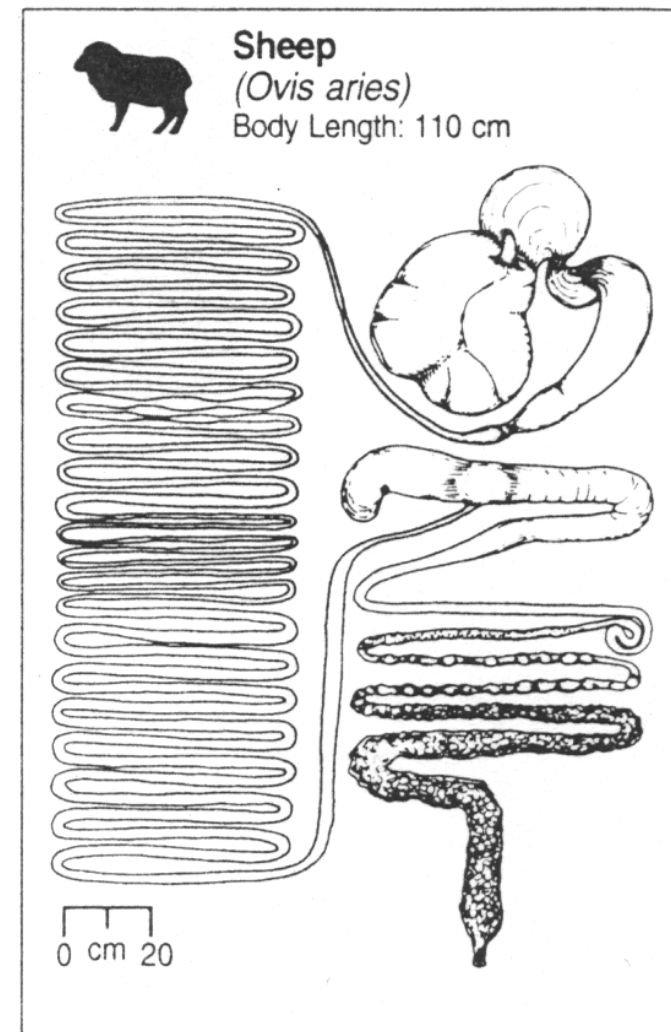
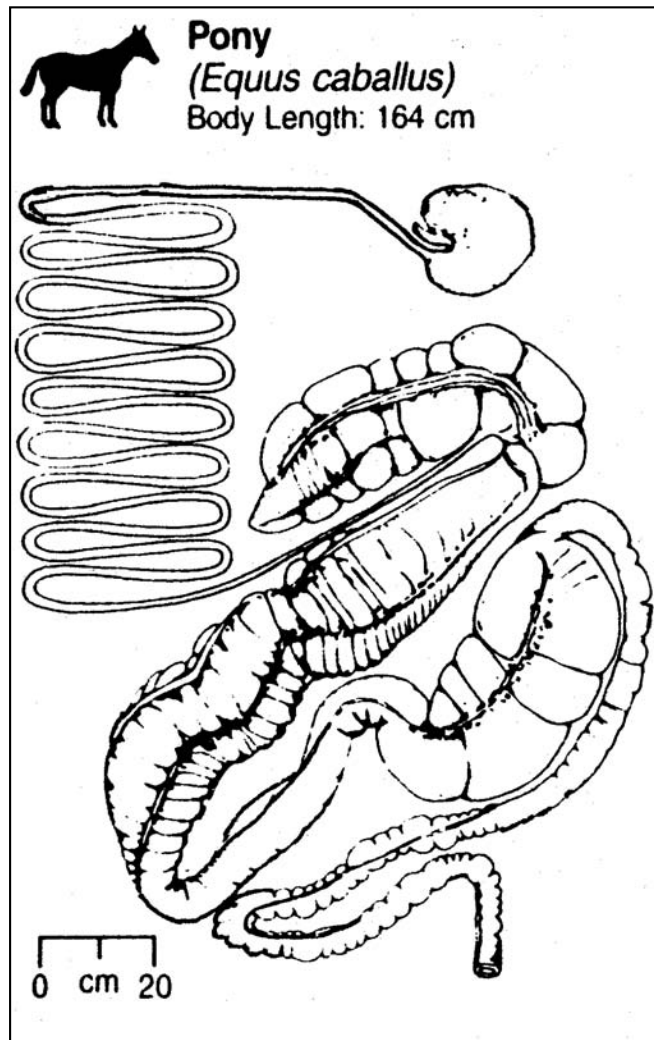
### 1. Common sense/experience

***It is a well known-fact in agricultural science that animals eat less if a forage is of lower nutritional quality.***

***This knowledge is derived from ruminants.***

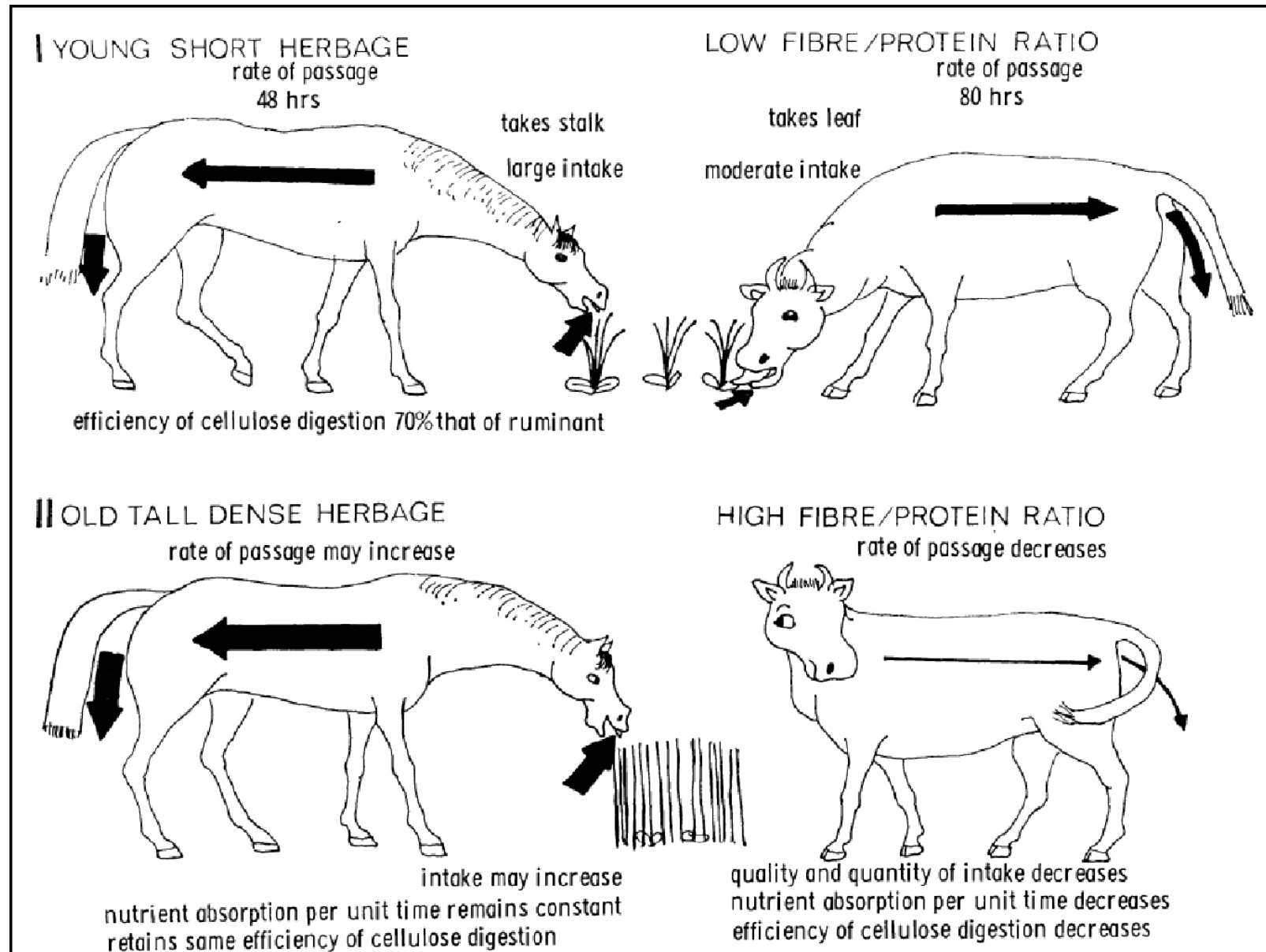


# The traditional view of foregut vs. hindgut fermentation





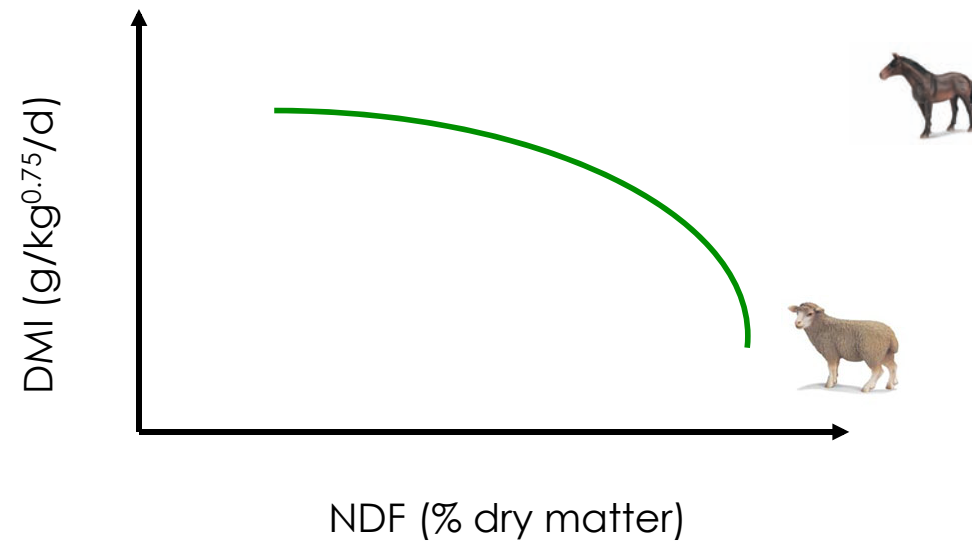
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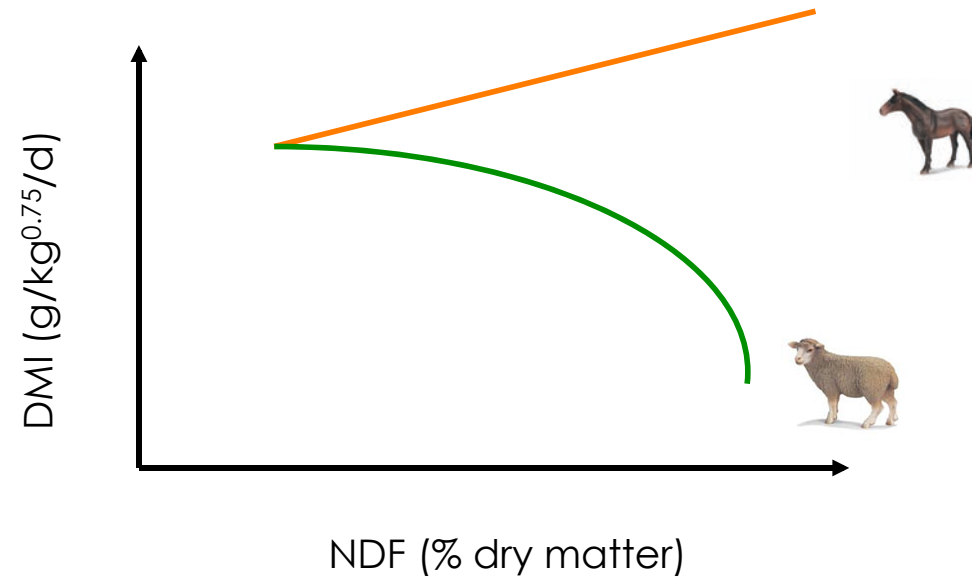
What is the expectation?





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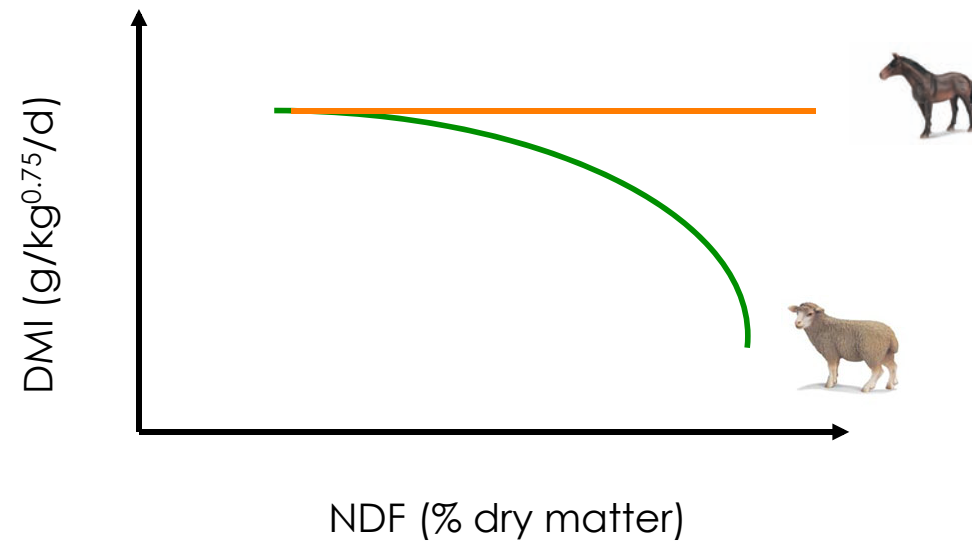
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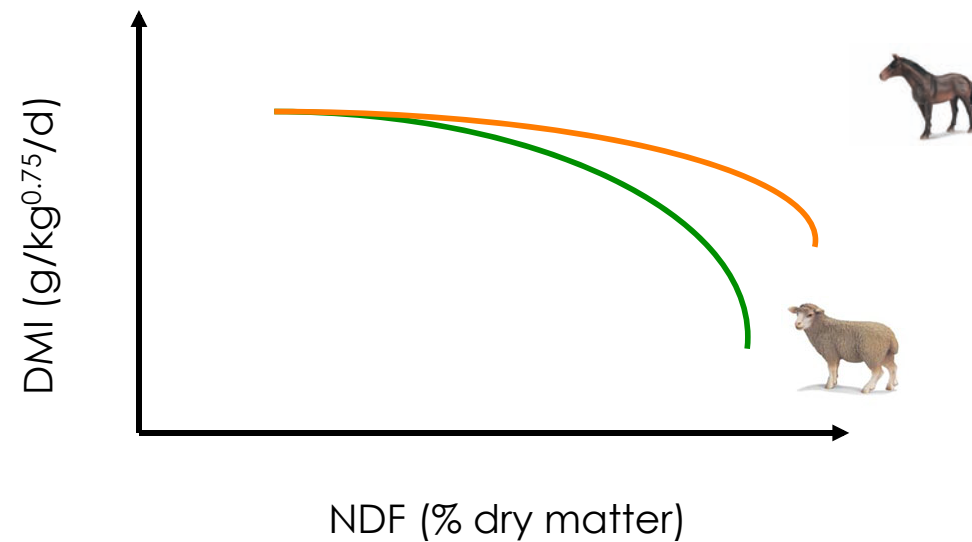
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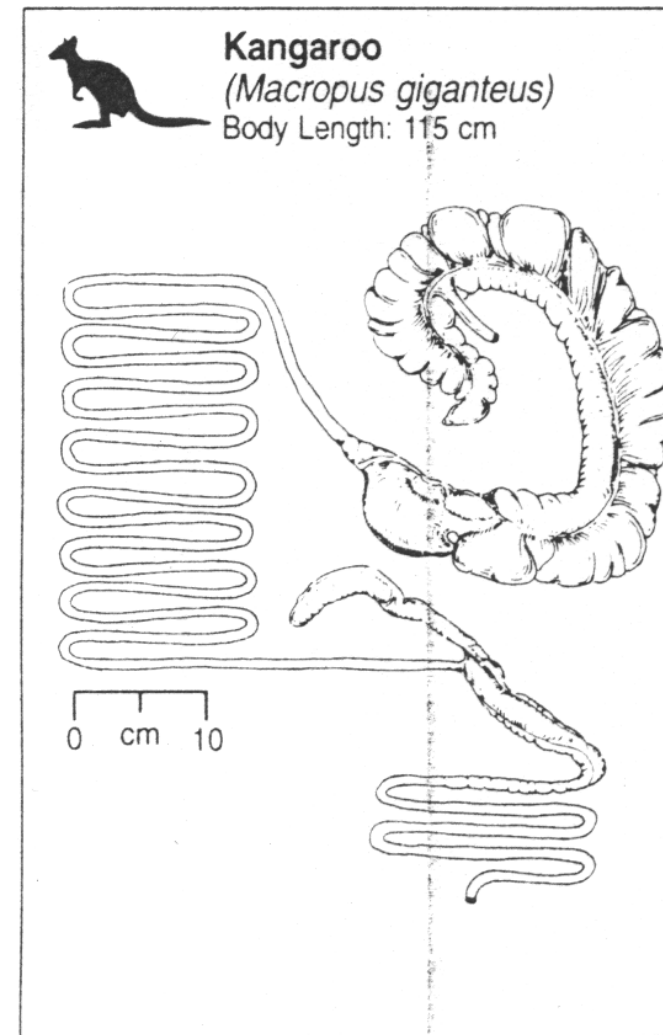
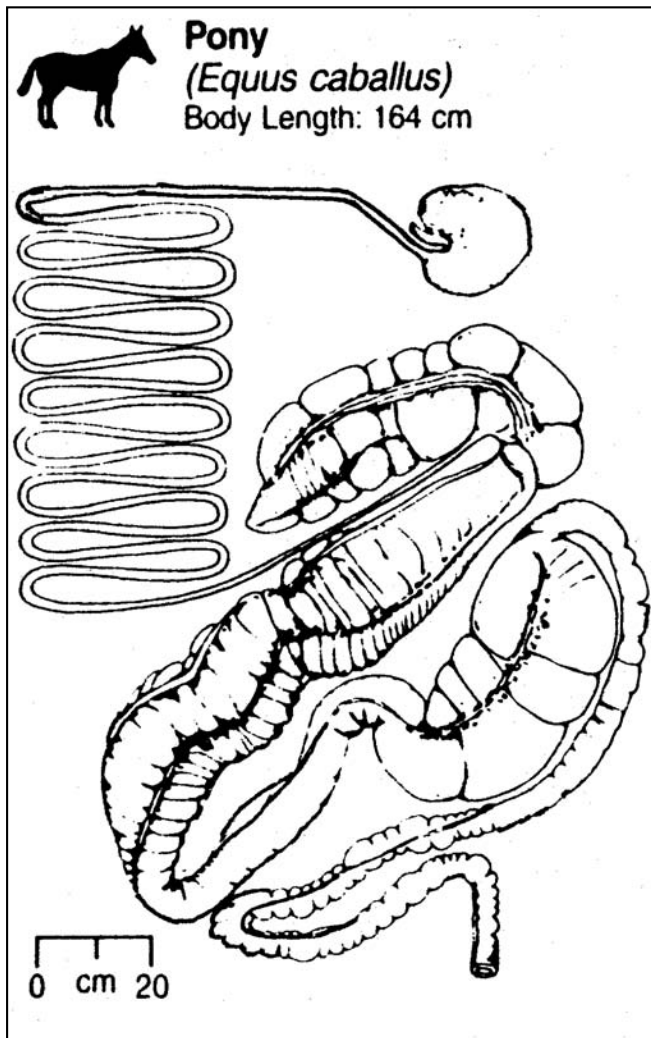
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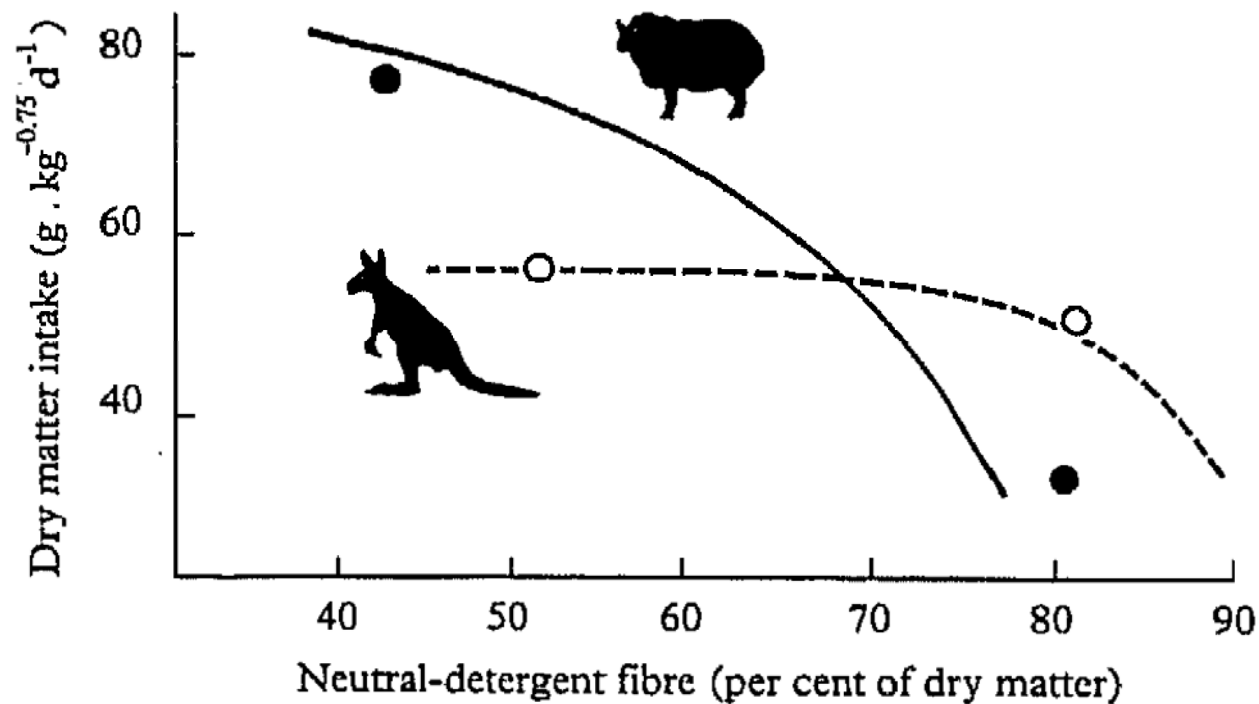






# The traditional view of foregut vs. hindgut fermentation

What is the expectation?





## Summary of questions

1. Do herbivores really eat more when forage quality declines?
2. Are ruminants/foregut fermenters the only exception to this rule?
3. Or, at least, can we say that hindgut fermenters reduce their food intake less with decreasing forage quality?
4. Do kangaroos resemble hindgut fermenters in this respect?

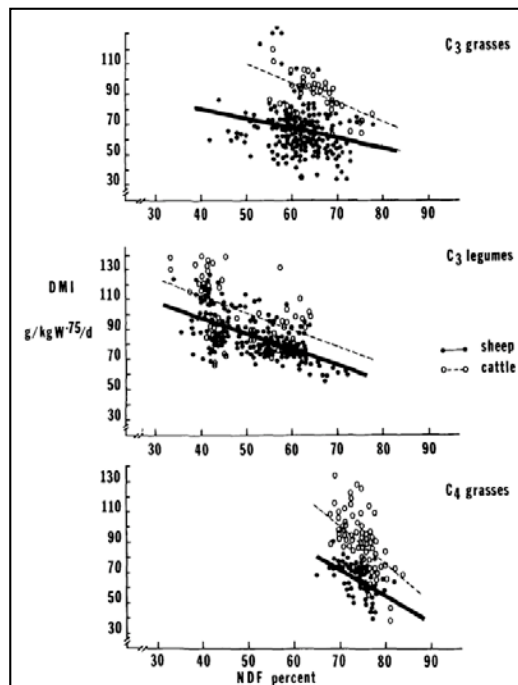


How can we answer the questions?



# How can we answer the questions?

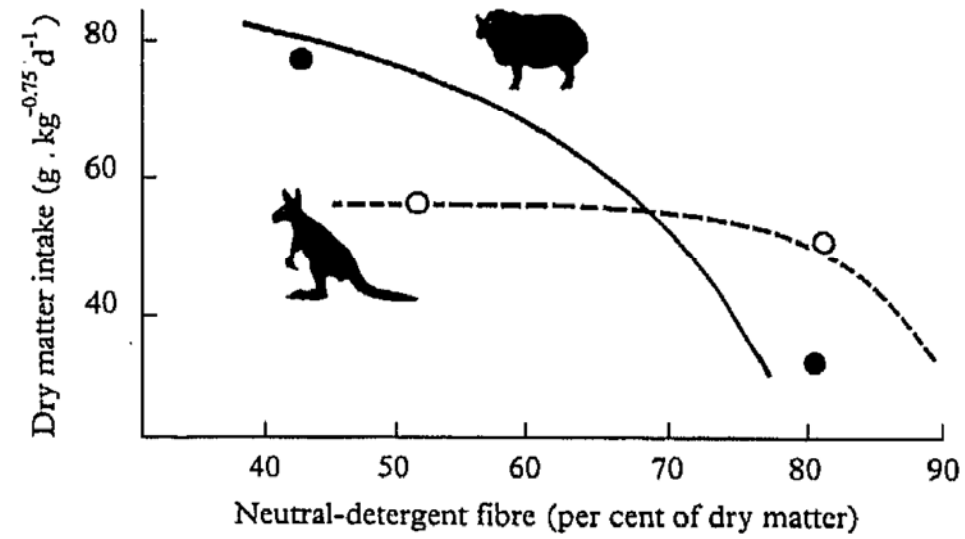
Go to the literature, and write down data on forage NDF and voluntary DMI in experiments where forage was fed ad libitum



EXTRACTION OF ORGANIC MATTER (OM) FROM ALFALFA HAY BY WILD SPECIES IN THE "ZOO STUDIES"															
SPECIES	N	WEIGHT		INTAKE		EXTRACTION		DIGEST. COEF.		EXTRACTION/REQUIREMENT					
		B.W. (KG.)	M.W. (KG. <sup>0.75</sup> )	(% OF B.W.)	(KG./KG. M.W.)	(% OF B.W.)	(KG./KG. M.W.)	(% OF B.W.)	(KG./KG. M.W.)	1 SX BASAL	2 SX BASAL	3 SX BASAL	4 SX BASAL		
African Elephant	3	2872	390	1.25	.04	.091	.008	.056	.003	61.73	2.01	1.71	.09	1.28	.07
Asian Elephant	1	3402	445	1.12	N.A.	.085	N.A.	.050	N.A.	58.91	N.A.	1.53	N.A.	1.15	N.A.
Indian Rhino	3	1852	282	1.19	.05	.078	.003	.051	.002	65.36	1.53	1.55	.06	1.16	.04
White Rhino	5	1780	284	1.19	.13	.074	.003	.050	.002	67.37	3.59	1.53	.05	1.14	.04
Black Rhino	3	1285	230	1.63	.28	.091	.011	.059	.004	64.66	3.71	1.79	.11	1.35	.08
Asian Tapir	2	218	56	2.06	.27	.080	.006	.041	.007	50.95	4.67	1.25	.20	.94	.16
American Tapir	4	133	39	2.00	.44	.068	.014	.036	.007	54.19	.42	1.11	.23	.84	.17
Grevy's Zebra	2	352	81	2.40	.16	.104	.009	.069	.005	66.10	.68	2.09	.16	1.57	.11
Mountain Zebra	3	257	64	2.76	.05	.111	.004	.064	.008	58.56	9.30	1.97	.23	.47	.18
Plains Zebra	4	215	56	2.88	.29	.110	.010	.068	.007	61.93	5.66	2.08	.22	1.55	.11
Asian Wild Ass	3	191	55	3.69	.10	.127	.005	.074	.003	57.83	3.06	2.25	.09	1.68	.07
Pigmy Hippo	3	219	61	1.15	.22	.042	.010	.029	.010	89.38	12.02	.89	.31	.67	.23
River Hippo	4	2211	340	.91	.12	.059	.008	.044	.006	73.70	3.95	1.33	.18	1.00	.13
Bactrian Camel	1	544	113	1.46	N.A.	.070	N.A.	.052	N.A.	73.66	N.A.	1.58	N.A.	1.19	N.A.
Dromedary Camel	3	544	113	1.52	.10	.073	.005	.050	.006	68.03	2.79	1.52	.17	1.15	.13
Guamaco	1	272	88	1.66	N.A.	.051	N.A.	.034	N.A.	66.15	N.A.	1.03	N.A.	.77	N.A.
Wapiti	2	284	69	1.78	.04	.073	.003	.047	.002	64.07	.18	1.43	.05	1.08	.04
Barasingha	2	193	56	2.01	.13	.069	.002	.050	.001	72.72	1.58	1.53	.01	1.15	.01
Giraffe	3	1399	256	.89	.01	.049	.006	.030	.004	60.70	6.19	.91	.12	.68	.09
Asian Buffalo	1	1270	253	1.80	N.A.	.091	N.A.	.068	N.A.	74.78	N.A.	2.06	N.A.	1.55	N.A.
African Buffalo (F)	3	302	72	2.46	.06	.102	.002	.075	.003	73.63	1.83	2.30	.10	.72	.10
Gaur	2	714	138	1.35	.00	.070	.003	.052	.001	74.40	1.56	1.58	.04	1.19	.04
American Bison	1	408	91	1.53	N.A.	.069	N.A.	.052	N.A.	75.23	N.A.	1.57	N.A.	1.18	N.A.
European Bison	1	2041	453	1.45	N.A.	.066	N.A.	.045	N.A.	69.40	N.A.	1.39	N.A.	1.04	N.A.
Gemsbok	2	204	54	2.35	.04	.089	.001	.060	.001	67.66	.54	1.83	.04	1.35	.01
Waterbuck	2	204	54	2.10	.01	.079	.004	.054	.001	67.95	1.41	1.64	.04	1.23	.03
Nilgai	2	193	52	1.67	.01	.062	.001	.043	.002	68.96	3.22	1.31	.05	.98	.04
Eland	4	408	91	1.77	.10	.079	.003	.047	.007	60.02	9.00	1.45	.21	1.08	.15

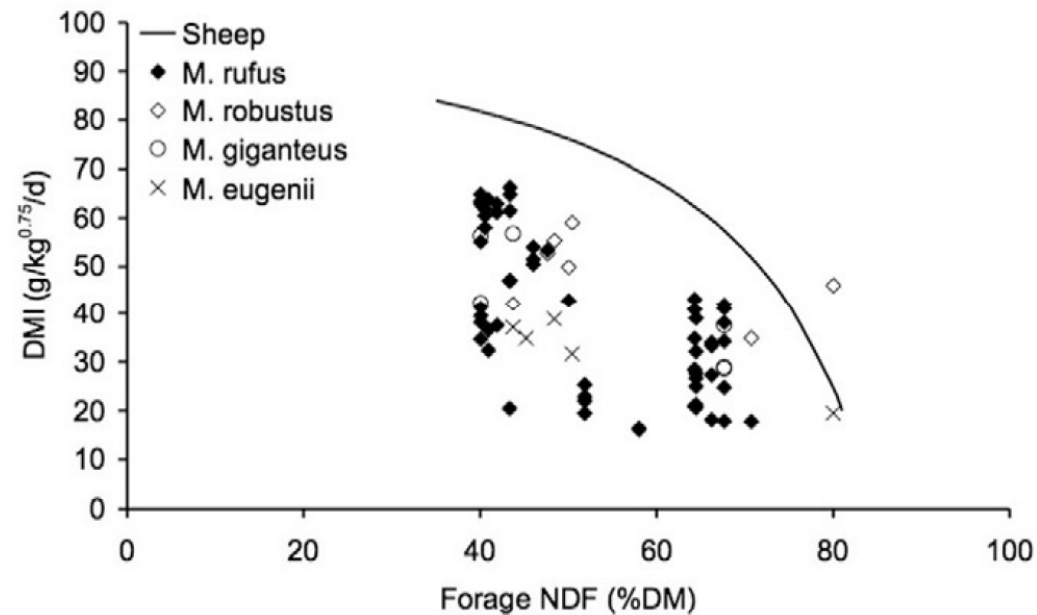
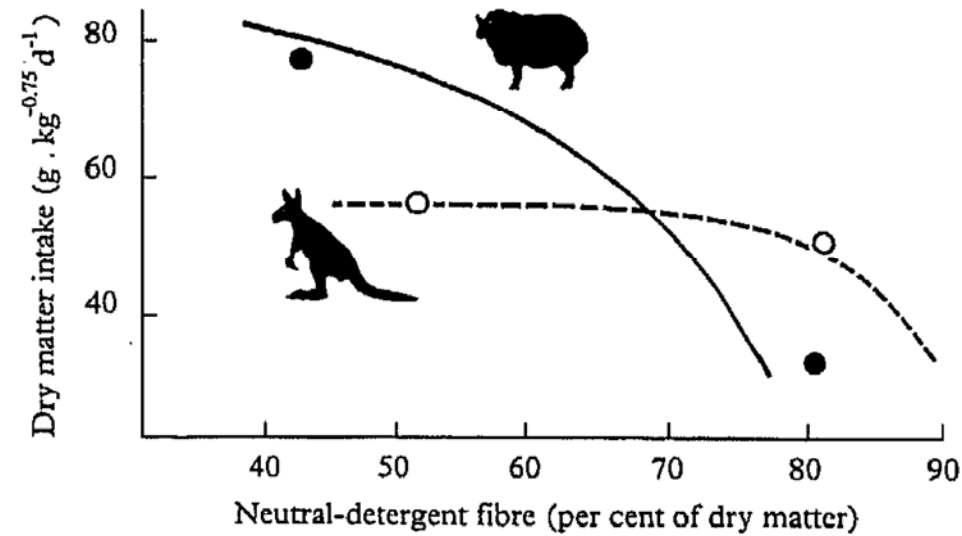


# Kangaroo data



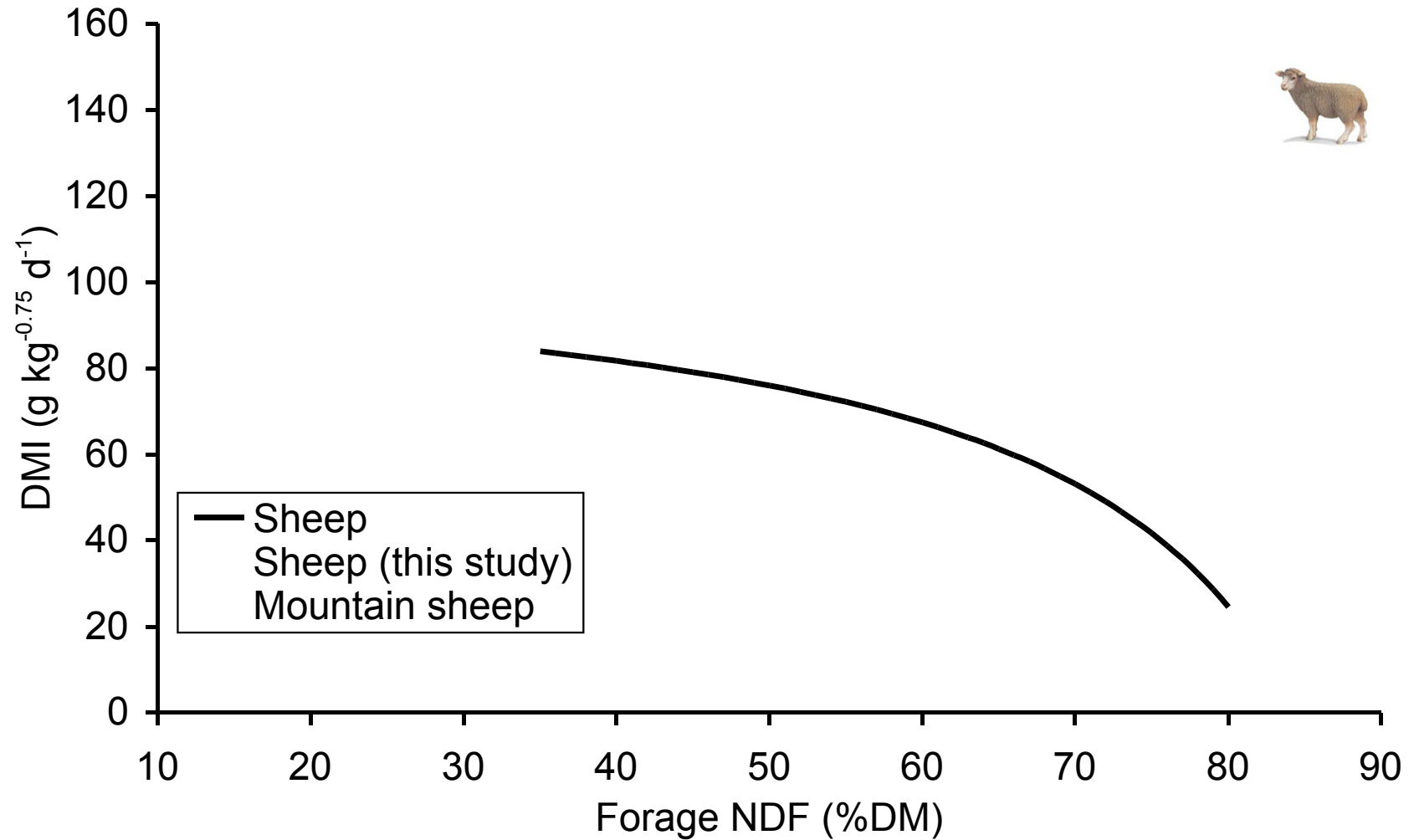


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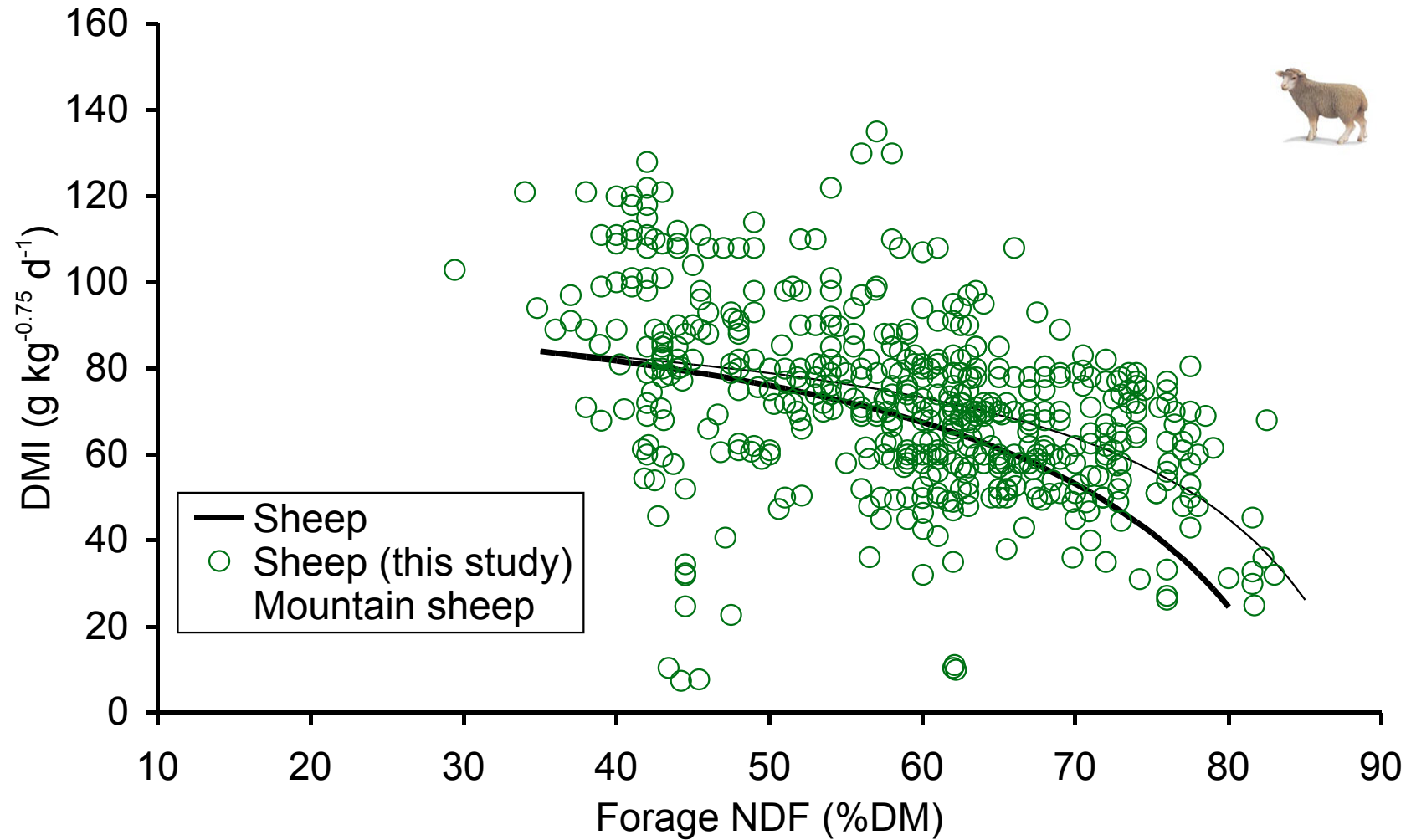


# Sheep data





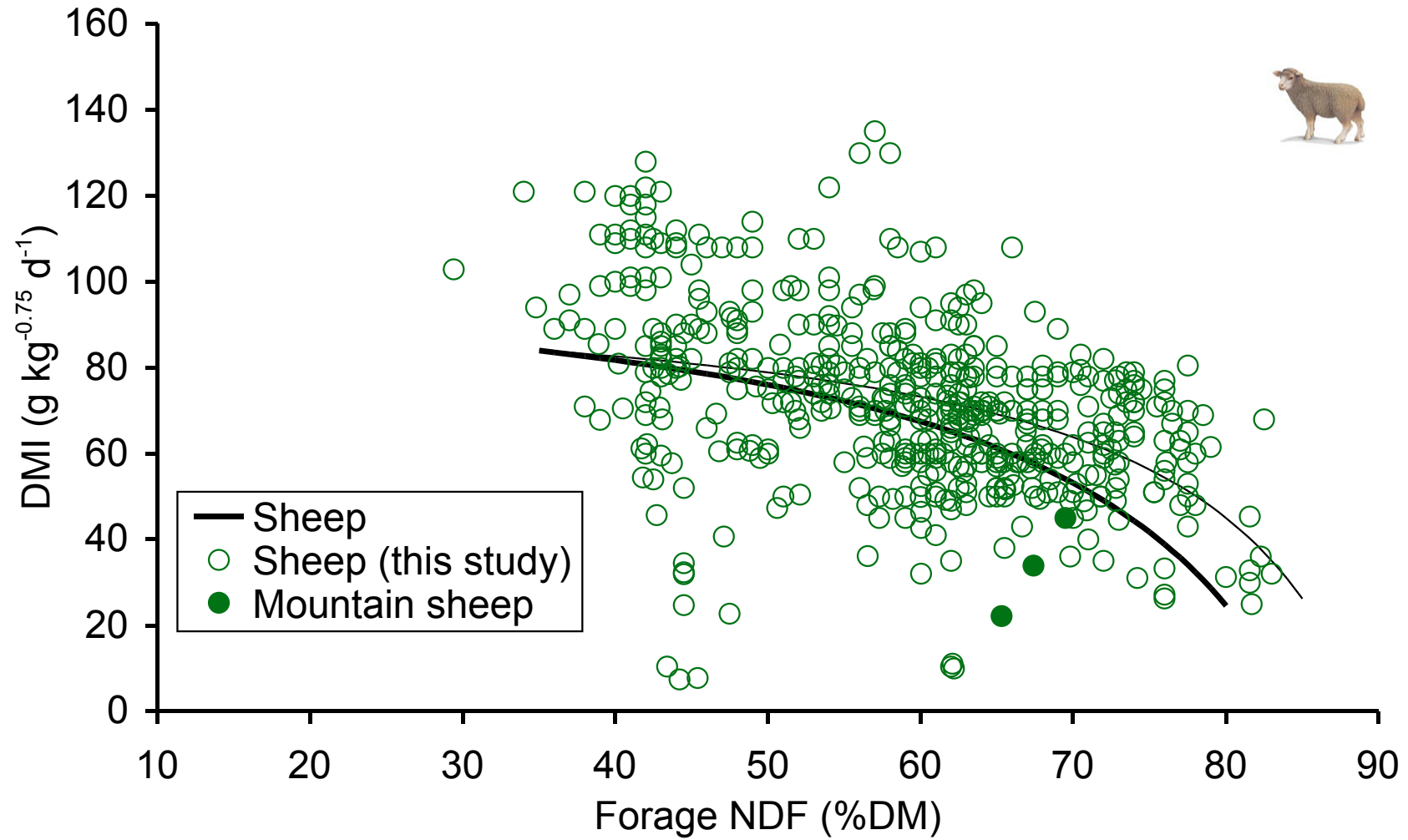
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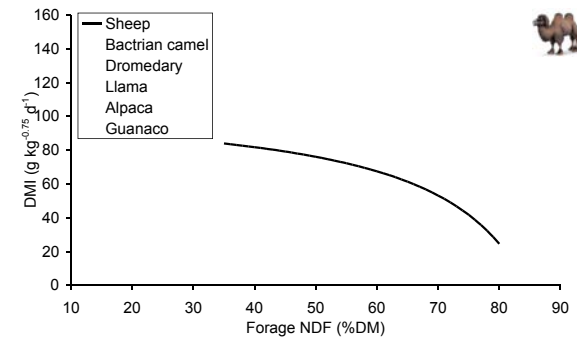
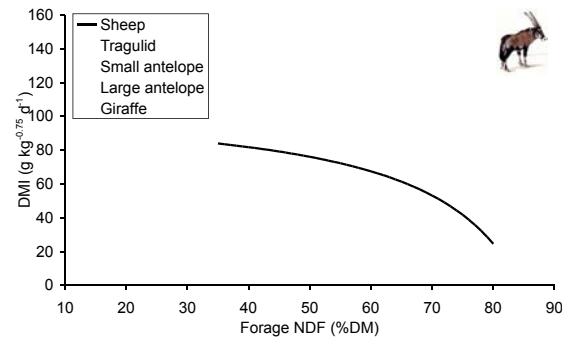
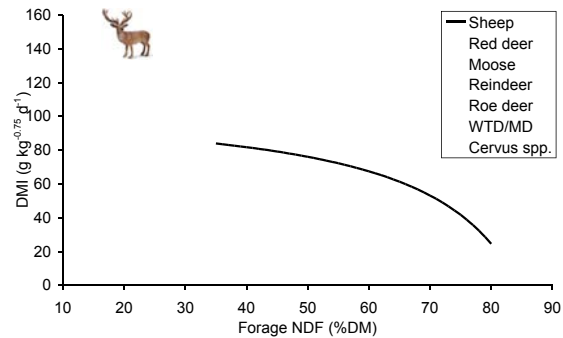
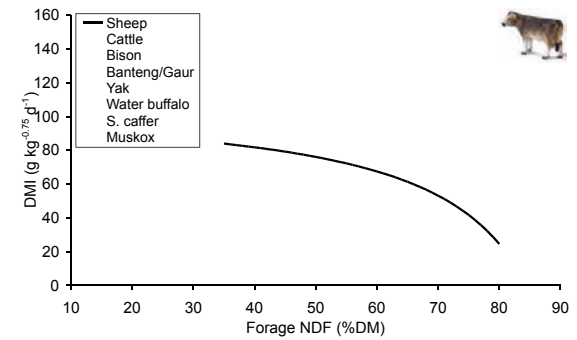
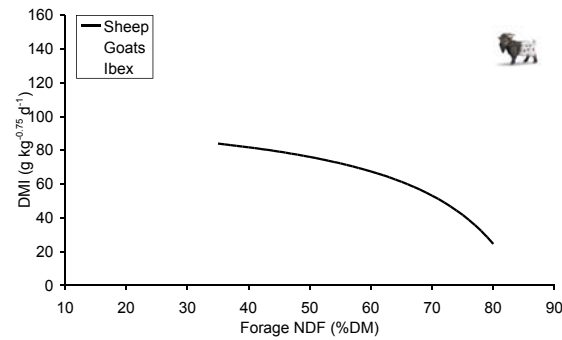
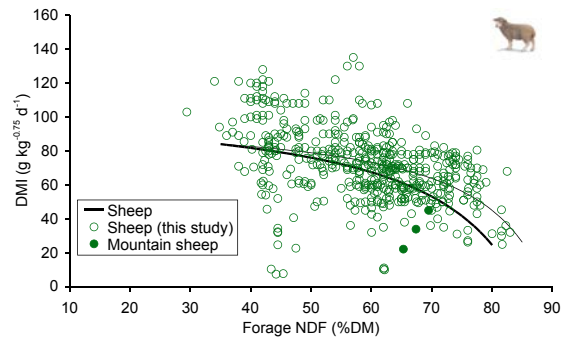


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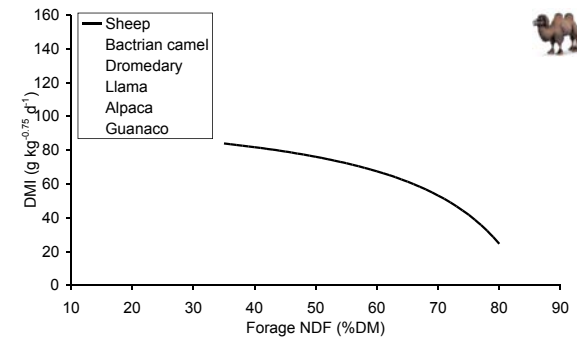
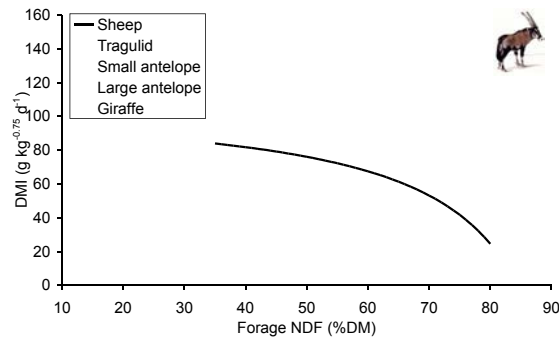
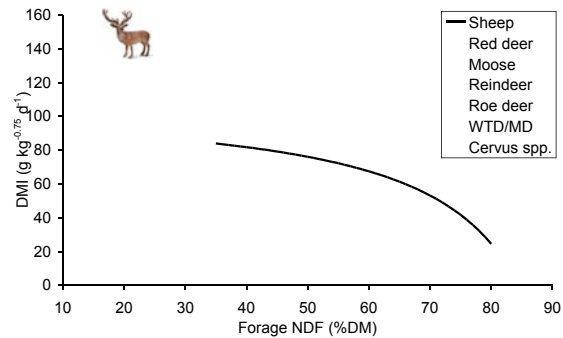
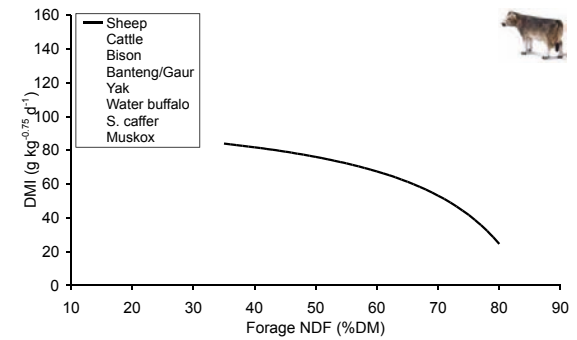
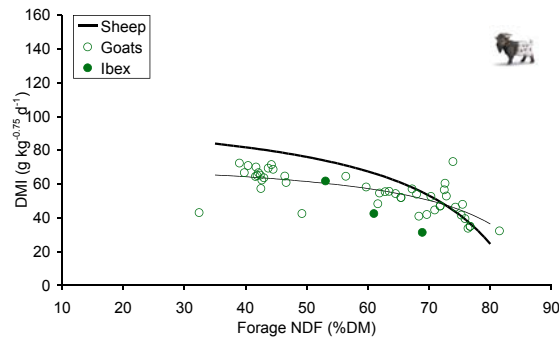
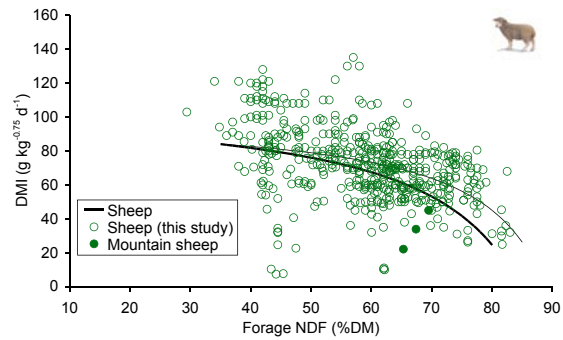


# Ruminant data



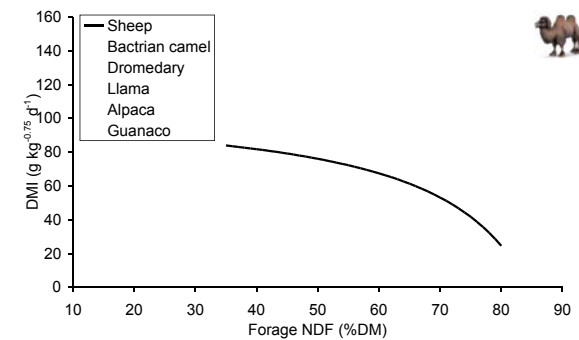
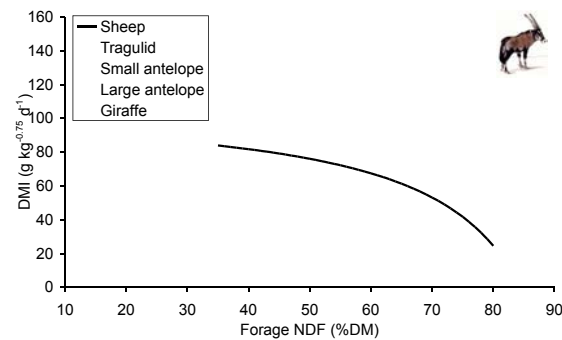
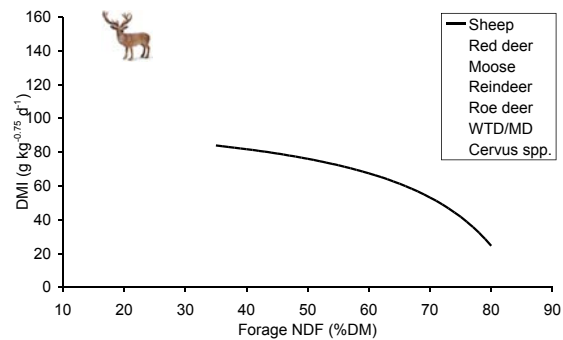
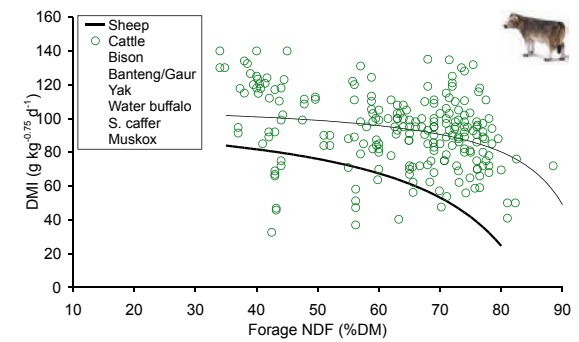
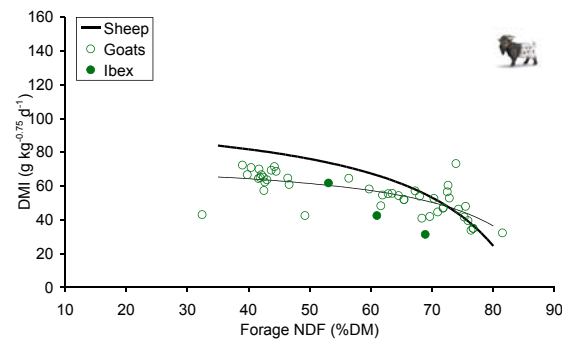
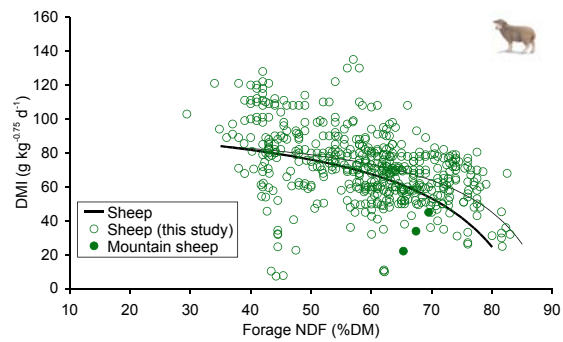


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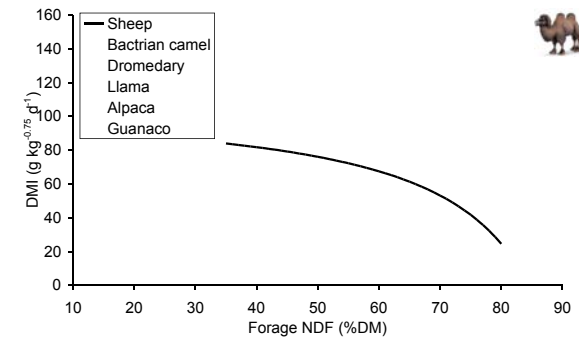
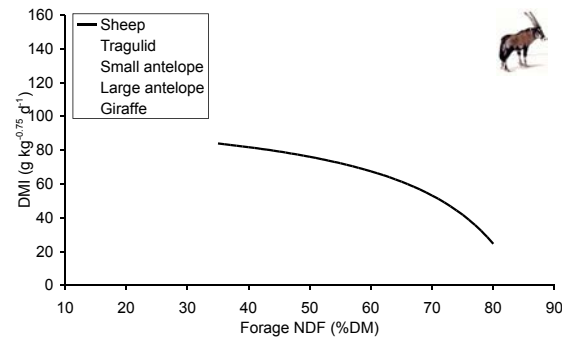
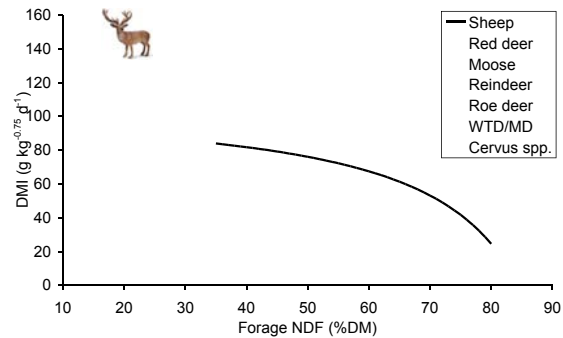
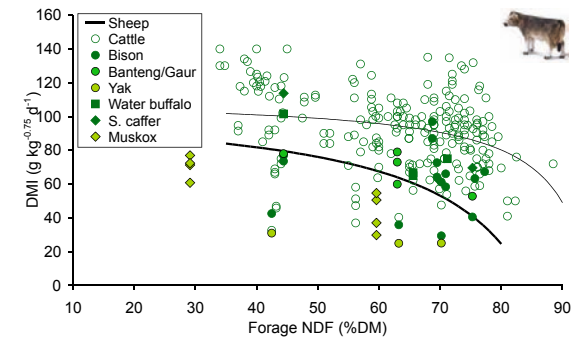
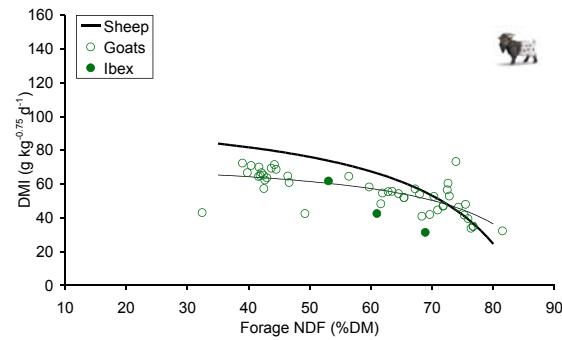
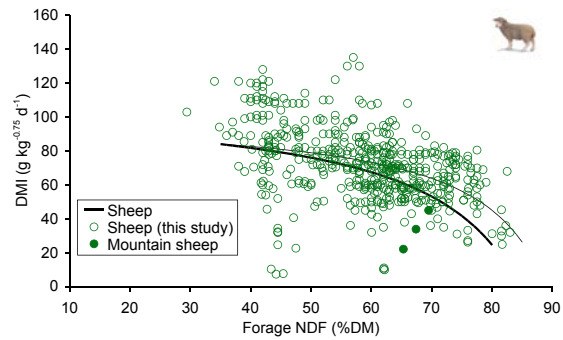


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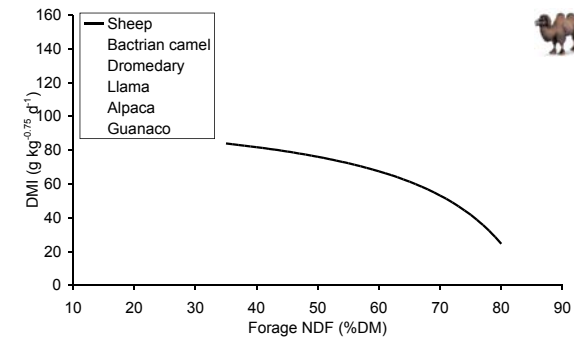
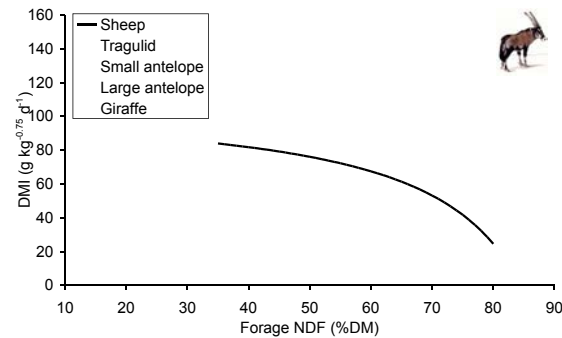
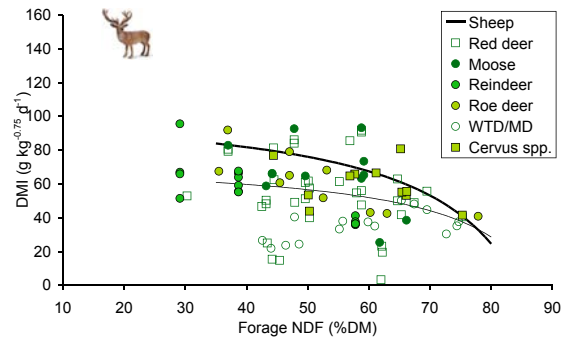
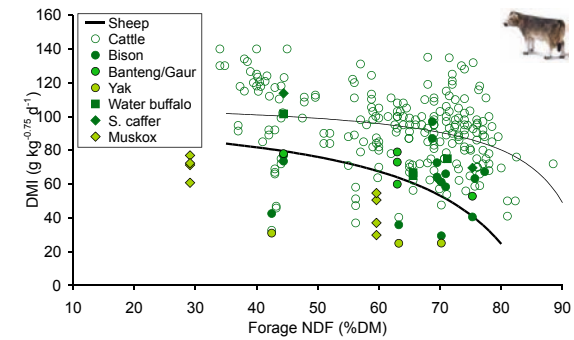
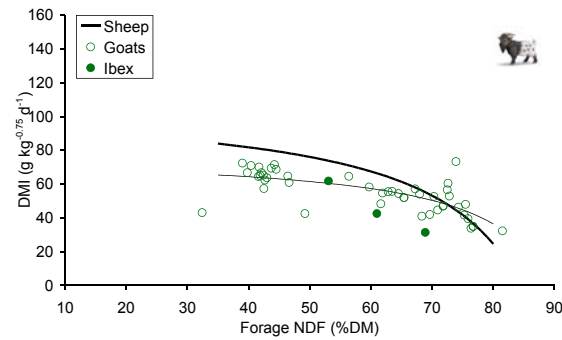
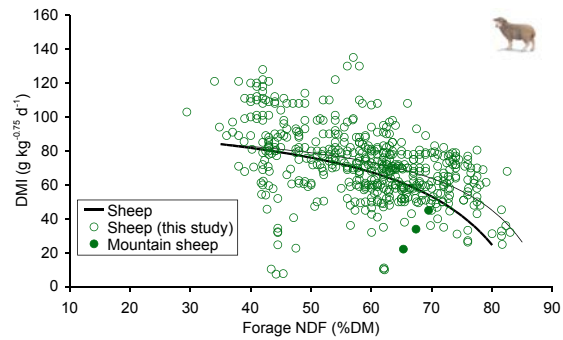


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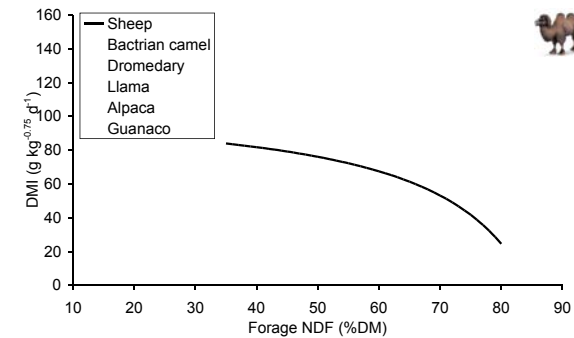
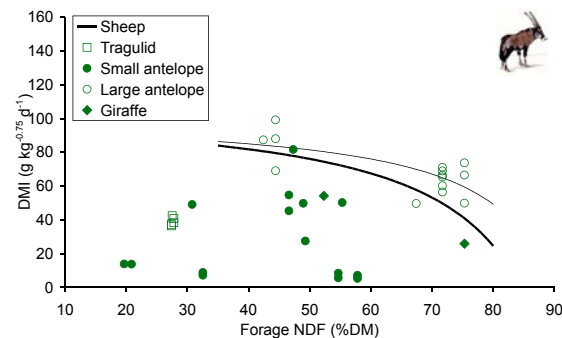
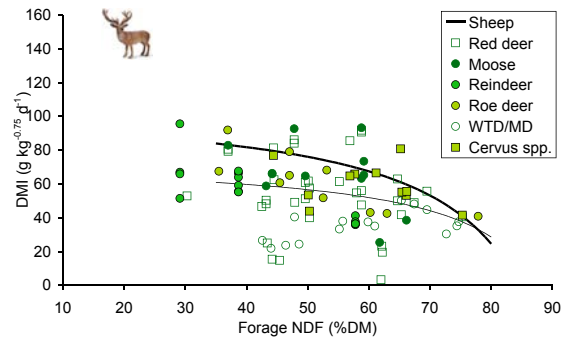
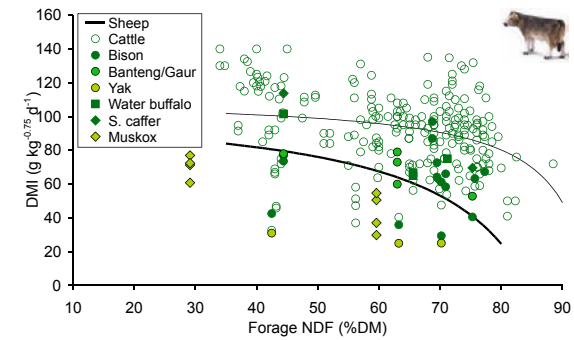
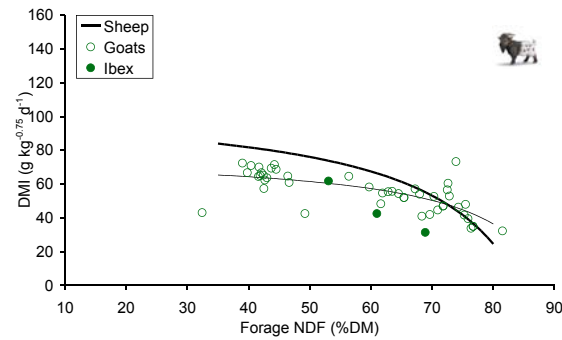
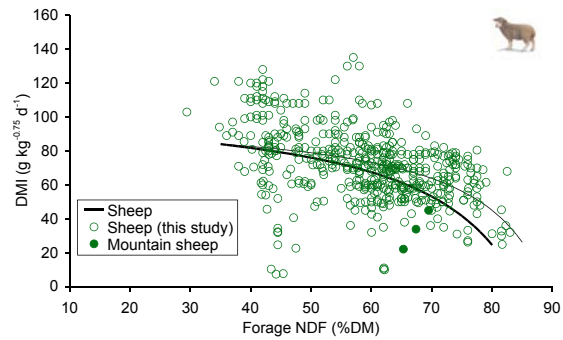


# Ruminant data



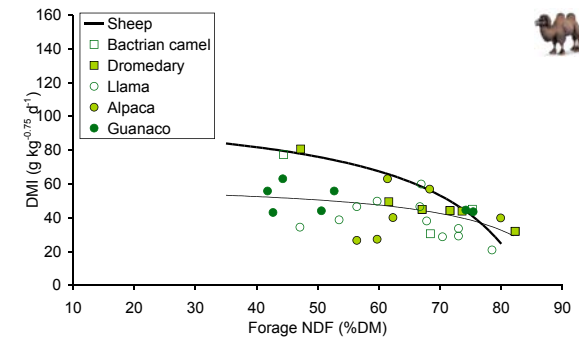
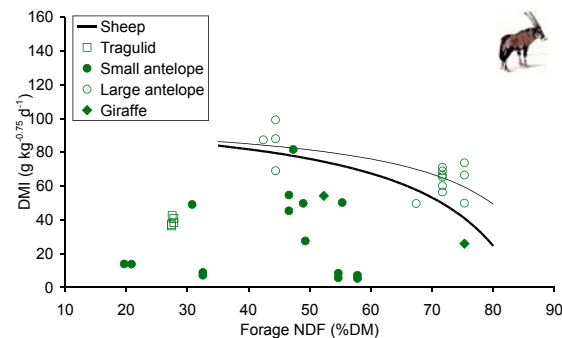
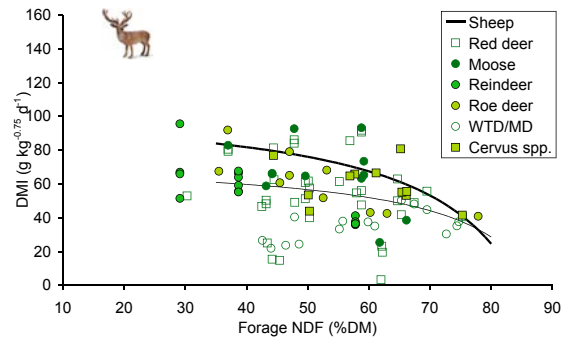
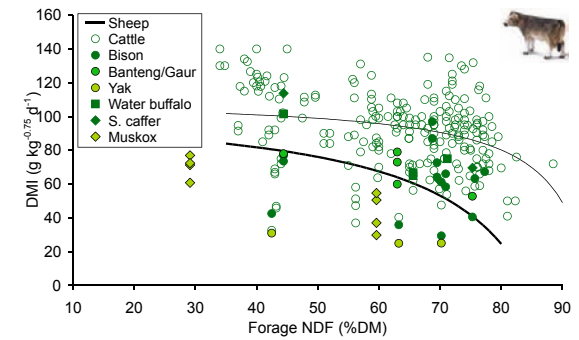
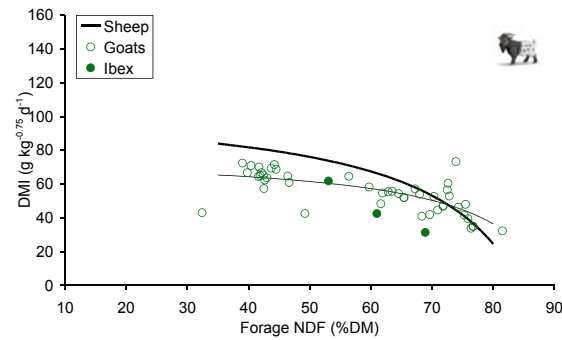
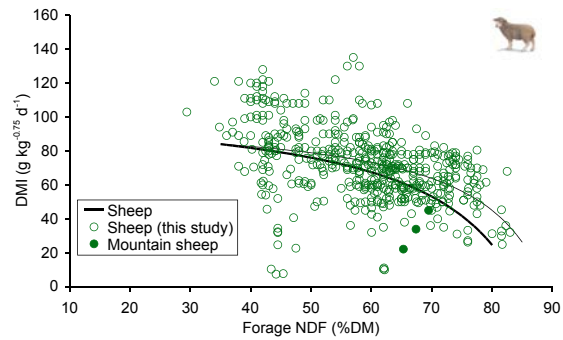


# Ruminant data





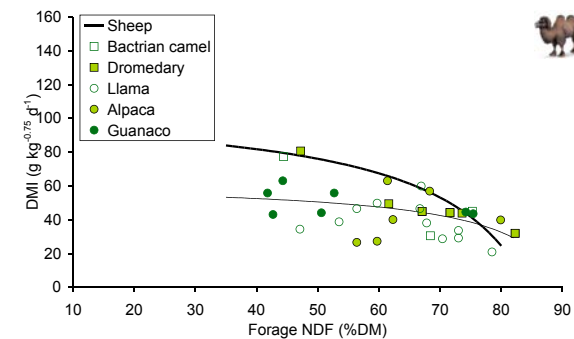
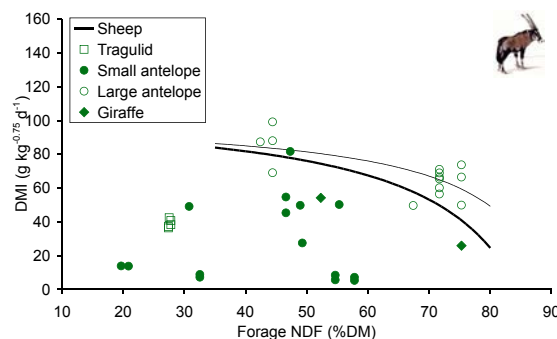
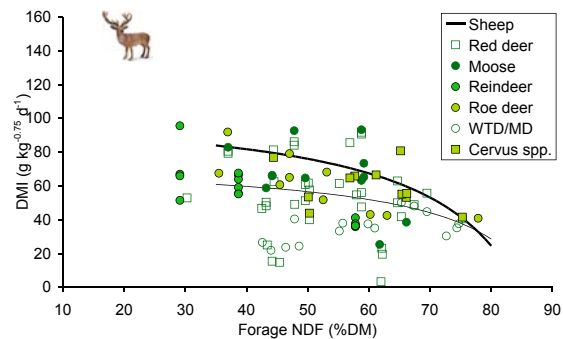
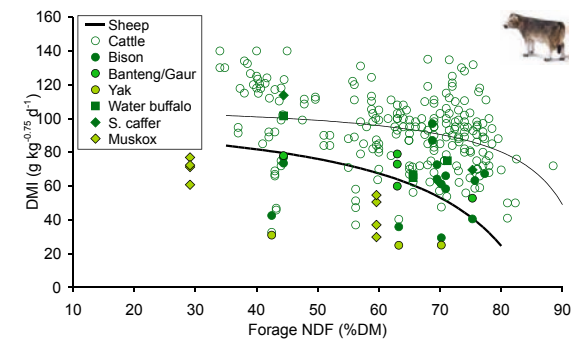
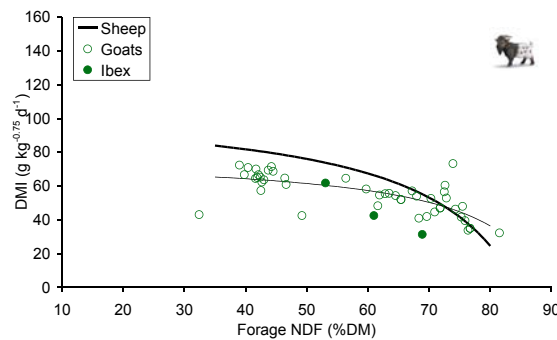
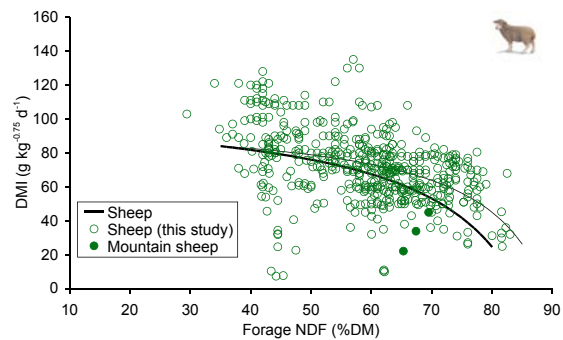
# Ruminant data







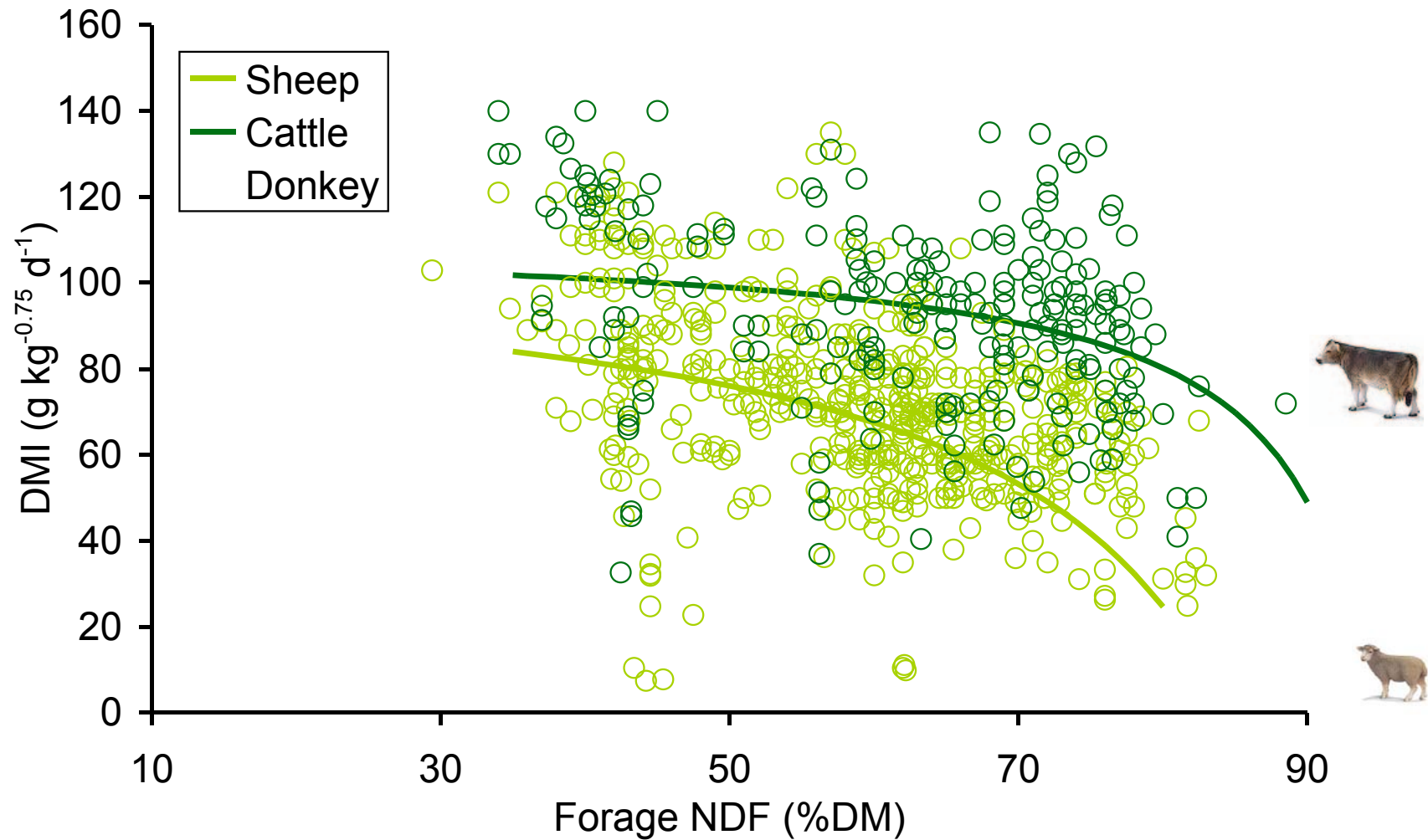
# Ruminant data



**=> in ruminants, food intake *decreases* with decreasing diet quality**

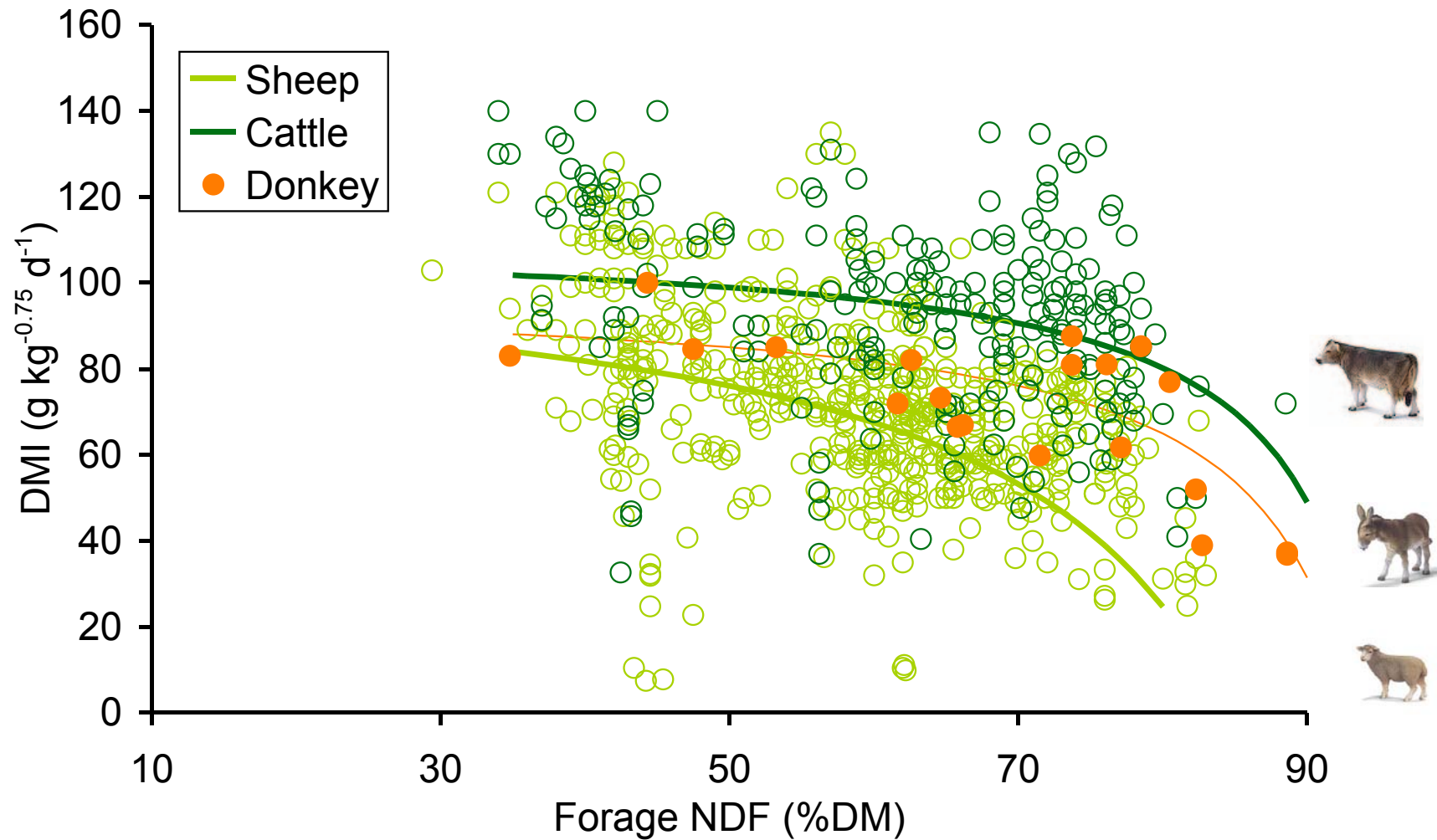


# Comparing ruminants and donkeys



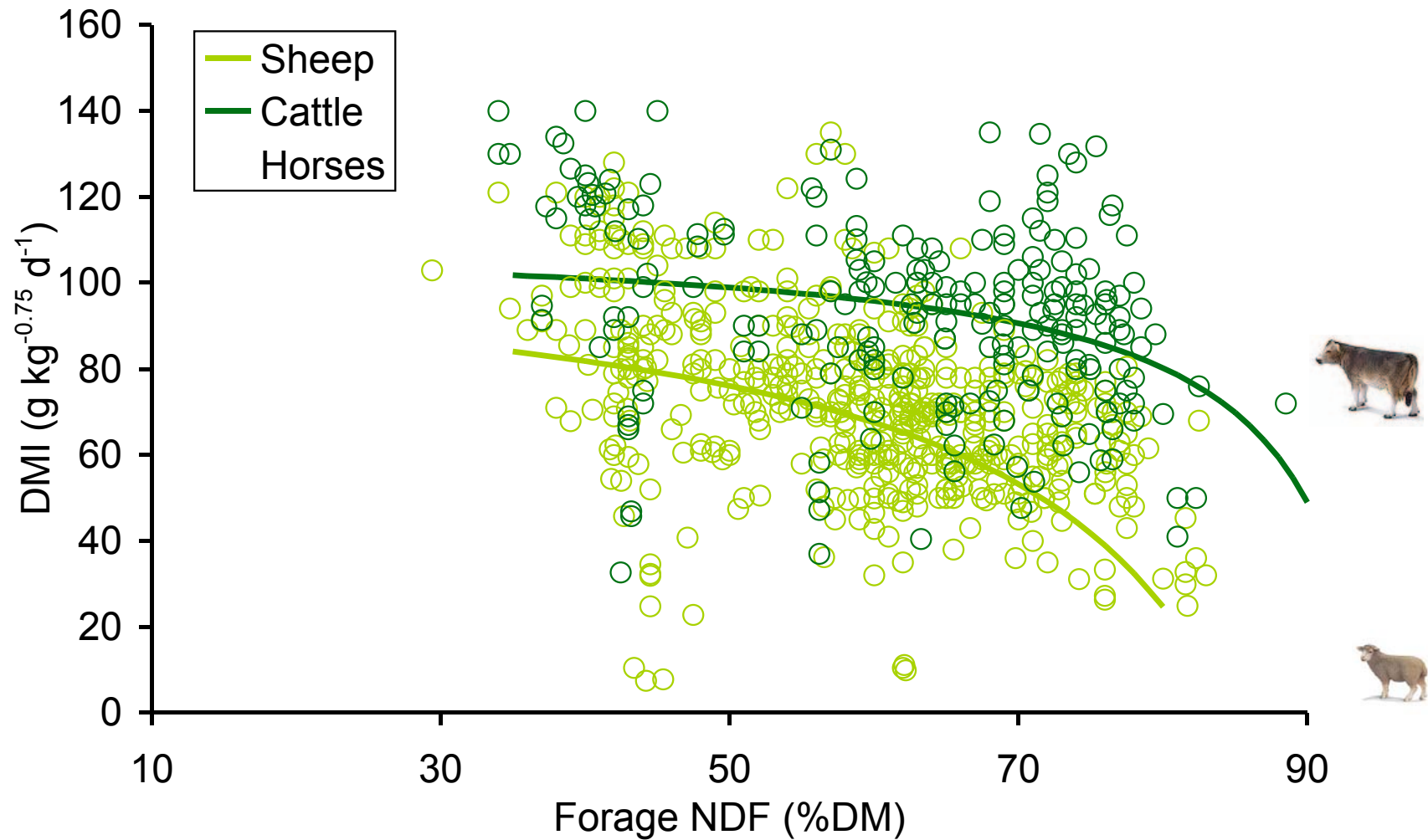


# Comparing ruminants and donkeys



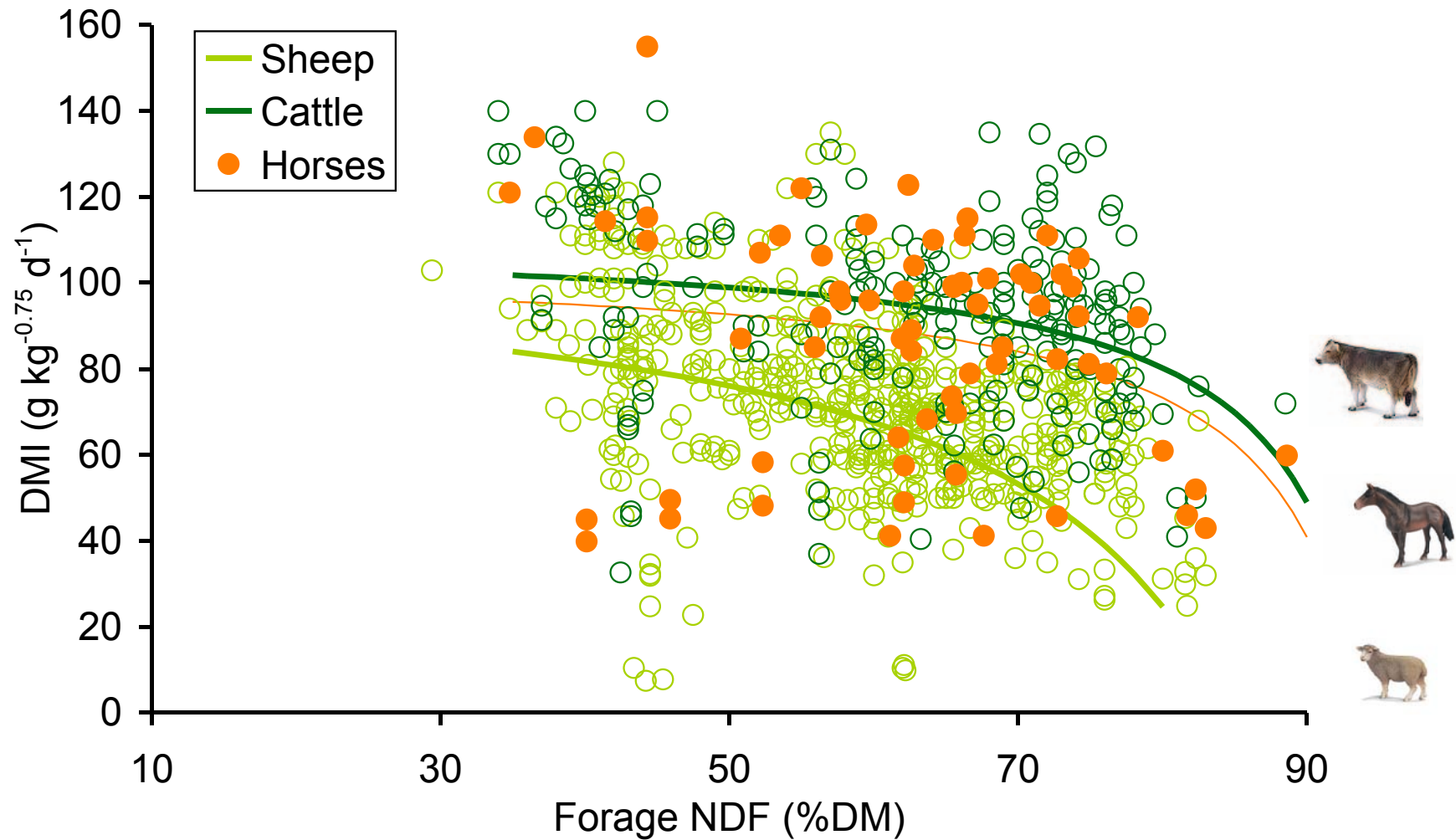


# Comparing ruminants and horses



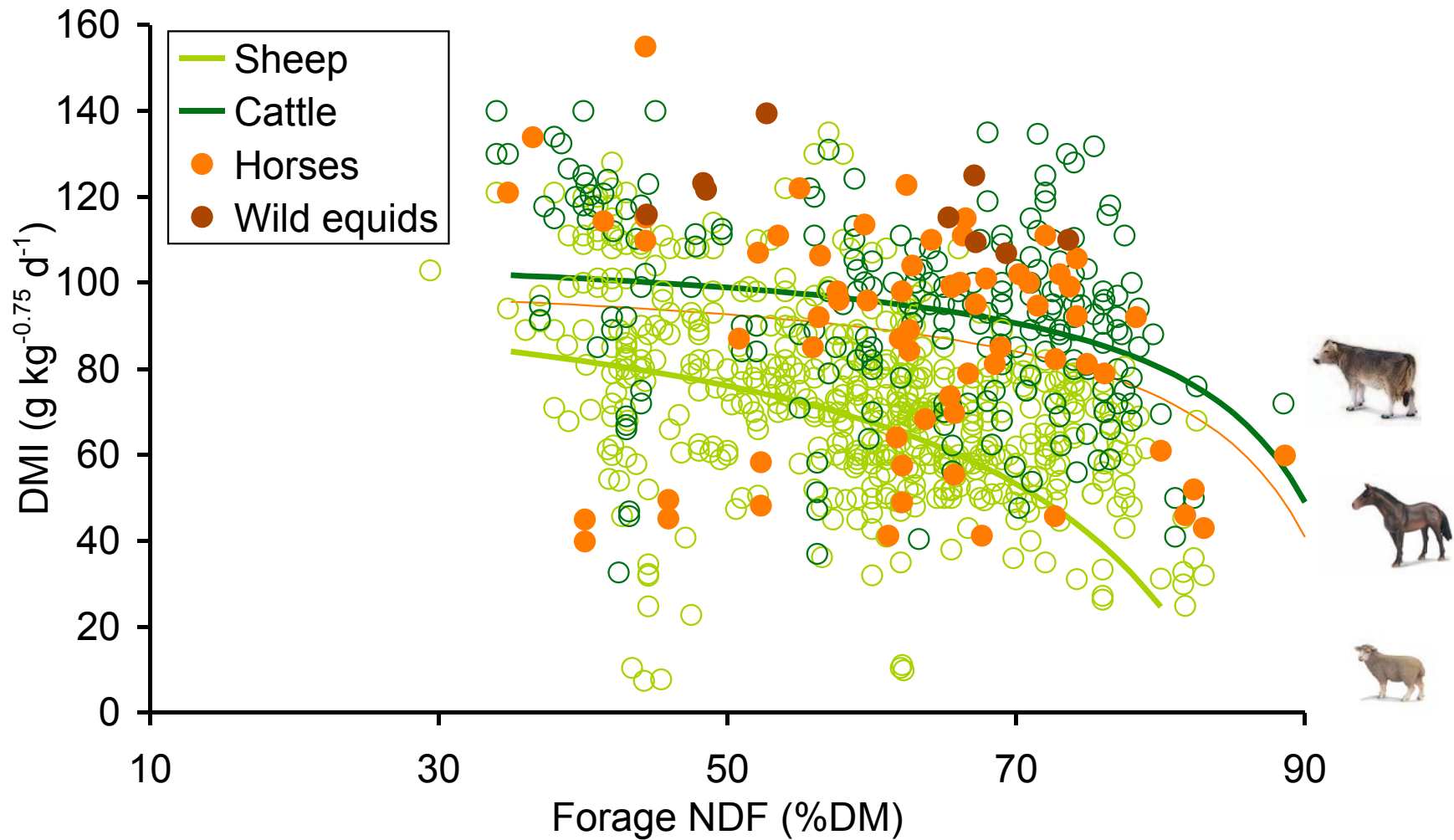


# Comparing ruminants and horses



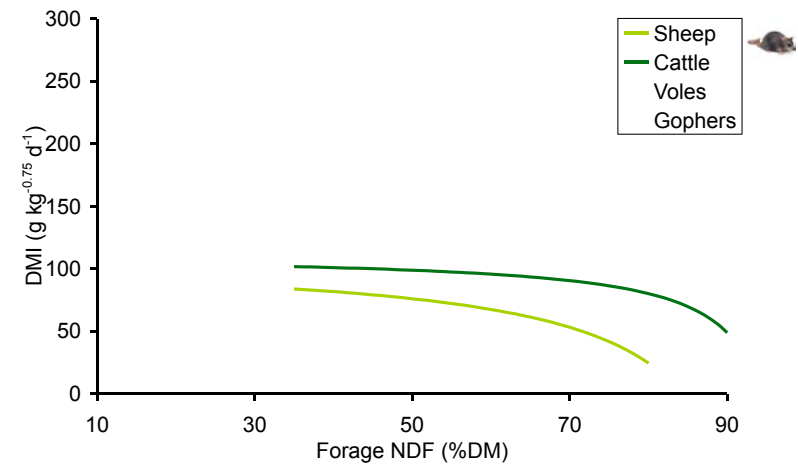
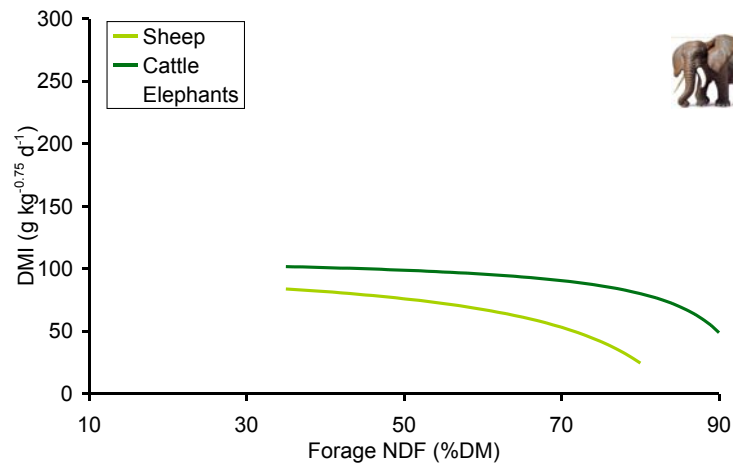
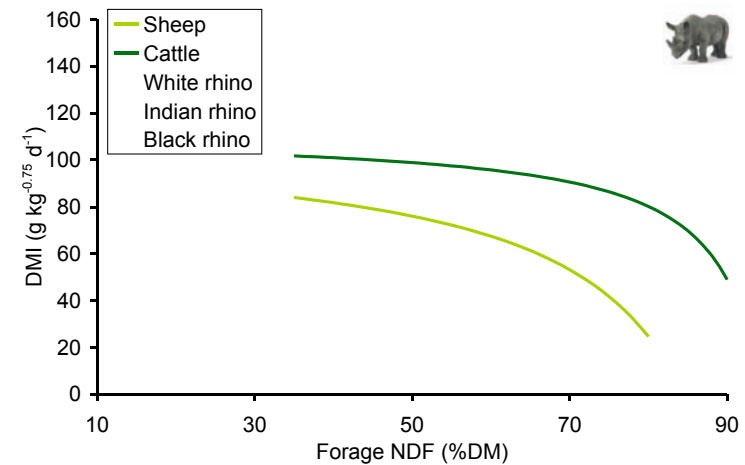
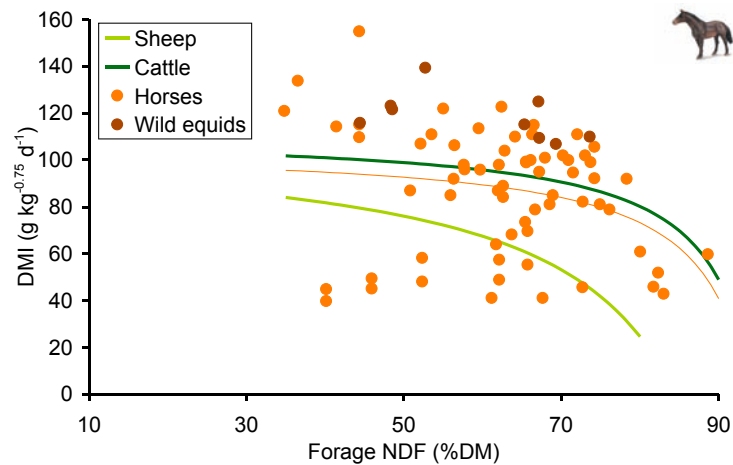


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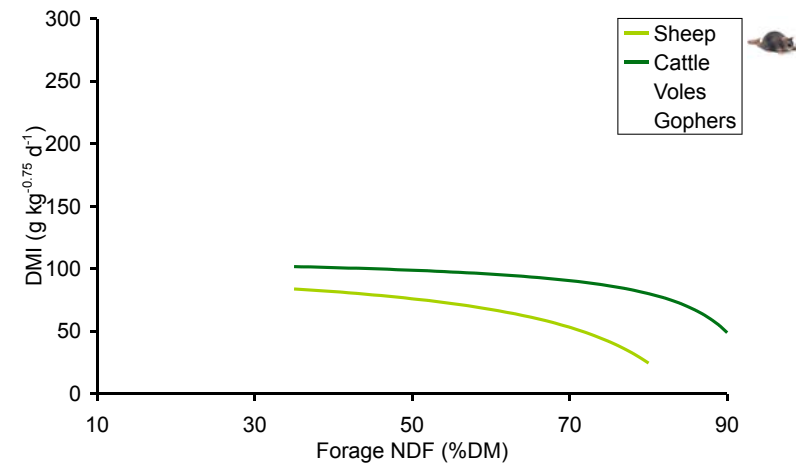
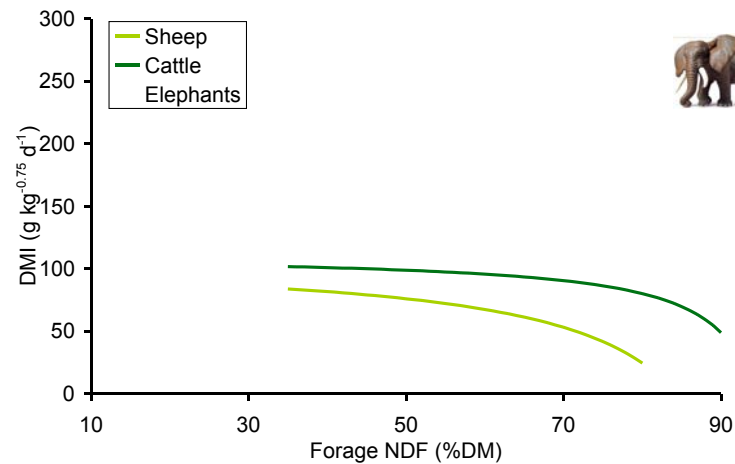
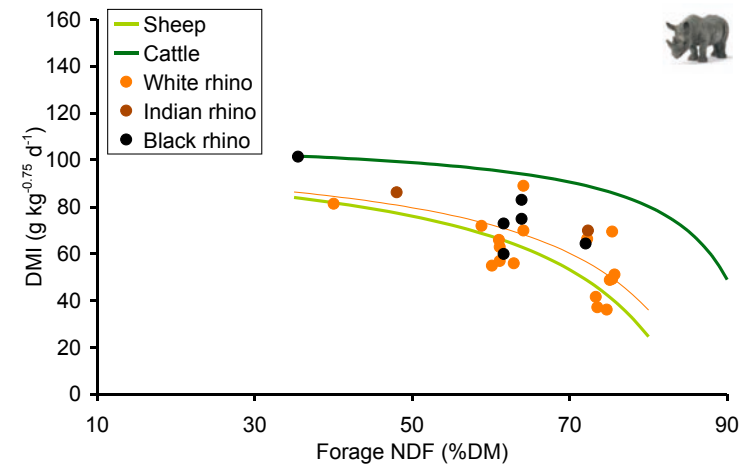
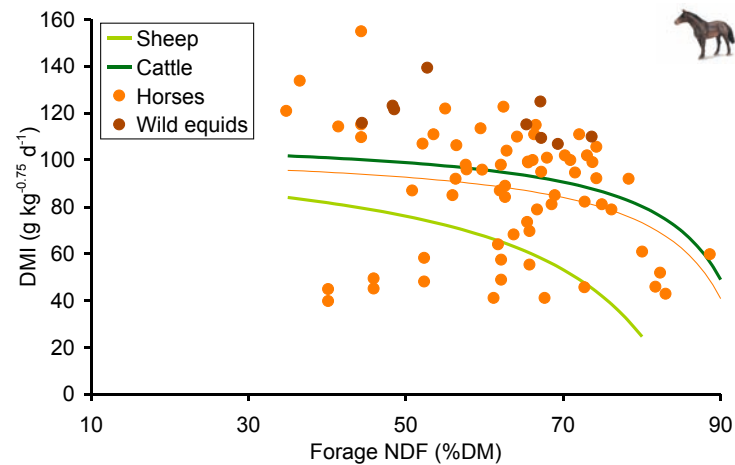


# Comparing ruminants and hindgut fermenters





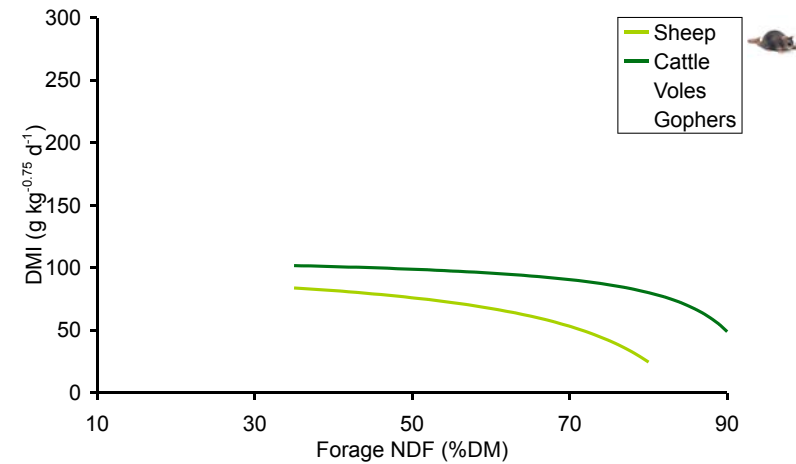
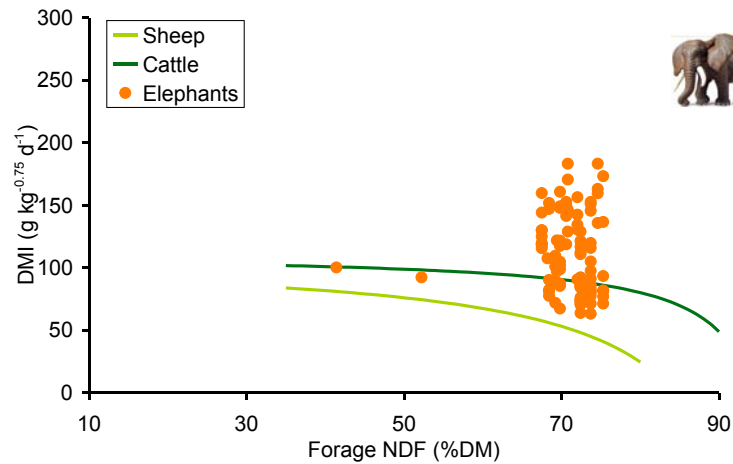
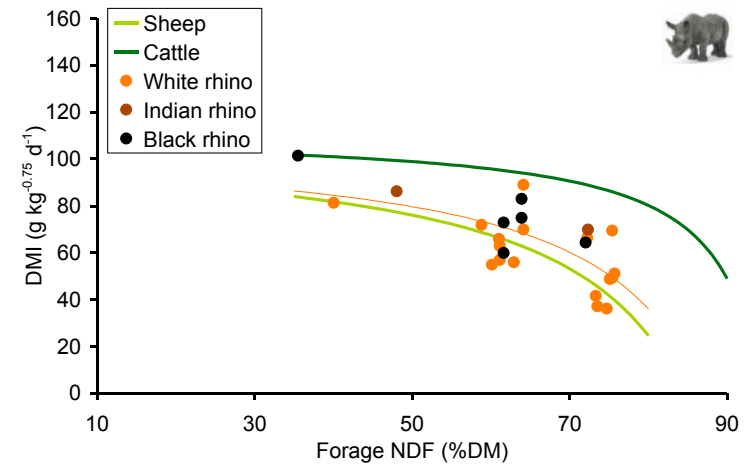
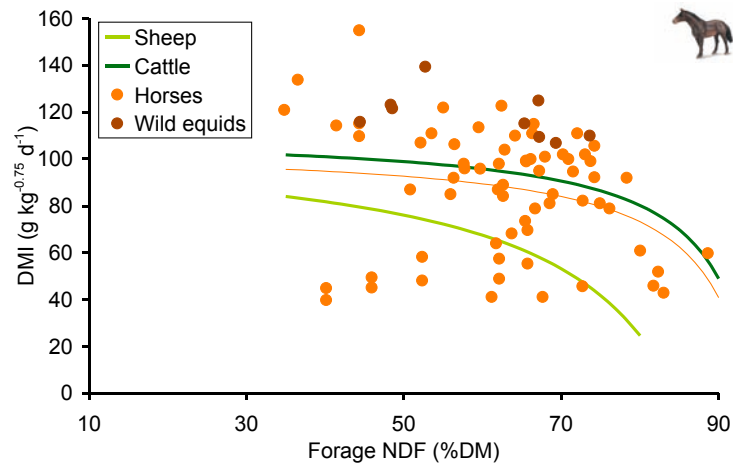
# Comparing ruminants and hindgut fermenters





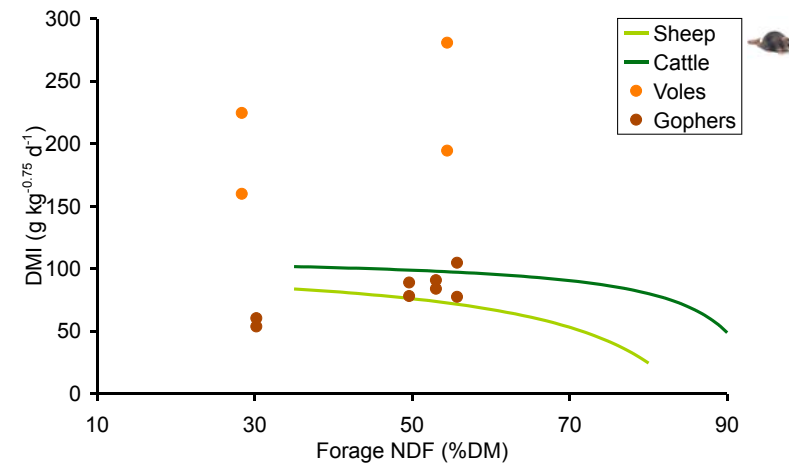
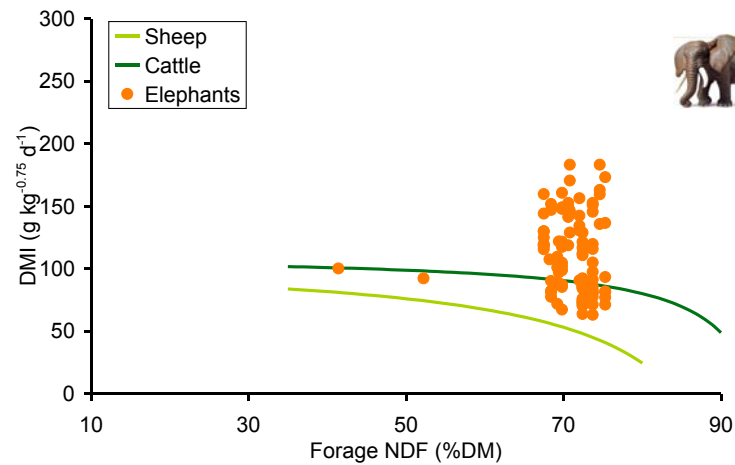
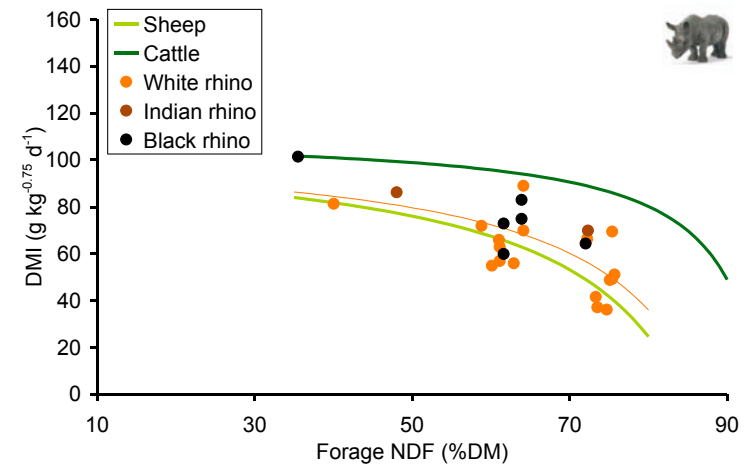
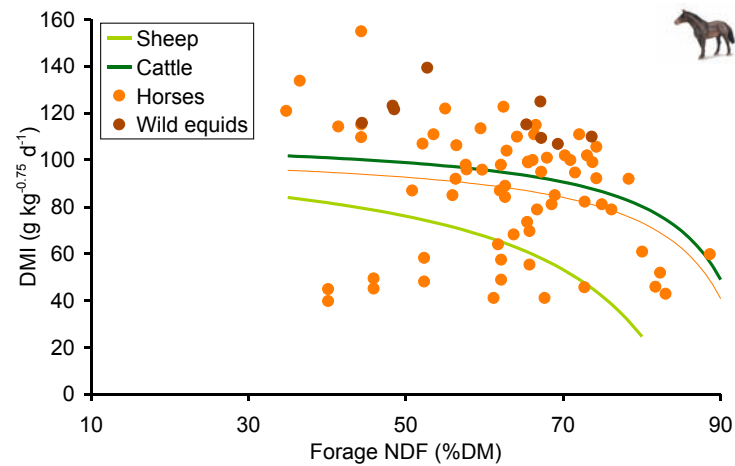


# Comparing ruminants and hindgut fermenters





# Comparing ruminants and hindgut fermenters





## Results

1. General paucity of experimental data for many species
2. Experimental data on most herbivores indicates **declining** intake as forage quality declines
3. Ruminants are similar in this respect to other groups such as horses or rhinos, or kangaroos
4. Elephants and small hindgut fermenters might be exceptions



# Implications

1. Rather than “eating more when forage quality declines”, many herbivores appear to follow a strategy to eat more when forage quality is high (“asynchronous response” as in a seasonal environment).



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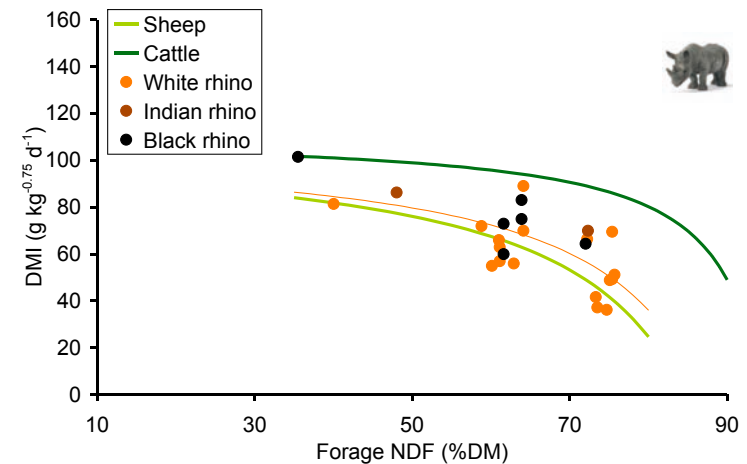
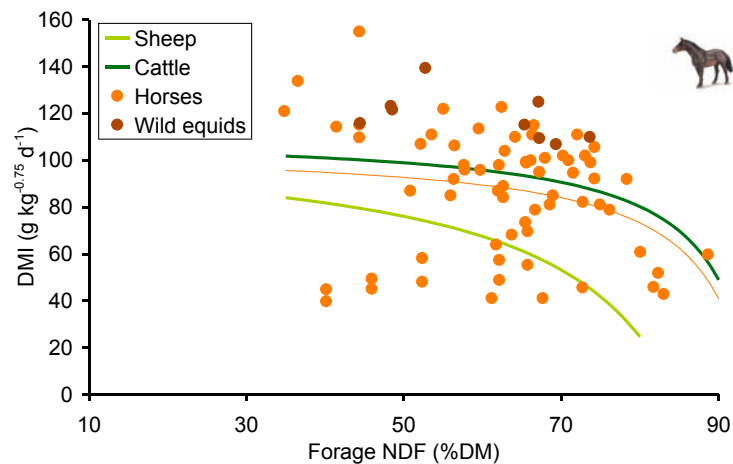
# Implications

1. Rather than “eating more when forage quality declines”, many herbivores appear to follow a strategy to eat more when forage quality is high (“asynchronous response” as in a seasonal environment).
2. No systematic difference due to digestive anatomy (difference between cattle and sheep as large as between equids and rhinos)
3. But hindgut fermentation design might allow higher intakes (elephants, voles/gophers)



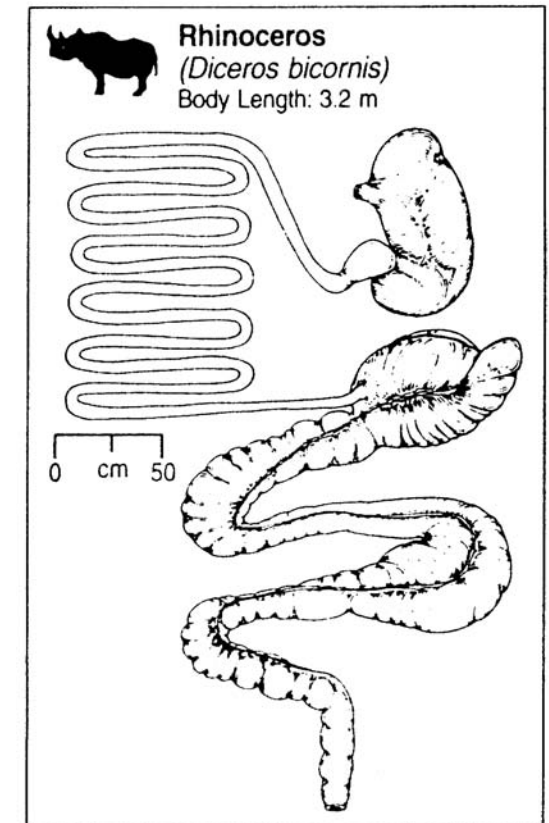
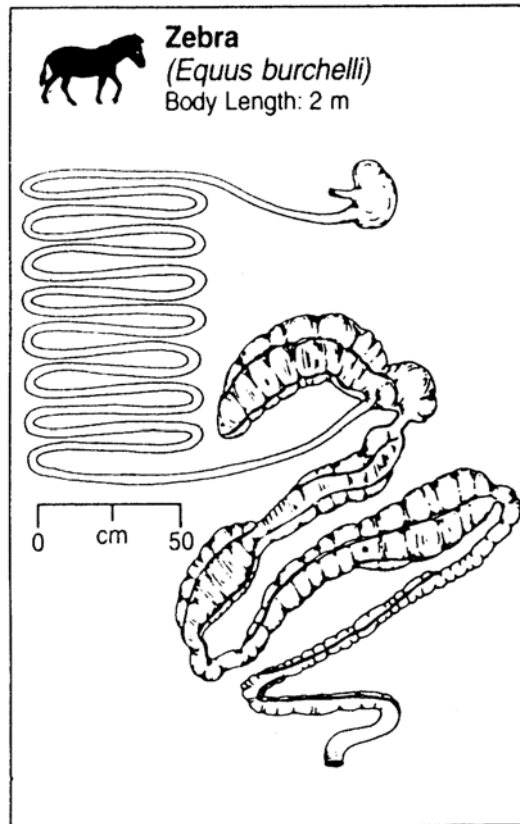
# Implications

## 4. Overestimation of relevance of anatomical features (equid-rhino-comparison)?





# Equids vs. rhinos

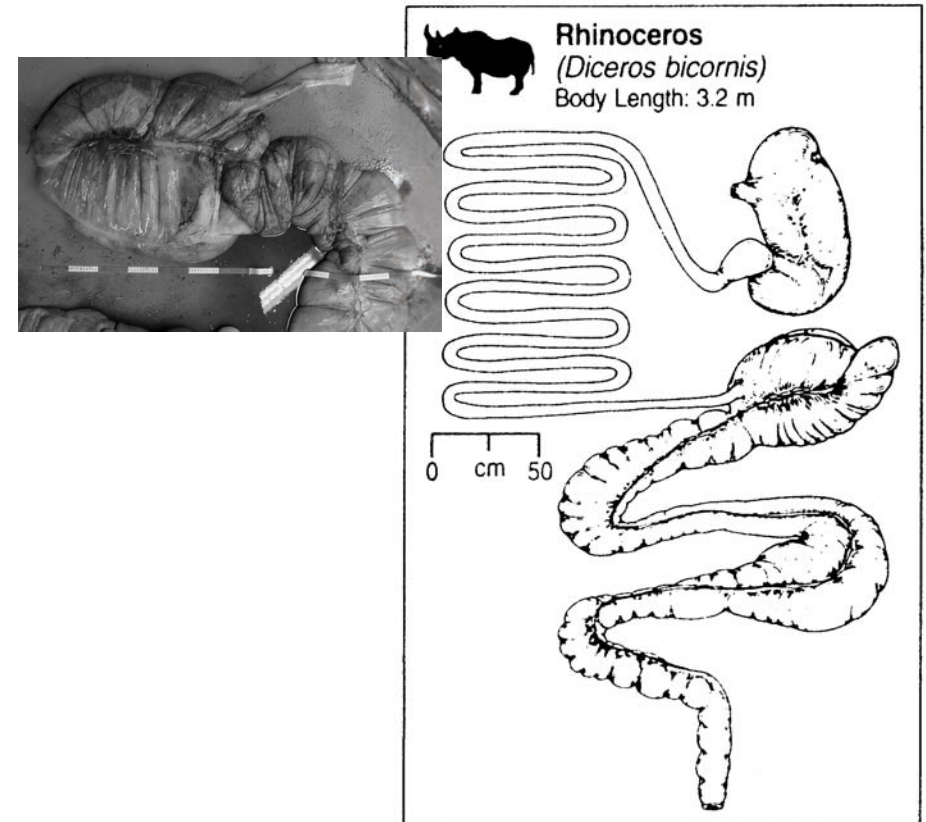
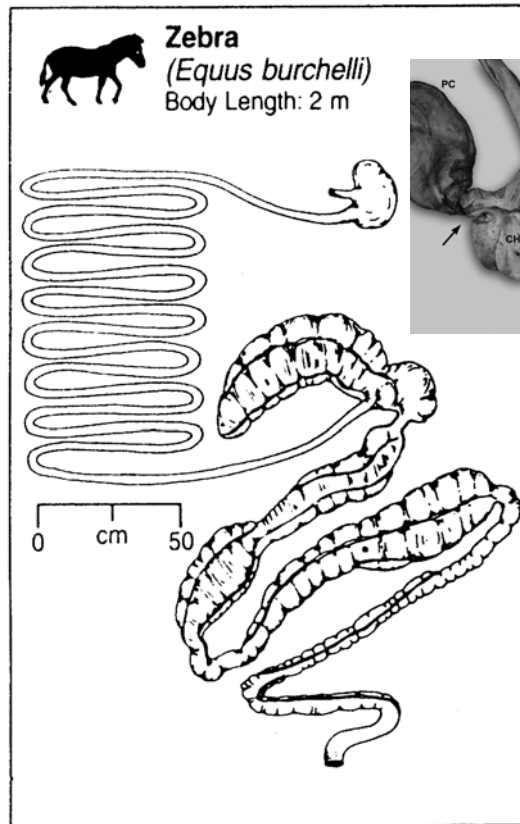


from Stevens und Hume (1995), Clauss et al. (2008)





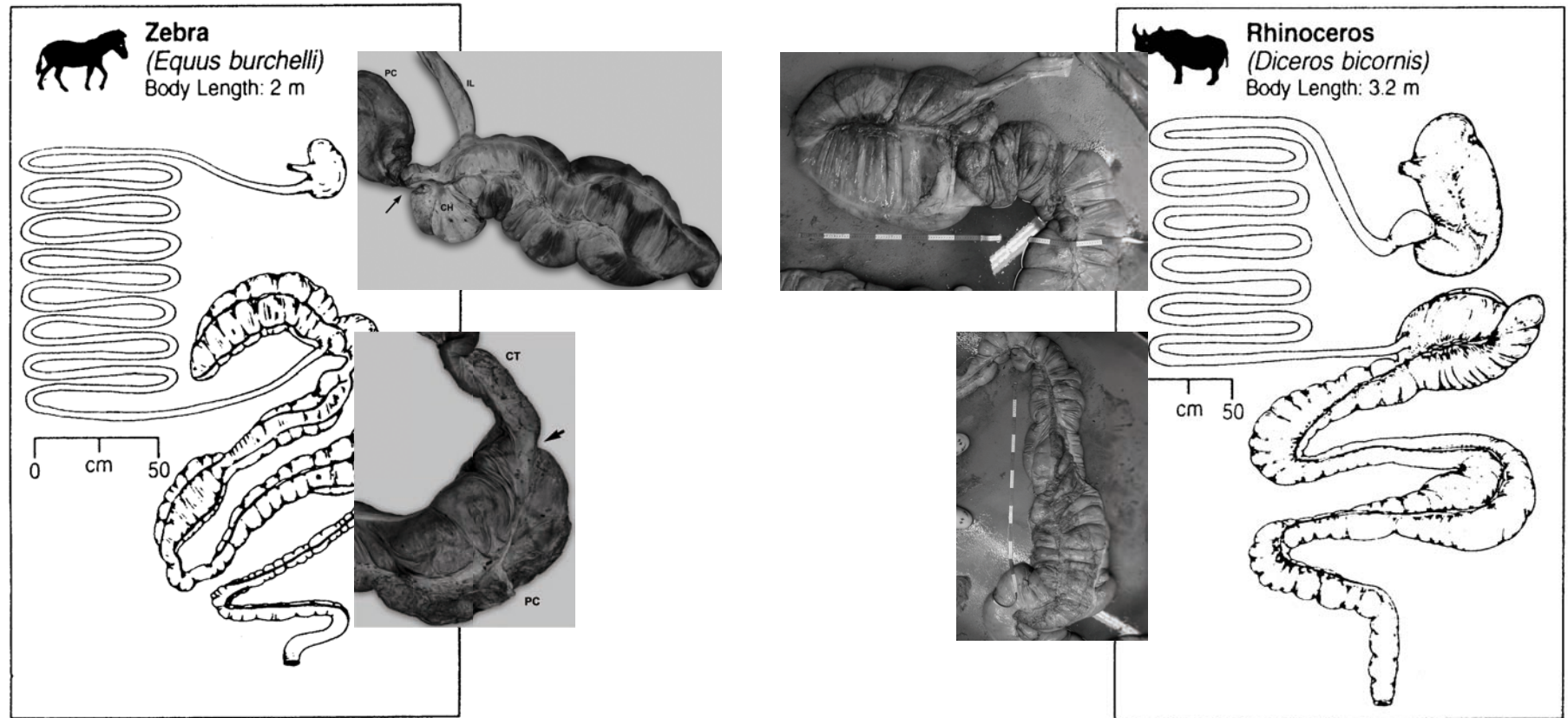
# Equids vs. rhinos



from Stevens und Hume (1995), Clauss et al. (2008); Photo D. Müller



# Equids vs. rhinos



from Stevens und Hume (1995), Clauss et al. (2008); Photo D. Müller



# Implications

4. Overestimation of relevance of anatomical features (equid-rhino-comparison)? (higher intake in equids in spite of anatomical bottlenecks)
5. Body size effect: seasonal strategy only possible at a certain body size (fat stores/fasting endurance) - small species cannot follow this strategy - they have to eat more on low quality or go into hibernation



# Implications

4. Overestimation of relevance of anatomical features (equid-rhino-comparison)? (higher intake in equids in spite of anatomical bottlenecks)
5. Body size effect: seasonal strategy only possible at a certain body size (fat stores/fasting endurance) - small species cannot follow this strategy - they have to eat more on low quality or go into hibernation
6. Higher endogenous losses on low-quality foods? Increase in food intake only possible if end. losses are limited - coprophagy?



# Implications

7. Need for long-term trials!

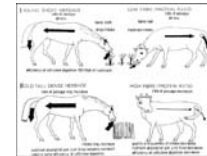


# Prerequisites for such a study



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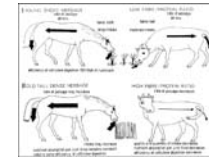
1. Knowledge of current concepts





# Prerequisites for such a study

1. Knowledge of current concepts
2. Understanding of forage quality



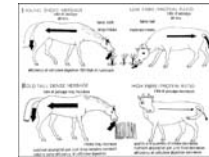
**NDF (%DM)**





# Prerequisites for such a study

1. Knowledge of current concepts
2. Understanding of forage quality
3. Understanding of allometry



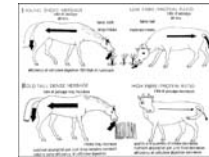
**NDF (%DM)**

**g/kg<sup>0.75</sup>/d**



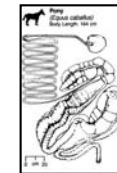
# Prerequisites for such a study

1. Knowledge of current concepts
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**NDF (%DM)**

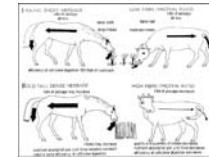
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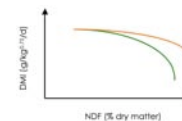
# Prerequisites for such a study

1. Knowledge of current concepts
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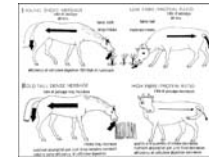
**$\text{g/kg}^{0.75}/\text{d}$**





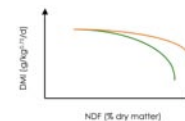
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5. Basic maths
6. Access to literature



**NDF (%DM)**

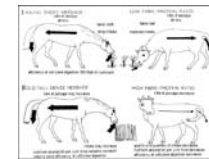
**$\text{g/kg}^{0.75}/\text{d}$**





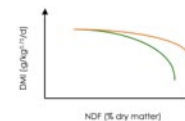
# Prerequisites for such a study

1. Knowledge of current concepts
2. Understanding of forage quality
3. Understanding of allometry
4. Understanding of anatomy/physiology
5. Basic maths
6. Access to literature
7. ... but no experiments!



**NDF (%DM)**

**$\text{g/kg}^{0.75}/\text{d}$**





*thank you  
for your attention*