Feeding ruminants

Marcus Clauss
Clinic for Zoo Animals, Exotic Pets and Wildlife, Vetsuisse Faculty
University of Zurich
mclauss@vetclinics.uzh.ch

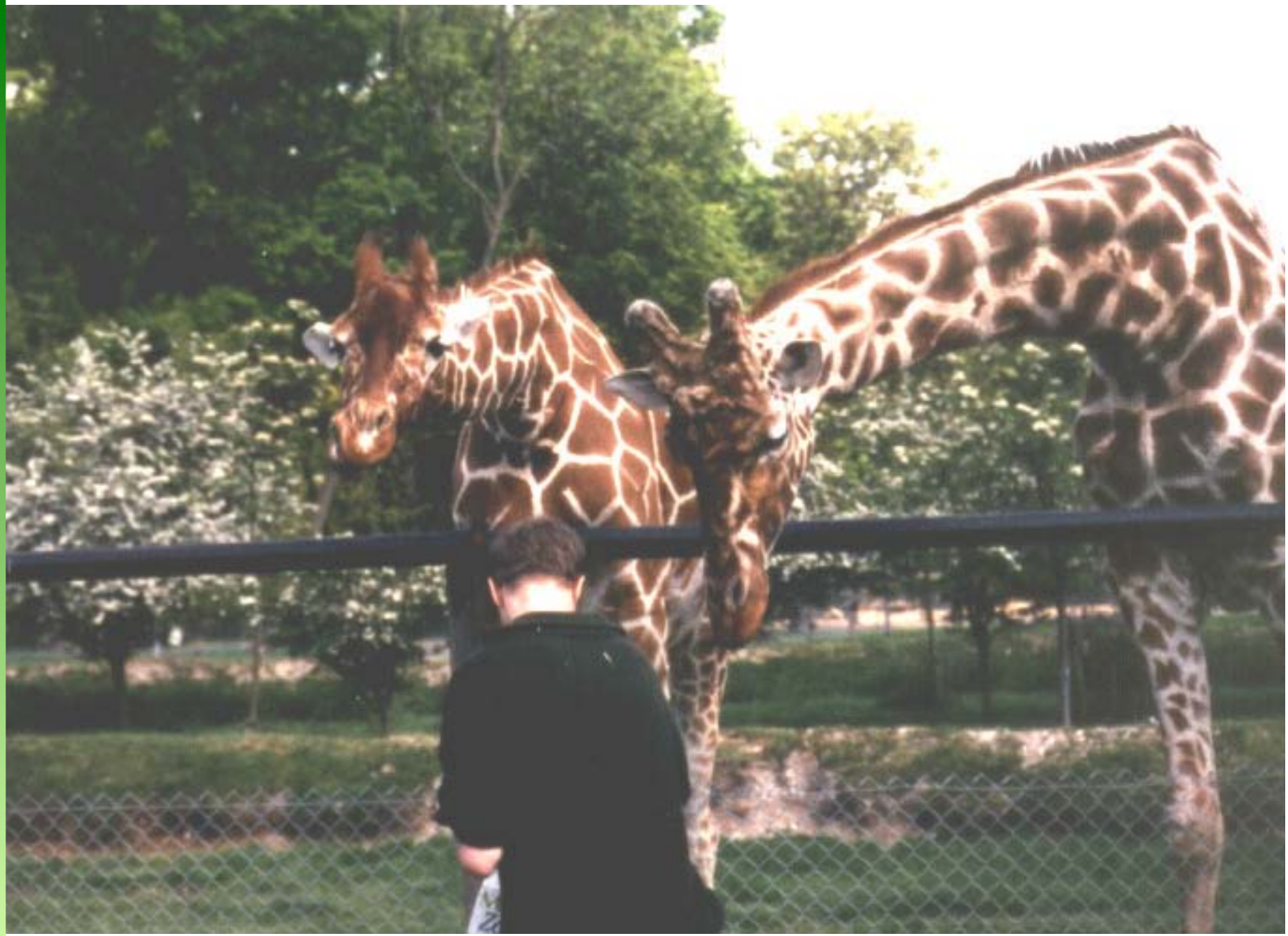


Photo: Irene Clauss

Nutrition-related problems in captive giraffe

- phytobezoars
- rumen acidosis
- partial ruminal papillation loss
- "peracute mortality syndrome"

Phytobezoars

Fox (1938), Gradwell (1976), Klöppel (1976), Altman (1978), Gorgas et al. (1978), Brancker (1980), Franz et al. (1984), Matern & Klöppel (1995)

- aggregation of fibrous plant particles
- in lower stomach chambers
- associated with high-fibre diets or grass ingestion

Rumen acidosis

Krische & Elze (1981), Clauss (1998), Clauss et al. (2002)

- high concentrate/low fibre diet
- increase in lactic acid producing bacteria
- drop in rumen pH
- unfavourable conditions for fibre-fermenting bacteria
- mucosal damage

Partial loss of rumen papillation

Fox (1938), Hofmann & Matern (1988)

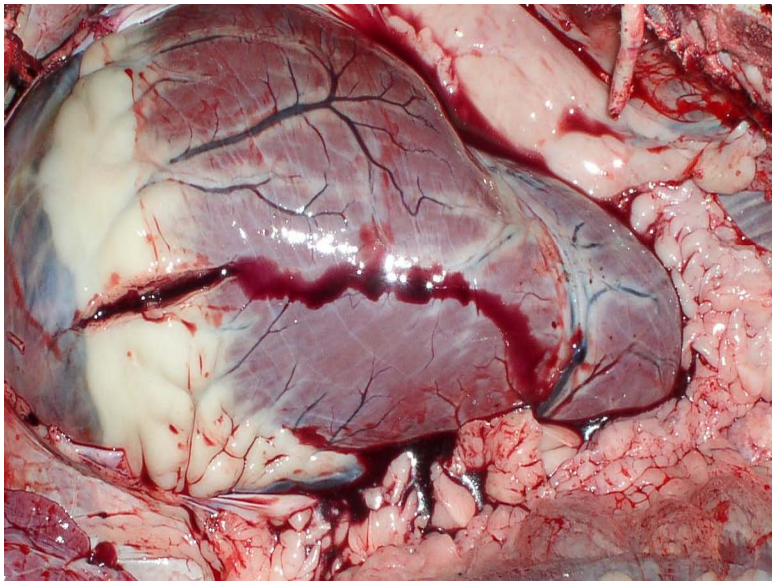
- high proportion of fibre in diet
- loss of papillae in the dorsal rumen region
- rumen "like a cow"

‘Peracute mortality syndrome’

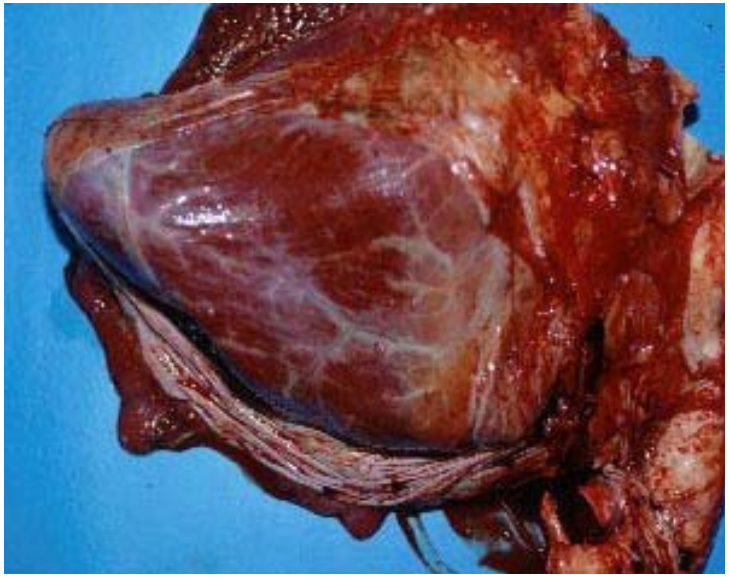
Cobbold (1854), Fox (1938), Chaffee (1968), Strafuss & Kennedy (1973), Kohm (1974), Janecek & Krávolé (1974), Fowler (1977, 1978), Altman (1978), Gucwinski & Ippen (1979), Moucha & Mikulica (1982), Stranberg et al. (1984), Cranfield et al. (1985), Mainka & Cooper (1989), Burton & Dierenfeld (1990), Junge & Bradley (1993), Clauss (1998), Ball et al. (2001), Enqvist et al. (2003), Potter & Clauss (2005)

- sudden death
- related stress epidsode
- no discernable cause of death
- total absence/atrophy of body fat stores

‘Peracute mortality syndrome’



normal coronary fat



no coronary fat

(photos courtesy John Potter 2004)

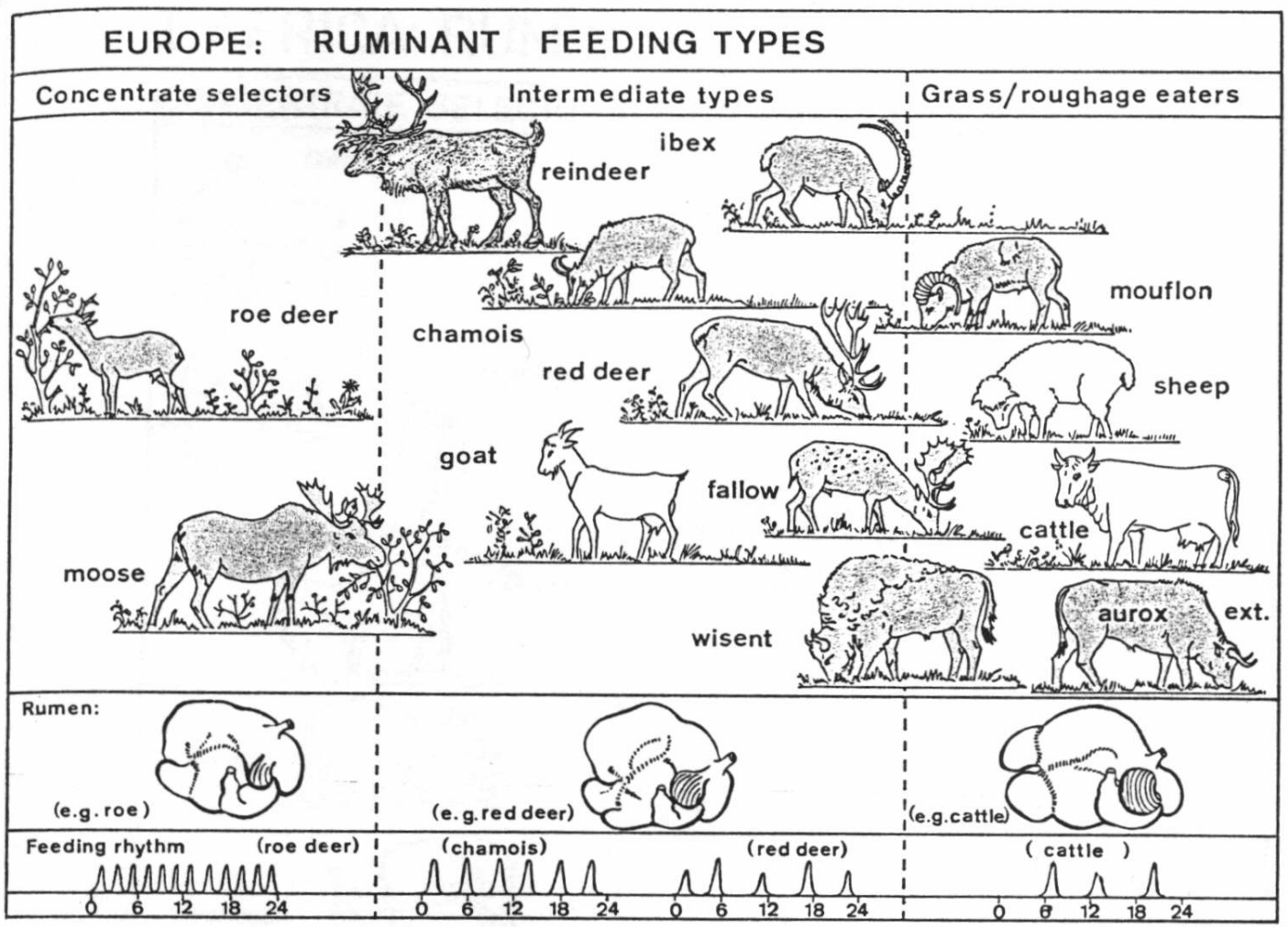
~~'Peracute mortality syndrome'~~

Cobbold (1854), Fox (1938), Chaffee (1968), Strafuss & Kennedy (1973), Kohm (1974), Janecek & Krávolé (1974), Fowler (1977, 1978), Altman (1978), Gucwinski & Ippen (1979), Moucha & Mikulica (1982), Stranberg et al. (1984), Cranfield et al. (1985), Mainka & Cooper (1989), Burton & Dierenfeld (1990), Junge & Bradley (1993), Clauss (1998), Ball et al. (2001), Enqvist et al. (2003), Potter & Clauss (2005)

'Serous fat atrophy syndrome'

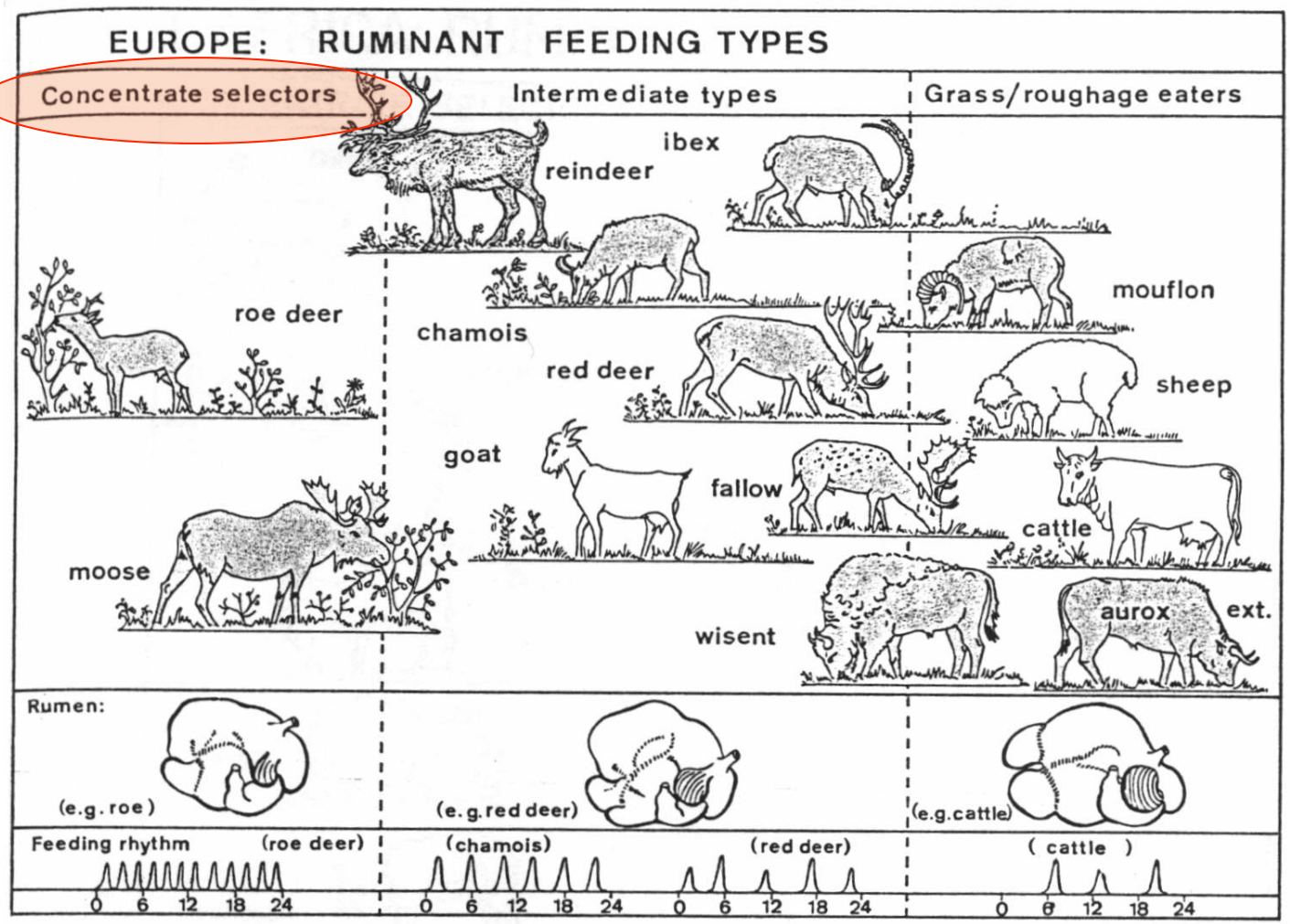
'Chronic energy deficiency'

Ruminant feeding types (Hofmann)



from Hofmann (1989)

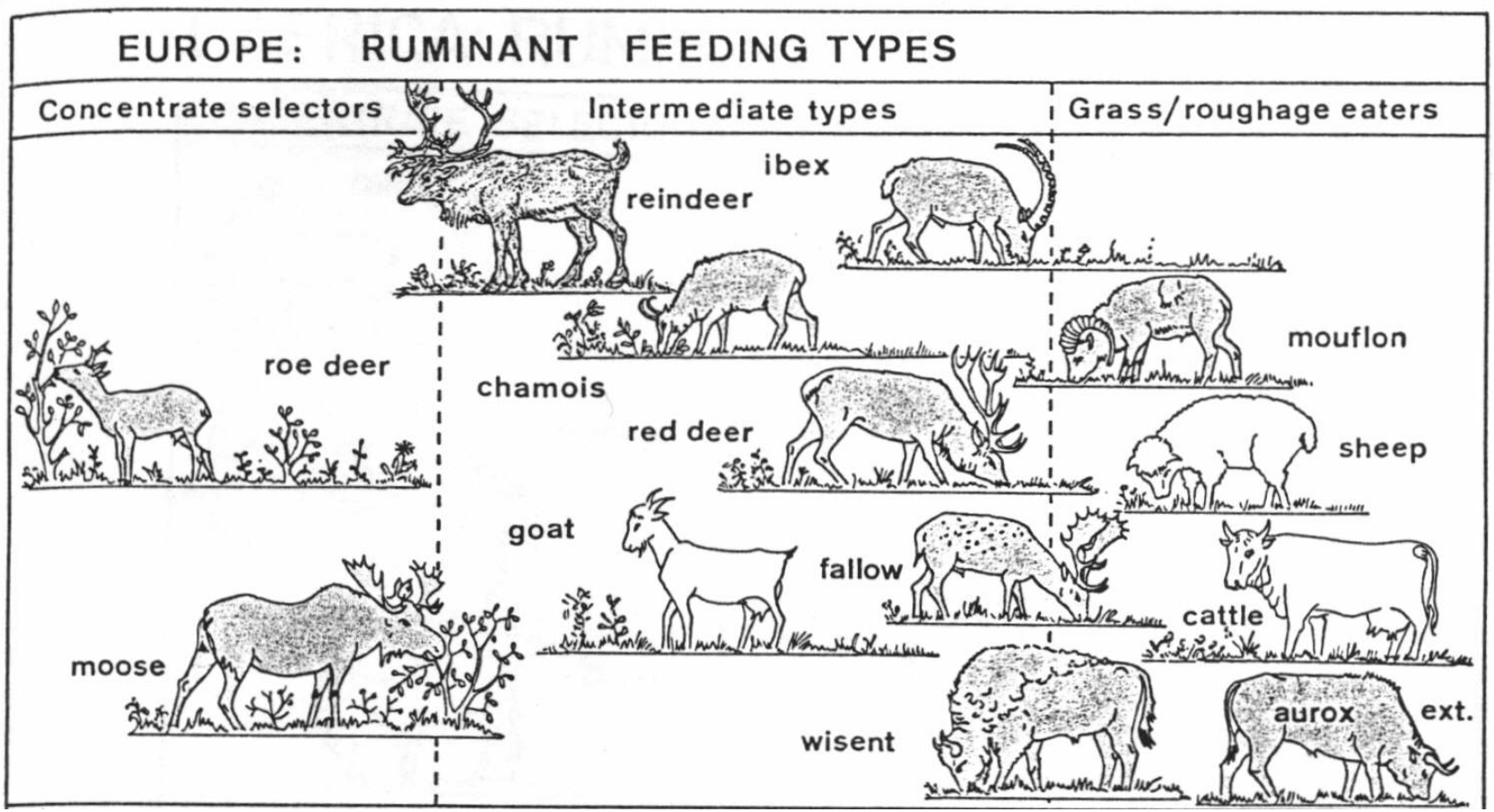
Ruminant feeding types (Hofmann)



from Hofmann (1989)

Don't believe names, think for yourself

- What is a 'concentrate selector'?



from Hofmann (1989)

Do diets of grazers and browsers really differ?

Species	Crude fiber (% dry matter)	NDF (% dry matter)
Giraffe (*Giraffa camelopardalis*)	-	50-70
Okapi (*Okapia johnstoni*)	-	43-48
Moose (*Alces alces*)	20-45	50-70
White-tailed deer (*Odocoileus virginianus*)	-	35-50
Buffalo (*Syncerus caffer*)	30-40	-
Waterbuck (*Kobus ellipsiprymnus*)	30-40	-

from Clauss & Dierenfeld (2008)

Differences between grass and browse

	Sugar	Starch	Pectin	Hemi-cellulose	Cellu-lose
	[% DM]	[% DM]	[% DM]	[% DM]	[% DM]
Grass	5-15	1-5	1-2	15-40	20-40
Browse	5-15	-	6-12	8-12	12-30

from Robbins (1993)

Don‘t lose perspective !

a slow car ?

Don‘t lose perspective !

an alcohol-free beverage ?

Don‘t lose perspective !

a ‘concentrate-selector?’

Crude fibre in rumen contents
(Drescher-Kaden & Seifelnasr 1977)

(%dry matter)

20 %	Area 1	20 %
24 %	Area 2	34 %

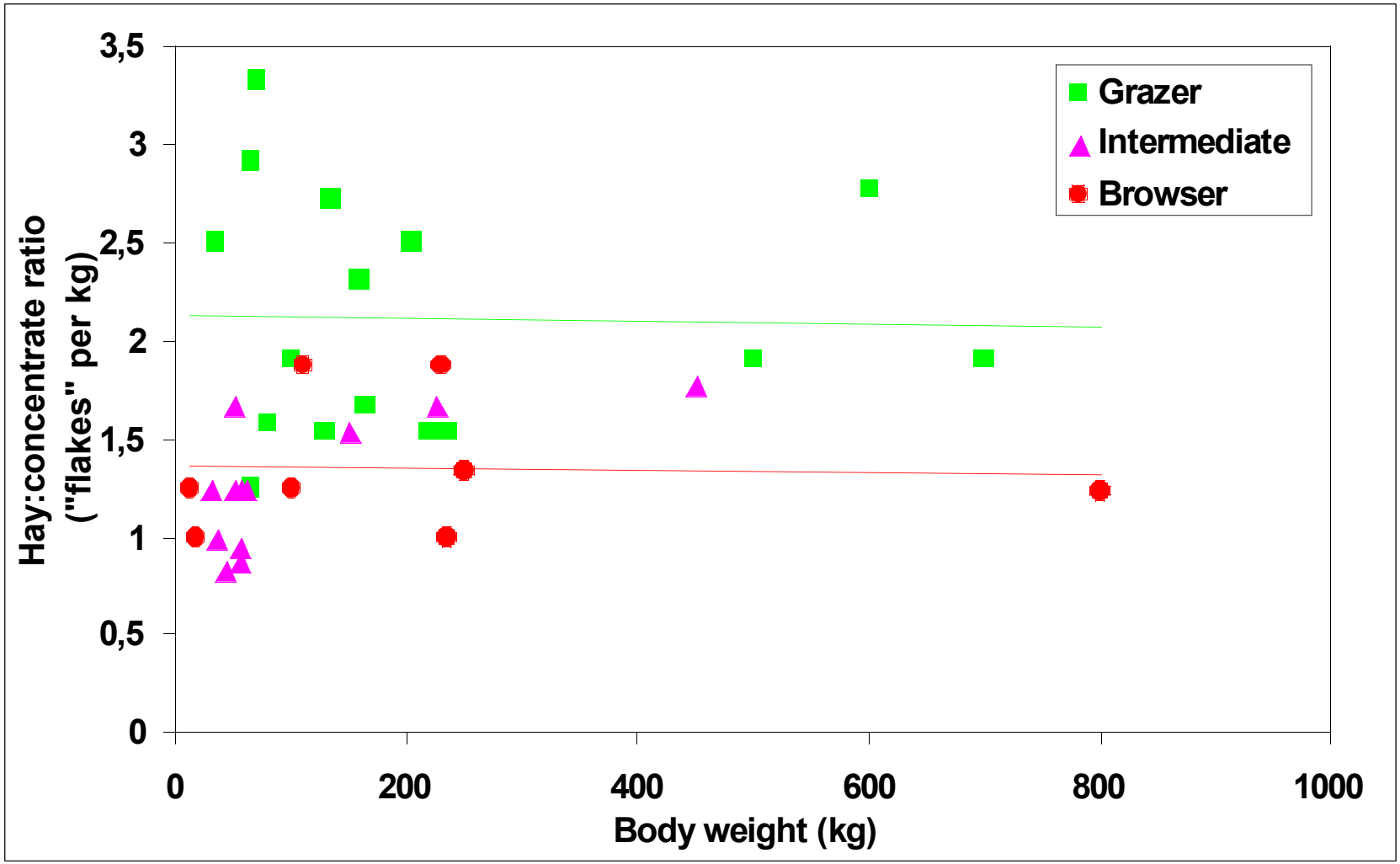
Traditional feeding approach

1. “Browse contains more protein, more soluble cell content, and less fibre than grass”

2. “’Concentrate selectors’ are adapted to a food high in rapidly fermenting carbohydrates”

=> “Browsers should receive more protein and less fibre than grazers”

Hay:concentrate ratio in different ruminant species in one zoo



Data from Grisham and Savage (1990)

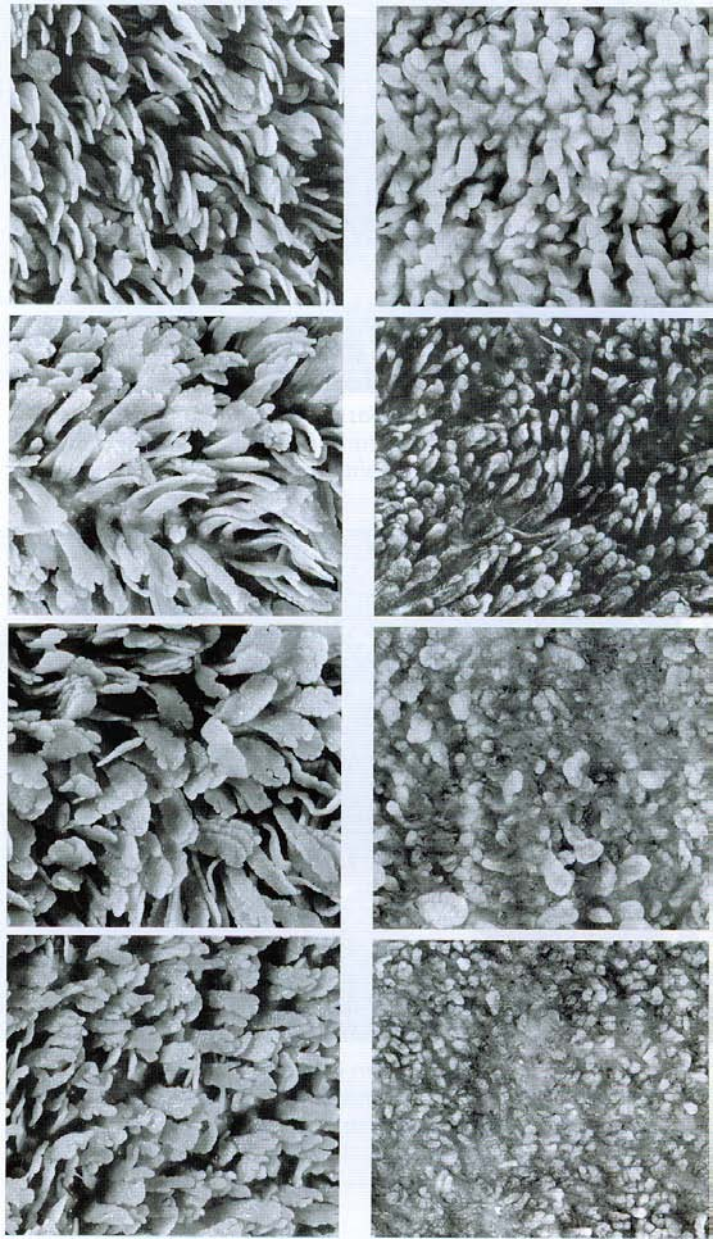
Diseases of the digestive tract

Feeding type	n	Diseases of the digestive tract (%)
Grazer	9	11
Mixed feeder	141	31
Browser	61	26

Data from Kiupel (1988)

Rumen mucosa of moose

Finnish moose



captive moose

(Whipsnade Zoo)

from Hofmann & Nygren (1992)

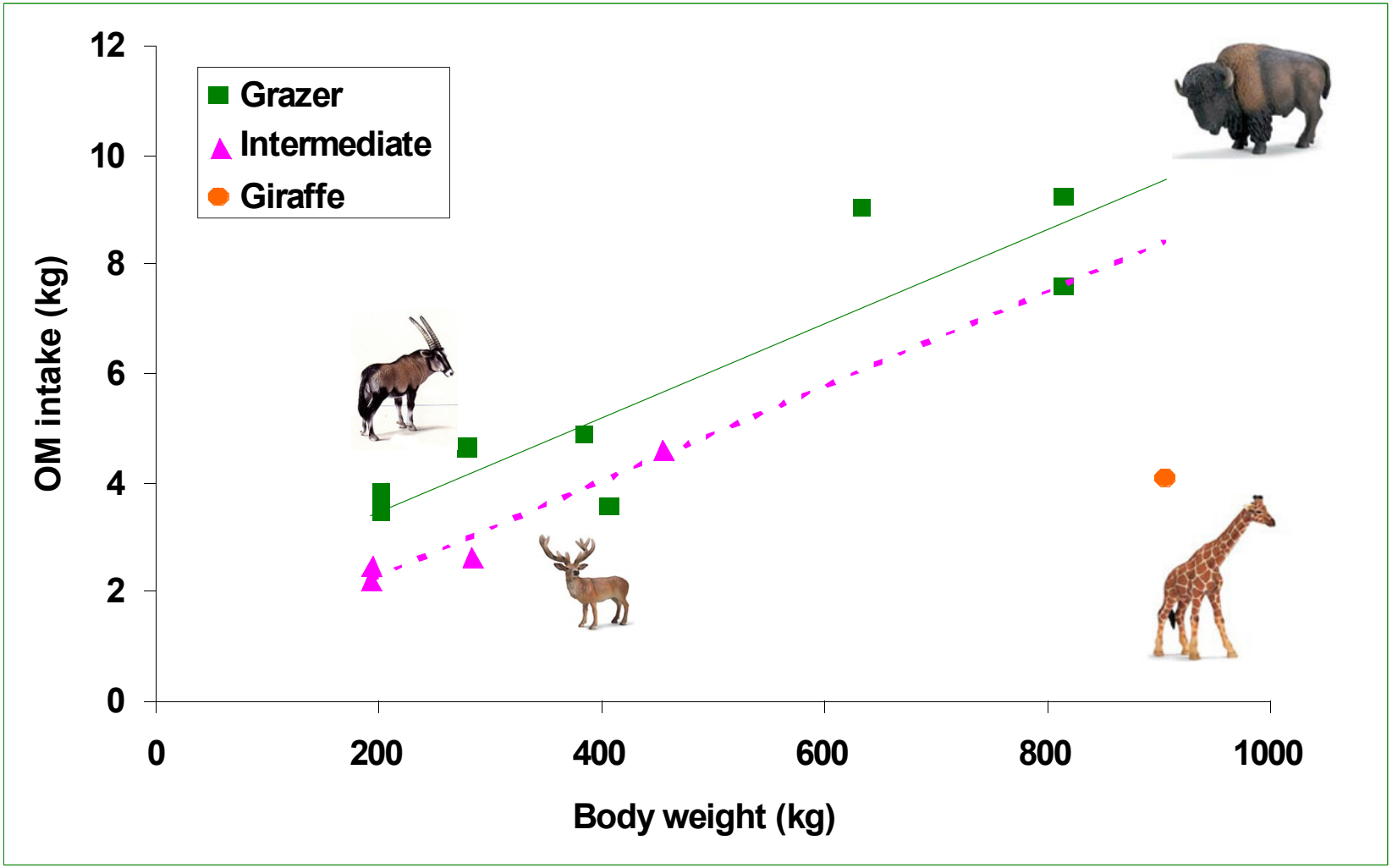
Changes in rumen mucosa indicating ruminen acidosis

Feeding type	n	Acidotic chanes of the rumen mucosa (%)
Grazer	13	23
Mixed feeder	30	27
Browser	24	83

Data from Marholdt (1991)

The so-called 'concentrate selectors' seem to suffer from the ingestion of too much concentrates!

Ad libitum intake of grass hay in zoo ruminants



from Foose (1982)

The so-called 'concentrate selectors' seem to suffer from the ingestion of too much concentrates ...

... or too little hay !

Problems with hay acceptance

Giraffe Fox (1938), Gradwell (1976), Kloeppel (1976), Altmann (1978), Gorgas et al. (1978), Brancker (1980), Foose (1982), Franz et al. (1984), Gutzwiller (1984), Hofmann and Matern (1988), Matern and Kloeppel (1995)

Moose Baines (1965), Landowski (1969), Heptner and Nasimowitsch (1974), Bo and Hjeljord (1991), Schwartz (1992), Schwartz and Hundertmark (1993), Shochat et al. (1997)

Mule deer Cahart (1943), Doman and Rasmussen (1944), Nagy et al. (1969), Schoonveld et al. (1974)

Roe deer Dissen (1983)

Chinese water deer Hofmann et al. (1988)

Duiker Cowan (1982), Luginbuhl et al. (1991), Van Soest et al. (1995)

Reindeer Eriksson and Schmekel (1962), Kurkela (1976), Valtonen et al. (1983)

Eland Hofmann (1973, p. 40), Miller et al. (2010)

Kudu Miller et al. (2010)

Scenario I:

Hay *ad libitum*

Concentrates
ad libitum

Scenario I:

Hay *ad libitum*

Concentrates
ad libitum

all ruminants ingest too much concentrates and develop rumen acidosis

Scenario I:

Hay *ad libitum*

Concentrates
ad libitum

all ruminants ingest too much concentrates and develop rumen acidosis

During evolution, herbivores learned to select for energy-dense feeds which are rare in their natural environment.

Scenario II:

Hay ***ad libitum***

Concentrates

restrictive

Scenario II:

Hay ***ad libitum***

Concentrates

restrictive

← Grazers eat enough hay to suit their ruminant GIT physiology

Scenario II:

Hay *ad libitum*

Concentrates
restrictive

Browsers often do not ingest enough hay to suit their ruminant GIT physiology

Scenario II:

Hay ***ad libitum***

Concentrates

restrictive

Browsers often do not ingest enough hay to suit their ruminant GIT physiology

Scenario II:

Hay *ad libitum*

Concentrates
restrictive

←

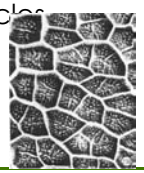
Browsers often do not ingest enough hay to suit their ruminant GIT physiology

why?

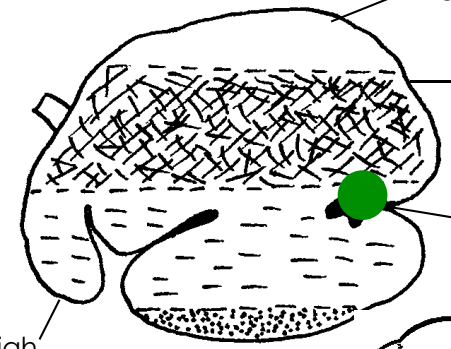
Grazer

Grass

longish, "fibre-like" particles



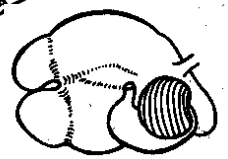
high reticular crests large omasum



dorsal attachment

irregular papillation

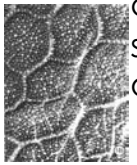
thick rumen pillars
strong rumen muscle layers



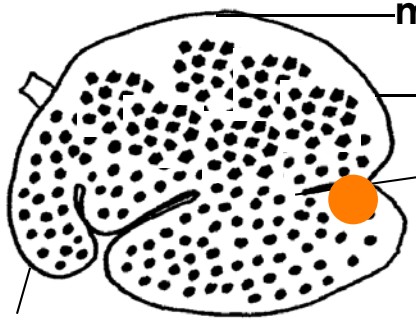
Browser

Browse

polygonal particles



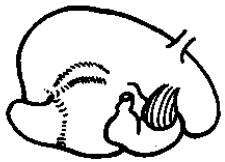
low reticular crests small omasum

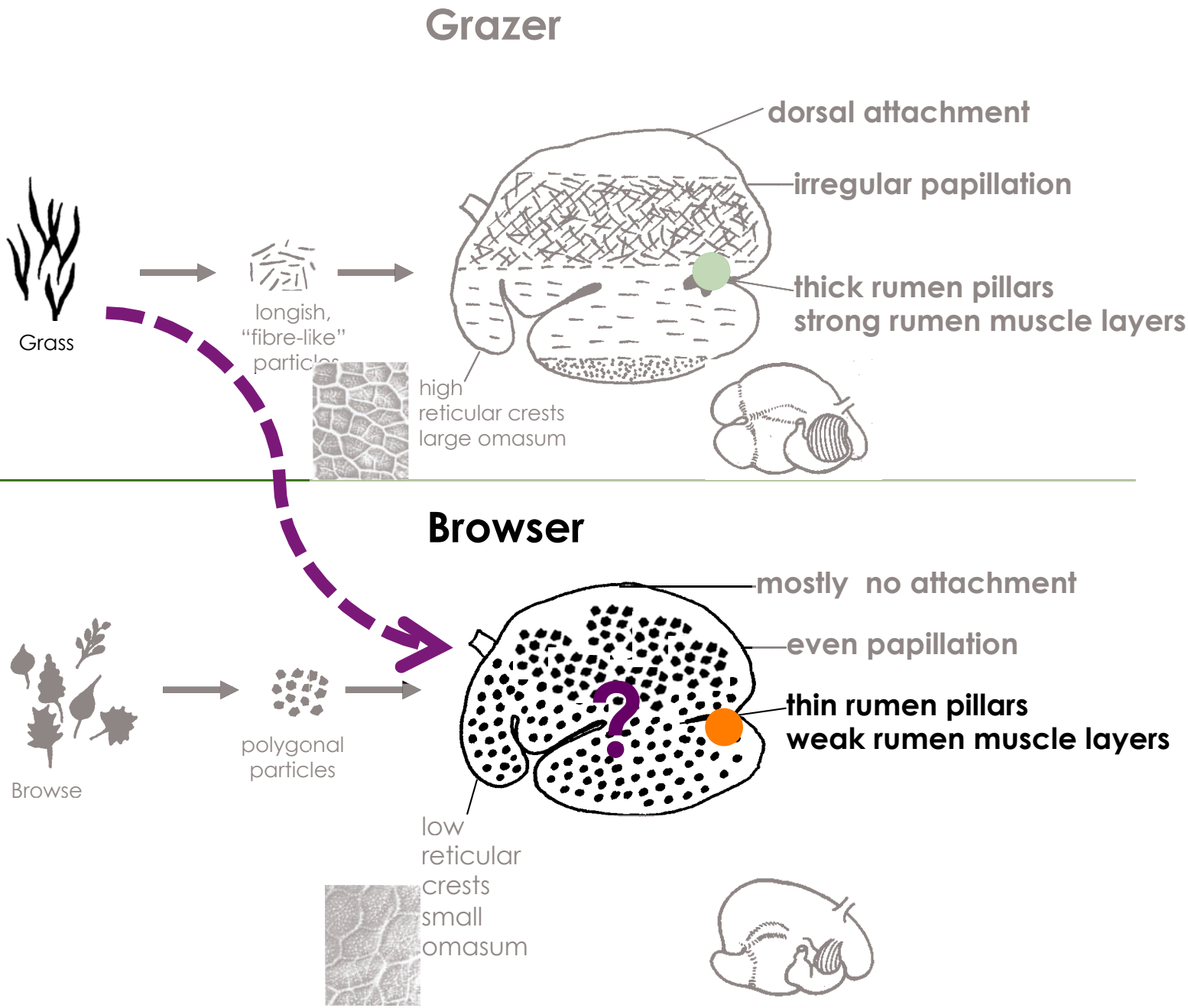


mostly no attachment

even papillation

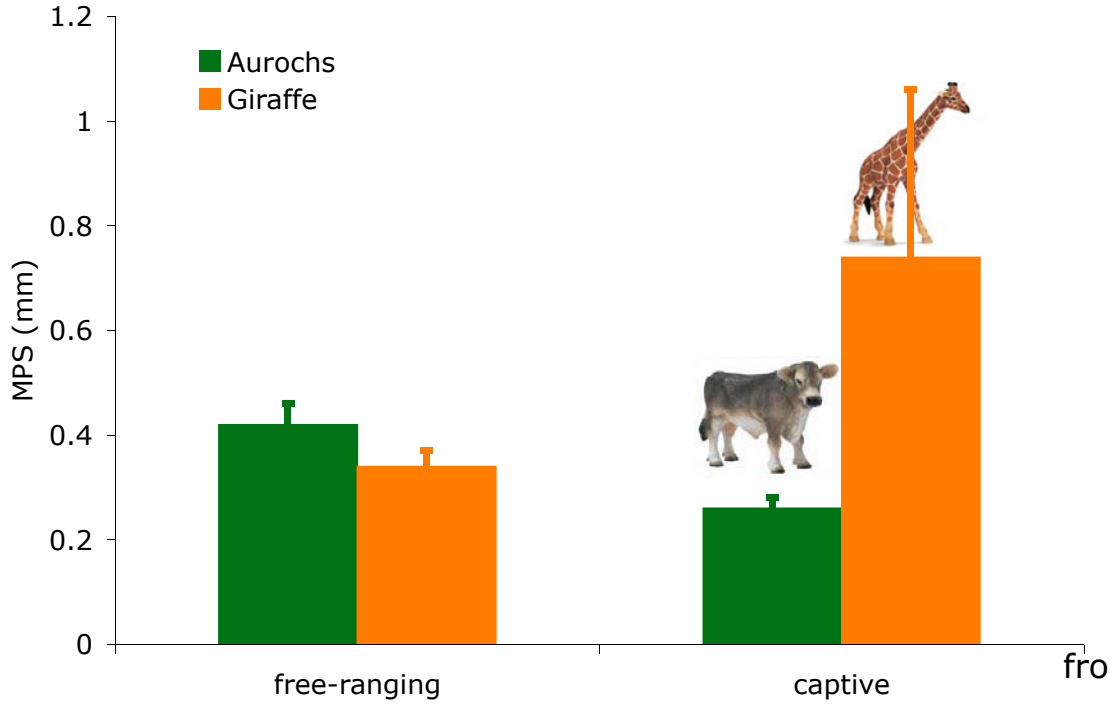
thin rumen pillars
weak rumen muscle layers




Grazer
dorsal attachment
irregular papillation
thick rumen pillars
strong rumen muscle layers
Grass
longish,
"fibre-like"
particles
high
reticular crests
large omasum
Browser
mostly no attachment
even papillation
thin rumen pillars
weak rumen muscle layers
Browse
polygonal
particles
low
reticular
crests
small
omasum

Fecal particle size in herbivores

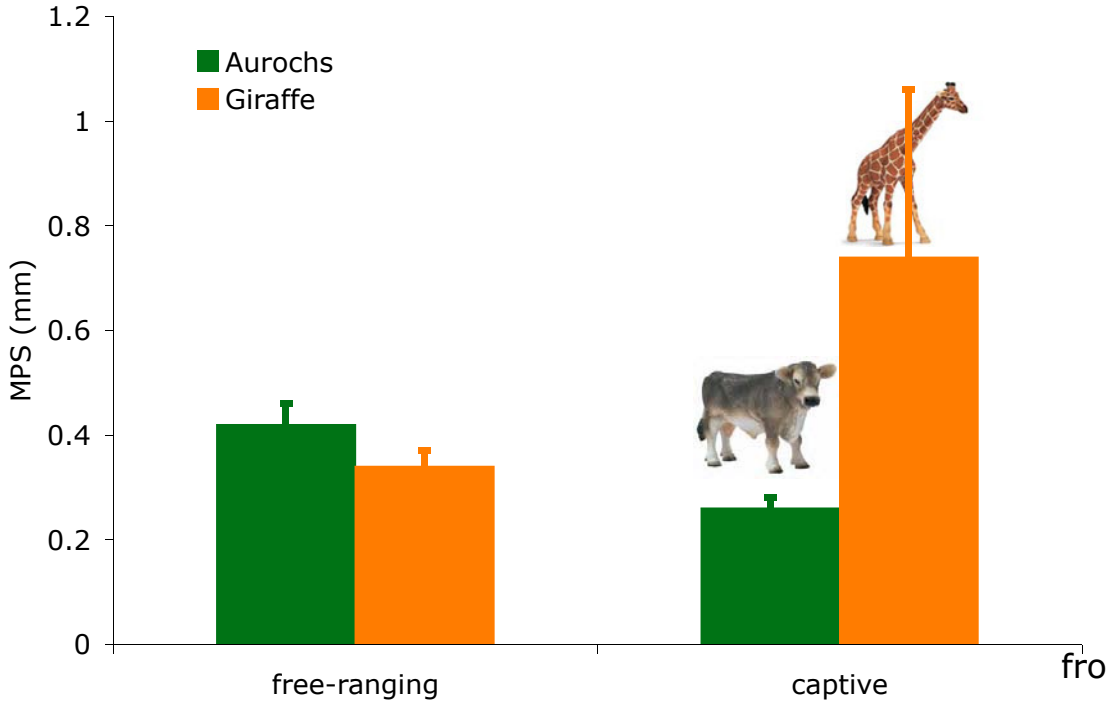
- **We expect captive herbivores to have finer faecal particles than free-ranging conspecifics (due to pellet feeding)**
- **This is confirmed in Aurochs but not in giraffes!**
- **Indication that giraffe teeth are adapted to chewing something else - not the diets offered in captivity.**

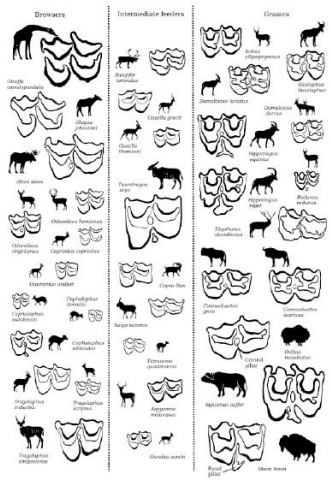


from Hummel et al. (2008)

Fecal particle size in herbivores

- **We expect captive herbivores to have finer faecal particles than free-ranging conspecifics (due to pellet feeding)**
- **This is confirmed in Aurochs but not in giraffes!**
- **Indication that giraffe teeth are adapted to chewing something else - not the diets offered in captivity.**





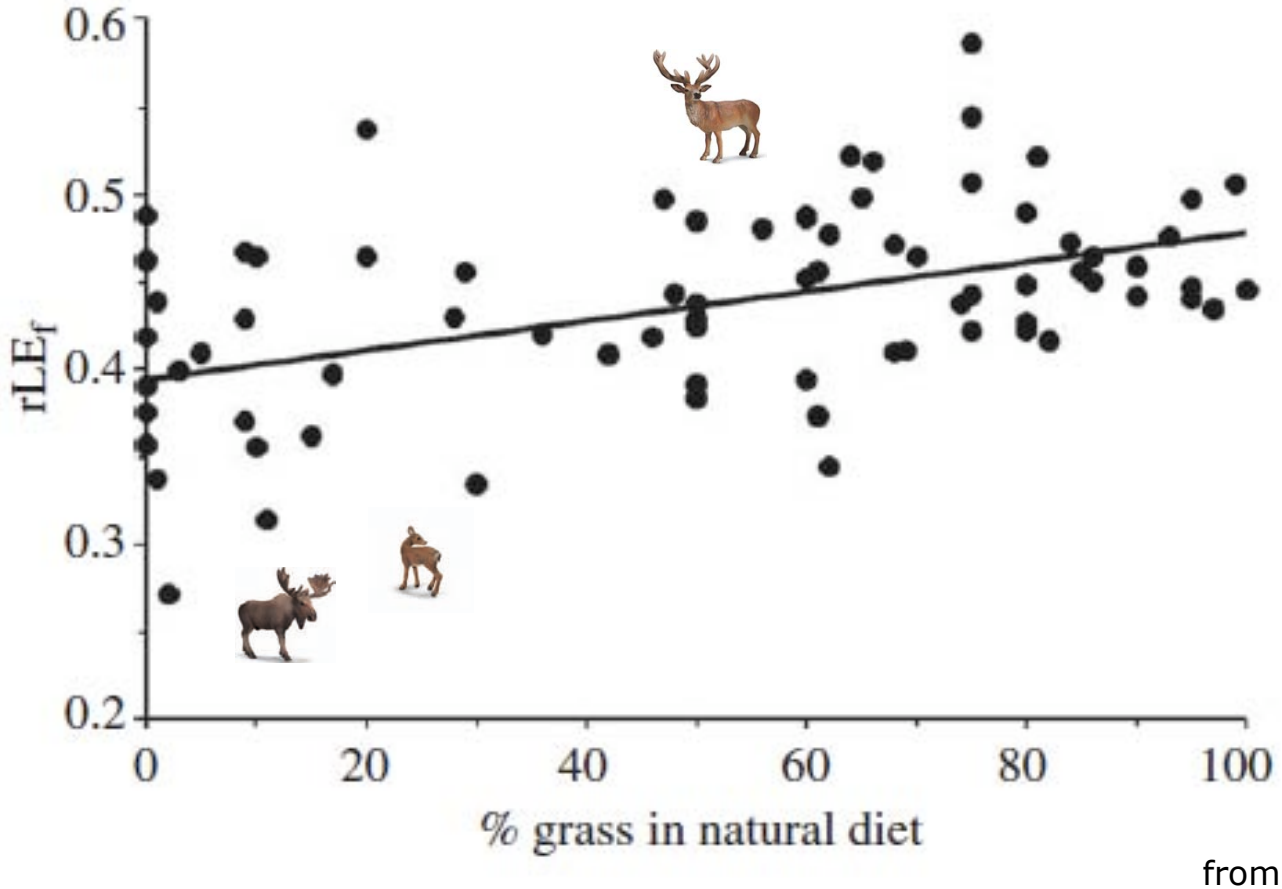
from Hummel et al. (2008)

Does it matter? Husbandry success

- Measured as average lifespan in relation to maximum lifespan (humans: 80/120 = 0.67)

Husbandry success

- Browsing ruminants have lower relative lifespans than grazing ruminants



from Müller et al. (2011)

High proportion of concentrates

High proportion of hay fibre

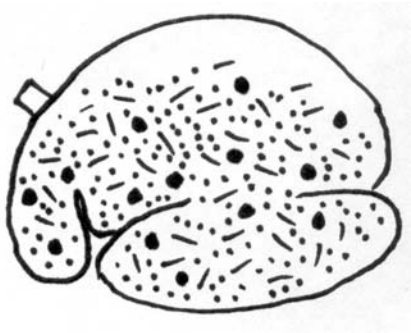
High proportion of concentrates

High proportion of hay fibre

individual animal feeding decision/habit

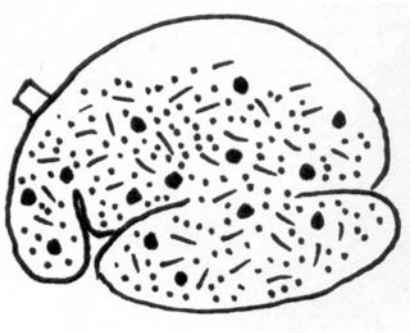
(hay quality)

High proportion of concentrates



High proportion of hay fibre

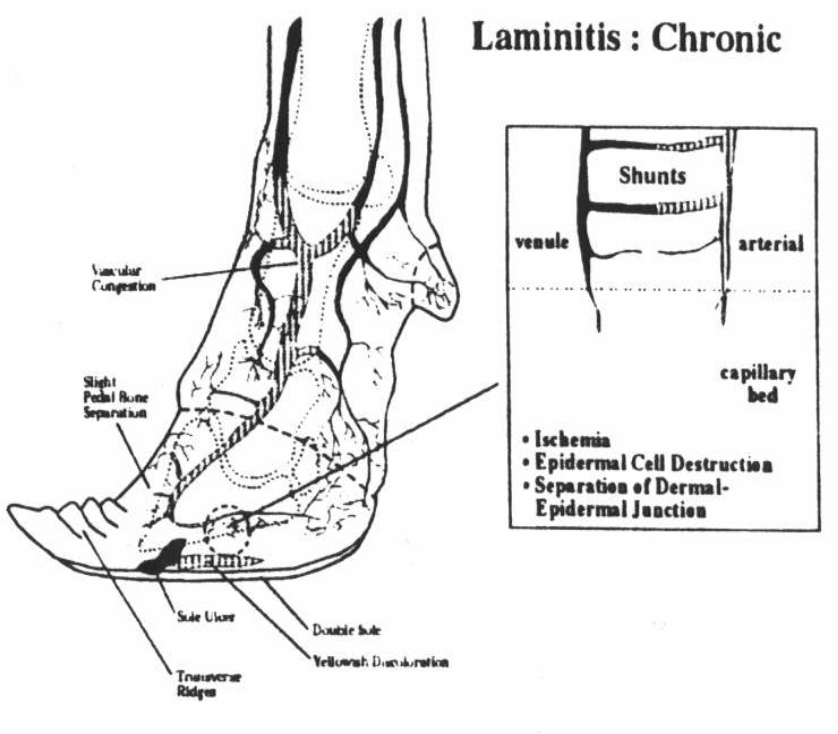
High proportion of concentrates



Chronic acidosis, hoof overgrowth, oral stereotypies

High proportion of hay fibre

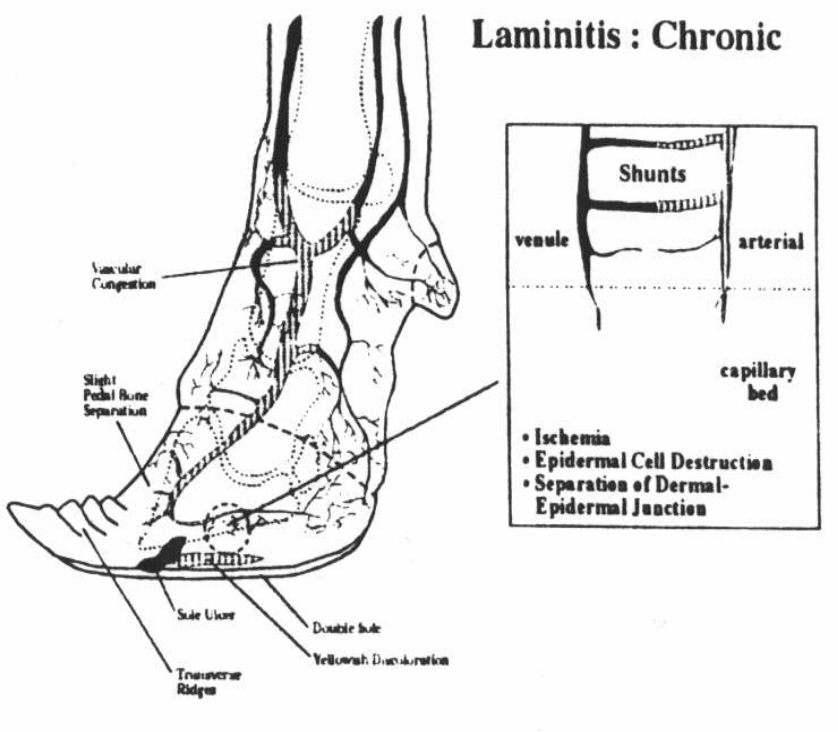
Hoof overgrowth / chronic laminitis



from Nocek (1997)

Photos: E. Flach, M. Claussi

Hoof overgrowth / chronic laminitis



from Nocek (1997)

Photo: W. Zenker

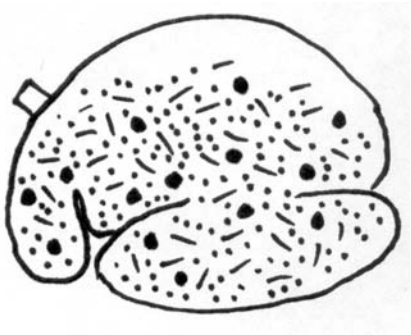
Hoof overgrowth - *'anecdotes'*

Giraffe survey: Zoos with hoof problems fed more fruits/bread/grains than zoos without such problems (Hummel et al. 2006).

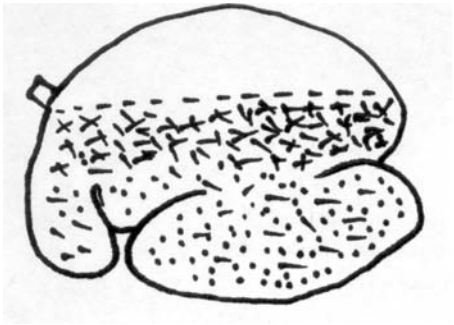
Moose survey: Zoos with hoof problems fed more non-roughages (incl. fruits) than zoos without such problems (Clauss et al. 2002).

Comparing two wild ruminant herds, the one with a higher proportion of concentrates had a lower rumen pH and worse claws (Zenker et al. 2009).

High proportion of concentrates

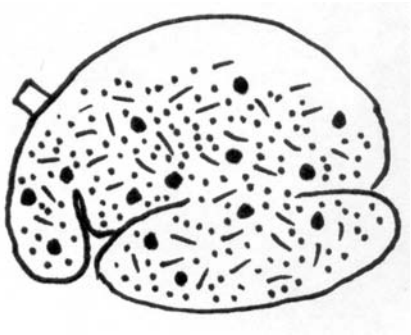


Chronic acidosis, hoof overgrowth, oral stereotypies

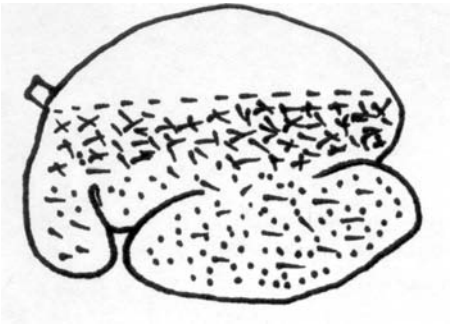


High proportion of hay fibre

High proportion of concentrates



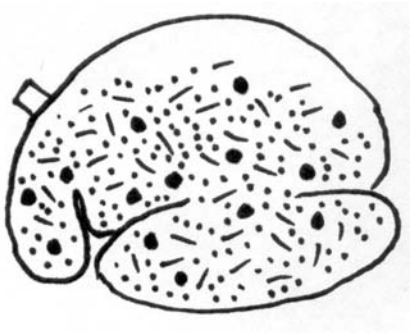
Chronic acidosis, hoof overgrowth, oral stereotypies



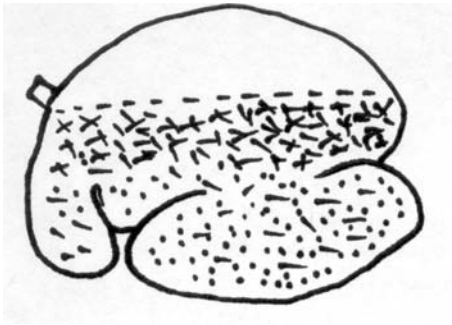
escape of large fibrous particles

High proportion of hay fibre

High proportion of concentrates



Chronic acidosis, hoof overgrowth, oral stereotypies

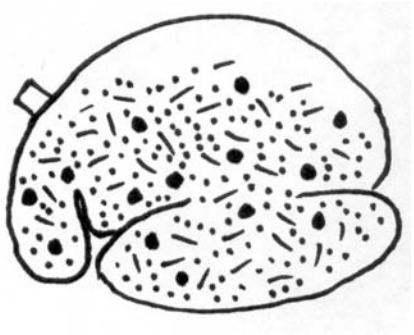


escape of large fibrous particles

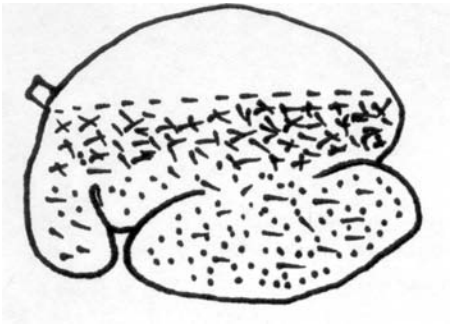
bezoar formation

High proportion of hay fibre

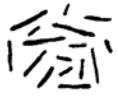
High proportion of concentrates



Chronic acidosis, hoof overgrowth, oral stereotypies



Loss of dorsal rumen papillation

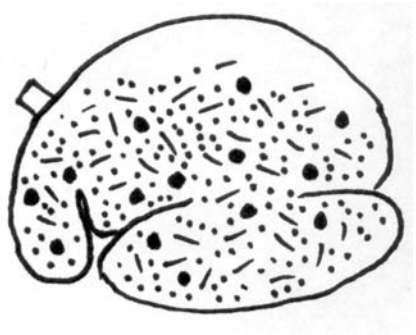


escape of large fibrous particles

bezoar formation

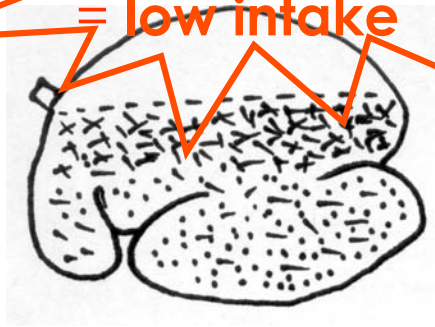
High proportion of hay fibre

High proportion of concentrates



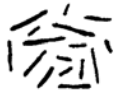
Chronic acidosis, hoof overgrowth, oral stereotypies

rumen "blockage"
= **low intake**



Loss of dorsal rumen papillation

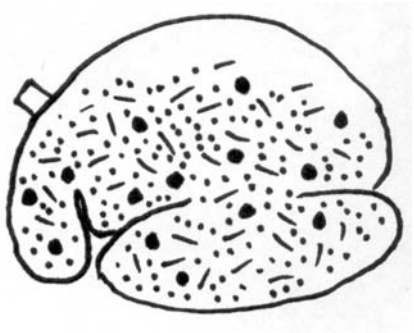
High proportion of hay fibre



escape of large fibrous particles

bezoar formation

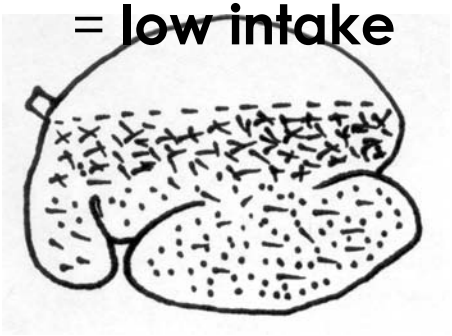
High proportion of concentrates



Chronic acidosis, hoof overgrowth, oral stereotypies

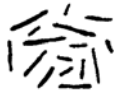
rumen "blockage" = **low intake**

No body fat stores, stress susceptibility



Loss of dorsal rumen papillation

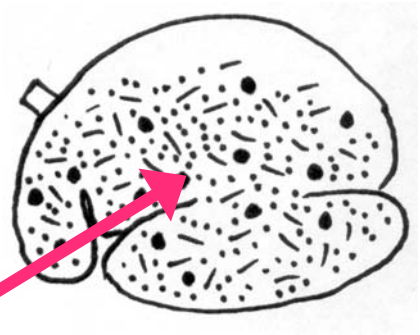
High proportion of hay fibre



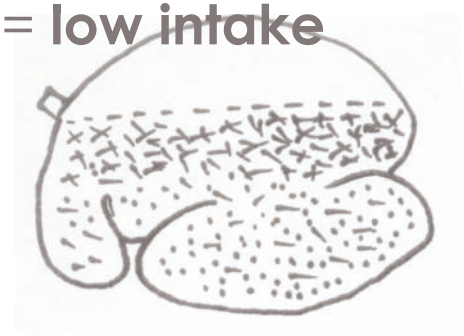
escape of large fibrous particles

bezoar formation

You want a concentrate food that does this …



rumen "blockage"
= **low intake**



***Chronic acidosis**, hoof overgrowth, oral stereotypies*

… without inducing this.

What‘s in a commercial food?

What‘s in a commercial food?

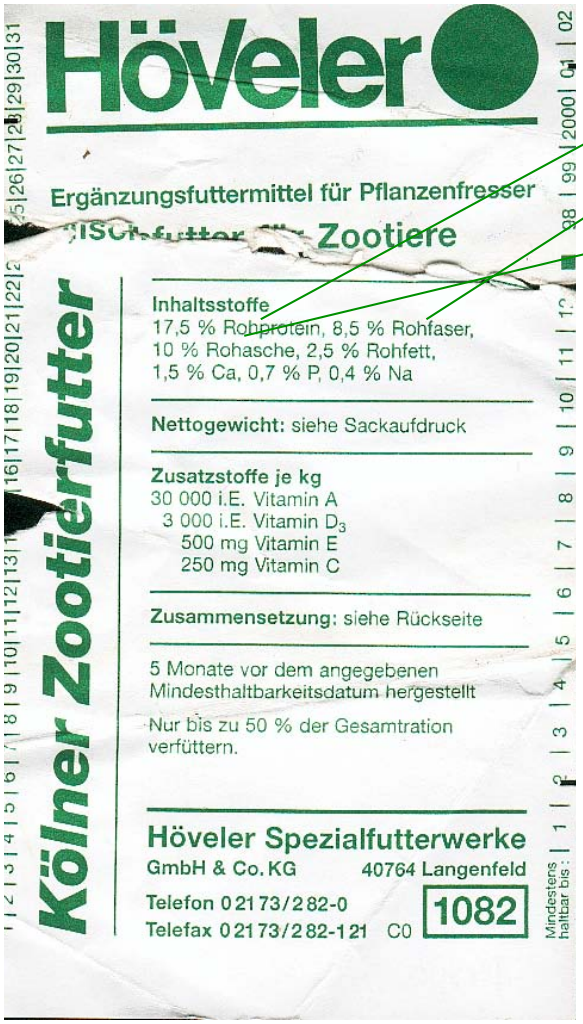
Protein 17.5 %

What‘s in a commercial food?

Protein 17.5 %

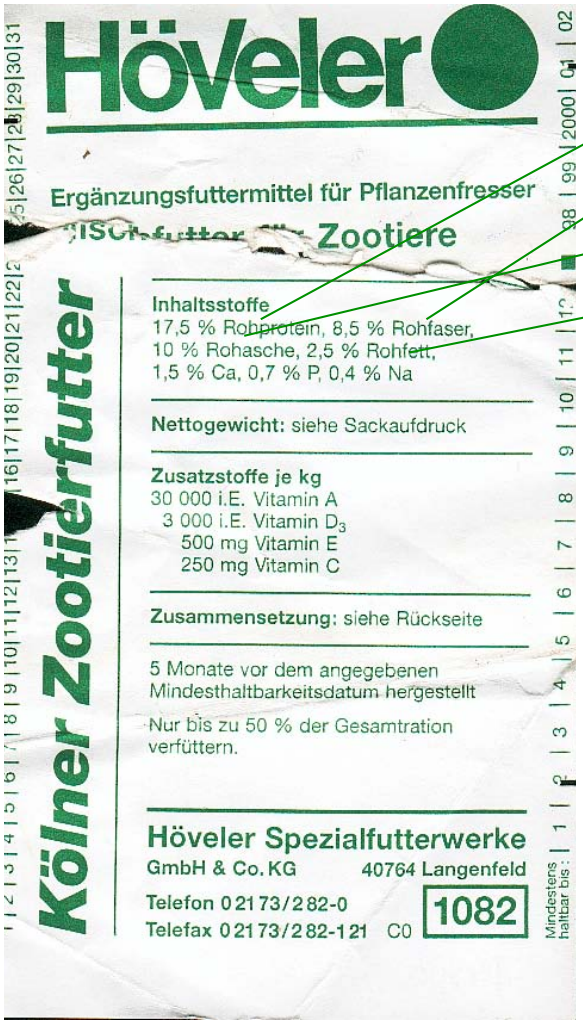
Crude fibre 8.5 %

What‘s in a commercial food?



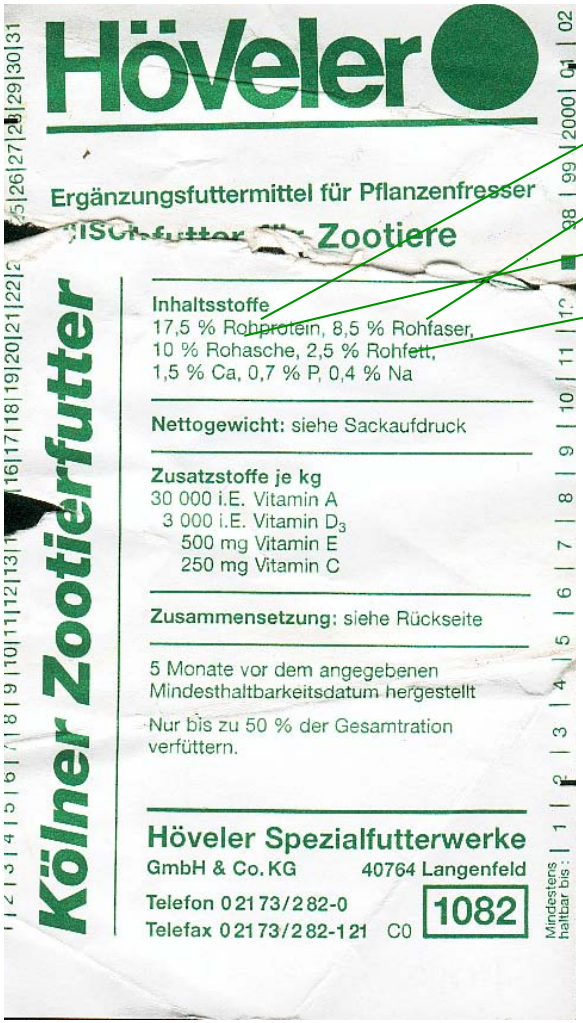
Protein	17.5 %
Crude fibre	8.5 %
Crude ash	10.0 %

What‘s in a commercial food?



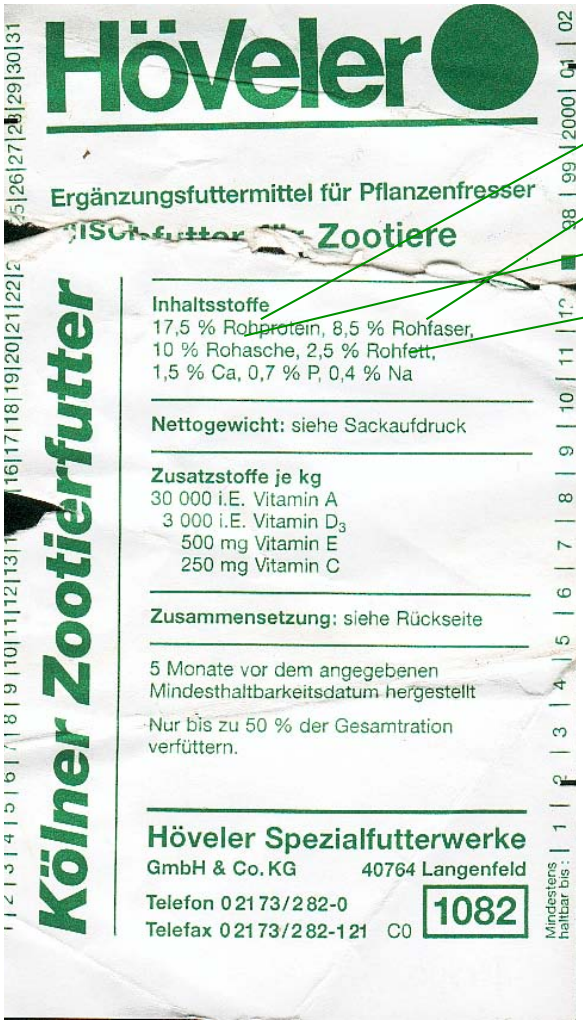
Protein	17.5 %
Crude fibre	8.5 %
Crude ash	10.0 %
Crude fat	2.5 %

What‘s in a commercial food?



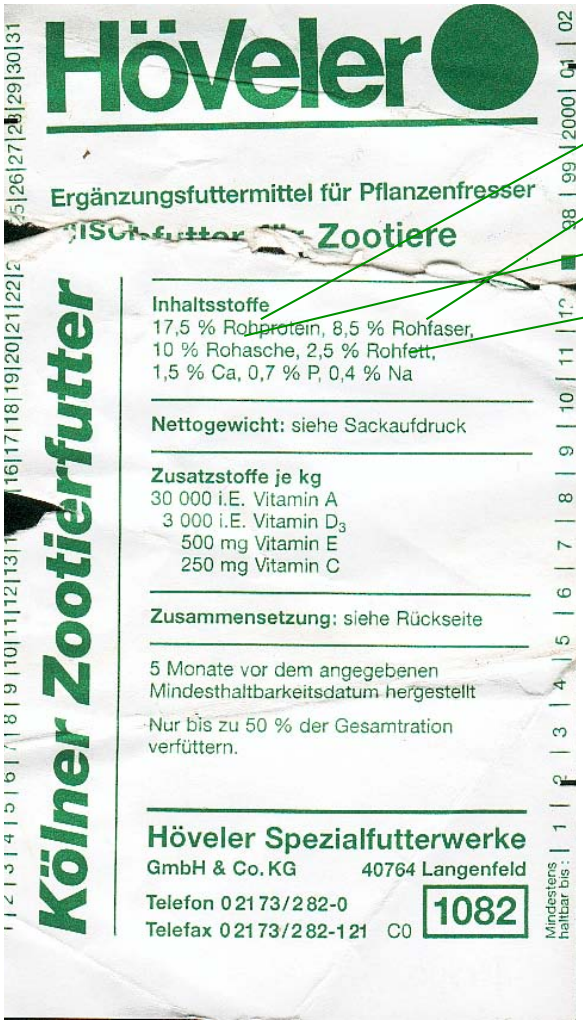
Protein	17.5 %
Crude fibre	8.5 %
Crude ash	10.0 %
Crude fat	2.5 %
Moisture	10.0 %

What‘s in a commercial food?



Protein	17.5 %
Crude fibre	8.5 %
Crude ash	10.0 %
Crude fat	2.5 %
Moisture	10.0 %
Total	48.5 %

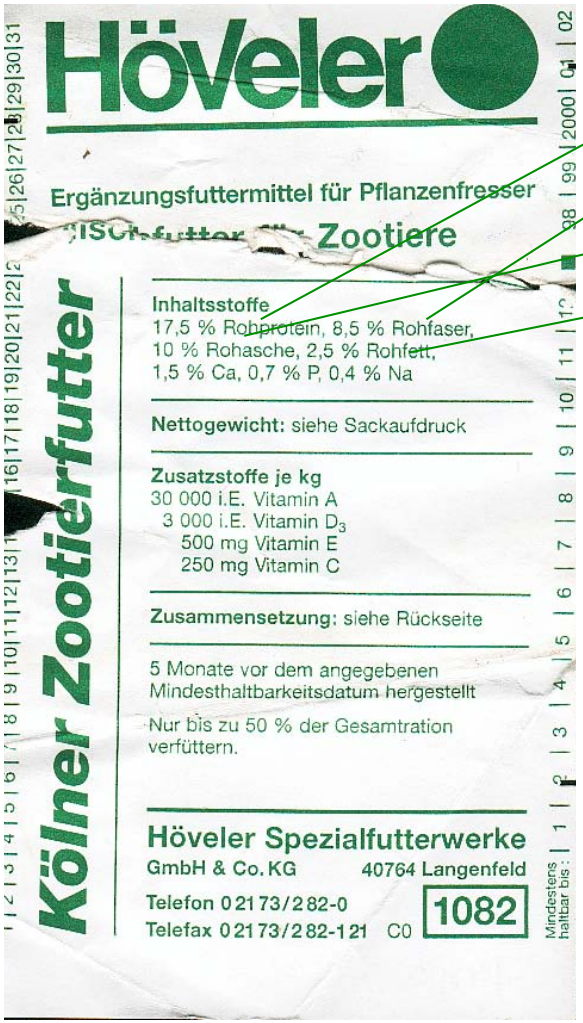
What‘s in a commercial food?



Protein	17.5 %
Crude fibre	8.5 %
Crude ash	10.0 %
Crude fat	2.5 %
Moisture	10.0 %
---	---
Total	48.5 %

What are the other 51.5 %?

What's in a commercial food?

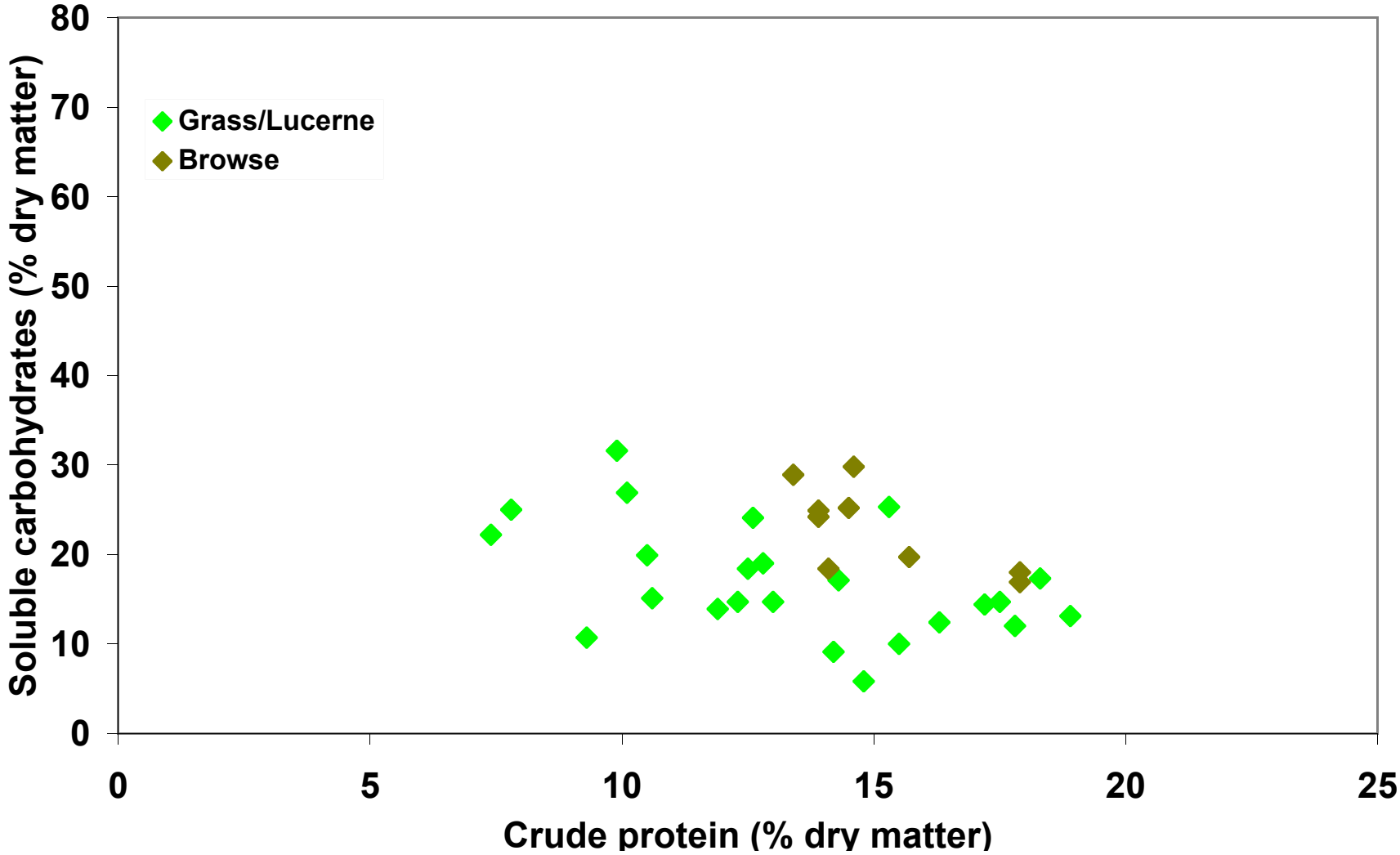


Protein	17.5 %
Crude fibre	8.5 %
Crude ash	10.0 %
Crude fat	2.5 %
Moisture	10.0 %
Total	48.5 %

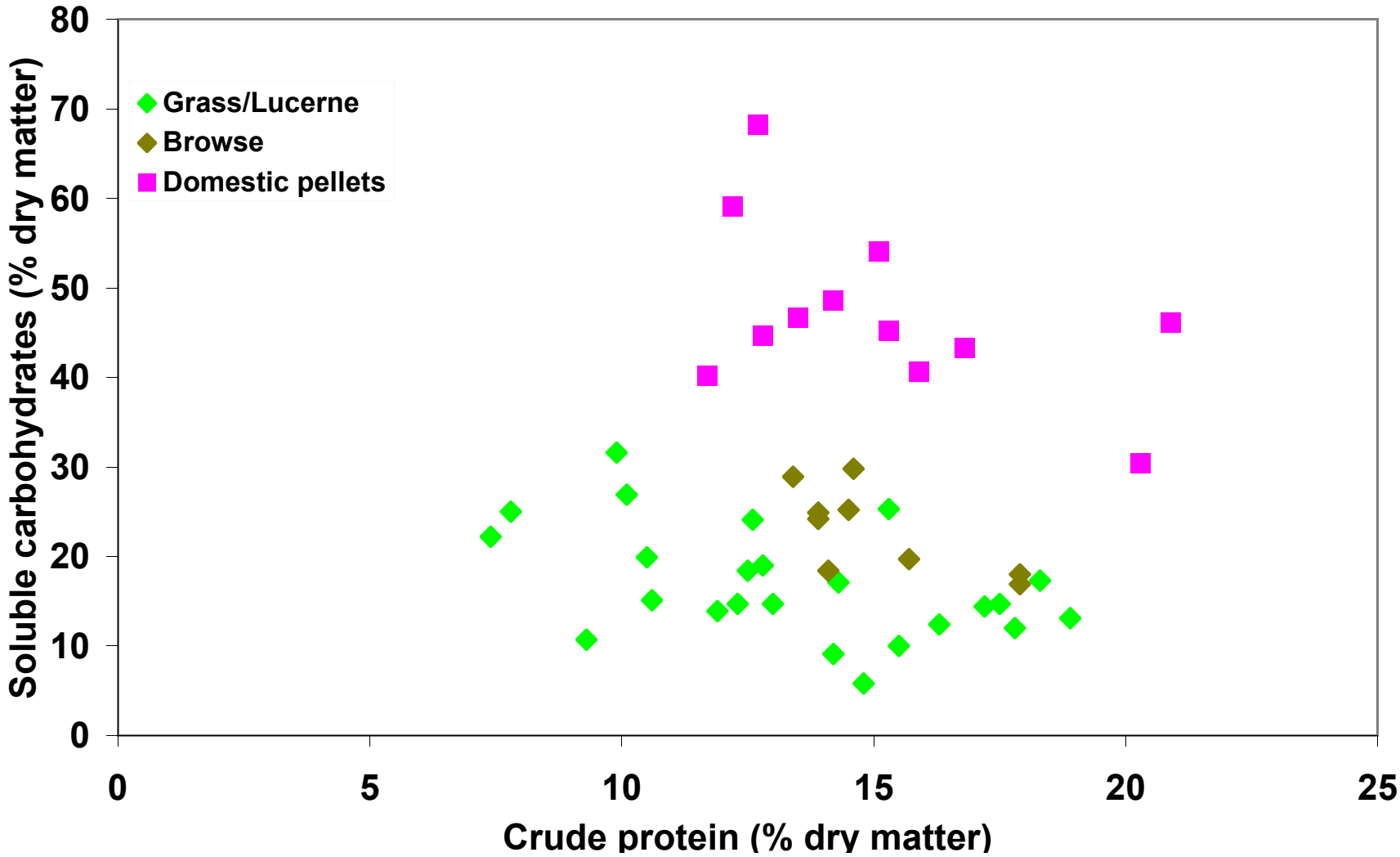
What are the other 51.5 %?

"Starch & Sugar" /
"Soluble fibre"

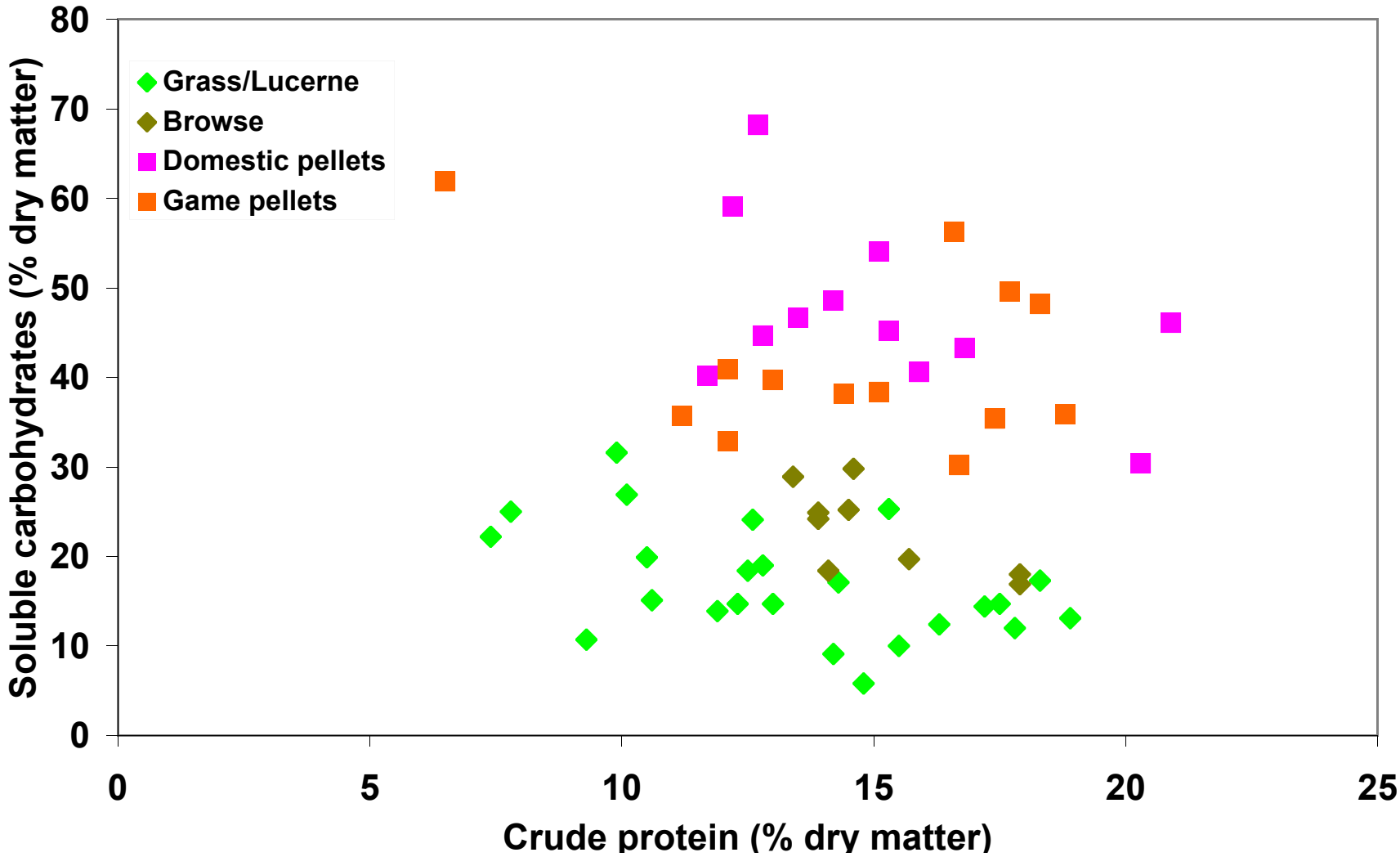
Choosing a pelleted diet



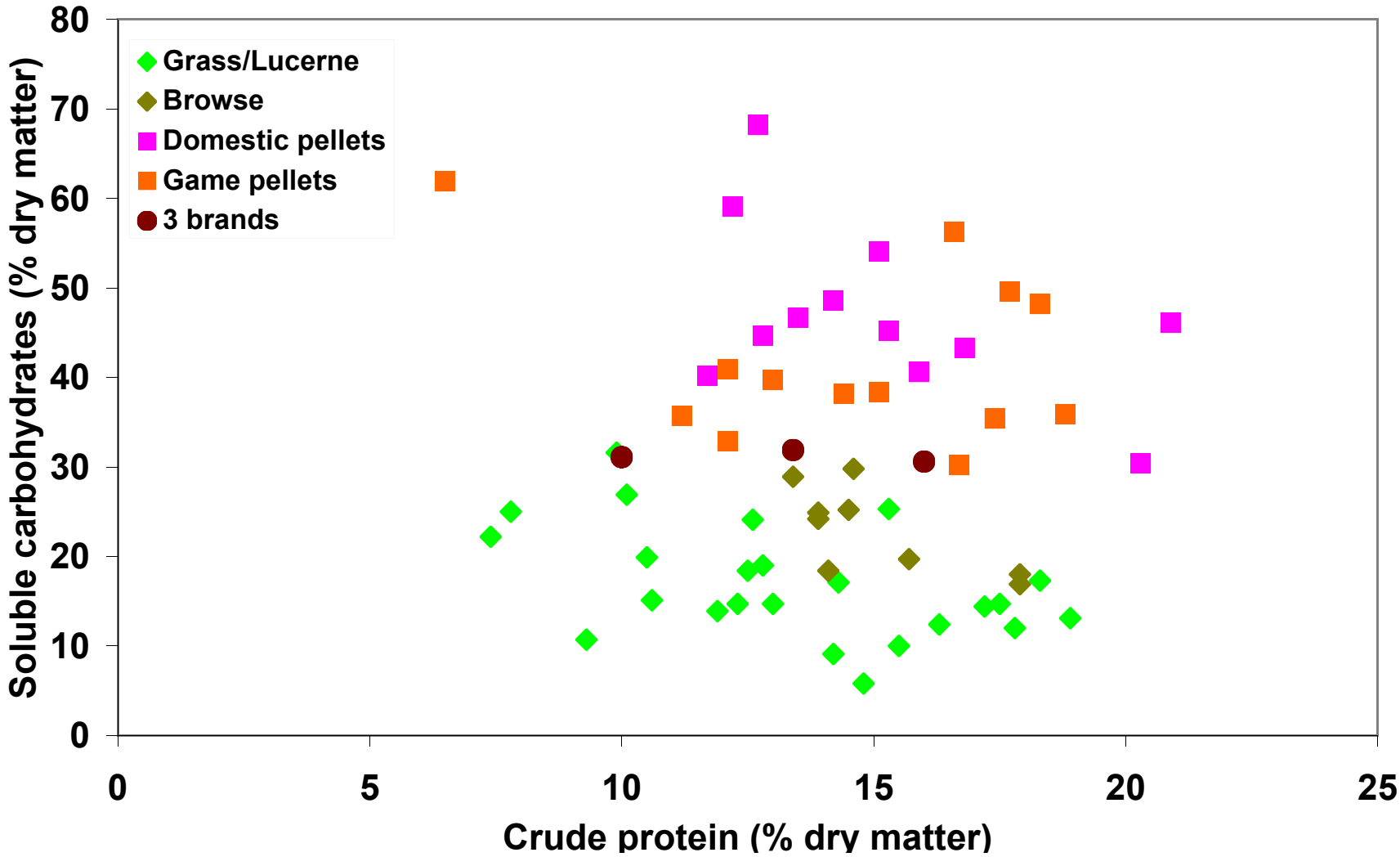
Choosing a pelleted diet



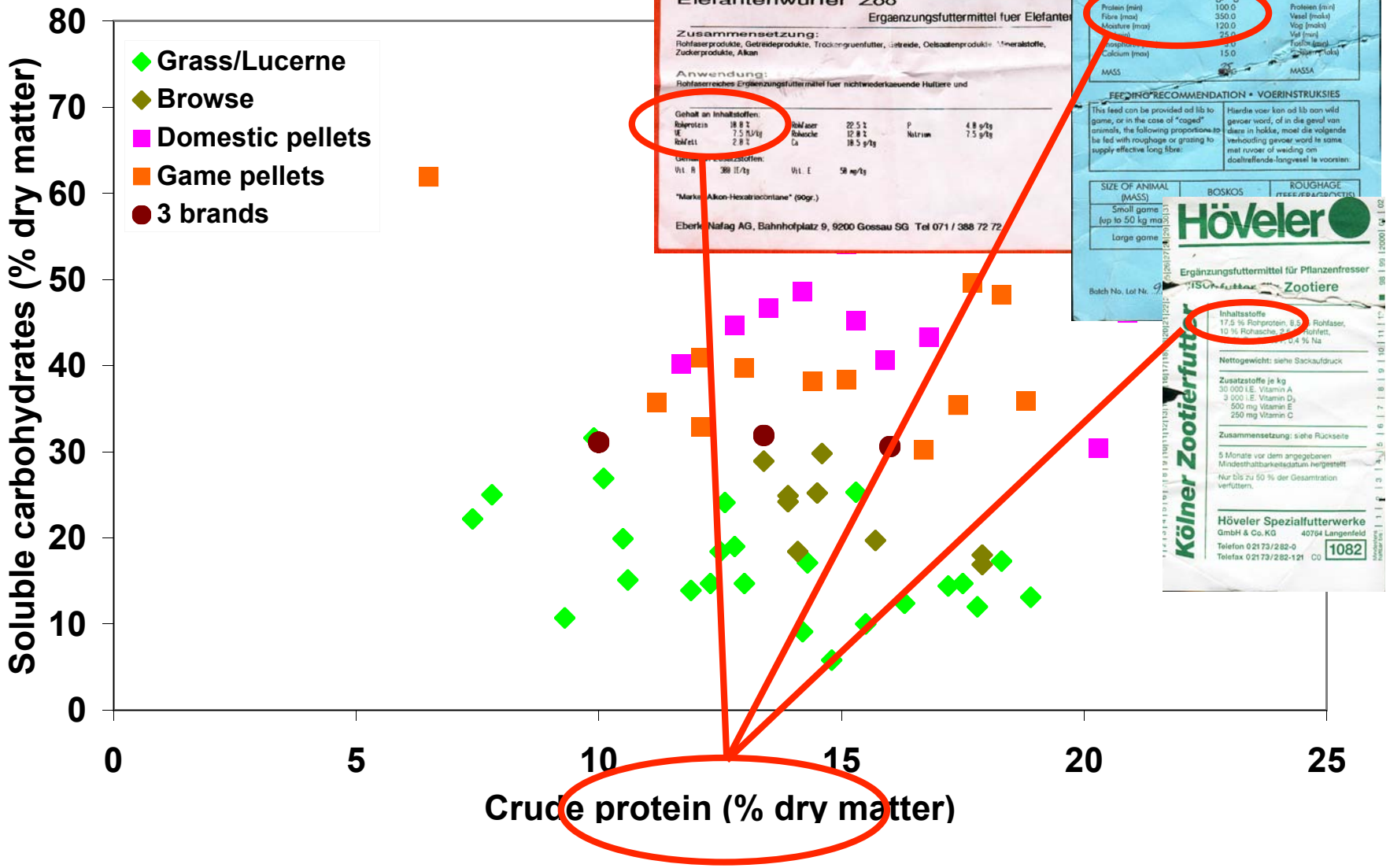
Choosing a pelleted diet



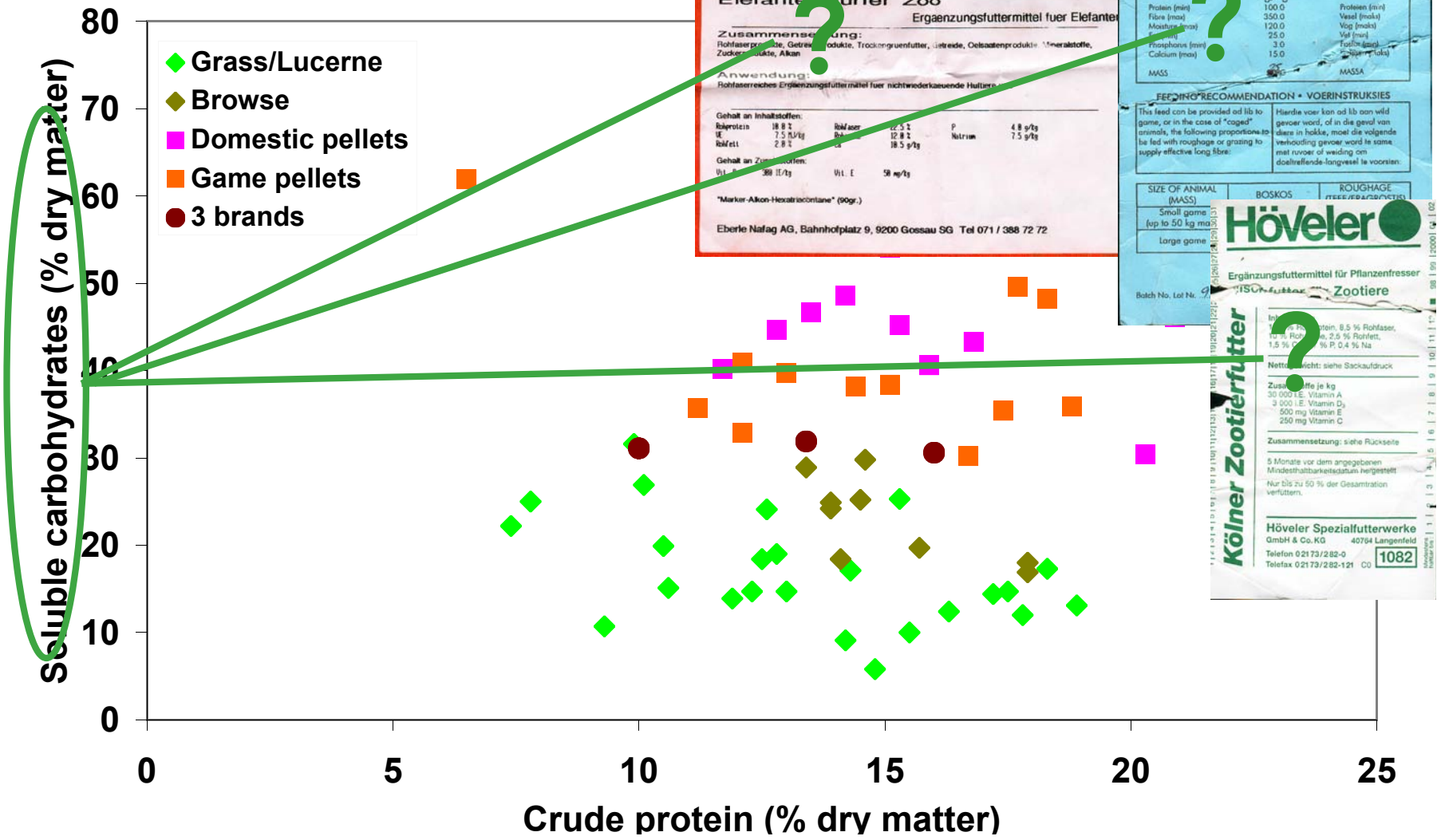
Choosing a pelleted diet



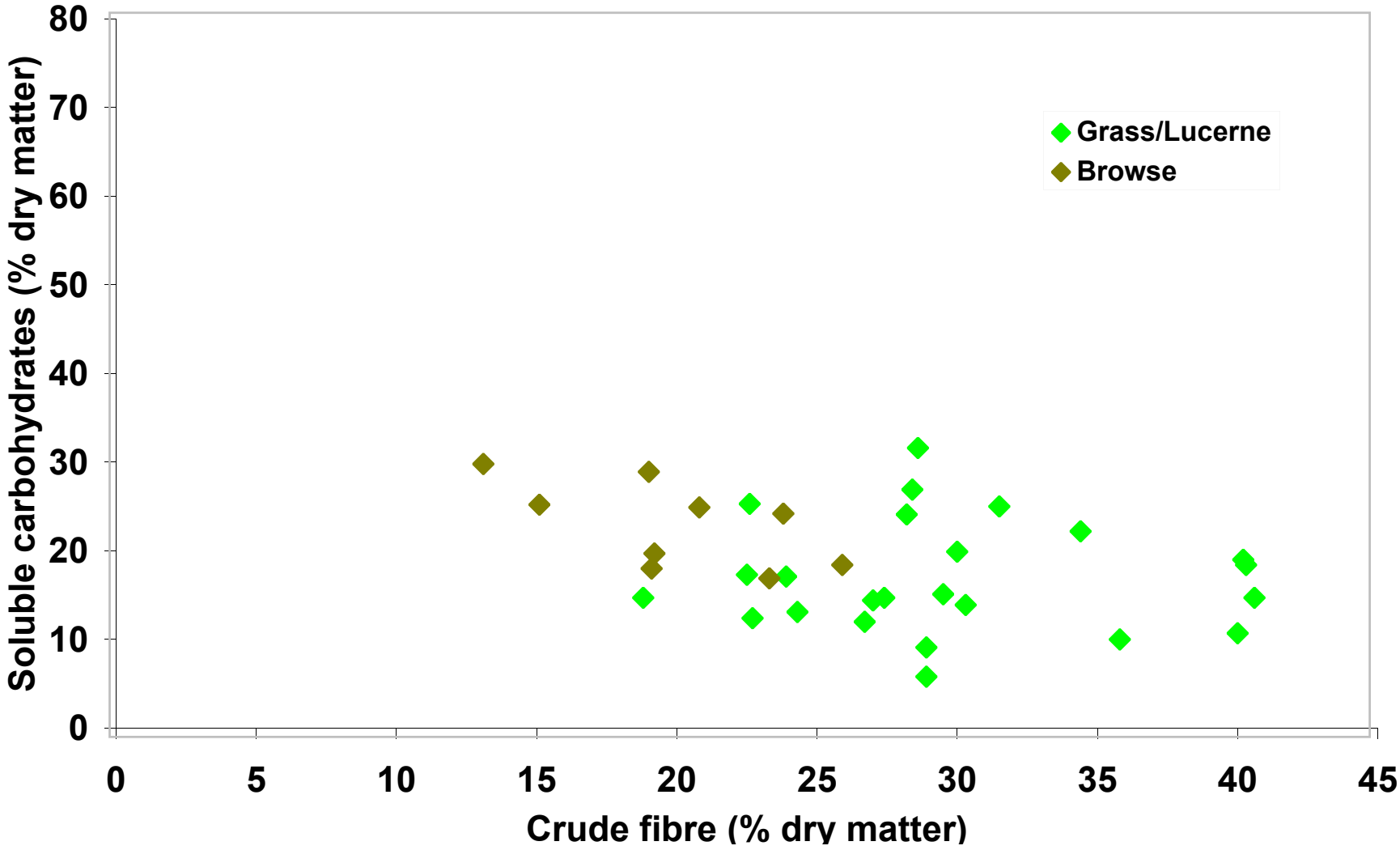
Choosing a pelleted diet



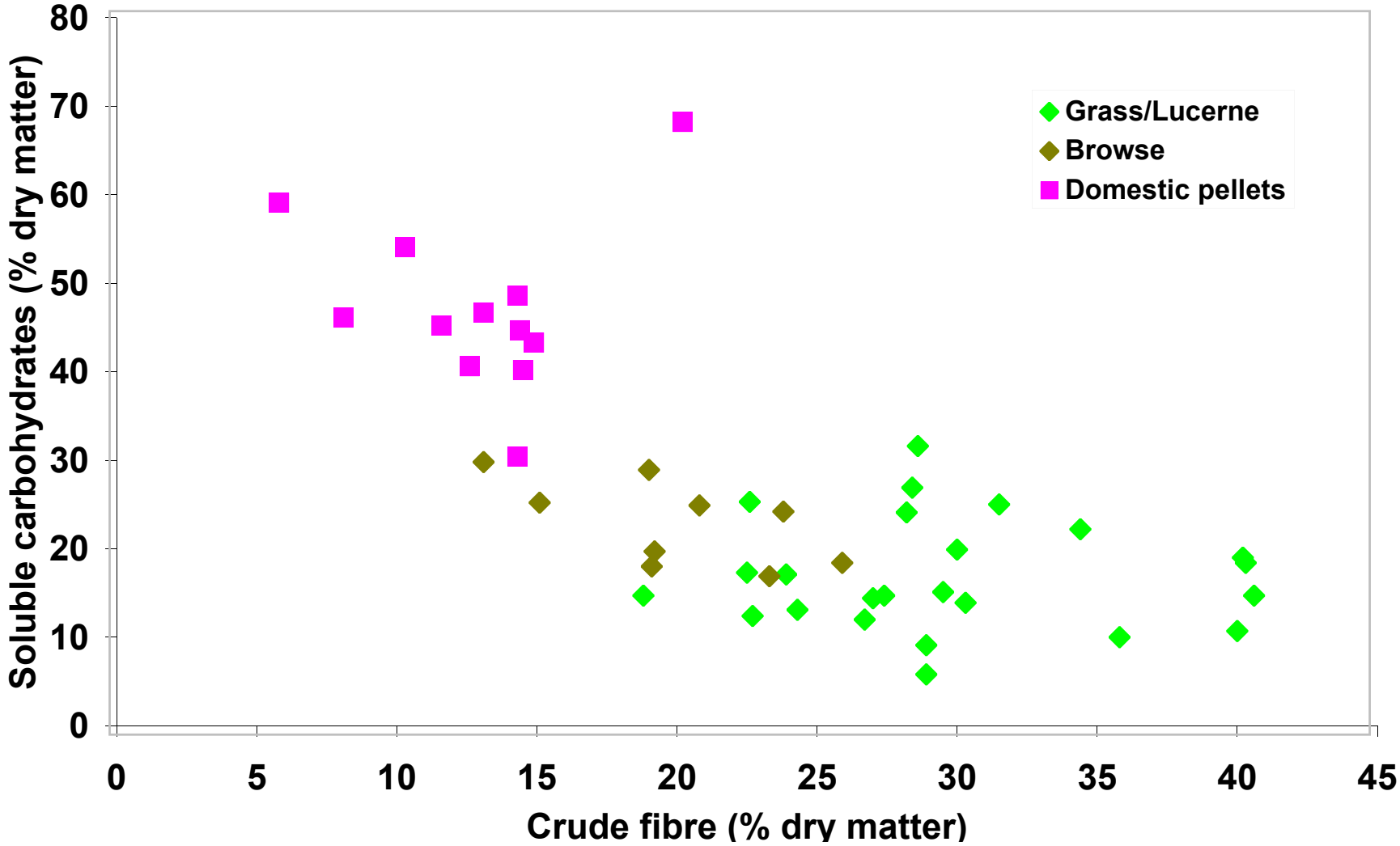
Choosing a pelleted diet



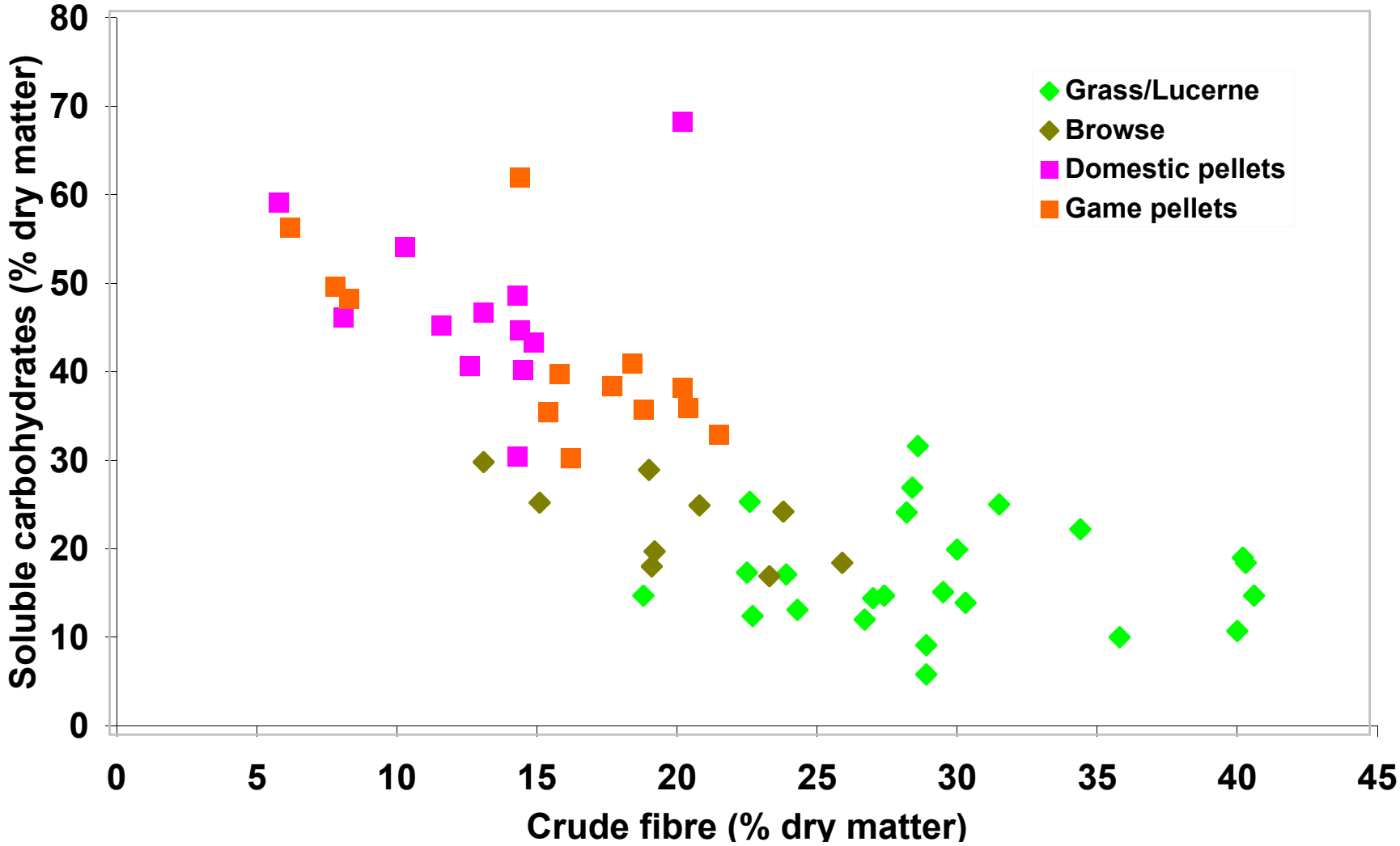
Choosing a pelleted diet



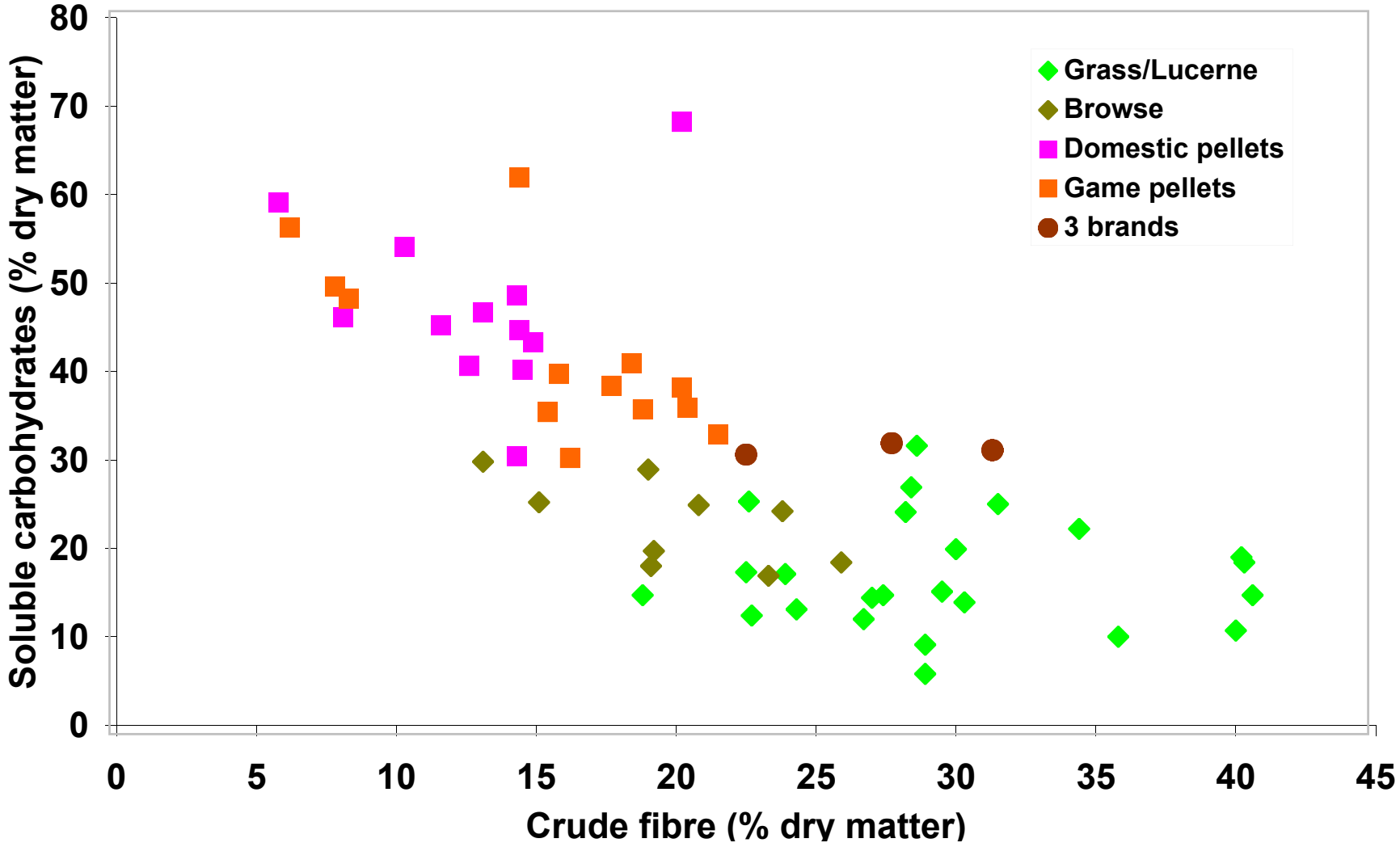
Choosing a pelleted diet



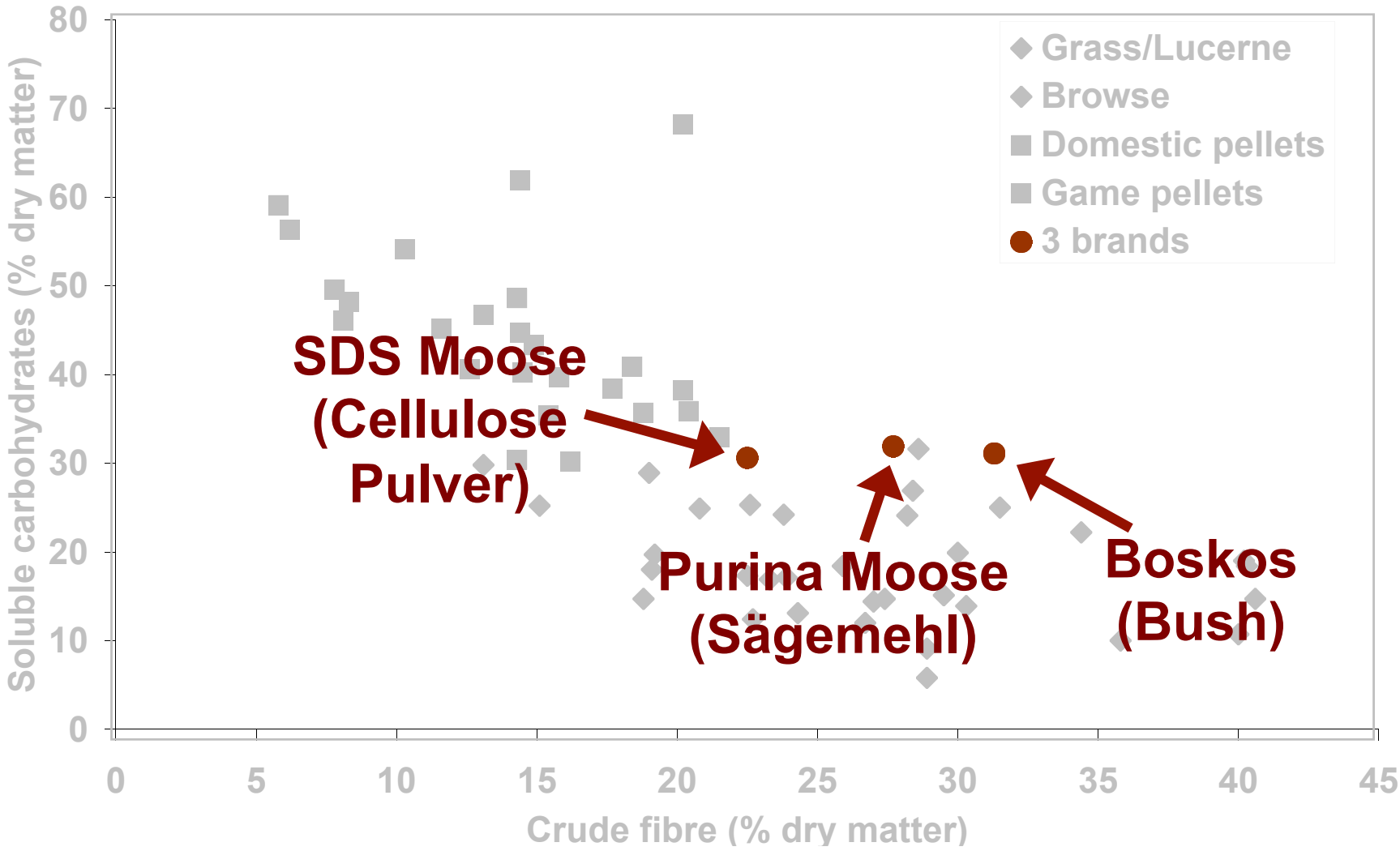
Choosing a pelleted diet



Choosing a pelleted diet



Choosing a pelleted diet

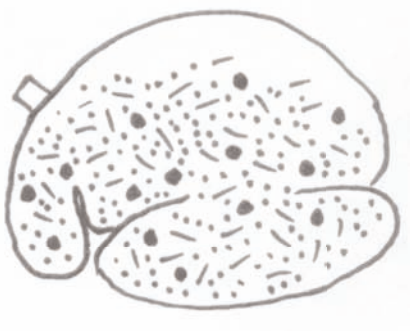


and if browsers don't eat enough hay ...

Brand name	Crude fibre (% DM)
Herbivore 16-ADF[1]	16.7
Herbivore 25-ADF[1]	25.6
Browser breeder[1]	27.8
Browser maintenance[1]	31.1
Moose maintenance[1]	35.6
Grazer[2]	11.2
Browser breeder[2]	18.6
Browser maintenance[2]	21.4
Moose[2]	24.0

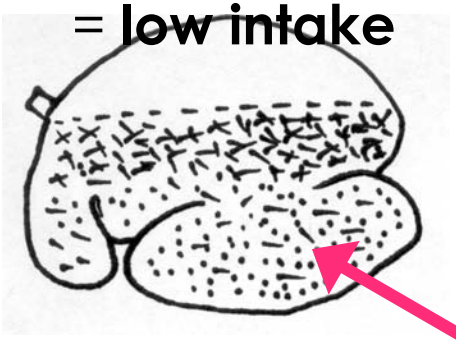
[1] Mazuri□(PMI, St. Louis, USA)
[2] Mazuri™ (SDS, Essex, UK)

from Clauss & Dierenfeld (2008)



Chronic acidosis, hoof overgrowth, oral stereotypies

rumen "blockage"
= **low intake**



You want a rougaghe that does not do this.


This represents app. 1.5 kg
edible browse per 5 animals.

Daily amount of browse for one okapi (on a browse-only diet)

(courtesy J. Hummel)

How do you know you feed enough browse?

1 hour after browse feeding:

Forages for grazers

Grass hay	Lucerne hay	Browse
For large Bovines hay of low feeding quality (not hygienic quality) acceptable; meet increased requirements (e.g. lactation) using hay of higher nutritional value	Not necessary	Not necessary

Additionally fresh green forage/silage

Forages for browsers

Grass hay	Lucerne hay	Browse
Is usually not accepted readily; high quality (mixed meadow, clover/ herbs) can be adequate	Best option; if high quality it allows selection of leafy parts	As much as available; ensile for winter

Additionally fresh green forage/silage


25-10-08
24/10/08
WILLOW
WILLOW
19/10/08

Forages for browsers

Grass hay	Lucerne hay	Browse
Is usually not accepted readily; high quality (mixed meadow, clover/ herbs) can be adequate	Best option; if high quality it allows selection of leafy parts	As much as available; ensile for winter

Offering a variety of roughages (NOT fruits/ concentrates) may be favourable for browsers - it allows selection among non-harmful substances; in other words: this is when they can use the nutritional wisdom they evolved in evolution!

Forages for browsers

Grass hay	Lucerne hay	Browse
Is usually not accepted readily; high quality (mixed meadow, clover/ herbs) can be adequate	Best option; if high quality it allows selection of leafy parts	As much as available; ensile for winter

Extreme browsers (like moose) are best kept if browse is available constantly from zoo-run plantations or from forests nearby.

What is she dreaming of?

What is she dreaming of?