Eco-systems of agricultural landscapes
and sustainable land use: Livestock systems

03 - Livestock Ecology - 3

Trophic environmental factors

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Theoretical background

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Strategies to overcome environmental constraints

Generalists

Generalists can thrive in a wide range of environmental conditions since they tolerate large and fluctuating amplitude of temperature, humidity, light, nutrient supplies and other environmental factors. Consequently they can colonise various habitats and can utilise widely differing resources. Most domestic livestock species can be classified as generalists as is demonstrated by their world wide distribution.

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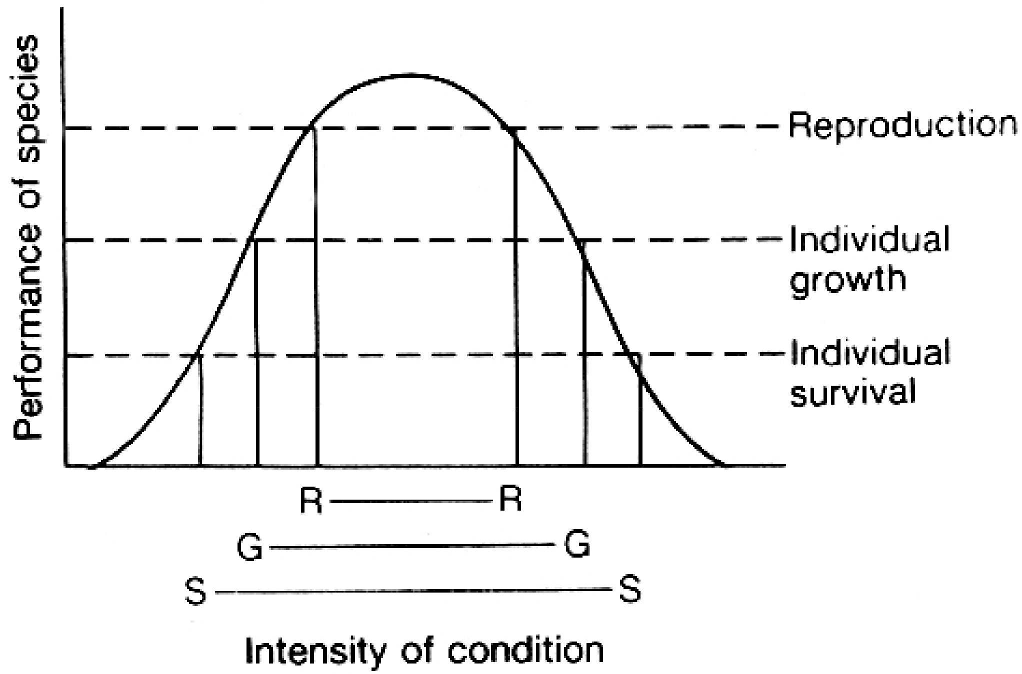
Strategies to overcome environmental constraints

Specialists

Specialists are adapted to narrow ranges of environmental conditions which may be extreme. Since they can tolerate extreme levels of aridity, cold, darkness, high salinity etc and/or feed exclusively on sources which are inaccessible, unpalatable or repellent to other organisms they avoid competition with generalists which do not tolerate extremes. Few domestic livestock species are true specialists, although camelids with their special adaptation to aridity or water buffalo with their tolerance of hot and humid conditions qualify to some extent.

A generalized graphical representation of the manner in which the performance of a species is related to the intensity of an environmental condition



The narrow range over which reproduction can occur (R-R) usually dictates where continued existence of the species is possible (though some plants can apparently persist indefinitely by vegetative growth alone)

Source: Ecology, Begon, Harper, Townsend, 1990

The fundamental niche

The sum of relationships between organism and their abiotic environment

The real niche

The sum of relationship between organism and their abiotic and biotic environment

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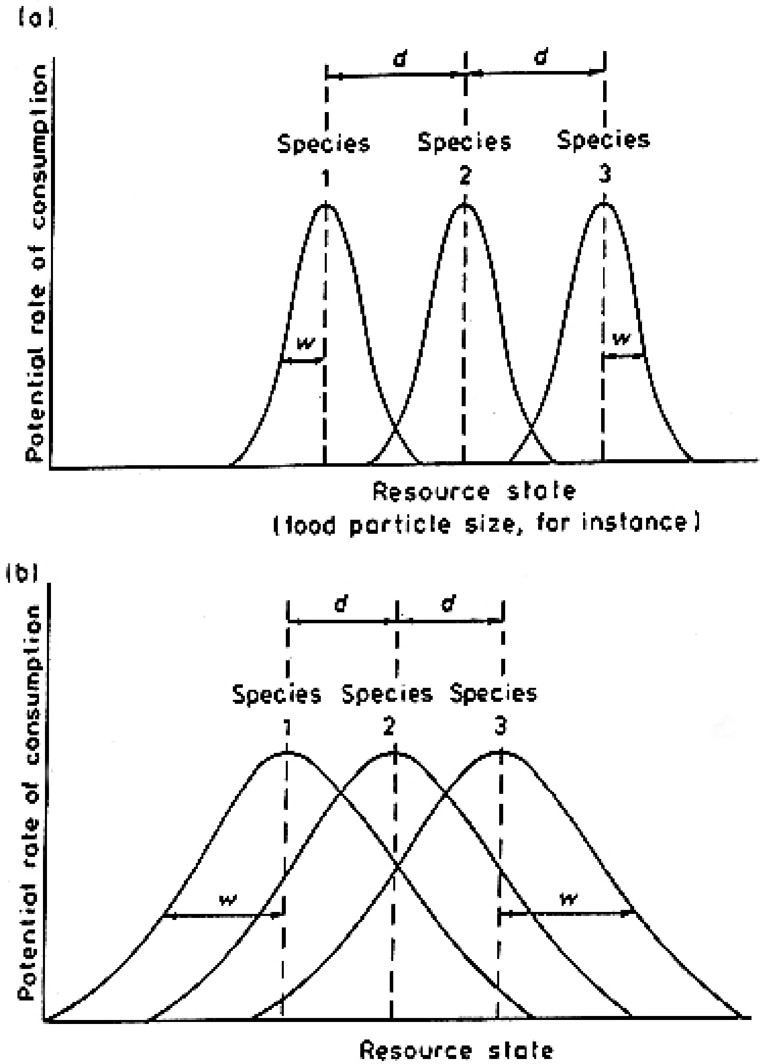
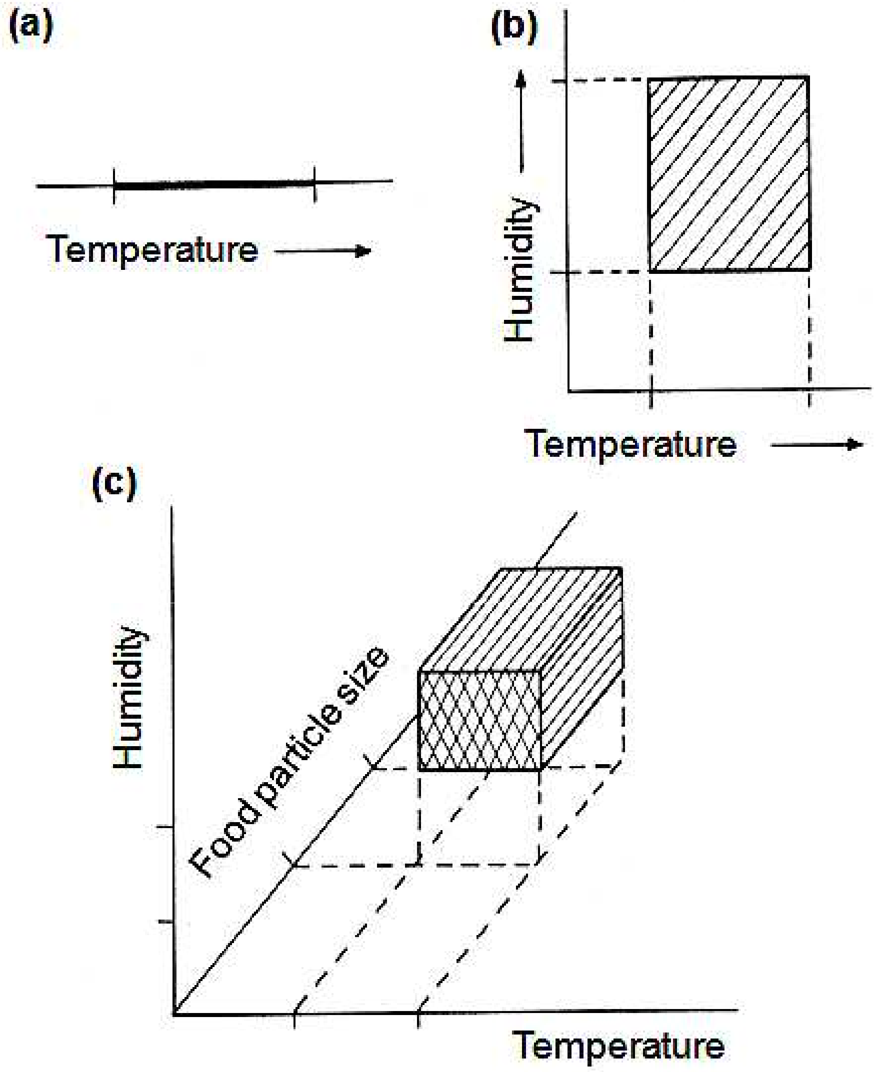
Resource utilisation curves for three species coexisting in a one-dimensional niche system



Source: Population Ecology, Begon & Mortimer, 1993

Building up the *n*-dimensional hyper-volume: Ecological niches



(a) in one dimension (temperature)

(b) in two dimensions (temperature and humidity)

(c) In three dimension (temperature humidity and food particle size)

Source: Population Ecology. Begon & Mortimer, 1993

Schematic presentation of the utilisation of a “super“ niche

1. Volume of super niche occupied by one generalist species(a); the actually occupied space is called the fundamental niche of that species

2. In the presence of a second, competing species (b) species (a) will be restricted to a realised niche where it has a comparative advantage.

3. If there are more species which can use the super niche the realised niches become smaller and smaller.

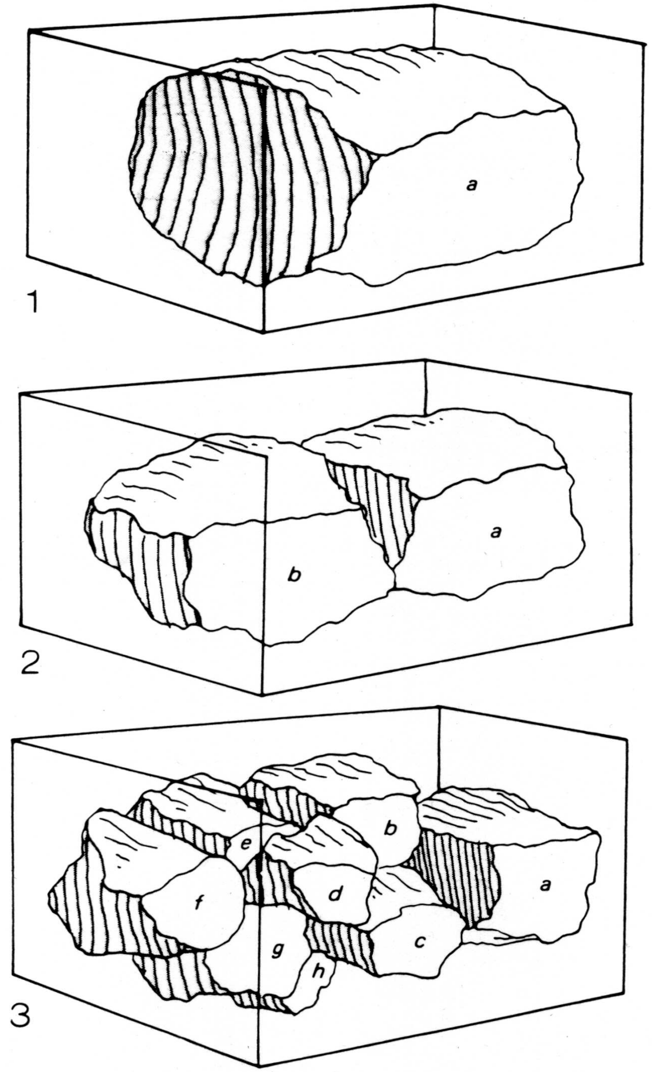
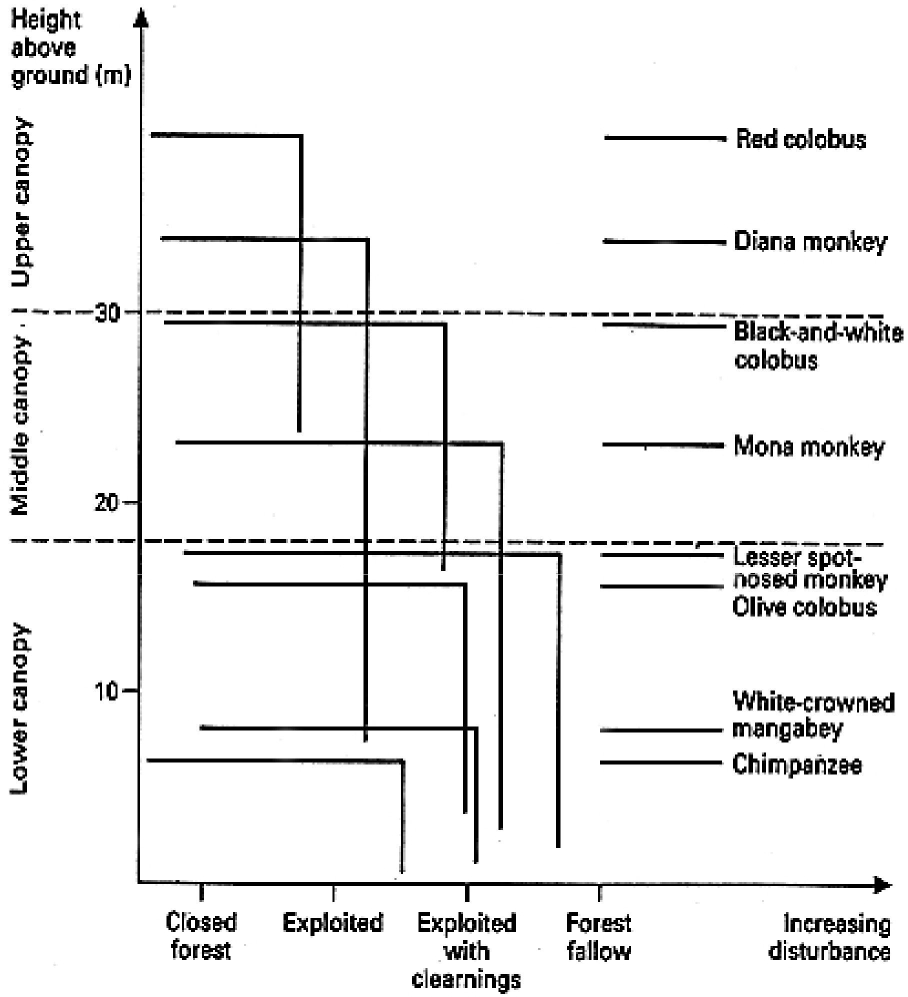


Diagram to illustrate the different niche requirements of primates species in the tropical forest of West Africa



Although the demands of the various species overlap, each has a particular height in the canopy or a type of site where it is most efficient and successful

Source: Biography, Cox & Moore, 1983

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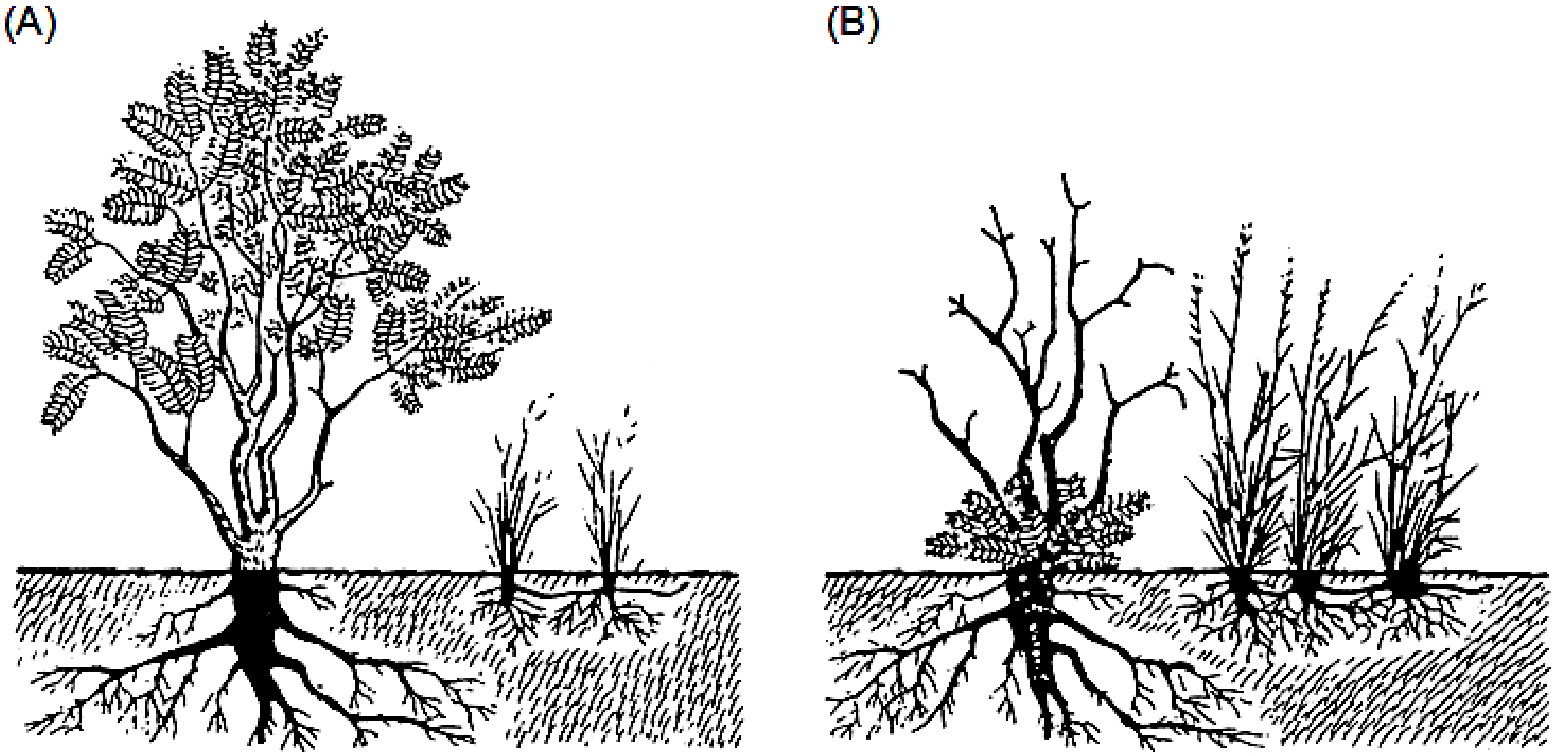
Changing niche availability through management interventions



(A) Diagrams show how fire favour grass over mesquite shrubs in the south-western United States. In the absence of fire, the mesquite chokes out the grass.

(B) After a fire, grass recovers quickly, growing with increased vigour under conditions of reduced competition. Controlled burning will eliminate the mesquite entirely and maintain the grassland.

Application to livestock systems

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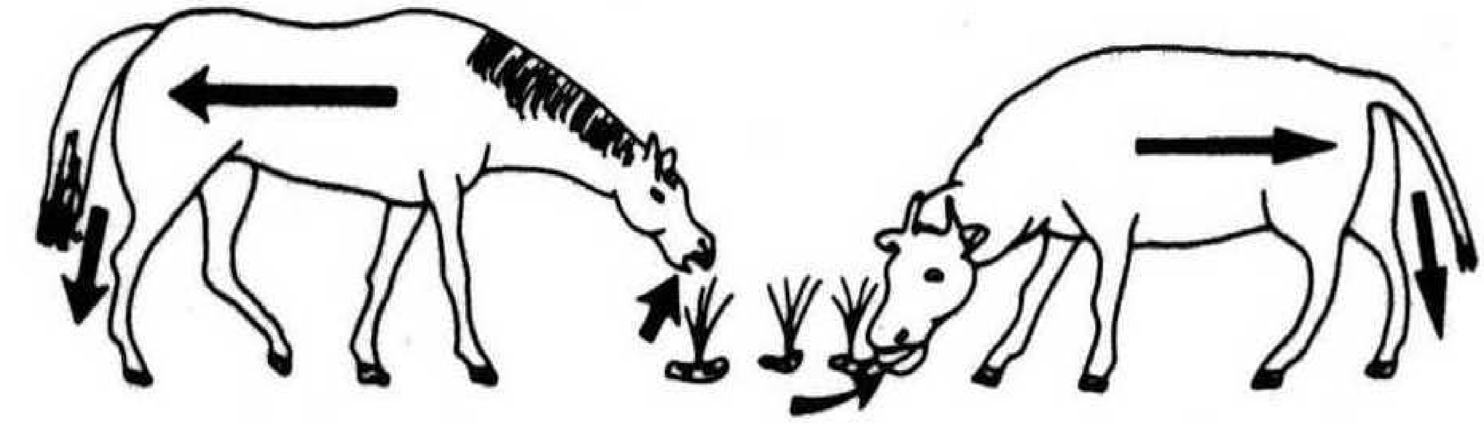
Differences between the food intake strategies of horses and cattle

A: food consists of young, short grass with low crude fibre content

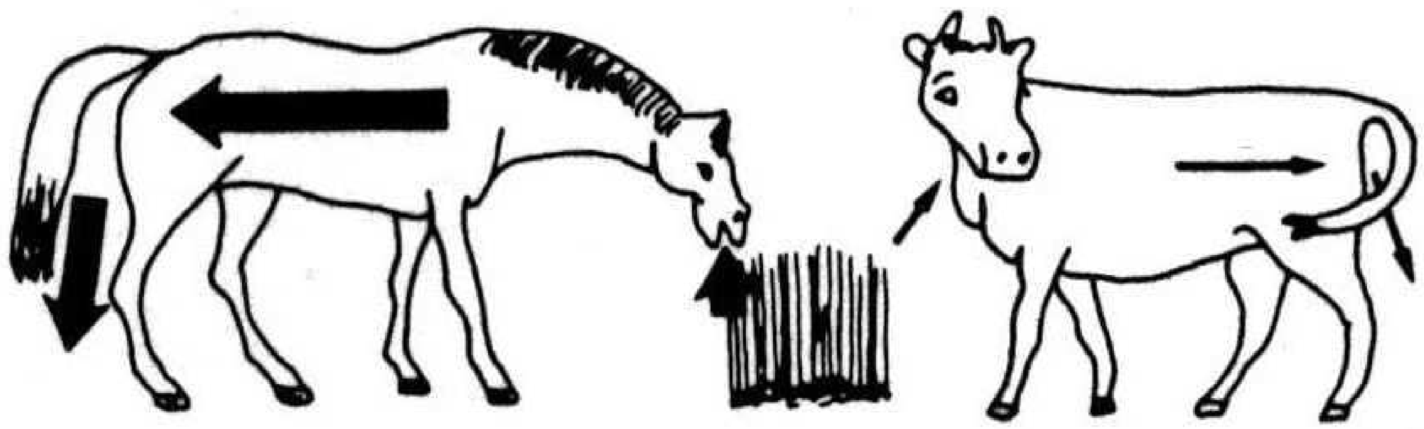


Food intake	moderate	moderate
Feed passage rate	48 hours	80 hours
Cellulose digestibility	70 % that of cattle	30-55 %

After W. von Engelhardt

Differences between the feed intake strategies of horses and cattle

B: food consists of long grass with high fibre content



Feed intake	more	less
Feed passage rate	faster	slower
Cellulose digestibility	worse	same or worse
Absorption of nutrients	same	worse

After W. von Engelhardt

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Feed preferences of herbivores are determined by

- growth or life form of the plant
- height of the plant above the ground
- nutrient contents of the plant
- physical characteristics of the plant
- proportion of a species in the plant community
- demand and intake capacity of the animal

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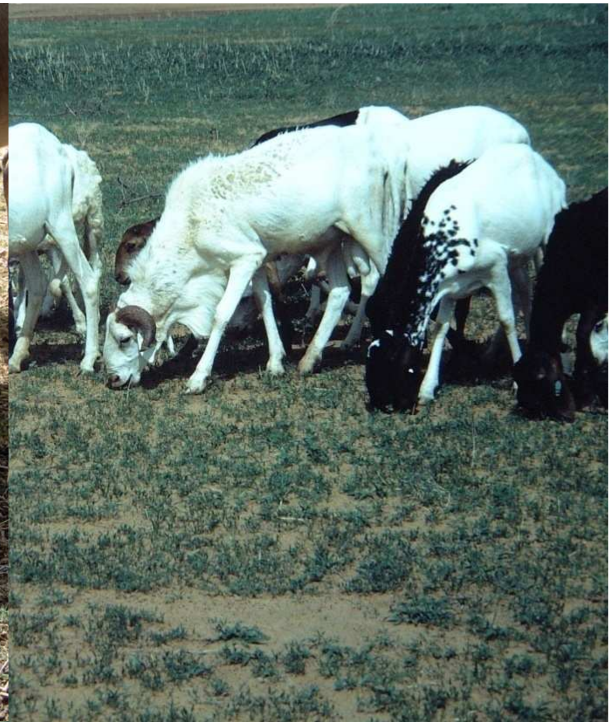

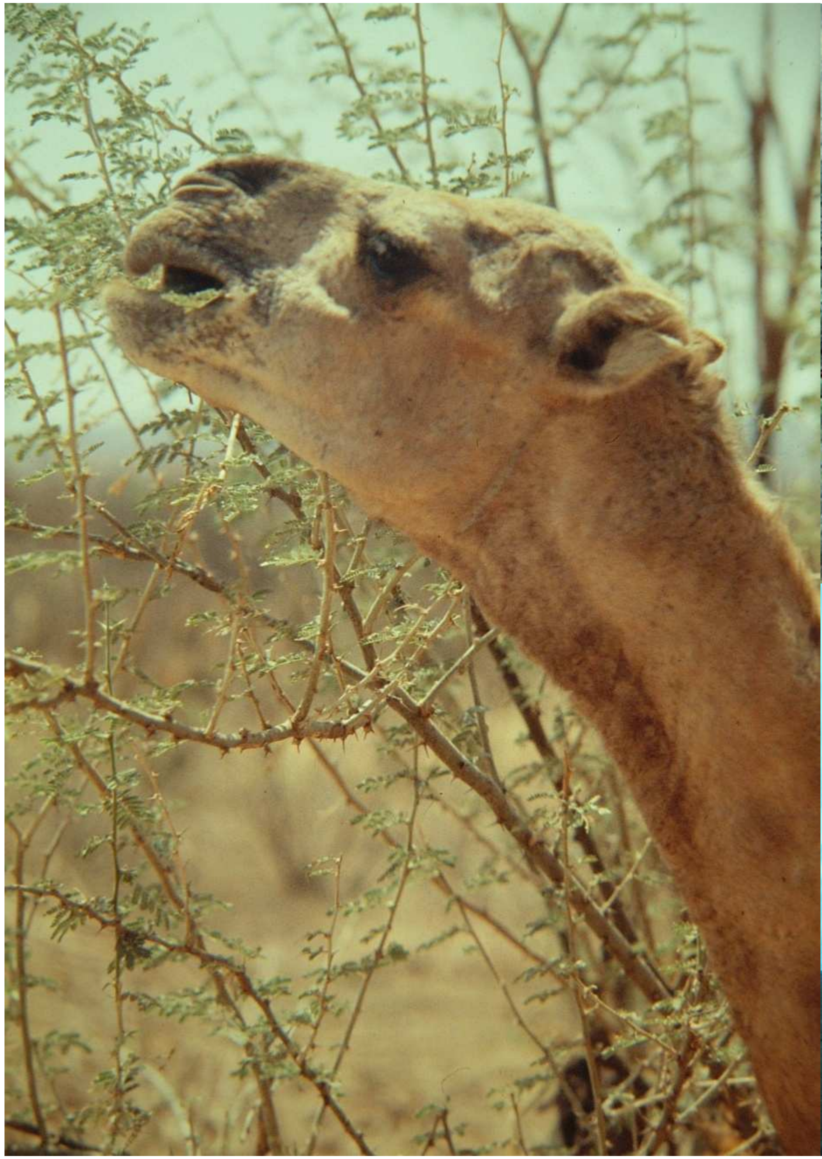

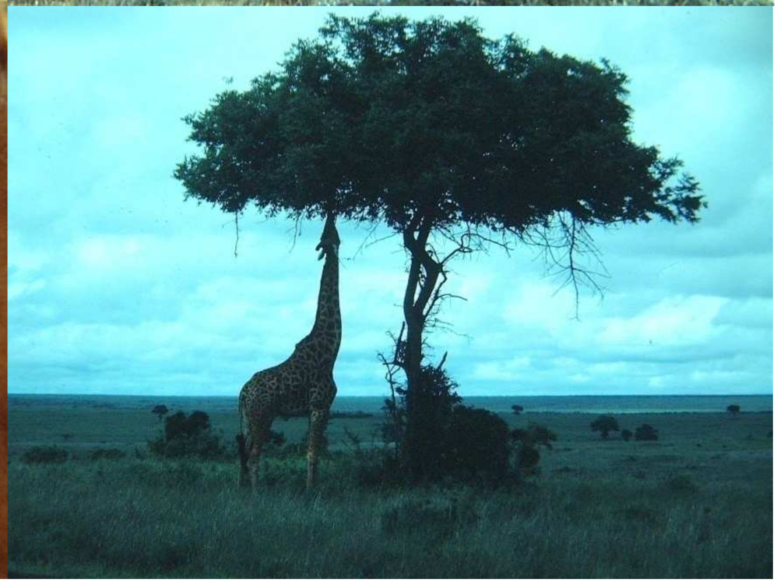

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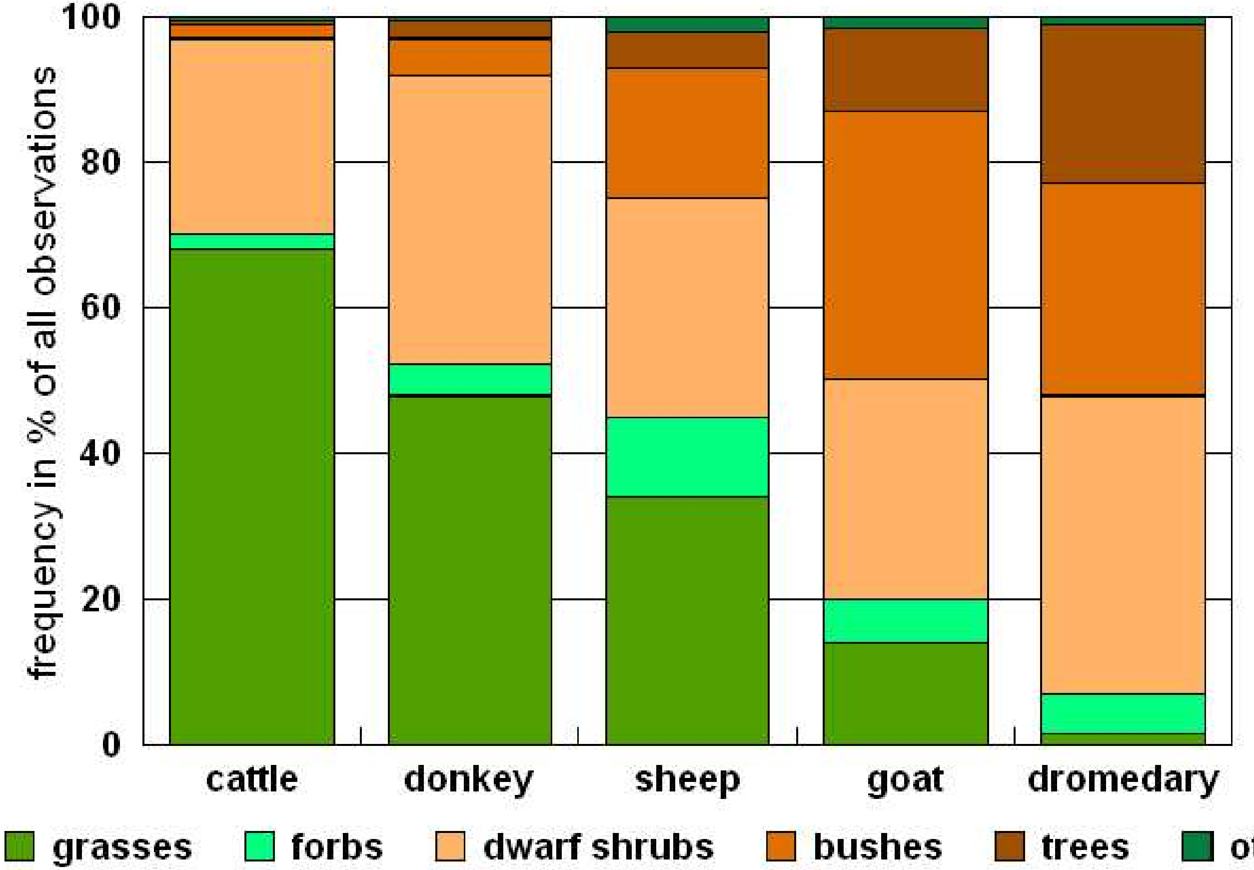
Observed frequency of occurrence (as % of all observations) of plant species, grouped by growth form, in the diet of free ranging domestic herbivores



Percentage similarity* (lower left) and Horn's index of feed preference overlap* (upper right) in the ingested diet of free grazing domestic herbivores on a semi-arid thorn bush savannah

	Goat	Sheep	Cattle	Donkey	Dromedary
Goat		.607	.553	.614	.721
Sheep	.411		.757	.797	.558
Cattle	.329	.551		.872	.264
Donkey	.415	.636	.703		.435
Dromedary	.555	.398	.165	.348	

* Based on number of observed feeding stations per forage species

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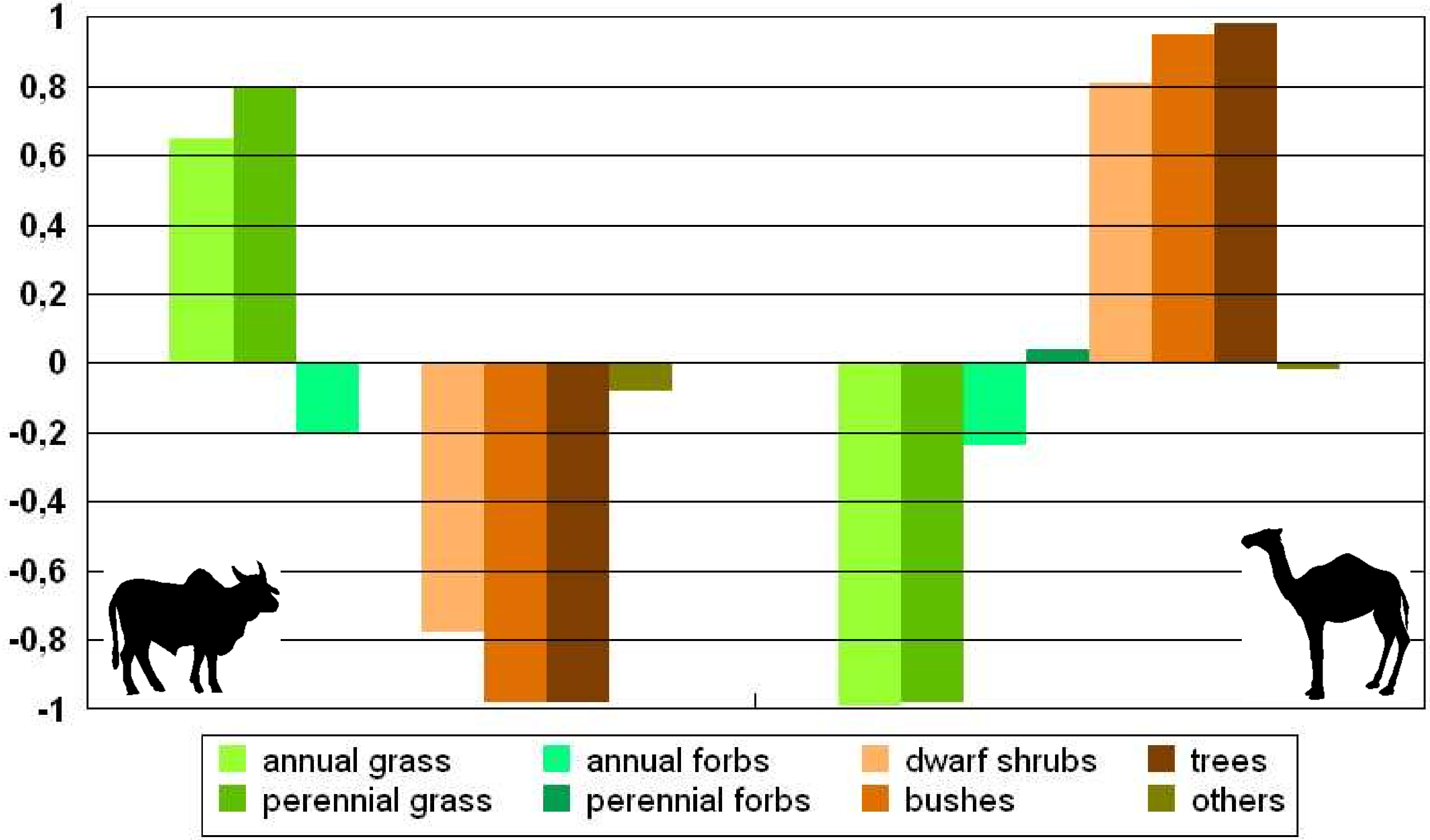
Selectivity index E by growth form of forage plants for zebu cattle and dromedaries measured on a semi-arid thornbush savannah



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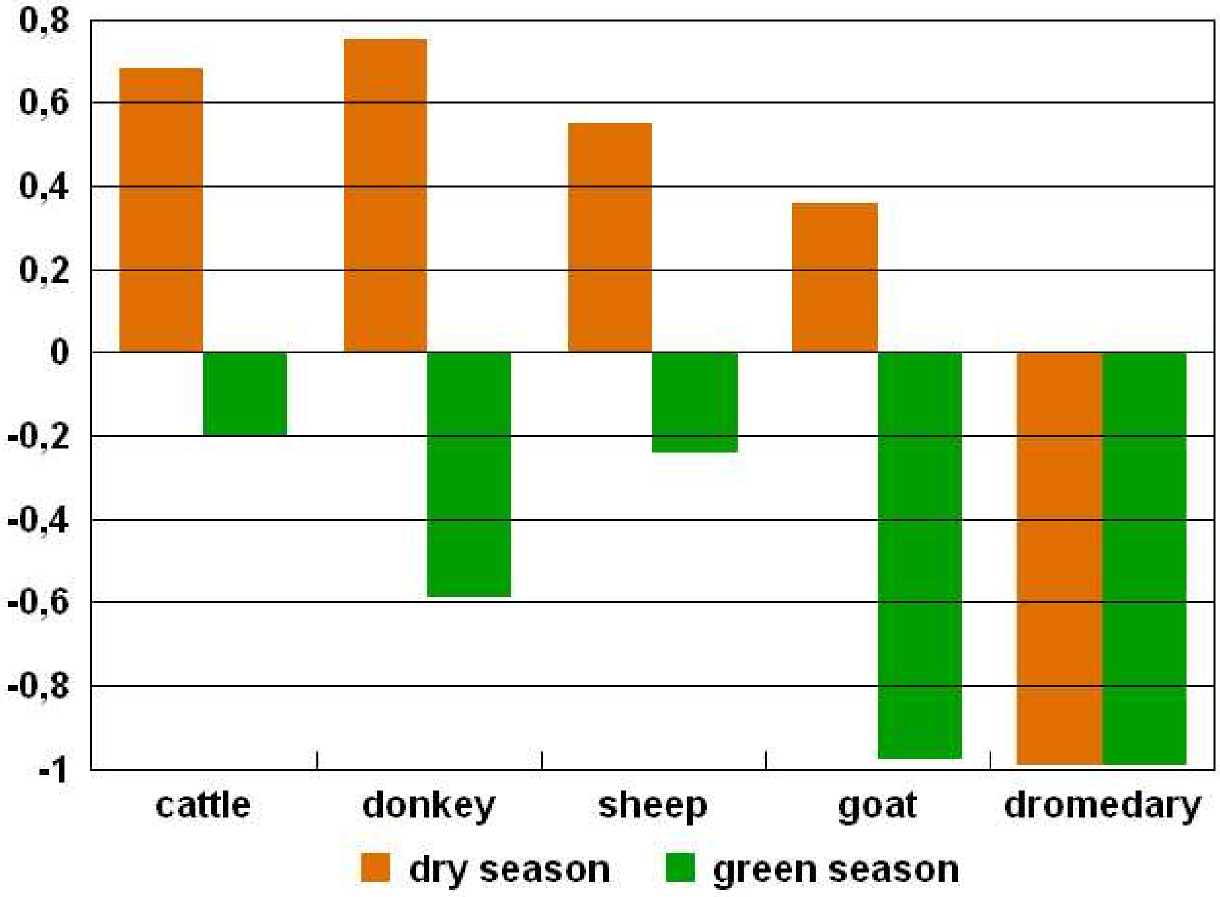
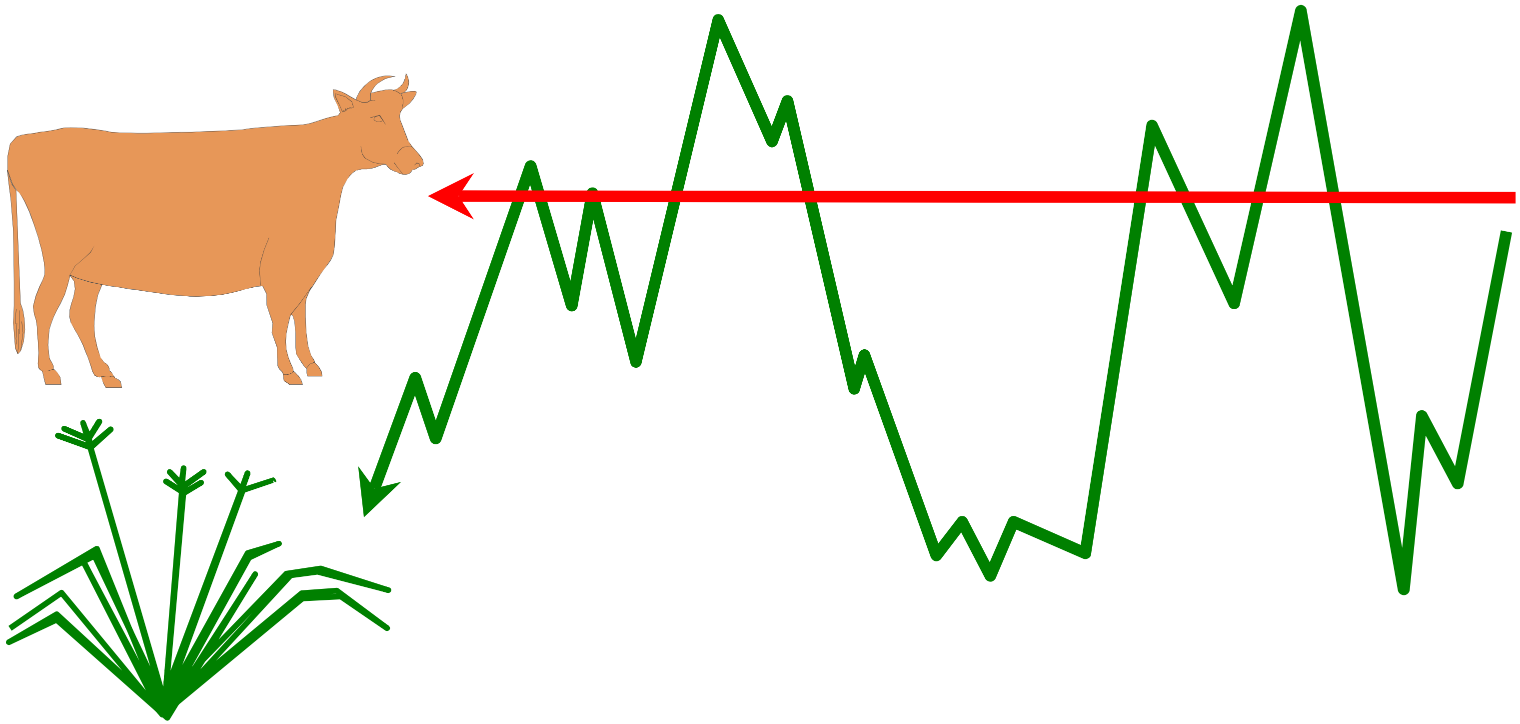
Selectivity index E for *Chrysopogon plumulosus* during two seasons, calculated for domestic herbivores on a specific experimental pasture at the Ngare Ndare Research Station, Isiolo District



Animal requirements are relatively constant, while feed supply fluctuates



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Variability of forage supply on natural pastures

Spatial	plant parts
	whole plants
	communities, vegetation mosaics
	landscapes
	regions
Temporal	seconds to hours
	days to weeks
	seasons, years, decades, centuries
Spatio-Temporal	spatial temporal interaction

Morphology of Lucerne (*Medicago sativa*) as an example of a typical feed plant with details of the digestibility of different parts of the plant

All leaves: 80-85 %

Stem Internodes 1 & 2: 65-75 %

Internodes 3 – 6: 50-65 %

Internodes 7 +: 40-50 %

After van Soest 94

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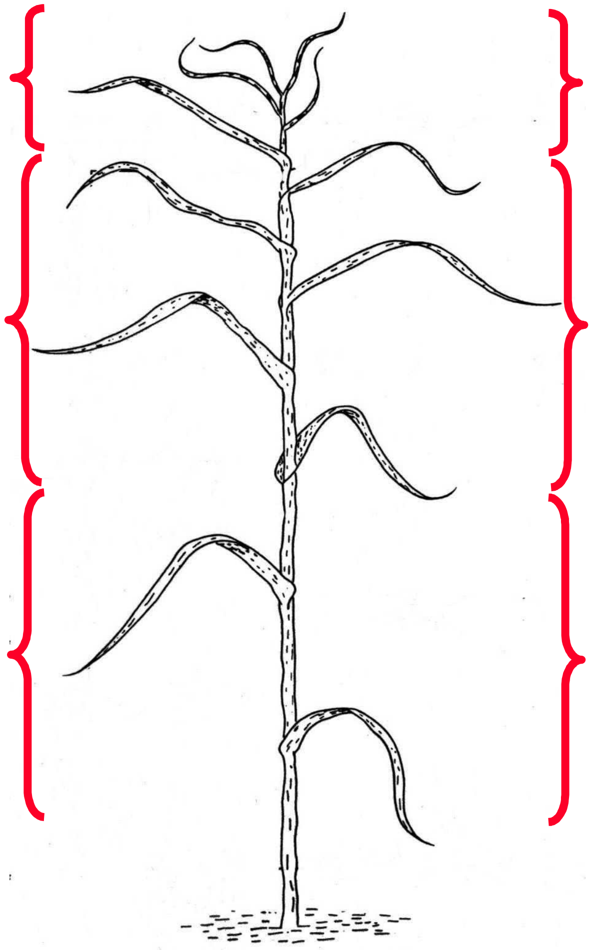
Differences in dry matter digestibility of different leaf and stem parts of a tropical grass

Growing stem: 60-70 %

Upper stem: 45-55 %

Lower stem: 45-55 %



Young leaves: 65-75 %

Mature leaves: 60-70 %

Old leaves: 50-55 %

After van Soest 94

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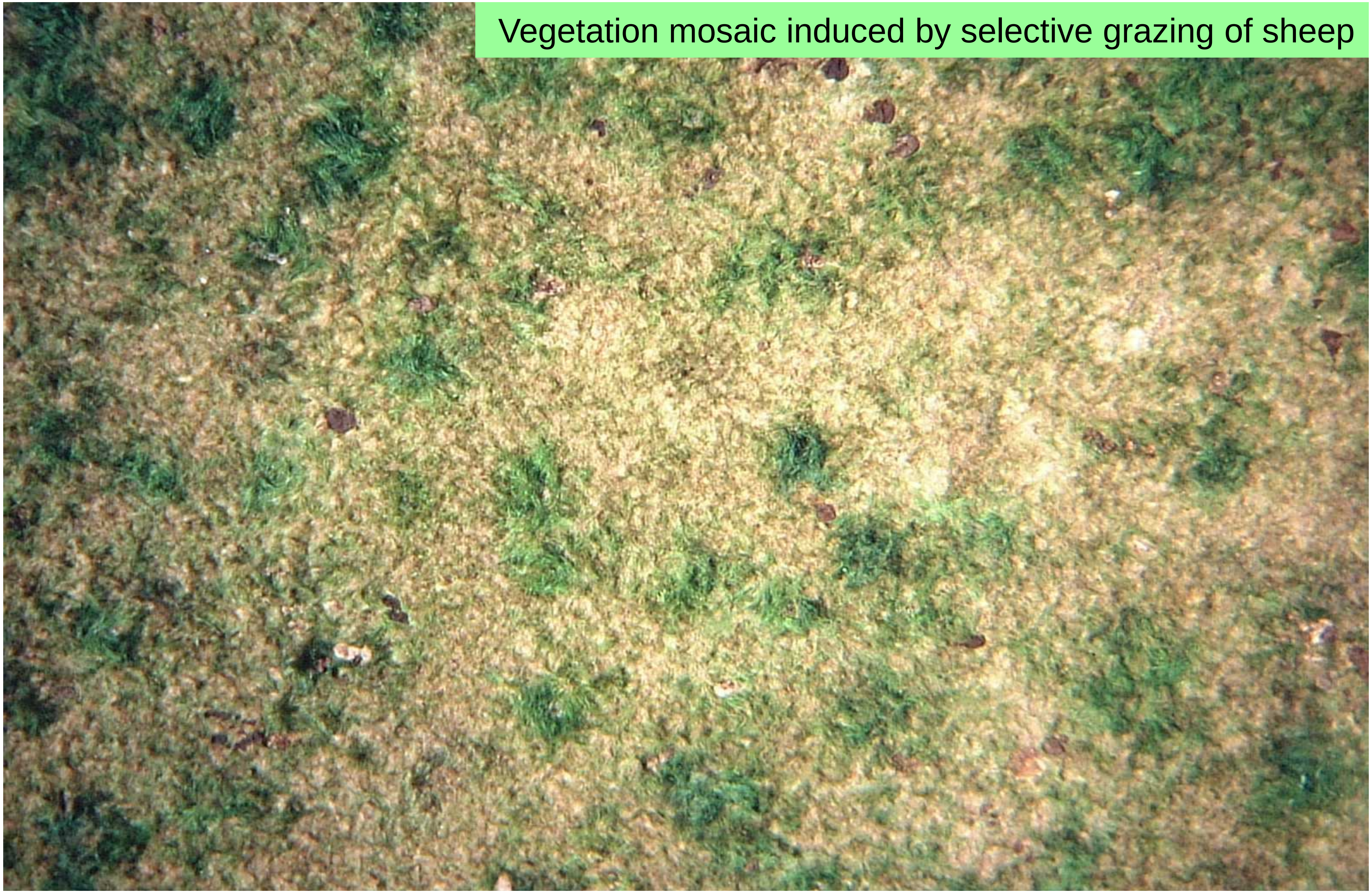
Vegetation mosaic induced by selective grazing of sheep



Blue Lemmon grass (*Cymbopogon afronardus*) on a heavily grazed pasture

Untouched thistle in a perennial grassland after grazing by cattle at high stocking rates

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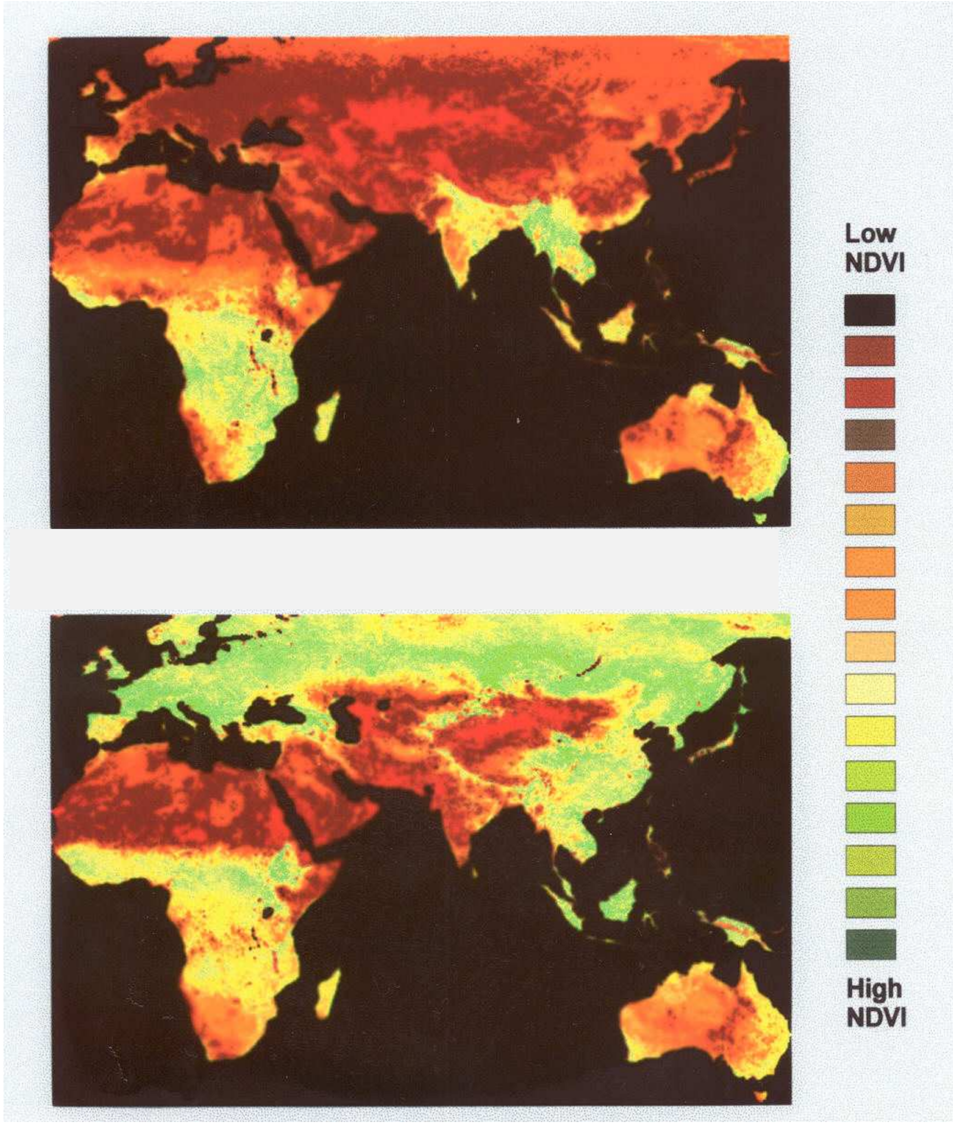
Presence of photo-synthetically active vegetation observed at different times of the year in the old world, mapped using NOAA satellite data

January 1999

July 1999



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General Strategies for the Avoidance of Seasonal Stresses

		Dormancy	Recession
Reactive	immediate	Quiescence	Evasion (undirected)
	delayed	Oligopause	Emigration (directed)
Proactive	obligatory	Parapause	Paramigration
	optional	Eudiapause	Eumigration

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Ruminant animal responses to temporal variability of forage quantity and quality

Adjust feed intake strategy

- shift of intake preferences
- change bite rate
- different grazing times
- different walking speed
- change grazing range

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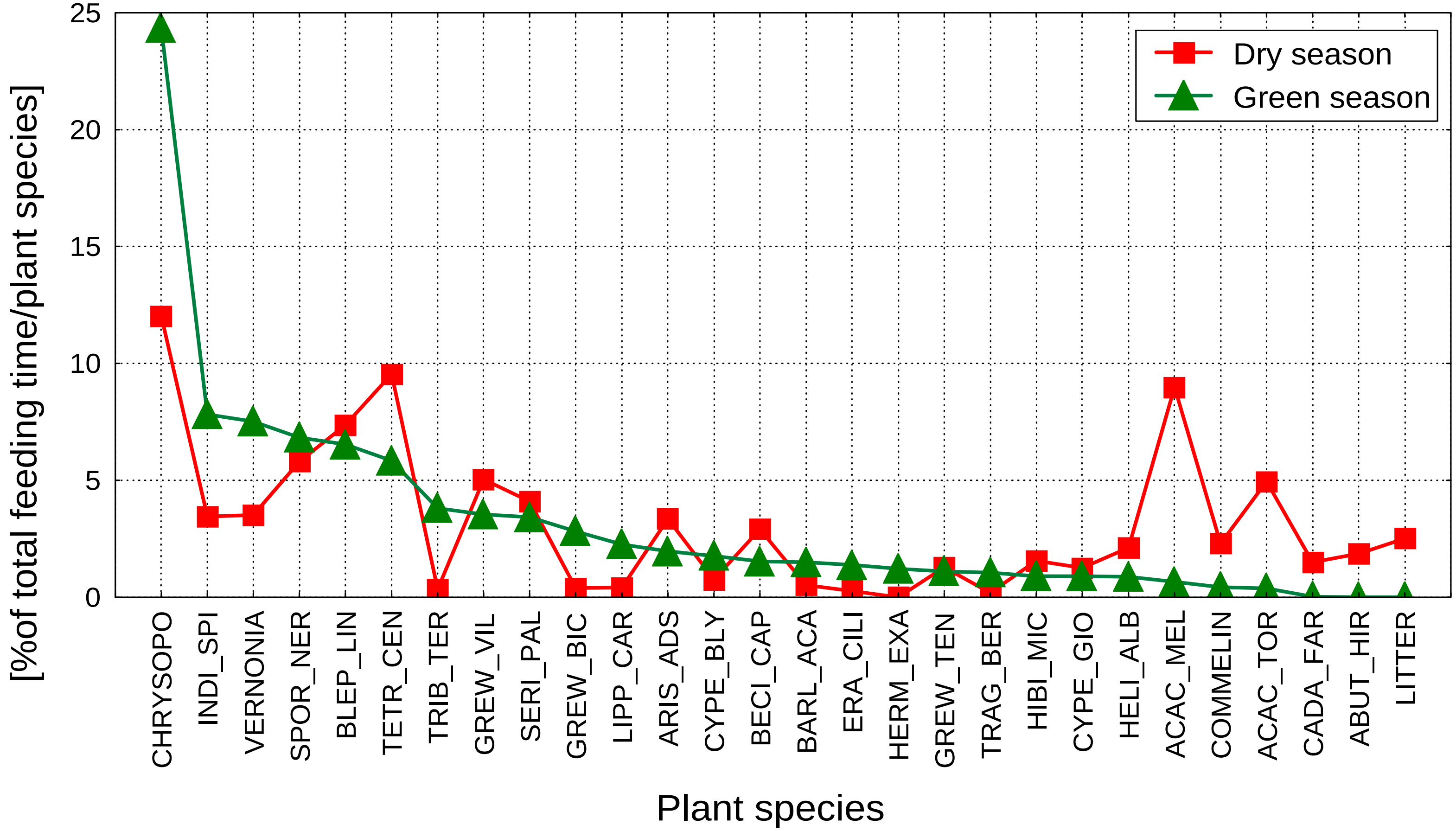
Observed intake preference [% feeding time/plant species] of sheep in dry and green season



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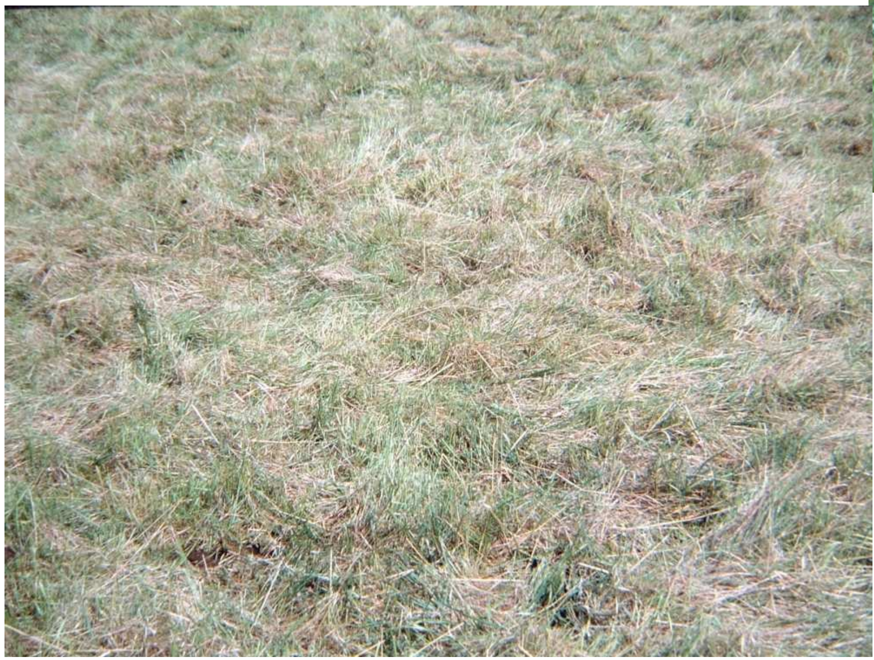
Cattle pasture after five days of grazing by 1,4 SSU/ha during the last decade of MAY



Cattle pasture after five days of grazing by 1,4 SSU/ha during the last decade of AUGUST

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Ruminant animal responses to temporal variability of forage quantity and quality

Adjust digestive strategy

- change of feed through-put
- adjust rumination time
- change of particle size reduction
- change of feed retention time

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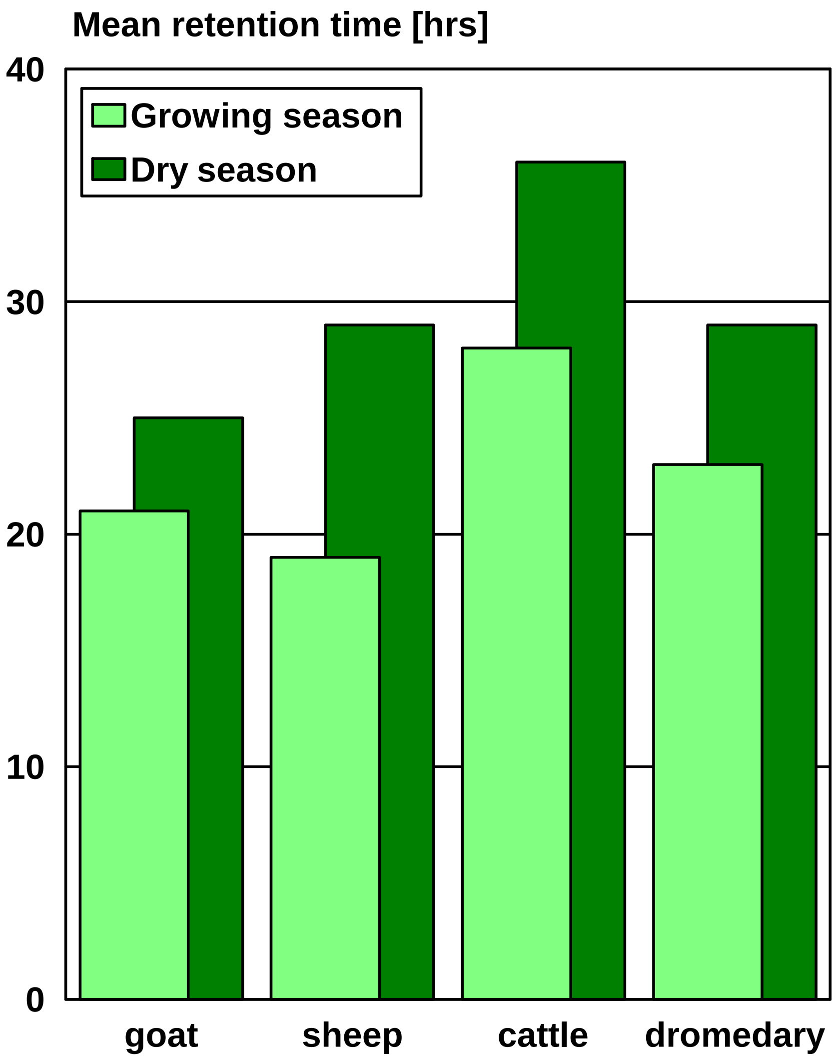
Seasonal Changes of mean retention time of feed particles in the forestomach of domestic ruminants and dromedaries on a semi-arid tropical pasture



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Ruminant animal responses to temporal variability of forage quantity and quality

Morphological adjustment of GIT

- change of rumen volume
- change of ruminal mucosa

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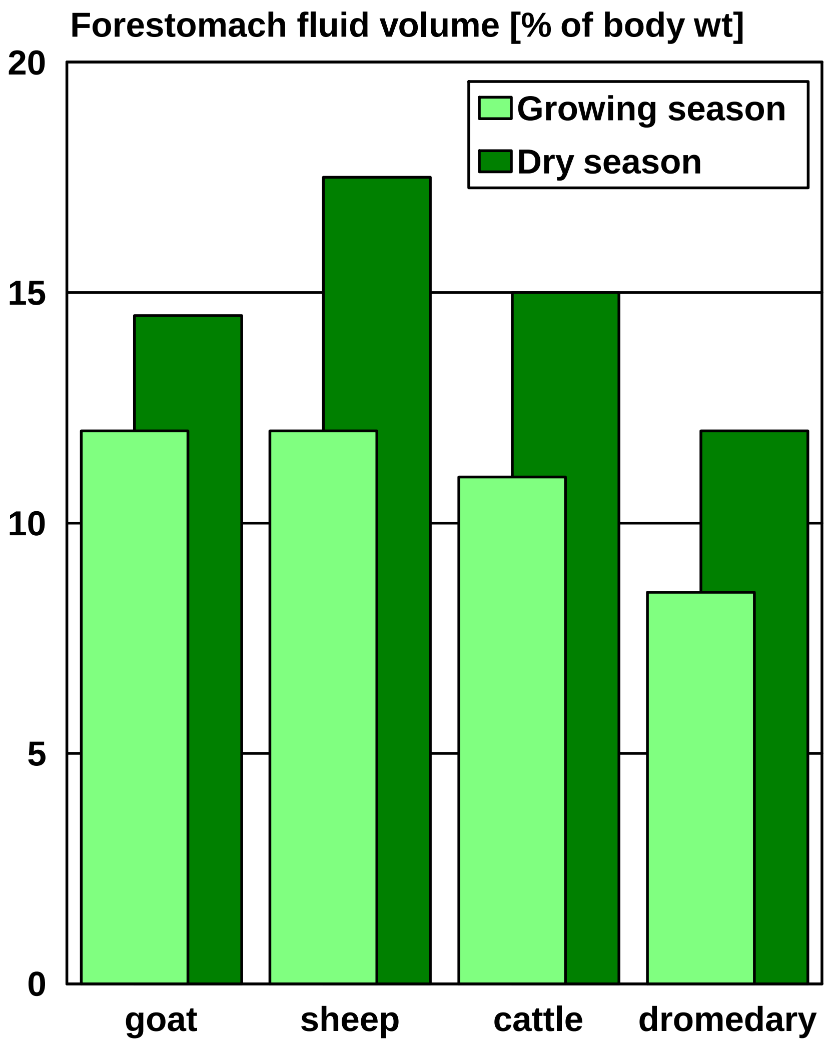
Seasonal Changes of the forestomach fluid volume of domestic ruminants and dromedaries on a semi-arid tropical pasture



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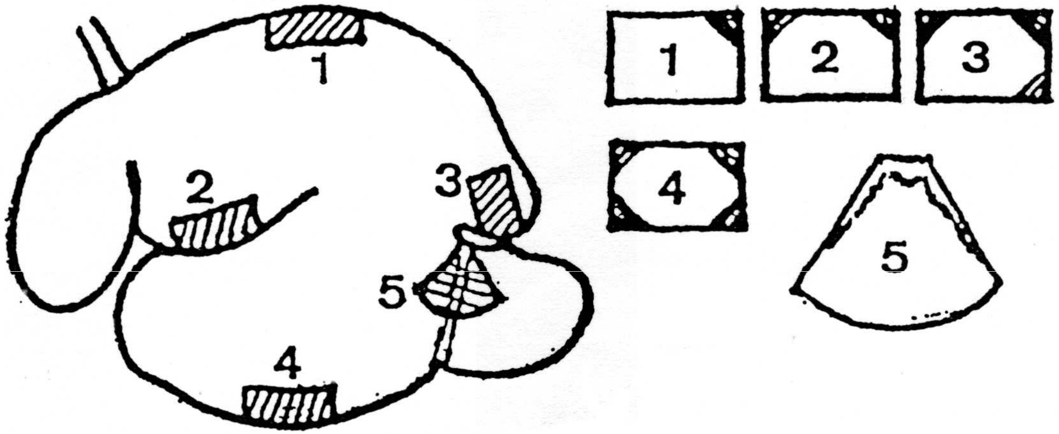
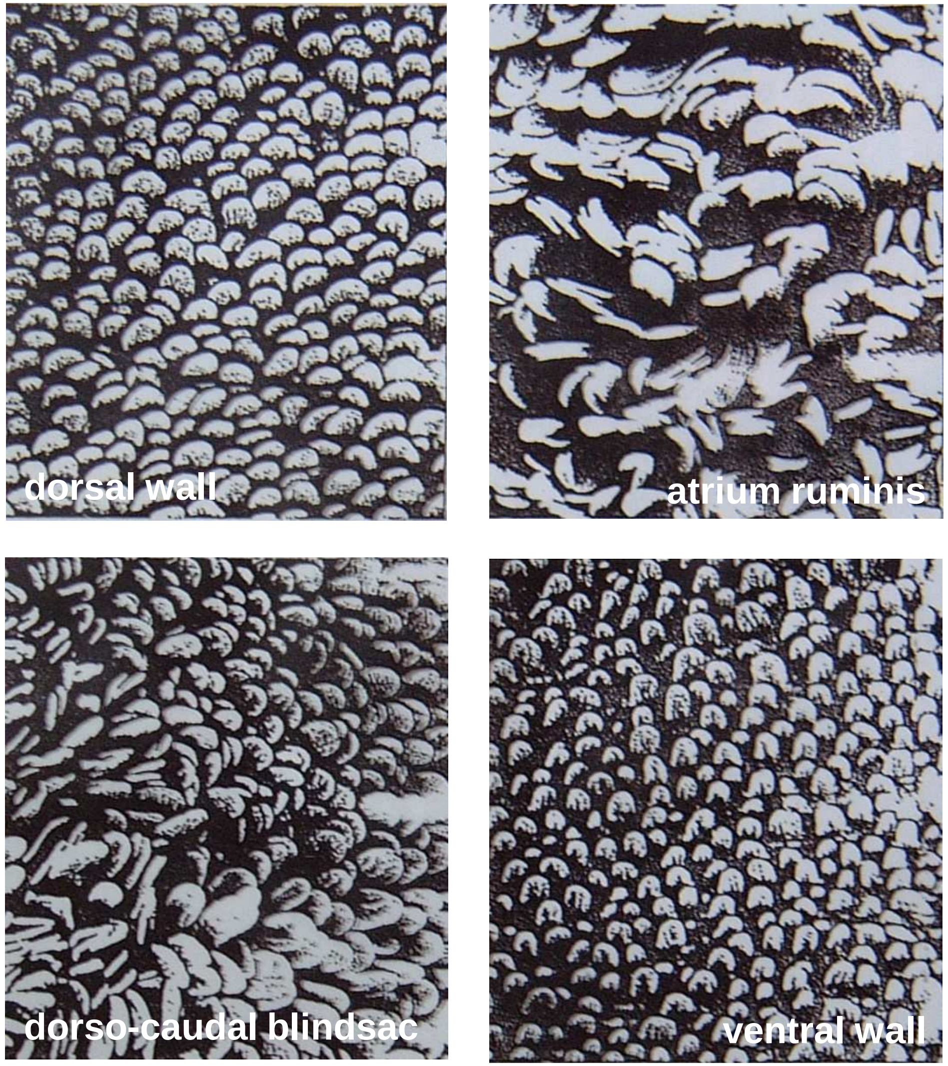
Schematic diagram of the sampling of forestomach mucosa of slaughtered goats and sheep



1 = dorsal wall; 2 = Atrium ruminis; 3 = dorsocaudal blindsac; 4 = ventral wall

Ruminant mucosa of small East African Goats at four different sampling sites



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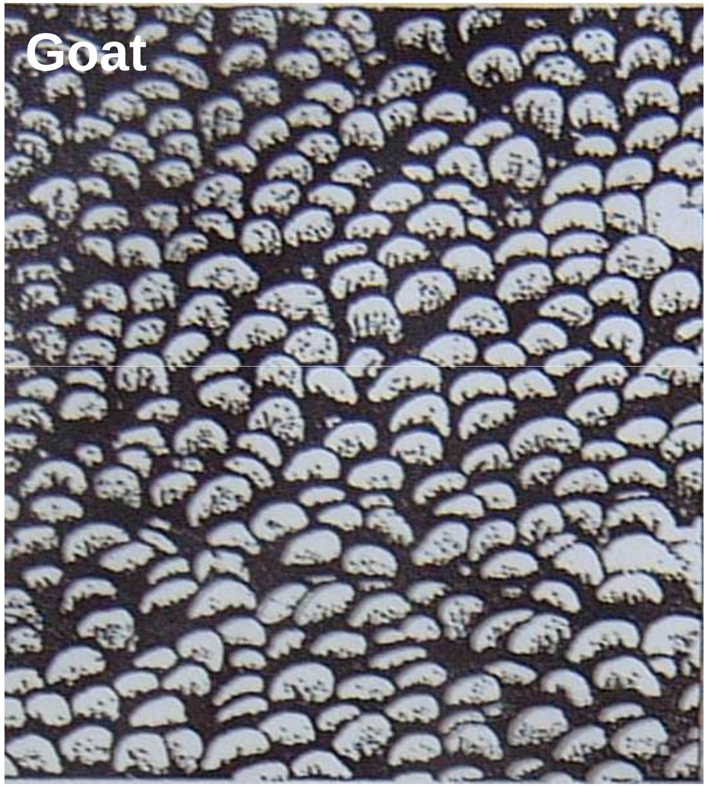
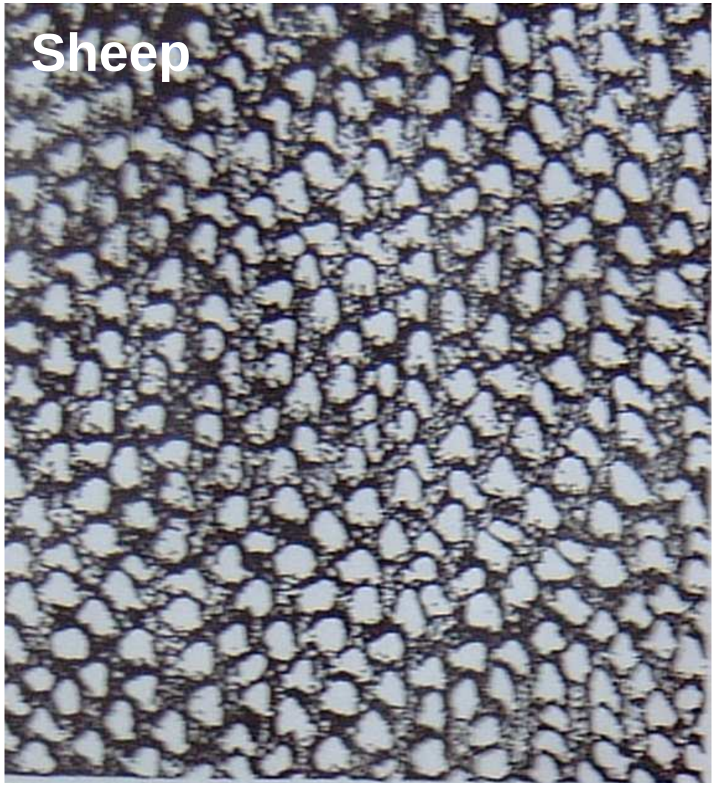
Mucosa samples from the dorsal forestomach wall of goats and sheep during the dry season





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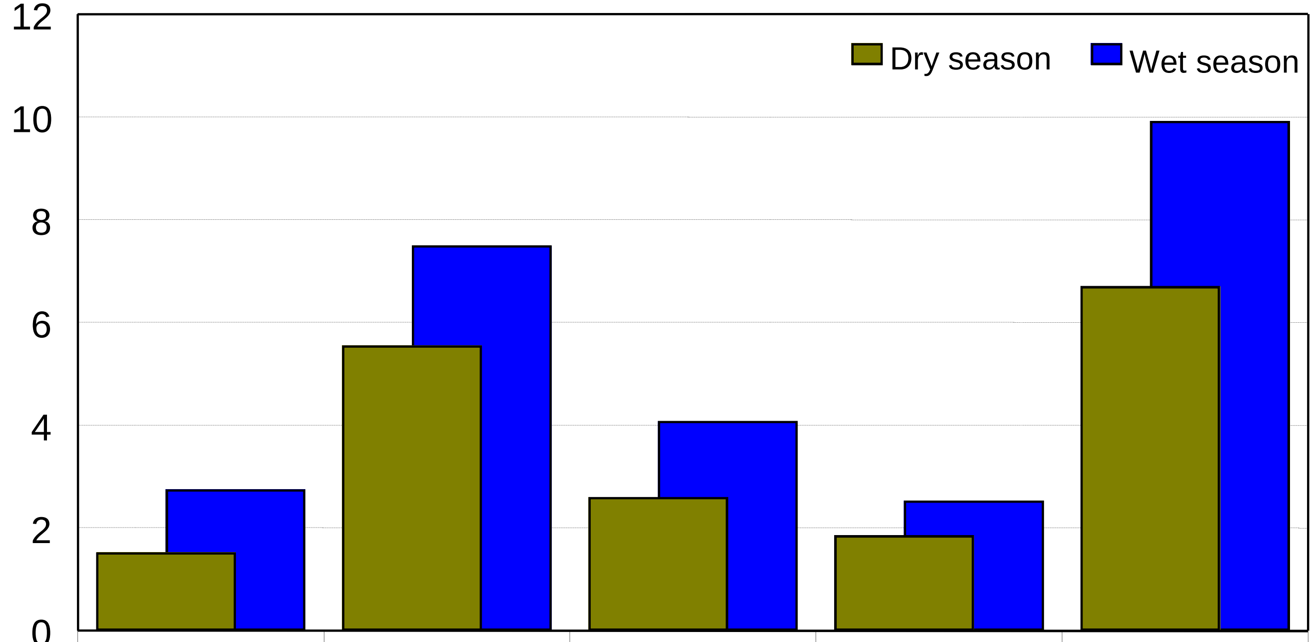
Seasonal changes in the surface enlargement factor of mucosal membranes in five areas of the forestomach of a sheep



	Area 1	Area 2	Area 3	Area 4	Area 5
Dry season	1.52	5.55	2.6	1.85	6.7
Wet season	2.75	7.49	4.08	2.53	9.92

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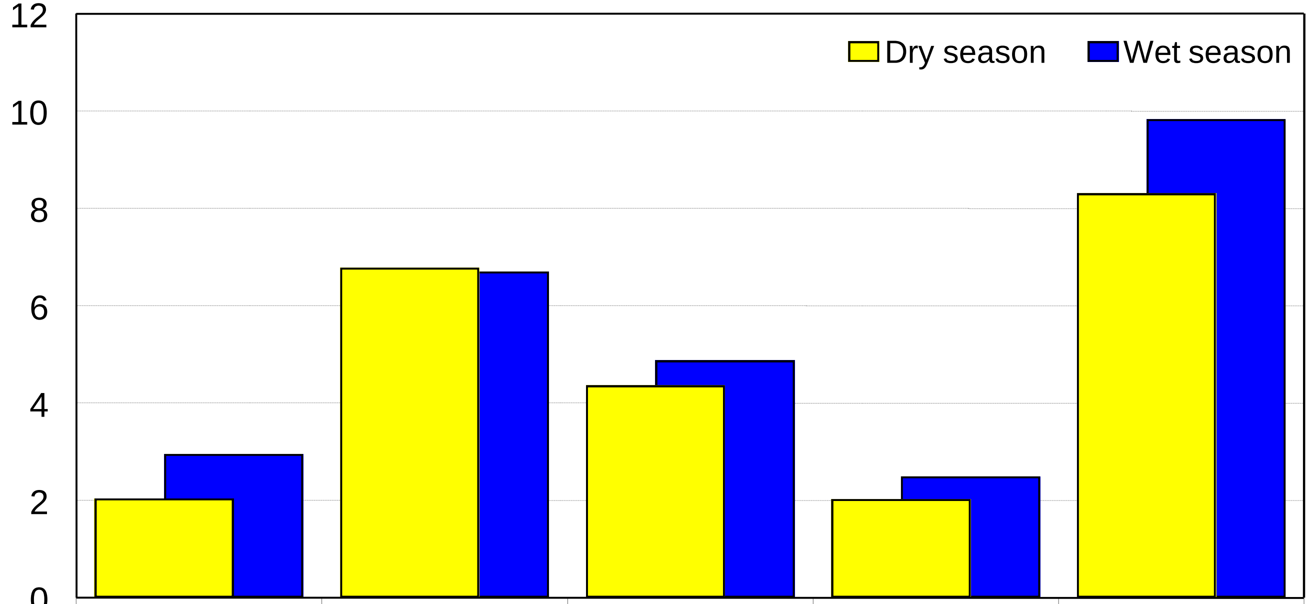
Seasonal changes in the surface enlargement factor of mucosal membranes in five areas of the forestomach of a goat



	Area 1	Area 2	Area 3	Area 4	Area 5
Dry season	2.04	6.78	4.36	2.03	8.31
Wet season	2.95	6.7	4.88	2.49	9.83

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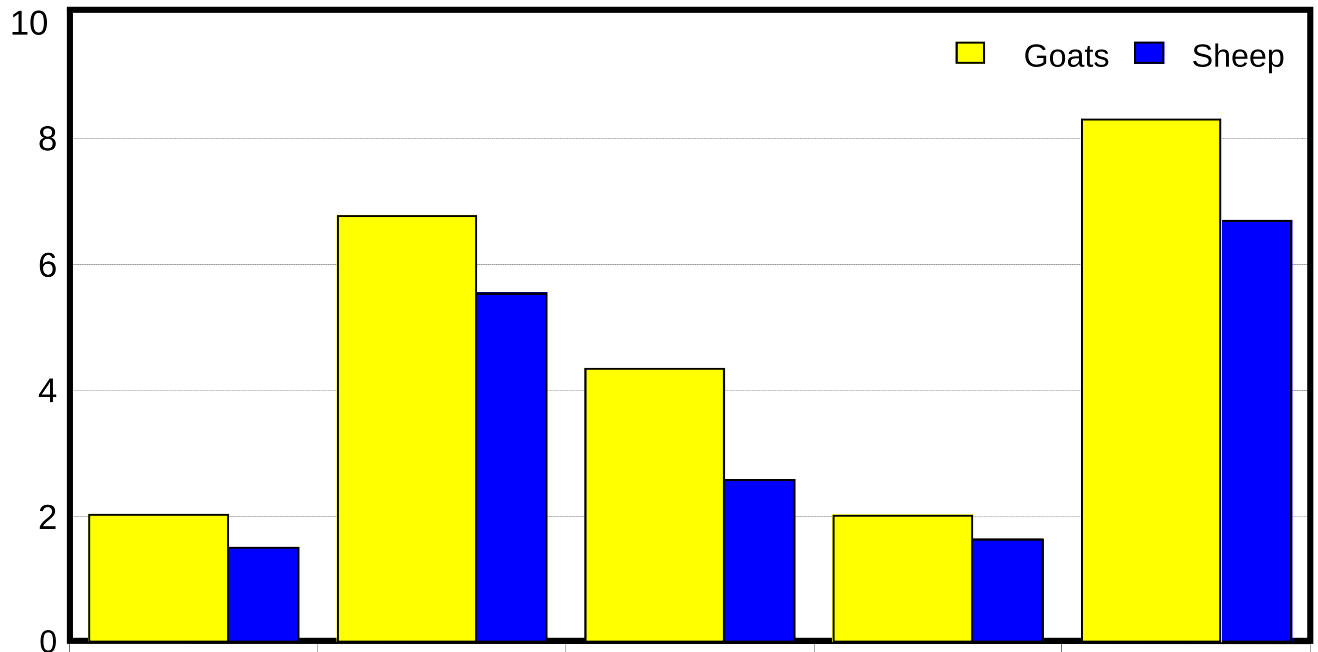
Average seasonal values of the surface enlargement factor of mucosal membranes in five areas of the forestomach of sheep and goats during the dry season



	Area 1	Area 2	Area 3	Area 4	Area 5
Goats	2.04	6.78	4.36	2.03	8.31
Sheep	1.52	5.55	2.6	1.65	6.7

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Ruminant animal responses to temporal variability of forage quantity and quality

Adjust metabolic strategy

- change of basal metabolic rate
- change of energy expenditure
- accumulate fat reserves
- change of reproductive patterns

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Ruminant animal responses to temporal variability of forage quantity and quality

Change resource base

- migration

(Destroy resource base)

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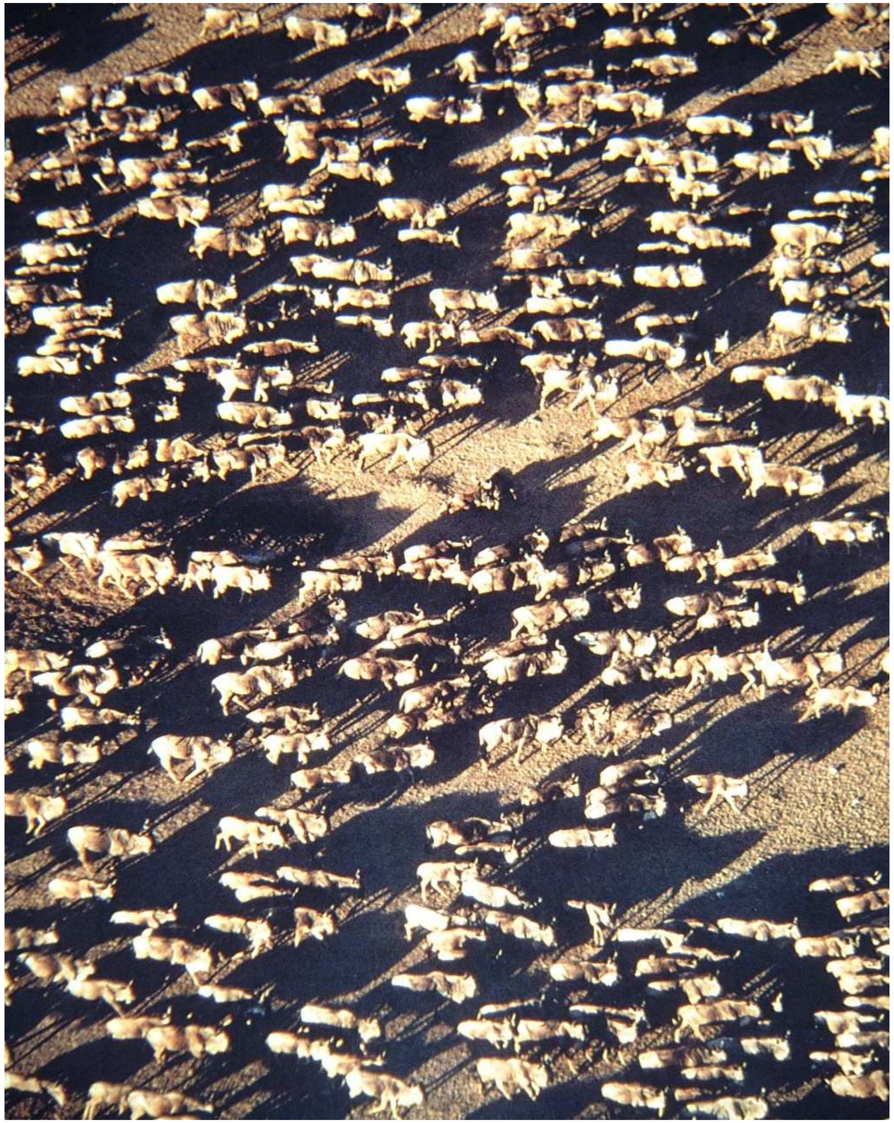
Adaptation of ruminants to temporal limitations of food supply and quality

Change of resource base

Migration



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Animals have developed strategies for coping with seasonal variations

BUT

all strategies carry biological costs

AND

Optimal solutions are dependent

- on individual animals

- on the species

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Strategies of animals to overcome seasonal nutrient shortages

- migration
- starvation (body reserves)
- energy saving
- seasonal reproduction
- increased specialisation
- increased acceptance
- water saving
- dormancy
- nutrient storage
- dependence on man

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