Primate Feeding Ecology

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Consumer side

Primates

Single species approach

Community level

Plant response ("simplified system")

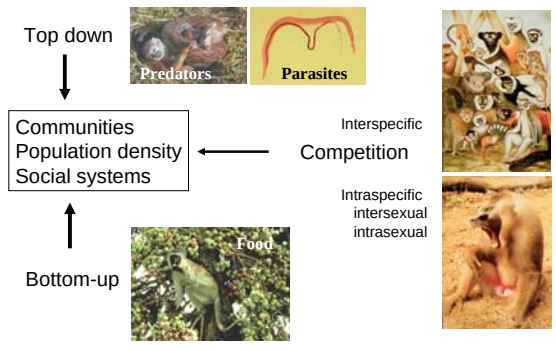
Moose - Willows

Methodological aspects

Stable Isotopes

Near Infrared Spectroscopy

Top-down and bottom-up effects



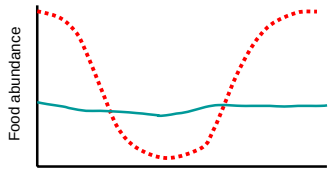
What is limiting ?

Food quality: protein
energy
toxins

or

Food quantity: average or extremes
(seasonal bottlenecks)

?



van Schaik *et al.* 2005

Carbohydrates

Energy content:
1 g= 4 kCal =16.7 kJ

- Plant photosynthesis
- 50-80% of plant material

- Monosaccharids
- Disaccharids
- Oligosaccharide
- Starch
- Fructane
- Alginsäuren
- Agar
- Carrageen
- Pektin
- Cellulose
- Hemicellulose

Carbohydrates

Not digestible

digestible

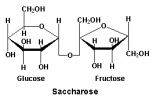
Monosaccharids
Disaccharids

Polysaccharids
starch

Polysaccharids
(except starch)

Fiber

Contains only
C , O , H

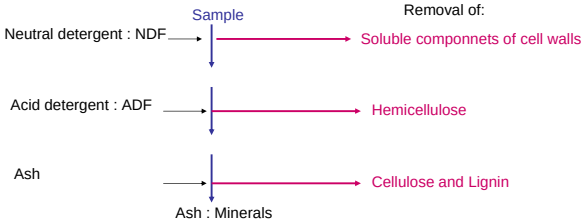


Fiber Fractions

- Cellulose
- Hemicellulose
- Pektin

Cellulose, Lignin – indigestible for Vertebrates
Hemicellulose – partially digestible

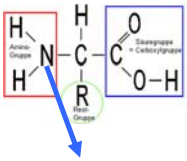
Fiber analyses van Soest,1994



Protein

Energy content:
1 g= 4 kCal =16.7 kJ

Basic components: Amino acids



Nitrogen
measured with Kjeldahl analyses

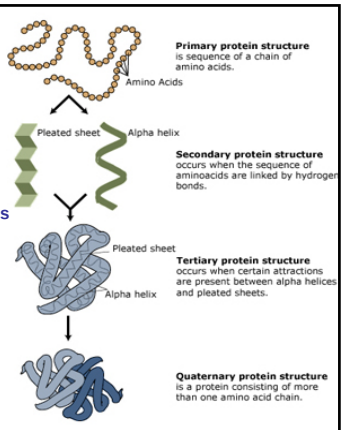


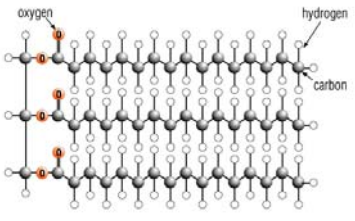
Image adapted from: National Human Genome Research Institute.

„Problems with Proteins“

- Kjeldahl measures nitrogen; nitrogen is found in many non-protein substances
- Conversion factor from nitrogen to „crude protein“ varies between 4 and 6.25
- Nitrogen does not consider amino acid composition (differs between plants and animals)

Fat

= Triglycerides: Ester of III-alcohol and fatty acids
Unsatuarated fatty acids contain double bindings
Essential fatty acids can not be produced by the organism



http://media.allrefer.com

High energy content:
1 g = 9.3kCal = 38kJ

Difference between plant and animal fat ?

	Fat	Protein	Soluble Carbohydrates	Fiber
Leaves		20% (55%)	15%	40%
„Fruits“	1 – 20%	2 – 9%	4 – 60%	
Seeds	1 – 75%	25%	60%	5%
Gum		5- 20 %	20 – 70%	
Meat	15%	70%	4%	

Classification based on main food resources

Guild:
Group of species which utilize the same type of resources

Insectivores	**Carnivores**	**Herbivores**	**„Gum“-eaters**	**Omnivores**
		folivor frugivor gramivor nectarivor		
		grazer browser		

Insectivores & Carnivores

Tarsius syrichta
Philippines

Galago zanzibaricus

http://de.wikipedia.org; Rowe 1996

„Herbivores“

Folivores

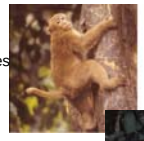
Alouatta

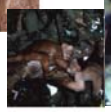
Folivores / Seed eaters

Colobine monkeys

Many lemurs

Frugivores





Grazer / Omnivores

Few lemurs; most Old and New World Monkeys

Baboons

Gum, Exudates, Nectar

Microcebus

Phaner

Cheirogaleus

Euoticus

Callithrix

Otolemur crassicaudatus

Simon Bearder

Differences:
Plants or Animals as Food

	Plants	**Animals**
Ratio **C : N**	40 : 1	8 : 1
Limiting component	Protein	Carbohydrates
Problems with the food	After consumption: Cell walls; Toxins	Before consumption Capture
Digestive tract	long	short

Primate solutions to cope with the different food characteristics

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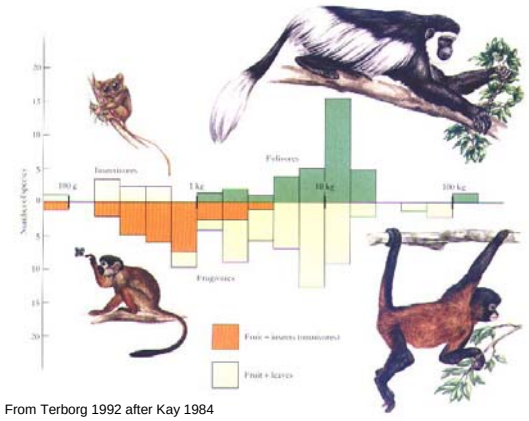

From Terborg 1992 after Kay 1984

From a nutritional perspective the evolution of primate species is based on the hypothesis that in general

protein

is the most limiting factor.

Protein in animal food

Advantage of animal prey:

- High protein concentration
- Identical C : N ratio as primates
- Correct amino acid composition
- No toxins (in most cases; but frogs; millipedes)
- Easy to digest

M. Vences

K. Schütte

Disadvantage of animal prey:

- Insects can only by caught at a maximum rate (insufficient for large primate species)
- Larger animal prey is hard to catch

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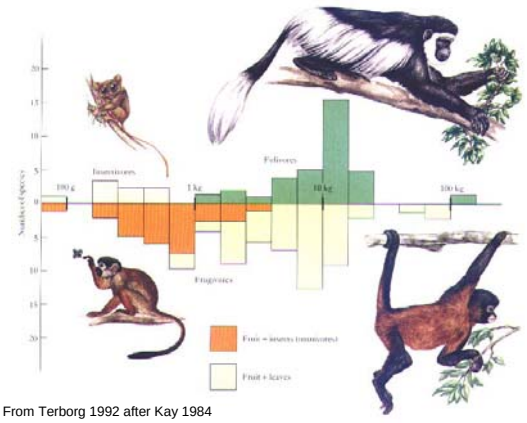


From Terborg 1992 after Kay 1984

Protein in plant food

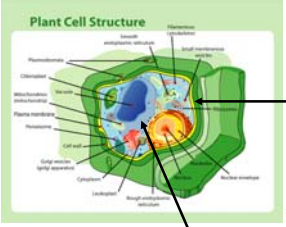
Advantage of vegetable food:

- Does not run away
- Seemingly superabundant

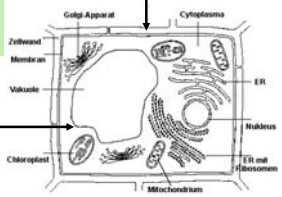
Disadvantage of animal prey:

- Difficult to digest
- Low protein content
- Different amino acid composition
- Seasonally available
- Toxins

Plant cell



Cell wall = barrier:
Non-Food (NDF, ADF)



Food

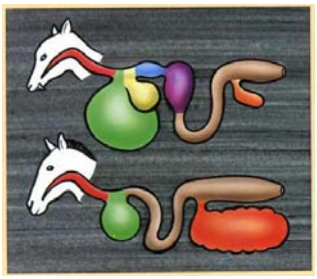
www.joergresag.privat.t-online.de/.../chap43.htm
www.bibel.com/gentechnik/basics.html

Digestion of Cellulose

(Fermantation / Breaking up cell walls)

Foregut:

Sacculated stomach



Hindgut:

Extended Caecum or Colon

Grzimek 1988

Difference Foregut – Hindgut Fermentation

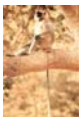
Foregut:

- Detoxification in stomach possible
- Protein produced by microbes can be resorbed in the small intestine

Hindgut:

- Toxins can become effective before they can be metabolised by microbes
- Protein produced by microbes can not be resorbed (fermentation chambers AFTER the small intestine
- Resorption of (volatile) fatty acids

Digestion of Cellulose / Fermentation

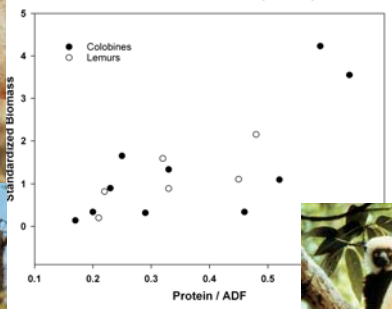
	Foregut:	Hindgut	
		Caecum	**Colon**
Primates:	Colobines 	*Lepilemur* *Alouatta*  	
Marsupials:	Kangaroo	Koala	
Ungulates:	Ruminants		Horses
Rodents:		Rabbits	

Hindgut fermentation in *Lepilemur*

	Protein [%]	Ratio Hemicellulose : Lignocellulose	
Food	15%	0.56	
Stomach	10%	0.54	
Caecum	45%	2.00	Fermentation, Digestion of Cellulose
Colon	38%	1.20	Resorption of fatty acids (energy)
Feces	27%	0.45	

Hladik 1978

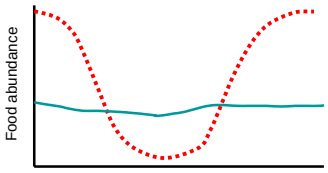
Biomass of folivorous Primates in Relation to Leaf Quality



Oates et al. 1990 Ecology 71: 328
Ganzhorn 1992. Oecologia 91: 540
Chapman et al. 2002. Int. J. Primatol. 23:

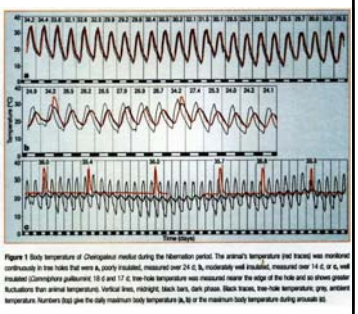
Seasonality?

What happens during the lean season ?



Adaptations of Lemurs to cope with the lean Season

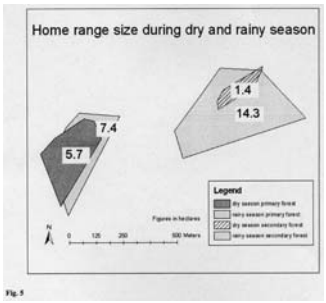
Torpor and Hibernation



Dausmann *et al*. 2004

Adaptations of Lemurs and many Old World primates to cope with the lean season

Reduction of home range



Schwitzer *et al*. In press

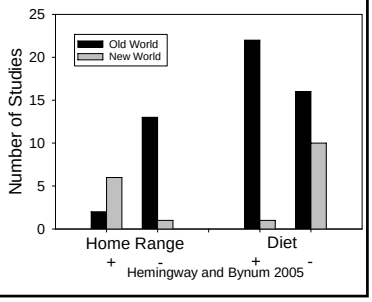
Adaptations of Primates to cope with the lean Season

During the lean season:

Old World Primates
decrease homerange
and increase dietary breadth;

New World Primates
increase homerange
and decrease dietary breadth

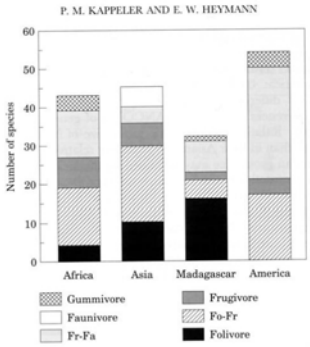
Different solutions!

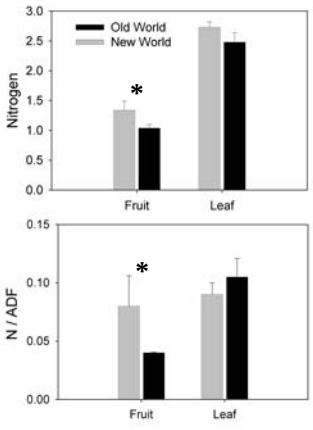


Hemingway and Bynum 2005

Community level Approach

New World has more frugivorous Primates and other frugivorous Mammals than the Old World





Fruit and leaf chemistry of Old and New World Samples

Means and SE; * $p < 0.05$