## EAZA <br> 8: Management Guidelines



2006

## EAZA <br> Husbandiry : Management ©ulidelines

## Ginaffer cameropoundrais

Produced as a result of a meeting held at Dvur Kralove


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Although keepers can sometimes have a close relationship with their giraffes, we can not recommend to try this at home

Picture by U. Brandt taken in 1979 shows giraffe keeper Karl Funke at Hannover Zoo with Baringo giraffe male Retsch (EEP \# 50649). Source: Unter die Lupe genommen! Annual Report Hannover Zoo 1979

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|  | Giraffa camelopardalis angolensis |
|  | Giraffa camelopardalis giraffa |
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## SECTION 1: BIOLOGY AND FIELD DATA

### 1.1 Biology

### 1.1.1 Taxonomy

Order: Artiodactyla
Suborder: Ruminantia
Infraorder: Pecora
Family: Giraffidae
Subfamily: Giraffinae
Genus: Giraffa
Species: Giraffe, Giraffa camelopardalis


The basic work describing sub-specific variation in the giraffe was undertaken about a century ago (Lydekker 1904, 1911) and was slightly revised in 1939 (Krumbiegel) and 1971 (Dagg),. Up to 11 different subspecies were described by these early authors. A more recent revision has been presented by Seymour (2002). Although some of his conclusions are conservative as they are based on small sample sizes, he states that it is very likely that not more than 6 valid subspecies can be defined. Following the rules of zoological nomenclature, these subspecies are:

- Giraffa camelopardalis reticulata
- Giraffa camelopardalis camelopardalis (including former G. c. antiquorum, G. c. congoensis $=$ cottoni and G. c. peralta)
- Giraffa camelopardalis rothschildi
- Giraffa camelopardalis tippelskirchi
- Giraffa camelopardalis thornicrofti
- Giraffa camelopardalis giraffa (synonymous to G. c. capensis, including former G. c. angolensis and G. c. wardi)

For a more detailed discussion see chapter 3.3 Separation of subspecies.


Cave drawing

### 1.1.2 Evolutionary history

It is thought that giraffes derive from small traguloid ancestors similar to present day chevrotains, the most primitive living ruminants. Giraffes may represent one of the earliest artiodactyls, combining a shift out of the forest with an enlarged body size. Most zoologists believe that the Giraffidae are more closely related to the Cervidae than to any other family of ruminants.

## Geological range:

Giraffids once were widespread and diverse in Africa and Southern Eurasia between 15 million and 1 million years ago. In historical times, Giraffa camelopardalis, one of the two surviving species, occurred in most of the open country of Africa. A combination of excessive hunting and climatic change has caused a great reduction in the distribution and numbers of giraffes. For about the last 1,400 years the species has been restricted to areas south of the Sahara. In the $20^{\text {th }}$ century, it was largely wiped out in most of western and southern Africa.

### 1.1.3 Morphology

## Height:

With a height up to 5.8 meters, giraffes are the tallest of all mammals. Height is dependent on subspecies, e.g. Reticulated giraffes are normally much smaller than Rothschild's. Male giraffes average about 5.3 meters while females average about 4.3 meters. Giraffes in captivity are rarely over 5 meters tall. In a normal standing position, a giraffe can add about 1.2 meters to its height with maximum extension. Newborn calves are 1.7 to 2 meters tall.

## Weight:

Adult males have been measured between 800 and $1,930 \mathrm{~kg}$, with an average of $1,100 \mathrm{~kg}$. Adult female have been measured between 550 and $1,180 \mathrm{~kg}$ with an average of 700 kg . At birth, the young weigh 47-70 kg.

## Colouration:

The colour pattern varies between individuals and subpopulations, but consists essentially of dark reddish to chestnut brown blotches of various shapes and sizes. The underparts are of a light and buff ground colour and are usually unspotted. Almost white animals have been observed in captivity.


Giraffe Rahna at Cheyenne Mountain Zoo, CO / USA

The same giraffe at Milwaukee County Zoo, WI / USA

The pattern is individually unique and occasionally has bizarre shapes, from uniform fawn or black to various blotchy permutations. The coat pattern of young giraffes does not change with age, though the spots may darken. In males, the colouration usually darkens with age. Several subspecies can be recognised based on skin pattern, particularly the reticulated and the Masai giraffe. Within these, further regional varieties are commonly recognised. However, there is so much individual variation that patterns which were supposed to distinguish different races or geographic areas, can often be found within a single herd.

Description:
The neck is elongated and maned with short erect-standing hair. Withers are much higher than the croup and sloping hindquarters. The limbs are of nearly equal length. The legs of a giraffe end in enlarged hocks and broad, large and heavy rounded hooves. Giraffes are artiodactylids, the hooves are formed from the third and fourth digits; the lateral digits are not developed. The tail extends down to the hock, with a terminal tuft. Both sexes possess two to four blunt, short, hornlike structures on top of the head. The main pair of horns can reach up to 13.5 cm in both sexes, but growth is less vigorous in the female. The horns are covered with skin and fur throughout life. Males' fully-grown horn ends are knobbed and hairless; females' are thin and tufted. In males, bony lumps continue to build up over the horns, orbits, nape and nose. In some subspecies, there is another protuberance, a median horn on the forepart of the frontal bones and the back of the nasal bones.


Male giraffe at the Ramat Gan Zoo (Israel). The bony lumbs and the medial horn are clearly visible

Neck elongated and tail hock length

## Adaptions:

Giraffes are unique in shape and gaits. They have an efficient digestion and a circulatory system with pressure-reducing valves. They also have unique shoulder-leaning techniques for fighting in which the heavily reinforced blunt-horned head is used somewhat like a club.

The giraffe has approximately fifty vertebrae and, like most mammals, seven neck vertebrae. The thoracic vertebrae, especially numbers four and five, have large forward-facing dorsal spines which form the conspicuous shoulder hump. This hump serves as an anchor for the attachment of the large muscles supporting the head and neck.

An adult male skull ( 13 kg ; 29lbs) may weigh three times much as much as a female skull ( 4.5 kg ; 10lbs). Male giraffe possess a large number of bony growths which contribute greatly to the weight of the skull. For its size the giraffe's skull is relatively light. The whole upper part of the skull is composed of large air sinuses, which are created by roofing bones dividing in the middle and growing apart. The space in between is then filled with thin lamellae or leaves, of bones.

The heart must pump blood 2.5 meters up to the brain when a giraffe is standing upright and 2.5 down when a giraffe stops to drink. To compensate for the sudden increase in blood pressure when the head is lowered, the giraffe's circulatory system has a mechanism to prevent blood from rushing too quickly back to the heart from the brain.

The giraffe has very elastic blood vessels and valves in the venous system of the neck. The jugular veins have valves that prevent a backflow of blood to the brain when the head is lowered, the presence of these valves allows for sudden changes in blood pressure.

The giraffe maintains alveolar ventilation by breathing about eight to ten times per minute. This is a slow respiratory rate, but serves to reduce the number of times per minute that the dead space - mostly in the long trachea - must be filled with air. The resting tidal volume is around 4 litres.

## Dentition

Giraffe have thirty-two teeth and a dental formula that is also present in cervids, bovids and pronghorn antelope.

| 0 | 0 | 3 |  |
| :--- | :--- | :--- | :--- |
| I | C | 3 |  |
| 3 | P | M |  |
|  |  |  |  |

Giraffes, being ruminants, possess no upper incisors or canines. The lower teeth which oppose the diastema, or gap, between the front teeth and cheek teeth, press up against a gummy hard palate. The front teeth are spatulate-shaped, thus indicating their function of combing leaves from branches. The canine teeth, one on each side of the lower front portion of the jaw, are two-lobed or even three-lobed and provide a greater surface area for chewing.

### 1.1.4 Physiology

Body temperature: $\quad 38.0^{\circ}$ to $38.8^{\circ} \mathrm{C} .\left(100,4^{\circ}-101,84^{\circ} \mathrm{F}\right)$
Heart rate: $\quad 66$ times per minute at rest
Respiration rate: $\quad 8-10$ times per minute at rest
Blood pressure: $\quad 180 / 120$ to $140 / 90 \mathrm{~mm} \mathrm{Hg}$ systolic/diastolic pressure.

### 1.1.5 Longevity

Maximum age in the wild is estimated at twenty-five years. Nigerian giraffe female "Sophie" (EEP \#1-0535) was born on 5 September 1966 in Paris and died in the same institution on 5 April 2000, at exactly 33 years and 7 months old. She is the longest living giraffe ever recorded in Europe. The oldest male was Rothschild "Kees" (EEP \#5-0895), who died at Lyon at the age of 27 years, 9 months.

### 1.2 Field data

### 1.2.1 Zoogeography/Ecology

## Distribution:

Giraffes were formerly found throughout the arid zones and drier regions of the northern and southern African savannahs, wherever trees grew. Giraffes range at altitudes up to 2000 meters, but are rare in precipitous hilly country. A giraffe dwells mainly on dry savannahs and in open woodland and is usually associated with scattered acacia growth.

## Home range:

Mean individual home ranges in different areas vary between about $23 \mathrm{~km}^{2}$ and $163 \mathrm{~km}^{2}$, but have been recorded to be as small as $5 \mathrm{~km}^{2}$ and up to $654 \mathrm{~km}^{2}$. The average size of the home range is about the same for each sex.

## Density:

Normal population densities vary from about 0.1 to 3.4 individuals per $\mathrm{km}^{2}$. In optimal habitats, densities of up to 2 giraffes per $\mathrm{km}^{2}$ are sustainable without prejudicing the much higher densities of other browsers on the same land.

## Biomass:

Giraffes' biomass varies, but in optimal habitats biomass contains $2,000 \mathrm{~kg} \mathrm{per} \mathrm{km}{ }^{2}$.

## Habitat:

Typical giraffe habitat includes open woodland, dry thorn country, acacia grassland and savannah, fairly thick bush with an admixture of acacias, highlands up to $2,250 \mathrm{~m}$ altitude and seasonal floodplains with abundant termitary thickets. Giraffes are especially associated with savannas where Acacia, Commiphora and Therminalia are abundant trees. Their range includes neither extreme desert nor rain forest. Male giraffes tend to live in the more heavily wooded country and females and young on the plains.


Group of giraffes in open woodland

## Population:

Giraffe populations may be divided into a northern and a southern group. In the northern populations, the coat usually has brown patches with regular edges on a lighter background and there is a short bony horn on the front of the head between the eyes. The northern giraffes include the subpopulations:

- Giraffa camelopardalis camelopardalis, (including former G. c. antiquorum, G. c. congoensis $=$ cottoni and G. c. peralta)
- G.c. reticulata,
- G.c. rothschildi

In the southern populations, the brown patches have deeply indented borders where they join the pale background and the horn on the frontal bone may or may not be developed.
The southern group of giraffes includes the subpopulations:

- Giraffa camelopardalis giraffa (synonymous with G. c. capensis, including former G. c. angolensis and G. c. wardi)
- G.c. thornicrofti and
- G.c. tippelskirchi.


## Conservation status:

Africans traditionally hunted giraffes with snares, arrows, swords and spears. With the arrival of pleasure hunters and guns in Africa, the balance swung dangerously close to the complete extermination of giraffes. By 1900, few giraffes remained and would certainly be extinct today, if there had not been a change both in public opinion and legislation. As early as 1913, the England's parliament discussed preservation of wild animals in Africa, but few game reserves were set aside until 1933, when the first Conference for the Protection of the Fauna and Flora of Africa was held in London. Today most of the countries in Africa protect their giraffes by law. While giraffes are not considered to be threatened by CITES, local populations are vulnerable in many localities.


Mother and her offspring

Estimated total numbers:
Considerable uncertainty surrounds the validity and geographical limits of most of subspecies of giraffe. Figure 1-1 gives a review of recent estimates for most areas known to support substantial populations, with a few exceptions such as southeastern Sudan. Total numbers include an average correction factor of 1.3 for undercounting bias in aerial surveys. Total numbers may be more or less stable, as the increase in numbers of southern giraffes matches the decline in numbers of the northern and western subpopulations (Data from 1998).

| Map Key: Estimat | Estimated numbers: |
| :---: | :---: |
| W: Western giraffes: | 3,500 |
| $\bigcirc$ G.c. camelopardalis |  |
| N: Nubian/Rothschild's giraffes: | 500 |
| - G.c. rothschildi |  |
| R: Reticulated giraffes | 36,000 |
| - G. c. reticulata |  |
| M: Masai giraffes: | 60,000 |
| - G. c. tippelskirchi |  |
| T: Thornicroft's giraffes: | 1,200 |
| - G. c. thornicrofti |  |
| S: Southern giraffes: | 40,000 |
| $\bigcirc$ G. c. giraffa |  |


but abundance unknown

Figure 1-1 Distribution of giraffes in Africa (from AZA Giraffe Husbandry Manual)

### 1.2.2 Diet and feeding behaviour

## Food preference:

Giraffes are known to feed from over 100 species of plants. Acacia, Commiphora and Therminalia are major staples. Giraffes feed on all common large shrubs and trees, on a few vines and creepers, but not usually on herbs and grasses. They eat leaves and small twigs, but also some bark, flowers and fruit. Feeding and movement patterns differ from wet to dry seasons. During the rainy season, marked by abundant green deciduous growth, giraffes tend to feed on deciduous foliage, tree shrubs, and vines. During the dry season, they concentrate where evergreens survive. To satisfy their mineral requirements, giraffes often eat salt or salty soil in the wild. (See Appendix 1 for a list of variation in food supply.) Browsing often takes place at a height of about 4 meters, but they also feed on bushes and trees of only 0.85 1.7 meters in height.

## Feeding:

Giraffes are browsing ruminants. The narrow muzzle has extremely long and flexible, hairy prehensile lips. The tongue is also long, flexible and prehensile, capable of being extended up to 45 cm . When browsing, a giraffe usually reaches out with its tongue, wraps the tip around a branch and draws it gently in between extended lips, ripping the branch from the tree. Sometimes only individual leaves, pods, or fruits are browsed. Adult bulls consume some 19 kg dry weight or 66 kg fresh weight browse daily ( $1.6 \%$ of body weight), cows 16 kg dry and 58 kg fresh weight ( $2,1 \%$ of body weight). The nutritional value and digestibility of browse should not be considered to be extremely high. (See chapter 2.2. Management in Captivity, paragraph Feeding.)

Giraffe feeding


## Feeding activities:

Feeding is the most time-consuming activity of giraffes in the wild. In a 24 -hour day, adult giraffes spend approximately $53 \%$ (female) and $43 \%$ (male) of their time feeding and $27 \%$ (female) versus $30 \%$ (male) ruminating. Giraffes often ruminate for short periods while lying, standing or walking. They chew each bolus about 40 seconds at a rate of one chew a second. The number of chews will depend on the size of the bolus and the type of food. The main feeding periods for giraffes are early morning and late afternoon, with least browsing activity just after midday when rumination is at its peak.

## Rumination:

The stomach of a giraffe is divided into four parts: rumen, reticulum, omasum and abomasum. After the browse has been chewed, it is swallowed and passes into the capacious rumen, where it is thoroughly moistened and partially fermented. The larger particles of the ingesta are regurgitated through the oesophagus into the mouth. The food mass is chewed thoroughly for a minute or so and then reswallowed. Rumination results in food being more thoroughly masticated, thus offering the rumen micro-organisms a larger surface in relation to particle volume for their digestive attack.


Ruminating giraffe

Water balance and thermoregulation:
Giraffes are relatively independent of open water. If water is available, they can drink about 7.5 litres a day depending on the temperature. They can extract a certain amount of fluid from green leaves (fresh leaves have a water content of at least $60 \%$ ). Giraffes drink more frequently in captivity, where they may have less opportunity to eat fresh leaves which contain moisture. Their long extremities greatly increase their surface area and therefore make heat loss easier.

## Method of drinking:

In order to drink or to pick up food from the ground, a giraffe has to straddle or spread its forelegs out to the side to get its muzzle down to the water. Exceptionally, it bends at the aspal joints, or may kneel down on the front legs. Like other mammals, a giraffe can swallow water even when its head is much lower than its stomach. Giraffes often drink without pause for 20 seconds to a minute before they straighten up again.


Giraffe drinking with straddled legs

### 1.2.3 Reproduction

## Sexual maturity/age at first breeding:

Sexual maturity is reached at the age of three to four years. Females become pregnant in their fourth year and usually give birth to the first calf when they are about five years old. Males become sexually mature when they are about three and a half years old, but are not mature enough to compete with other adult bulls before the age of seven.

## Seasonality:

Reproduction is typical for non-territorial ungulates. Breeding is perennial and calves may be born throughout the year, but different calving peaks can occur in different areas, with most conceptions occurring during the rainy season.

## Gestation:

A female giraffe comes in heat for one day about every two weeks. The gestation period varies between 420 and 468 days (14-14.5 months), with an average of 457 days. They can get pregnant again while still nursing their last offspring, several months before the end of lactation. Intervals between births are usually not longer than 17-20 months. Cows can give birth to a total of ten young if one is born every 18 months and she can reproduce until she is at least 20 years old.

## Parturition:

Approximately a month before parturition, the udder swells and milk secretions leak out. The sacral muscles above the tail usually relax about one week before birth and occasional muscular contractions of the uterus may be visible. Some females pace about restlessly when about to give birth, others lie down. Most eat only a little. The calf presents front end first; the forefeet preceding the head, which lies close along the forelegs. Horns are bent backwards and inwards. During the labour contractions, the mother remains standing with her hind legs spread apart and her head extended forward as she strains. The young giraffe starts life with a drop from a considerable height. The female may stoop slightly to lessen her young's drop to the ground. The umbilical cord breaks during the fall. The entire process of calving lasts about one to two hours.

## Birth rate and sex ratio:

Giraffe twins are reported from the wild. In captivity world-wide, twenty-two cases of twin births have been described. Twin pregnancies in captivity often result in abortion, stillbirth or dystocia. Only a few, unproblematic cases are known. Recently, twins have been successfully born and reared in the zoos of Paris, Duisburg, Karlsruhe, Leipzig, Olomouc and Warsaw. Of 1697 giraffes born in European zoos from 1990 through 2005, 52\% were males.

## Development:

A newborn calf has a total height of about 1.7 meters and weighs between $45-70 \mathrm{~kg}$. A calf usually struggles to its feet twenty minutes to one hour after birth. Two hours may pass until it succeeds in holding itself upright. Normally a calf will begin to suckle within one and a half hours after standing. Calves start nibbling at bushes when only two to three weeks old, begin to ruminate within four months, but continue to suckle at least until the age of one year. Calves stay with their mothers until about sixteen months old. The youngsters grow at a tremendous pace, 0.3 cm a day, about 1 meter within the first year. The males do now grow more quickly than the females, but they reaching a greater final height. This is caused by a significant slowing down of growth rate in females after about three years (Reason and Laird, 2004).

Female nursing her young


Mother-calf relationship:


For the first week after birth, mother and calf remain in isolation, avoiding or warding off approaches by other giraffes and very much on guard against predators. After a week or so, newborn calves may join other young calves in so-called crèches. The enhanced security within such a nursery frees mothers to browse 100-200 meters away and leave during the middle of the day for periods of up to $41 / 2$ hours to travel to water. Absent mothers usually return before dark, suckle their offspring and remain with them overnight. After 3-4 months, the calves begin to accompany their mother for gradually increasing periods of time. By six months, calves move independently with the adults. But the mother-calf bond is strong and may last up to 22 months.

Mother-calf bond

### 1.2.4 Behaviour

## Activity:

Giraffe are active mainly in the evening and early morning, and rest during the heat of the day. All giraffes lie down for part of the night, beginning right after sunset.. While dozing, which is more common, they rest on their withdrawn legs, but the neck remains stretched out, eyes are half closed and the ears continue twitching. Occasionally a lying giraffe curls up and falls into deep sleep for about five minutes.

## Locomotion:

The giraffe has only two gaits, an ambling walk (pacing) and a gallop. Its normal gait is pacing in which both limbs on the one side move forward almost in unison. The neck moves in synchrony with the legs and helps the giraffe maintain its balance. Walking movements are slow and measured. In a gallop, the hind legs move forward almost simultaneously and are spread, so that they can by-pass and overreach the forelegs on both sides. The neck sways back and forth rhythmically, the head describing something like a figure of 8 or a rolling motion. When a giraffe runs, it twists its tail over its back and switches it at regular intervals. The speed of the gallop is estimated to be between 30 and $50 \mathrm{~km} / \mathrm{hrs}$, with a speed record of $60 \mathrm{~km} / \mathrm{hour}$ for a distance of a couple of kilometres. With this gallop, the giraffe can transfer the weight on the hock by twisting the hoof forward. Even when traveling at high speed, the giraffe appears to be moving in slow motion. If a group is stampeded, the young animals soon sprint ahead of the adults. Both young and adults are able to outstrip most predators.


Difference in gaits between walking and galloping

## Predation:

Occasionally, young giraffes are grabbed by crocodiles and drawn into the river. Leopards are known to attack calves. Wild dogs and spotted hyenas sometimes prey on giraffes, but certainly cannot be considered to be major predators on adult giraffes. Lions take the most victims. Giraffes are especially vulnerable to lion predation when lying down, ground feeding, or drinking. Between $50 \%-75 \%$ of all giraffes fail to survive their first year.

## Camouflage:

Giraffes make no apparent effort to conceal themselves among vegetation. The coat pattern of a giraffe camouflages the animal very effectively among trees and bushes, but when a giraffe is approached, it often retreats behind a low bush so its neck and head stands out strikingly. Giraffes often switch their tail, wag their ears and shake their heads, thus immediately drawing attention to themselves. Giraffes seem to be far more concerned in having a clear view of the predator than in being camouflaged.


Behaviour in presence of predators:
A herd of giraffes standing motionless, erect, and facing into one direction is generally a clue to the presence of a predator. Large body size, superior day and night vision, speed and formidable hooves make adult giraffes difficult prey for predators. Their senses of smell, hearing, and vision are acute. Their height gives giraffes the greatest range of vision of any terrestrial creature. In case of danger, the calf runs to the mother and backs underneath her belly, turning its head into the direction of the disturbance. The cow thus has a free area in front of her so she can kick an approaching predator with her forelegs. Giraffes can kick their hind legs with a cowlike swing, chop-kick with their forelegs like a horse, or strike with a stiff foreleg. Its main defence against predators however, is not its devastating kick, but its constant alertness.

Group associations:
Backhaus defined a herd as a number of the same kind of animals that move together and are usually engaged in the same activity at any one time, such as eating, drinking, resting, walking or running. By this definition, giraffes form looser herds or groups than most other species; it is common for one member of a group to wander off, e.g. over a hill, while the others remain behind. Members of a herd may be so spread out - as much as a kilometre between individuals - that even though they are engaged in the same activity, usually eating, they may not seem to belong together. Giraffe herds contain an average of 6-12 animals, and may consist of almost any possible combination of sexes and ages at any given moment. They will almost certainly not remain in the same configuration for many hours. Herds may consist of bulls only, or bulls and cows, or cows and calves, with perhaps a bull or two. There is very little cohesion in such groupings and individuals are always coming and going, joining this party or that, then wandering off again. All social units are temporary. Adult male giraffes can be vestigially territorial and some but


Giraffe herd not all monopolize all matings and tend to be intolerant towards other large bulls at the cores of their very variably sized home ranges. Cores may be as large as $80 \mathrm{~km}^{2}$ but yearlong movements are known to range between 5 and $650 \mathrm{~km}^{2}$ or more. Females have very unstable home ranges that may vary from year to year. These overlap those of many other females with which they may associate in mixed sex groups of up to 50 animals. Such associations are temporary. The only stable associations of female giraffes are the yearlong periods of motherhood and the traditional, highly localized, calving area to which they return to give birth.

Individual distance:
Giraffes rarely group closely except when browsing the same tree, when the approach of a predator makes them nervous, or when they occur in large numbers in open tree grassland. Even at rest they stay over 20 meters from each other.


#### Abstract

Hierarchy: Position in the male dominance hierarchy is largely a function of seniority and is decided usually before maturity through contests in the bachelor herds. Mature bulls know their place in the hierarchy and normally avoid confrontations, even when an oestrous female is at stake. Giraffes show no obvious signs of territorial behaviour and bulls make no attempt to occupy and hold a piece of ground by defending it against other males. Some sort of hierarchy exists within the groupings, unstable and haphazard as these may be.


## Sexual behaviour:

Necking and sparring between bulls occurs during all times of the day and in every season. Fighting among bulls establishes the ranking order among the males which inhabit a certain area. During necking, usually two bulls stand side by side facing in the same direction or in opposite directions, or circle slowly about. Every few minutes, one male swings his head at the other. The other retaliates with an equally unpunishing blow. The sexual, related types of sparring occur in the head to tail position. The matches are initiated by a challenger that, on approaching another male, assumes a posturing movement with the shoulders directed toward the opponent and the legs and erect neck hold rigid. If the opponent assumes a similar posture, both straddle their stiff legs to obtain a firm stance and curve their necks away from each other prior to the first blow. A serious sparring match during which one participant is injured is rare. No matter how badly a fight is going, the loser never resorts to kicking or biting.


Necking bulls

Mating behaviour:
There are four phases of mating behaviour. The first phase is the approach phase. In this stage the male explores the vulva of the female with his nose, rubs his head against her haunches and rump, perhaps even licks or nibbles her tail, until he succeeds in inducing her to urinate. The male lowers his head, catches some of the urine in his mouth and tastes it carefully. After that he draws back his lips as though grinning, inhales air so that the vomeronasal organ is stimulated by the female's pheromones. This exercise is called flehmen and occurs several times. When the urine of the tested female shows that she is in heat, the second or demonstration phase starts. The male raises his neck, presumably to increase height and impress the female. The female shows no reaction and ignores the male. In the third or chasing phase the bull begins to follow the female, walking close behind her with his head held high. He pushes her gently with his head; if she responds full courtship ensues. The fourth phase is the copulation itself.

When a female is ready to stand for copulation, the bull stands immobile with his head high and often with his penis unsheathed. Before mounting, the male bows his head down over female one or more times, and touches the female's hind legs with his front legs, moving his


Bull exploring anal region of the female hind legs closer to his front legs. This behaviour is called "Laufschlag". Then the male mounts a female by sliding his forelegs loosely onto her flanks and stands bolt upright while giving an ejaculatory thrust that propels the cow forward and ends the courtship bout. An oestrus female may attract close attention from many bulls, but the majority of matings are with one or another of a few very large bulls.

## Intraspecific communication:

Giraffes are exceptionally silent, but in fact they do occasionally make rather weak bleating noises and sometimes a snort of alarm has been heard. Cows seeking strayed calves may give a roaring bellow. Numerous sources have reported sounds like moaning, snoring, hissing, gurgling and flutelike sounds. When adults are excited they may moo somewhat like a cow and now and then, though very rarely, they bleat and grunt. Alarmed, annoyed or hungry giraffes sometimes grunt or snort; a male may cough during mating. Calves may moo or bleat when they are lonely, and females may call their young with a whistling sound. While they make limited sounds audible to humans, they also produce infrasound, using very low
wavelengths. Infrasound is considered ideal for long distance communication. A behaviour called a "neck stretch" is correlated with producing these sounds - the giraffe throws its head and neck back over the body until the nose is pointing up. Or the head may be lowered and then only the head thrown up, this is termed a "head throw".

## Interspecies contacts:

Giraffes live side by side with most of the other herbivores of the African plains. They tend to ignore animals of other species. Zebras (Equus burchellii), ostriches (Struthio camelus) and impalas (Aepyceros melampus) can often been seen feeding close to them. It may well be that giraffe's superior ability in spotting potential danger gives the other animals a certain amount of security, but this has never been proven.


Giraffe associated with Equus burchelli


Several types of birds live commensally with giraffes, these include the Buffalo weaver (Textor niger) and two tickbirds; the Redbilled oxpecker (Buphagus erythrorhynchus) and the Yellow-billed oxpecker (Buphagus africanus). These birds are useful to giraffes in that they search through their hair for ticks, and other parasites. In the process they clean the giraffes' hide by removing dirt and bits of dry skin.


Oxpeckers searching for parasites

## SECTION 2: MANAGEMENT IN CAPTIVITY

## Introduction

The following recommendations are made with the well-being of the individual in mind.
Single individuals should not be kept in zoos - all institutions should keep a core group of at least three giraffes. With a herd of two, if one dies, the remaining giraffe can be alone for a long time before a new companion can be identified and transported, because of veterinary or financial reasons.

There are three basic models of social situations:
Small breeding herd (SH): 1 adult male, 2-3 adult females plus calves Large breeding herd (LH): $\quad 2+$ more adult males, $4+$ more adult females plus calves Single sex group (SG):
either only males or only females.

### 2.1 Enclosure

### 2.1.1 Indoor facility

The indoor facility should consist of either
a) Joint pen(s) plus separation pens or
b) Several stalls with interconnecting doors, allowing various combinations


Examples of separation pens

### 2.1.1.1 Dimensions

SH: 1 joint pen (64-100 $\mathrm{m}^{2}$ with a minimum length of wall of 8 m ) plus 3 extra stalls (each $16-25 \mathrm{~m}^{2}$ with a minimum length of wall of 4 m ) for separation, or several stalls with interconnecting doors, allowing various combinations of room sizes.

LH: 2 joint pens plus 4-6 separation pens
SG: 4-6 stalls that can be interconnected.

### 2.1.1.2 Boundary

Walls and fences between indoor pens should be at least 3.5 m high

## Material:

Enclosures should be constructed preferably of wood but can also utilize strong synthetics. All materials should be treated only with non-toxic compounds. Metal edges, nuts, and screws must be secured to prevent injuries. Bars should have no sharp edges or points and fence angles should not be less than 90 degrees to prevent entrapment. If material such as wire netting is used for walls or fences, the portion from the ground up to 1 meter should be made of solid material to prevent a hoof from getting trapped. The spaces between vertical bars in the enclosure and between door and door-frame should not be larger than $4.5-5 \mathrm{~cm}$ to prevent injuries. If using wire netting, the work has to be done with particular care and strength, so that the giraffes cannot untwist the wire with their tongues. If using wooden boards, gaps should not be larger than 10 cm , to prevent a calf passing its head through and getting stuck. The topmost board should be made of extra hard wood, e.g. oak, as giraffes will chew on it.


Gaps should not be larger than 10 cm

### 2.1.1.3 Ground substrate

## Ground surface:

Floors should allow safe footing of the animals. Common materials are concrete and asphalt. The floor should have a slight slope (maximum $5^{\circ}$ ) from the centre to the periphery to ensure proper drainage.

## Floor covering:

Flooring should not consist solely of hard surfaces such as concrete or asphalt, but include resilient surfaces such as rubber matting, straw, wood-shavings, crystal sand, hemp or flax, to avoid degenerative joint arthritis.


Avoid this material


Better substrate, or use rubber matting or woodchips

## Bedding:

Moist peat, wood or bark shavings (a layer of 10 cm at minimum), hemp or flax (only when thoroughly wetted with water; 20 litres water for 1 bale), with a dry layer of straw or hemp or flax on top may be used for bedding. This avoids hooves becoming dry and brittle, but ensures that the giraffe's body doesn't get wet when lying down to rest.

## Joint pens:

A minimum of $50 \%$ of the surface should be covered with soft bedding material so that each animal has enough space to lie down),

## Separation pens:

Straw bedding or soft bedding. Enclosures where calving may occur need to have special attention. They should be covered completely with a thick layer of absorbent material that provides secure footing to prevent calves from splaying while attempting to stand.

### 2.1.1.4 Furnishing and maintenance

## Watering:

Fresh water sources should be always accessible. Automatic water level troughs are recommended. Animal-operated water sources are not suitable.

A video camera that can be put into use immediately when needed can be a valuable tool.

Access to a scale is strongly recommended, so that weight monitoring is possible.


Automatic water level trough

Giraffes can be flighty and care should be taken to avoid placing possibly injurious obstructions in their path. Indoors, walls should be clear of projections that could cause injury. Drinkers and feeders should be placed away from travel paths or doorways. Enrichment devices should be attached in such a way as to provide opportunities for the giraffe to engage in natural feeding and investigative behaviour yet prevent the possibility of entanglement or injury. Outdoor enclosures should follow the same practice, with attention to containment barriers.

## Feed presentation:

Diets should be presented in troughs at a height that allows a normal comfortable feeding posture.


Feeding throughs at a height that allows a normal comfortable feeding posture

## Doors:

Doors should be a minimum of 3.5 metres high and 1.2 metres wide, well insulated and flush with the ground or walls to avoid draughts. Horizontally divided doors are recommended this allows the upper section to be kept open while the bottom half is closed. Contact between animals can be maintained when animals are kept both outside and inside (e.g. separation of mother and calf, ill animal). This also allows good ventilation of the inside areas. There should be at least two exits to the outside enclosure. It must be possible to position a transport box or truck close to the main door between house and enclosure. (See chapter 2.6.5 Transportation.)


## Avoid draughts

Divided doors for communication and ventilation


## Pathways:



The connecting corridor between the indoor enclosures and the doors leading to the outdoor enclosure should be at least 1.2 metres wide to facilitate manipulation and transport and to avoid stress. There should be a free space of at least $25 \times 6$ metres (a corridor from 2.5 m on each side of the door and stretching 25 m in length) around the door on the outside the house to facilitate the arrival of a transport vehicle and the process of loading and offloading (See chapter 2.6.5 Transportation).

Connecting corridor

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Two adjustable panels must be available to enclose the ramp on both sides of the door during loading. There should be no narrow, long and/or curved connecting corridors between the house and the enclosure. These may cause problems with any new animal unfamiliar with the system and result in its getting jammed and injured. If a corridor, deviating from the recommendations above, is absolutely necessary, it must be at least 3 m wide, straight - no sharp turnings - and without steps or bridges (See chapter 2.6 Handling).

### 2.1.1.5 Environment

## Ventilation:

Adequate ventilation must be available but draughts should be avoided. The whole construction of the house should be based on good insulation to allow maintenance of a constant room temperature.

## Temperatures/humidity:

An incidence of high mortality in free-ranging giraffes after a period of exceptionally cold and wet weather has been reported from Southern Africa. When discussing minimum room temperatures for giraffes, it is often argued that low night temperatures also occur in the natural habitat of giraffe. But these rare occurrences in the wild do not persist during daylight hours and do not continue for several months. Continuous exposure to low temperatures will pose an additional energy demand to maintain the normal operating body temperature of $37.5-38.8^{\circ} \mathrm{C}\left({ }^{\circ} \mathrm{F} 99.5-101.8\right)$.

Temperatures in the house should be maintained at a minimum of $20^{\circ} \mathrm{C}\left(68^{\circ} \mathrm{F}\right)$, and at no time should fall below $18^{\circ} \mathrm{C}\left(64^{\circ} \mathrm{F}\right)$. Floor heating is not recommended - it can contribute to dry hooves and increase the evaporation of ammonium fumes. Air humidity is not of special importance.

## Daylight/illumination:

The indoor day/night cycle should be set to at least $12 / 12$ hours, even during the winter months. A supply of natural daylight through windows or transparent roofs is recommended. Windows enabling giraffes to look outside also serve as behavioral enrichment. A dimmed night-light is recommended, especially if video recording is possible.

### 2.1.1.6 Visitor access

If the giraffe house is designed to be accessible by visitors, the flight instinct of giraffes must be considered. The animals must have a view over the visitors' space to avoid situations leading to fear and panic. There should always be separation between the public and the inside enclosure to avoid too much disturbance. Bullet-proof glass is suitable as a means of separation, as it filters noise, but the glass should be a suitable distance from animals or visitors.

### 2.1.2 Outdoor facility

### 2.1.2.1 Outdoor temperatures

Adult animals may stay outside all day when temperatures don't fall below $12^{\circ} \mathrm{C}\left(53^{\circ} \mathrm{F}\right)$, for young ones up to 9 months of age the critical temperature lies at $16^{\circ} \mathrm{C}\left(60^{\circ} \mathrm{F}\right)$. If exposed only for a very short period of time, temperatures may fall below these values down to the freezing point. Longer exposure can cause frostbite on the ears and tips of tails. Exposure to wind and/or rain or other sources of humidity have a chilling effect and shortens the outdoor stay considerably.

### 2.1.2.2 Boundary

Dry moats:
When using dry moats for confinement from the public, the vertical wall towards the public should be no less than 2.5 m high. On the animals' side, the moat should slope gradually, not exceeding $25^{\circ}$, so that this part of enclosure may also be used by the animals. The surface should have safe footing. Ditches with strictly vertical walls (U-moats), even low ones, are considered too dangerous and are strongly discouraged.


No U moats


## Fences:

Wire-netting, wood poles, bars or walls are all acceptable fencing. Any type of fencing should be of solid construction to prevent the fence from being uprooted or untwisted by the animals. Fencing can be combined with an electric device. Electric fencing as the only confinement barrier is strongly discouraged, as it cannot prevent animals from escaping. It should be used exclusively in conjunction with other measures, but is still not the best solution because animals can get entangled in loose wires. In general, fences should be at least 3.5 m high to hinder animals from slumping over a barrier (e.g. in Dvur Kralove a male slumped over a 2 m high door). Animal that are able to reach out with necks can become dangerous to themslves as well as visitors and staff. If poles and wood are used, they must be treated with non-toxic chemicals only.


Electric wire for fencing

### 2.1.2.3 Separation means

Solid physical barriers should be used between enclosures. If two enclosures are connected, they should be connected by at least 2 gates, allowing the animals to roam without danger of being trapped.

## Water moat:

Water moats can be used as barriers but one should consider giraffes entering the water and drowning, especially if young calves are in the enclosure. They are of limited use due to icing in central and northern European zoos during the winter.

### 2.1.2.4 Substrate

## Surface:

The enclosure should include various types of substrates. Solid materials such as gravel and volcanic material (e.g. dolomite) not only provide adequate footing but also allow the abrasion of hooves. Damper areas that include surface water (e.g. clay-sand bed) soften the hooves, facilitating abrasion. Natural ground invites giraffes to walk, play and run. Sandy areas are preferred resting places, which should lie in a distance from the public, but in a sunny part of the enclosure. The surface should not be covered with sharp stones because they may get stuck between the claws. Attention should be paid when other species (in a mixed exhibit) dig holes, into which the giraffes can tread and stumble or break a leg.

### 2.1.2.5 Furnishing and maintenance

## Feeding places:

In both indoor and outdoor enclosures, the giraffes should have several feeding stations and water placed a distance from each other to induce the animals to walk. Hay should be available ad libitum. Automatic water bowls should be fixed in a height of 2 m at minimum to avoid being kicked off or otherwise damaged by the adults. If necessary, younger and smaller animals will need an extra water supply (i.e. a bucket in a trough) until they can reach the water bowl. Giraffes should be trained to take food (e.g. bits of banana) from the keeper's hands for easy administration of medication.

## Special furnishings:

Several rubbing posts should be provided, e.g. trunks of dead hardwood trees, i.e. oak. They can also serve as a place to affix browse.

## Sun and wind shelters:

Trees and/or other vegetation or walls provide shelter against sun and wind. Sheds should be at minimum 4 m high.


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## Access for trucks and heavy machinery:



Outdoor facilities must have at least 1 entrance/exit for trucks. Access to the house for trucks and sky workers for house maintenance, removal of carcasses etc. is indispensable (See also chapter 2.6.5 Transport).

The various places of interest to the animals (concentrates, browse, water, rubbing posts, resting places) should not be placed in close proximity, but spaced throughout the exhibit in order to enhance movement of the giraffes and to avoid competition.
The enclosure must be accessible for heavy machinery

### 2.1.2.6 Environment

## Protection of trees or other objects:

Trees can be circled with wire-netting combined with electrical devices. It may be sensible to install electricity from both the main lines and from a battery source, in case the electrical supply fails.

## Pools and water basins:

These are not recommended. Giraffes will not use them - on the contrary, they could expose animals to contaminated water and the danger of slipping and/or drowning. Natural large pools in Safari sections can be a problem; any access to water should be shallow with a depth of not more than 1.5 m .

### 2.1.2.7 Dimensions

Size of enclosures:
An enclosure should measure not less than $1500 \mathrm{~m}^{2}$, the shorter side a minimum of 25 m in length.

There should be one or more smaller enclosures at the keepers' or animals' disposal near the main enclosure, enabling communication between animals when separated.

If the holding facility is located in a cold climate zone, at least one of the separation enclosures should be furnished with a roof so that the giraffes can go out if there is snow or ice in the main enclosure. For giraffes kept in mixed exhibits, see chapter 2.3.3-Sharing enclosure with other species.


### 2.2 Feeding

## A. Knowledge of giraffe nutrition in the wild



It is important to know what giraffes are feeding on in the wild, when determining the proper diet in captivity

### 2.2.1 Selection of feeding plants

Hofmann (1973) classifies the giraffe as a browser. Tree or shrub browse are the dominant food plants (for a compilation of literature references see section 4, part D), leaves and shoots making up the most important items of the diet (Table 2-1). Selectivity of feeding behaviour is characterised by Van Soest (1994) to be of an intermediate degree. Due to its large body size, a giraffe just cannot afford to feed as selectively as smaller ruminant species.

Table 2-1: Description of feeding behaviour

| Plant parts ingested | Importance to the diet | Reference |
| :---: | :---: | :---: |
| Leaves, small twigs | ++ | Leuthold and Leuthold |
| Some bark, flowers and fruits | + | $(1972,1978)$ |
| Leaves and shoots of trees and shrubs | ++ | Owen-Smith (1988) |
| Herbaceous material (climbers, vines, tall forbs) | Up to 7 \% | Owen-Smith (1988) |
| Shoot tips | 78 \% |  |
| Leaf whorls | 14 \% |  |
| Flowers | 5 \% | Pellew (1984a+b) |
| Pods | 3 \% |  |
| Others | $1 \%$ |  |

If new growing shoots are available (including young leaves, twigs and thorns), they represent the favoured food resource according to Sauer et al. (1982). Older leaves are ingested when shoots are not available. Owen-Smith (1988) reports considerable amounts of woody material to be included in the $\operatorname{diet}$ ( $5 \%$ in the rainy and $15 \%$ in the dry season).

### 2.2.2 Nutrient composition

Nutrient composition of giraffe food in the wild has been reported by some authors (Table 22). As can be expected for a ruminant, cell wall/fibre content in the diet is high, although it may be lower than in grass diets (depending on the level of woody material ingested). The crude protein contents analysed should be regarded with some caution, due to the presence of protein-binding secondary plant compounds (such as tannins) and potential analytical shortcomings. Protein actually available for the animal was considered to be only $66 \%$ of the analysed crude protein value by Pellew (1984a+b).

Table 2-2: Nutrient composition of giraffe diets in the wild according to Pellew (1984a+b), Sauer et al. (1982), Owen-Smith (1988)

|  | Crude Protein <br> (XP) | Fibre (Cell wall) $^{1)}$ | Lignin (ADL) |
| :---: | :---: | :---: | :---: |
| Mean | 14.9 | 39 | 22 |
| Min/Max | $12 / 19$ | $18 / 45$ | $14 / 25$ |

${ }^{1)}$ measured as ADF or XF (Crude fibre)
Table 2-3 compares the carbohydrate composition of grass, legumes and browse. While the sugar content is more or less the same in browse and grass, browse contains considerably more relatively fast fermenting pectins, while grass contains more slowly fermenting hemicellulose and cellulose. When deriving the nutrient composition of captive diets from the composition of natural diets in the wild, there should be no overdue emphasis on the giraffe as a „concentrate selector". Diets of free-ranging animals give no indication that giraffes need particularly high protein levels or high levels of starch and sugar in their diet. However, the data show that giraffe are adapted to a high-fibre browse diet (with its biochemical and mechanical differences to grass diets), and that, when compared to grazers, they might be particularly adapted to the fermentation of soluble fibre fractions, such as pectins.

Table 2-3: Carbohydrate composition of different forage [ $\%$ of dry matter]

|  | Grass | Legumes | Tree and shrub <br> leaves and twigs |
| :---: | :---: | :---: | :---: |
| Soluble sugars | $5-15$ | $2-16$ | $5-15$ |
| Starch | $1-5$ | $1-7$ | - |
| Pectin | $1-2$ | $5-10$ | $6-12$ |
| Hemicellulose | $15-40$ | $3-10$ | $8-12$ |
| Cellulose | $20-40$ | $7-35$ | $12-30$ |

Adapted from Robbins (1993)
Few estimations of energy content of giraffe feeding plants have been reported. Rees (1974) estimates the metabolizable energy (ME) - content of browse from Northern Zambia (fed to cattle) to be 7.7 MJ ME/kg DM (range 4.9-9.7).

Energy and protein values are not the only factors influencing selection of plant material. For giraffe, browse mineral contents of $1.3 \% \mathrm{Ca}, 0.2 \% \mathrm{P}$ and $0.1 \% \mathrm{Na}$ (all in DM) are reported by Pellew (1984a+b). As can be expected for browse, the Ca:P ratio (6.5:1) is rather high (but obviously no problem for the animal, as would be expected in a ruminant species; deviations
in the direction of a $\mathrm{Ca}: \mathrm{P}$ ratio larger than $2: 1$ are no problem, while $\mathrm{Ca}: \mathrm{P}$ ratios $<1: 1$ cause severe problems).

Forage species of wild giraffes have developed several important defence mechanisms such as thorns, symbiotic ant species living on the trees or secondary plant compounds like tannins (Madden \& Young, 1992; Furstenburg \& Van Hoven, 1994; Stanton \& Young, 1999; Caister et al., 2003). Generally, giraffe tend to avoid high levels of tannins in their diet, although they will invariably consume moderate levels as there is rarely forage available that contains no tannins. This should not automatically lead to the conviction that small amounts of tannins are necessary for the species. Research on the effects of (small) amounts of dietary tannins in captive wild ruminants is still too limited to allow any conclusions (reviewed in Clauss 2003; giraffe: Clauss et al., 2003a; roe deer: Clauss et al., 2003b).

### 2.2.3 Activity budget

Like all herbivores, giraffes have to ingest and process large amounts of food. Due to the patchy distribution and the protection mechanisms of browse plants, giraffes are reported to move constantly while feeding. Daily foraging and rumination times are considerable (Table 2-4). Simulation of these long foraging times represents a major task of giraffe husbandry.

Table 2-4: 24 hour activity budgets of wild giraffe according to Pellew (1984a+b); the higher value for females is explained by high additional energy requirements for reproduction

|  | Adult males | Adult females |
| :---: | :---: | :---: |
| Feeding / Foraging | $\sim 10.5 \mathrm{~h} /$ day | $\sim 13 \mathrm{~h} /$ day |
| Ruminating | $\sim 7.5 \mathrm{~h} /$ day | $\sim 6.5 \mathrm{~h} /$ day |

### 2.2.4 A short note on physiology - the particularities of browsing ruminants

Data on feeding behaviour in the wild clearly show the preference of giraffe for dicot plants, predominantly for browse. In addition to this data, Hofmann (1973) classified the giraffe as a browser with the morphological features typically associated with this feeding style such as even distribution of rumen papilla, relatively weak rumen pillars, relatively small rumen and omasum, and very low reticular crests. It has been hypothesised that retention time of food particles in the digestive tract is shorter for browsing ruminants like the giraffe (Clauss et al., 1998; Clauss \& Lechner-Doll, 2001). Based on experiences in zoos, a browsing feeding habit is often correlated to a higher probability of nutrition-related problems mostly due to the fact that browsers do not ingest grass hay (or even lucerne hay) to the same amounts as grazers do (Clauss et al., 2003c). However, this observation is not based on a large-scale quantitative study but the impression gained by collating different experiences and anecdotal reports. The theoretical explanations for the potential reluctance of browsers to ingest grass material in large proportions are (a) that the teeth of browsers are adapted to the grinding of a particular material (browse leaves, which can be expected to pose less resistance to oral comminution than grass); these adaptations, however, make their teeth less effective for the grinding of lucerne and in particular grass hay, resulting in larger faecal particles in captive than in free-
ranging giraffes; and (b) that grass induces a stratification of rumen contents with a floating fibrous "raft" to a higher degree than browse.

Hofmann and Matern (1988) documented differences between the forestomach morphology between free-ranging and zoo giraffe as indicators that zoo giraffe consume more of a stratification-inducing forage that leads to a reduction of rumen papillae in the dorsal rumen region (i.e., the rumen looked more like a grazer rumen). A pronounced stratification may "block" the rumen of the browser who cannot work against this relatively firm mass as well as a grazer due to the relatively weaker rumen musculature of browsers; due to their relatively smaller rumens, browsers should be particularly dependent on a fast clearance of rumen contents, which is more difficult to achieve with stratifying material. Browse, on the other hand, does not seem to induce a rumen contents stratification to the same degree that grass hay does.

## B. Feeding of giraffes in zoos



### 2.2.5 Husbandry problems potentially related to diet

Traditionally, giraffe have been considered to be among the nutritionally most challenging ruminants in captivity. Several husbandry problems have been related to a nutritional context. Among those are:

## Rumen acidosis:

When any material is fermented in the rumen, short chain fatty acids (SCFA) are produced, which are then absorbed by the rumen wall and represent the main energy source for ruminants. Normally, the rumen pH is maintained at relatively stable levels, as production of these "acids" and their absorption are in balance, and saliva released during chewing serves as a buffer. However, if either the production of these acids is accelerated or the inflow of buffering saliva is reduced, the rumen contents can become acidic (lower pH ). This will lead to changes in the rumen microflora and to changes in the rumen epithelium.

If such a drop of pH occurs suddenly, it can cause the death of the animal. This could, e.g., happen if visitors feed large amounts of bread to one animal, or if one animal gains access to a whole bag of oatflakes. One would expect the chronic form of the disease to occur more
often, manifesting itself sometimes clinically in a variable (differing from day to day) and generally lower food intake, or poor body condition, or diarrhoea, or episodes of laminitis.

Feeds that induce a rapid or even "explosive" fermentation in the rumen are those containing sugars or starches, i.e. many concentrate feeds based on grains, bread, and especially fruits. Additionally, these feeds induce little chewing and hence little saliva production. In giraffes, rumen acidosis has not been reported particularly often (but see Krische \& Elze, 1981; Elze et al., 1978; Clauss, 1998; Clauss et al., 2002), but this could also be due to the difficulty of diagnosing chronic acidosis and demonstrating an immediate effect. In the real world, we are often faced with reports from zoos where animals were maintained on diets that could, in theory, lead to chronic rumen acidosis, but no particular disease symptoms were observed. As it is mostly impossible to evaluate the longevity of animals on such diets in a rational way, we here adopt a conservative approach to giraffe ration design that will most likely prevent the occurrence of rumen acidosis; in doing so, we do not claim that any other feeding regimes will lead to the demise of the animals, we only claim that they are more risky.

In an evaluation of giraffe necropsy reports, the pH of rumen contents was measured in 4 out of 62 available reports; in 2 of these 4 cases a pH was measured that indicated an acute rumen acidosis. Evidently, acidosis should be checked for more often in giraffe necropsies.

Rumen acidosis could contribute to several other problems in captive giraffe, including:

## Oral stereotypies:

See chapter 2.4, Behavioural enrichment. It has been suggested for cattle that, in the absence of actual forage to chew on, oral stereotypies - tongue play - are the only option for the animal to increase saliva flow to the rumen, and might therefore be adaptive on acidosisinducing diets.

One set of combined intake measurements and behavioural observations in giraffes and okapis seemed to indicate a higher incidence of oral stereotypies in those individuals that consumed proportionally more concentrate (i.e. acidosis-inducing) feeds (Hummel et al. 2002). While chronic rumen acidosis is unlikely to be the only cause for oral stereotypies in captive giraffes, it might be a contributing factor.

## Laminitis/hoof overgrowth:

See also chapter 2.6.2, Chemical restraint. In domestic cattle and in domestic horses, laminitis is a sure diagnostic indication of acidosis - in the rumen in cattle, in the caecum in horses. The drop in pH damages the epithelium, which loses its barrier function to pathogens. This allows toxins and biologically active substances to enter the bloodstream; subsequently, they reach and damage their predilection sites of activity - the capillary beds of the hoof corium, leading to laminitis, which in turn can also manifest itself at times in hoof overgrowth (see Clauss and Kiefer, 2003, for a review). In domestic animals, it is well known that sugars and starches - those substances that lead to acidosis - induce laminitis. The traditional concept of high-protein diets that lead to hoof overgrowth has long been abandoned in domestic animal science and can be explained by the fact that diets high in protein (i.e. high in concentrates)
mostly have high proportions of starches or sugars as well - and that a reduction in protein levels generally means a simultaneous reduction in sugar and starch levels.

Obviously, factors related to floor characteristics like softness, abrasiveness and moisture contribute even more significantly to hoof overgrowth problems.

## Chronic energy deficit or Serous fat atrophy syndrome or Peracute mortality syndrome:

Captive giraffe often die suddenly without a history of disease; as the death in these cases is usually unexpected, the term "peracute mortality syndrome" was introduced when this phenomenon was first fully described in 17 animals in 1977 (Fowler, 1977; 1978). On postmortem, there is serous fat atrophy, particularly around the heart, and frequently gastrointestinal ulceration, pulmonary inflammation and edema (Fowler, 1978). A second survey in 1993 revealed 11 more cases (Junge \& Bradley, 1993), a literature review in 1998 (Clauss, 1998) collated 12 other literature reports on giraffe deaths with similar findings - the earliest of which dated from 1854 (Cobbold, 1854) -, and additional cases have been reported since (Ball et al., 2002-2 cases; Enqvist et al., 2003 - 4 cases; Potter \& Clauss, 2005 - 5 cases). Poor nutrition, particularly inadequate protein levels in the diet, diets with a high proportion of grass or alfalfa hay and a low proportion of browse, intake problems due to worn teeth, environmental stress and increased energy demands due to cold have all been suggested as contributing factors to the peracute deaths (Fowler, 1978; Junge and Bradley, 1993; Clauss et al., 1999, 2001, 2002; Ball et al., 2002; Enqvist et al., 2003). Of these potential factors, „inadequate protein levels" appears to be an improbable explanation; Junge and Bradley (1993) explicitly state that the problem was also observed in animals whose diet contained high protein levels. On the other hand, any factor leading to a negative energy balance - be it due to low energy intake (low acceptance of the offered forage, tooth problems, rumen blockage or chronic acidosis) or increased energy metabolism (cold, stress) - are relevant factors that should be pursued.

In an evaluation of 62 necropsy reports on giraffe available for these guidelines, there were 21 cases in which serous fat atrophy was directly mentioned and an additional 7 cases where the body condition was described as thin/cachectic. The most prominent finding is the regular presence of gelatinous material in the coronary groove of the heart (Figure 2-1a+b).


Figure 2-1a+b: Giraffe heart with a) normal and b) depleted pericardial fat deposits (Pictures: JOHN POTTER, Auckland Zoo / New Zealand)

In only 4 cases was the presence of fat specifically mentioned. While this does not mean that "energy deficit" is the primary cause of death in all these cases, it stresses that a low energy intake can occur easily in giraffes - and maybe more often than in other species - be it as a primary or a secondary problem.

As energy deficiency with loss of body condition and complete mobilisation of the body fat stores is not a sudden event but the result of a medium-term to chronic process, the term "peracute mortality syndrome" probably does not reflect the pathogenesis of the problem but rather its human perception. Wild animals usually mask diseases or weakness as long as possible. In order to detect chronic malnutrition, regular weighing of giraffe or, alternatively, the use of a body condition score (BCS, see Table 2-5) is warranted. Additionally, sporadic measurements of food intake and calculations of the energy ingested would be desirable in many giraffe facilities.

Table 2-5: Giraffe body condition score (Kearney and Ball, 2001)

| Score | Description | Notes/Comments |
| :---: | :--- | :--- |
| $\mathbf{1}$ | No fat can be palpated. Ribs and spine of scapula <br> may be visible. Muscle wasting has occurred. | Emaciated. |
| $\mathbf{2}$ | Cervical vertebrae are visible. Protruding spine. <br> Distinct hollows cranial to hipbones. Crest of <br> illium is visible. Outline of scapula is visible. Thin <br> legs. Hips appear sunken and shoulders are slim. | Poor condition. Cause for <br> concern. |
| $\mathbf{3}$ | Hipbones prominent. Definite outline of spine. <br> Sacrum is visible. First two cervical vertebrae <br> visible. Chest may appear sunken. | Occasionally seen following <br> a growth spurt in young <br> adults. |
| $\mathbf{4}$ | Tailhead is noticeable and point of hipbone is <br> visible. Slight hollow in center of chest. Sufficient <br> muscling in hindquarters, shoulders, and neck. | Nicely muscled, but with <br> little fat. Commonly seen in <br> growing giraffe over 1.5 <br> years of age. |
| $\mathbf{5}$ | Back and hips rise smoothly to topline with no <br> visible outline or denting along backbone. Some <br> palpable fat around tailhead. Point of hipbone just <br> visible. | Good condition. |
| $\mathbf{6}$ | Back is level and wide. Hipbone not visible, but <br> easily palpated. Smooth chest. Visible thickening <br> in lower neck. | Good condition. Ideal for <br> calves under 1\&1/2 years. |
| $\mathbf{7}$ | Slight crease along backbone. Hipbones difficult to <br> palpate. Smooth chest and thick neck. | Overweight. |
| $\mathbf{8}$ | Definite crease along backbone. Tailhead no <br> longer clearly visible. Soft fat palpable along <br> tailhead. Thick neck. | Obese. |

## Skin lesions:

In one case of a female giraffe with a long-term history of skin lesions resistant to treatment (Flach et al., 1997), the skin lesion disappeared within three months after linseed extraction chips had been added to the diet (Clauss, 1998; Clauss et al., 2000). This could be attributed to the fact that linseed chips contain linolenic acid (an omega-3 fatty acid) as their major polyunsaturated fatty acid, and that many zoo animals generally receive a diet of lower polyunsaturated fatty acid content, and of a higher omega- 6 to omega- 3 ratio, than their freeranging counterparts (Grum et al., 2005); omega-3 fatty acids are considered to be important in skin health. Omega-6 fatty acids are predominant in grain products and many oils (e.g. sunflower oil), which therefore should not be used to a large extent. A diet with a high proportion of forage, even if that forage is dried (hay), will provide more omega-3 than omega-6 fatty acids; the omega-3 proportion will be even more favourable if fresh forage or ensiled forage is used rather than dried forage.

White muscle disease or Vitamin E deficiency:
Low blood vitamin E levels for captive giraffe have been observed by Rüedi et al. (1979), Gutzwiller (1984), Brush \& Anderson (1986), Ghebremeskel \& Williams (1988), Burton \& Dierenfeld (1992) and Dierenfeld \& Traber (1992). Muscle pathology due to vitamin E deficiency was observed by Bolau (1910), Lopatynski (1937), Strafuss \& Kennedy (1973), Heldstab \& Rüedi (1980), Griner (1983) and Burton \& Dierenfeld (1992). Further articles are cited by Letzner (1987). An interesting feature is that even in adult animals, lesions are often located in the tongue, indicating the importance of this muscular organ in giraffes. A regular vitamin supply in a supplement or a balanced pelleted feed should generally prevent such cases. In certain regions known for selenium deficiency, particular selenium and vitamin E supplementation may be needed.

## Metabolic bone disease or Calcium deficiency:

Metabolic bone disease was observed in giraffes by Weinland (1863), Bruch (1864), Iles (1957), Gölthenboth \& Keller (1970), Langman (1978) and Gucwinski \& Ippen (1979). A century ago, metabolic bone disease was called "the giraffe disease" (Bruch, 1864). In comparison to other ruminants, giraffe appear to have particularly high calcium requirements (Mitchell et al., 2005) which are, however, adequately met by their natural diet. In captivity, the cause of the problem is mostly a dietary calcium deficiency caused by the excessive use of diet items with a low calcium content and an unfavourable calcium:phosphorus ratio, such as fruits, cereals/grains, bread, without an adequate mineral supplement. As these diet items can also induce acidosis (see above), their use should be minimised in general. The widespread use of mineral supplements and balanced pelleted feeds has reduced the incidence of metabolic bone disease in zoo animals; however, even in more recent times, cases may be observed in large herbivores due to the use of grain products and an insufficient intake of forage (e.g. Caliguri et al., 1989). Due to the high calcium content of alfalfa hay, a ration based on alfalfa will generally prevent metabolic bone disease.

## Mandibular fractures:

Mandibular fractures seem to occur relatively frequently in giraffes (Kaandorp, 2001; additional cases reported personally by Baumgartner/Neurohr, Flach, Wenker). In many cases, these fractures seem to be linked to the hay rack design - an animal inserts its mandible between the bars and when suddenly frightened, jerks its head out and breaks its jaw. It is therefore recommended that either hay be offered in flexible nets or that the spaces between the bars of racks be too small for a giraffe to insert its jaw. Additionally, both measures increase the behavioural value of the forage offer by enhancing the use of the tongue (see also chapter Behavioural enrichment). Surgical treatment of jaw fractures has been performed successfully on several occasions (Kaandorp, 2001).

## Chronic diarrhoea:

Diarrhoea has been repeatedly reported in captive giraffe (Altman, 1978; Arnhold et al., 1993). Apart from other veterinary diagnostic procedures, diarrhoea should induce a reevaluation of the diet, particularly with respect to the ratio of forage to concentrates - not on the basis of the food offered but of the food ingested. Diarrhoea can be a consequence of rumen acidosis. Animals with diarrhoea should receive food and water, and an increase in the intake of forage (including browse) is beneficial.

A special case of chronic diarrhoea was reported by Lechowski et al. (1991) who noted low pancreatic enzyme activity in the faeces of the diseased animals as compared to healthy ones. They diagnosed a pancreatic insufficiency (supported by histological findings in two deceased animals), and supplementation with external enzymes led to an improvement of the condition.

## Urolithiasis (Bladder stones):

After the first report of multiple bladder and urethra stones in a captive giraffe (Wolfe et al., 2000), a survey in the USA has revealed a series of additional cases (Wolfe, pers. comm.). The stones appear to be struvit stones (magnesium-ammonium-phosphate); such stones are a common finding in sheep and feedlot cattle fed high-concentrate diets. Grain-based concentrates often provide an excess of phosphate. As they also require less mastication, there is less saliva production - saliva being an important route of non-renal phosphate excretion in ruminants. Therefore, a diet with an adequate proportion of roughage, and a pelleted feed with a reasonable, non-excessive supply of minerals, must be regarded the best prophylactic measures against uroliths in giraffes. Kidney stones found in free-ranging giraffe, in contrast, contained only traces of phosphate (Langman, 1978).

## Phytobezoars/Abomasal obstruction:

The obstruction of the abomasum (the glandular stomach) by plant material conglomerates (phytobezoars) has been reported frequently in captive giraffe (Fox, 1938; Gradwell, 1976; Altmann, 1978; Gorgas et al., 1978; Brancker, 1980; Franz et al., 1984; Beyer, 1991), and additional cases have been conveyed anecdotally to the authors. The descriptions do not allow conclusions as to the material, but it appears that not only grass hay, but also lucerne hay can be the substrate of phytobezoars. In the 62 necropsy reports available for these guidelines, 2 cases of phytobezoars were reported. The development of phytobezoars has been linked to the fact that giraffes' teeth are less suited for grinding lucerne and in particular grass hay. One EEP facility explicitly linked the use of grass hay to the occurrence of phytobezoars in their animals. As a preventative measure, the quality of the lucerne hay should be high, grass or grass hay should not be used as the sole roughage, and browse should be given as often as possible; however, these recommendations cannot be backed with data so far.

## Summary:

Several disease syndromes in captive giraffe could be linked to feeding. These have been summarized in Fig. 2-2. It is speculated that the stratification of rumen contents triggered by inadequate roughage (especially grass hay, but also low-quality lucerne) cannot be compensated for by giraffes. Note that a restrictive feeding of adequate amounts of concentrates, an appropriate concentrate composition (with an emphasis on lucerne or green meal, beet pulp, and very limited starch and sugar sources), and a high-quality lucerne hay, must be considered the most important prophylactic measures so far.


Figure 2-2: Potential relations of nutrition and symptoms found in giraffe in captivity

### 2.2.6 Amounts of food ingested by giraffe

An exact quantification of the nutrition of giraffes is an essential step in the evaluation of diets. Results of projects on food intake and digestive performance are given in table 2-6. Few studies are available that give an estimation of the food intake of giraffes under natural or semi-natural circumstances. Pellew (1984) estimates food intake on the basis of bite size and frequency counts on naturally foraging giraffes. Compared to data of Pellew (1984a+b), captive animals seem to consume less than their wild conspecifics: A fully grown giraffe with maintenance requirements (including moderate locomotion levels) consumes about 8.5-12 kg of dry matter (DM) per day on a captive diet ( $1.2-1.3 \%$ of body weight).

Table 2-6: Daily Dry Matter intake of giraffe; data from Prins \& Domhof, 1984; Baer, et al., 1985; Hatt, et al., 1998; Dinglreiter, 2000; Clauss, et al., 2001; Hörhager, 2002; Clauss, et al., 2003; Hatt, et al., 2005; Kearney, et al., 2005

|  | Sex | Total [kg/d] | DM-Intake \% BW/day [\%] | $\begin{gathered} \text { \% BW } \mathbf{B W}^{0.75} \\ \text { per day } \\ {[\%]} \end{gathered}$ | Amount of Forage [\% of diet] | Reference |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Wild | ${ }^{7}$ | 19.0 | 1.6 | 9.3 | 100 | $\begin{gathered} \text { Pellew } \\ \left.(1984 b)^{4}\right) \end{gathered}$ |
| Wild | $q^{1)}$ | 16.6 | 2.1 | 11.0 | 100 | Pellew (1984b) |
| Captive | $\delta^{2}$ | 8.2-17.8 | 1.0-1.5 | 5.5-8.7 | $\approx 50$ | See reference list |
| Captive | $+^{2)}$ | 6.0-11.2 | 0.9-1.3 | 4.7-6.1 | $\approx 50$ | See reference list |
| Captive | $q^{3)}$ | 7.7-16.9 | 1.1-2.4 | 5.5-12.3 | $\approx 50$ | See reference list |

[^0]Fresh matter intake obviously can be considerably higher, since fresh food includes high amounts of water. Figure 2-3 gives estimations for the average DM-content of some feeds.


Figure 2-3: Dry matter / water content of different feeds

Only limited data exist on nutrient composition of ingested diets of giraffes in captivity. Data are available from two EEP and one SSP facility (Table 2-7). Protein contents in these diets were $15-19 \%$, which can be considered to be sufficient and uncritical in all cases. The values for fibre ( $21 \%$ ) and lignin ( $4 \%$ ) have to be seen more critically, since they are on the lower spectrum of the respective values found for African browse. It is encouraged that diets in captivity should be higher in fibre.

Table 2-7: Nutrient composition of some zoo diets

|  | Nutrient composition of diet |  |  |
| :---: | :---: | :---: | :---: |
|  | [\% DM] |  |  |
| Characterisation of diet | Protein (XP) | Fibre (ADF) | Lignin (ADL) |
| High amount of alfalfa hay, access to browse | 15 | 31 | 10 |
| Low amount of alfalfa hay, access to browse* | 18 | 30 | 7 |
| Low amount of alfalfa hay, no browse | 19 | 21 | 4 |

[^1]
### 2.2.7 Body weights of giraffes

For any consideration on nutrition, a good estimation of the body weight of an animal is crucial. This can be a critical point in captive diet evaluation, since a scale is rarely available at the giraffe department of a zoo. Weight estimations have to be made, best based on observations on animals with known weights, easily available anatomical measurements like shoulder height and judgement of the body condition of the respective animal. Hall-Martin (1975) gives estimations of giraffe BW based on shoulder heights:

$$
\begin{gathered}
\text { BW } \widehat{\overparen{o}}[\mathrm{~kg}]=6.752 * \mathrm{~S}[\mathrm{~cm}]-1051 \\
\text { BW } O[\mathrm{~kg}]=5.659 * \mathrm{~S}[\mathrm{~cm}]-783
\end{gathered}
$$

Where BW is body weight and S is shoulder height.
Transports can be used to gain weight data opportunistically by weighing the transport vehicle before and after unloading the giraffe. Table 2-8 gives an overview on published data on giraffe body weights.

Table 2-8: Body weights of captive and wild giraffes from the literature

|  |  | Sub-species | Body weight [kg] | n |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Female | Wild | tippelskirchi | 798 | 1 | Talbot and Talbot 1961 |
| Female | Wild | tippelskirchi | 676 | 28 | Kajanga and Blankenship <br> 1973 |
| Female | wild | thornicrofti | 1125 | 1 | Wilson 1968 |
| Female | wild | giraffa | 785 | 1 | pers. comm. Wilson <br> (according to Hall-Martin <br> 1975) |
| female 6-8 y | wild | giraffa | 752 | 9 | Hall Martin et al. 1977 |
| female 9-11 y | wild | giraffa | 773 | 10 | Hall Martin et al. 1977 |
| female 12-20 y | wild | giraffa | 863 | 6 | Hall Martin et al. 1977 |
| Female | wild | average | 800 |  | Owen-Smith 1988 |
| Female | captive camelopardalis | 748 | 1 | Crandall 1964 |  |
| Female | captive | camelopardalis | 605 | 1 | Crandall 1964 |
| Female | captive | reticulata | $637(576-715)$ | 6 | Kearney 2005 |
| Female | captive | reticulata | $730(700-790)$ | 3 | own data |
| Male | wild | tippelskirchi | 1097 | 1 | Sachs 1967 |
| Male | wild | thornicrofti | 1269 | 1 | Wilson 1968 |
| male 8-9 y | wild | giraffa | 1096 | 8 | Hall Martin et al. 1977 |
| male 10 y | wild | giraffa | 1183 | 6 | Hall Martin et al. 1977 |
| male 11-23 y | wild | giraffa | 1288 | 5 | Hall Martin et al. 1977 |
| Male | wild | average | 1200 |  | Owen-Smith 1988 |
| Male | captive | reticulata | 990 | 1 | own data |
| male ( $\sim$ 3 years) captive | reticulata | 636 | 1 | own data |  |

Based on a data collection of Reason \& Laird (2004) for SSP giraffes, an approximation of weight gain of growing giraffe can be made (Table 2-9; Figure 2-4) based on non-linear regression. Large individual differences in body size and weight are known, so these data can only be regarded as a guideline.


Figure 2-4: Development of body weight in SSP giraffes (based on data of Reason \& Laird

Table 2-9: Body weight development of giraffes (data of Reason and Laird 2004)

|  | Body weights [kg] |  |  |
| :---: | :---: | :---: | :---: |
| Age in month | Males | Females |  |
| Birth | $(64)$ | 63 | $(61)$ |
| 3 month | 132 |  |  |
| 6 month | 200 |  |  |
| 9 month | 261 |  |  |
| 12 month | 317 |  |  |
| $11 / 4$ years | 369 | 415 | 588 |
| $11 / 2$ years | 457 | 549 |  |
| $13 / 4$ years |  | 597 |  |
| 2 years | 503 | 636 |  |
| $21 / 2$ years | 577 | 667 |  |
| 3 years | 640 | 739 |  |
| $31 / 2$ years | 694 | 768 |  |
| 4 years | 740 | 780 |  |
| 6 years | 868 | 787 |  |
| 8 years | 937 | Up to 800 |  |
| 10 years | 975 |  |  |
| 15 years | 1009 |  |  |
| Max BW | Up to 1200 |  |  |

### 2.2.8 Nutritional Targets

## Energy supply:

From the discussion of potentially diet related husbandry problems (B.2.1) it follows that a major task of giraffe nutrition is to provide an adequate energy supply, while excluding conditions that might promote the occurrence of unphysiological rumen acidification at the same time.

Based on the assumption that estimations of maintenance energy requirements for other ruminants are valid for giraffes, daily energy requirements of an animal with basically maintenance requirements are $0.45-0.60 \mathrm{MJ} \mathrm{ME} /\left(\mathrm{kg} \mathrm{BW}^{0.75} * \mathrm{~d}\right)$, already including some safety supplements. The influence of (horizontal) locomotion in a zoo environment on energy requirements must not be overestimated (e. g. only 2 KJ per kg body weight and kilometre for cattle) (see table 2-10).

Table 2-10: Estimation of energy requirements of captive giraffe

|  | Energy requirement [MJ ME/(kg BW $\left.{ }^{0.75}{ }^{\mathbf{0}} \mathbf{d}\right)$ ] | References |
| :---: | :---: | :---: |
| Domestic ruminants* maintenance requirements | 0.40-0.53 | $\begin{gathered} \hline \text { GfE 1995, 1996, } \\ 2001,2003 \end{gathered}$ |
| Additional requirement for locomotion (10\% ) | 0.04-0.05 | Blaxter 1962 |
| Sum | 0.44-0.58 |  |

*Giraffe maintenance metabolism is estimated to be 0.30 (basic metabolic rate) * $1.33=0.40$ $\mathrm{MJ} /\left(\mathrm{kg} \mathrm{BW}{ }^{0.75} * \mathrm{~d}\right)$ by Pellew (1984b)

Table 2-11 gives the estimations of energy requirements for maintenance for different body weights.

Table 2-11: Relation of body weights and energy requirements (Assuming requirements of $0.45-0.60 \mathrm{MJ} \mathrm{ME} /\left(\mathrm{kg} \mathrm{BW}^{0.75} *\right.$ day $)$

| Body weight <br> [kg BW] | Metabolic body weight <br> [kg BW | Energy requirement <br> [Mj/day] |
| :---: | :---: | :---: |
| 600 | 121 | $55-73$ |
| 800 | 150 | $68-90$ |
| 1000 | 178 | $80-107$ |
| 1200 | 204 | $92-122$ |

Assuming Metabolisable Energy contents of 8 or 9 MJ ME/kg DM for a diet, a 700 kg giraffe with maintenance requirements should meet its requirements by ingesting about $7-10 \mathrm{~kg} \mathrm{DM}$ of this diet, depending on the estimation of energy requirement ( $0.45-0.60 \mathrm{MJ} \mathrm{ME} /(\mathrm{kg}$ $\left.B W^{0.75} * d\right)$ ).

Obviously the energy demands of pregnant and especially lactating animals have to be considered to be fairly higher (see point Peculiarities in the feeding of reproducing giraffes).

Table 2-12: Calculation of daily intake necessary to meet the maintenance energy requirements of giraffe of different body weights (assuming 0.6 or $0.45 \mathrm{MJ} \mathrm{ME} / \mathrm{kg} \mathrm{BW}^{0.75}$ and alfalfa hays of different energy contents)

|  | Alfalfa hay with an energy <br> content of 8 MJ ME/kg DM <br> (low quality) | Alfalfa hay with an energy <br> content of 9 MJ ME/kg DM <br> (reasonable quality) |  |  |
| :---: | :---: | :---: | :---: | :---: |
| Assumed energy requirement <br> [Mj ME/kg BW |  |  |  |  |
| Necessary daily intake <br> (forage +concentrate) <br> [kg DM/day] | 0.60 | 0.45 | 0.60 | 0.45 |
| 600 kg BW |  |  |  |  |
|  | 8.1 | 6.1 | 7.6 | 5.7 |
| 700 kg BW | $(4.9+3.2)$ | $(3.7+2.4)$ | $(4.6+3.0)$ | $(3.4+2.3)$ |
|  | 9.2 | 6.8 | 8.5 | 6.4 |
| 800 kg BW | $(5.5+3.7)$ | $(4.1+2.7)$ | $(5.1+3.4)$ | $(3.8+2.6)$ |
|  | 10.0 | 7.5 | 9.4 | 7.1 |
| 900 kg BW | $(6.0+4.0)$ | $(4.5+3.0)$ | $(5.6+3.8)$ | $(4.3+2.8)$ |
|  | 11.0 | 8.2 | 10.3 | 7.7 |
|  | $(6.6+4.4)$ | $(4.9+3.3)$ | $(6.2+4.1)$ | $(4.6+3.1)$ |
| 1000 kg BW | 11.9 | 8.9 | 11.1 | 8.3 |
|  | $(7.1+4.8)$ | $(5.3+3.6)$ | $(6.7+4.4)$ | $(5.0+3.3)$ |

An unpredictable influence comes from low environmental temperatures; since giraffe are described to be poorly insulated despite their large body size and display fluctuations in body temperature with the environmental temperature (reviewed in Clauss et al. 1999), low environmental temperatures may increase the energy requirements of the animals considerably.

## Protein:

Protein requirements of giraffes and comparable browsing ruminants are probably comparable to grazing species, although the protein (nitrogen) content in their natural diet can be considerably higher. Estimations of the protein requirement for maintenance of browsing cervids (moose; white tailed deer) are considerably lower than average giraffe diets (as low as 6-7 \%; Robbins 1993; Holter 1979; Schwartz 1987). The claim that giraffe should have protein levels of $18 \% \mathrm{DM}$ in their diet is not supported by any evidence.

On the other hand, the protein contents of giraffe diets in captivity generally can be considered as uncritical for the animals; if at all, excessive protein levels should be avoided as a prophylactic measure against urolithiasis (magnesium-ammonium-phosphate stones: ammonium is a metabolic product of protein). As stated before, high concentrations of protein cannot be regarded as a cause for excessive hoof overgrowth. There is little reason to include particularly protein-rich food items in a diet consisting mainly of high-quality lucerne hay that already has a high protein content in order to increase the protein content of the whole diet even further.

## Proportion of forage:

A quantification of the forage proportion of a diet is one of the first measures when evaluating giraffe diets (see picture below for comparison of volume and weight in hay and concentrates). It is fairly difficult to estimate the comparative amounts of pelleted feed and roughage adequately. In practice, the high density of pelleted feeds can easily lead to an underestimation of its amount with the danger of offering too much of it; the low density of roughage can easily lead to an overestimation of its amount giving a false security that the animals consumed a lot when in reality the weight consumed is not that high.


Difference in volume of the same amount of pellets and lucerne hay

The concentrate: forage ratio has important influences on several aspects of digestion. Forage intake influences feeding/rumination behaviour and therefore also rumen balance and tendency for oral disturbances. Table 2-13 gives the feeding/rumination times of cattle on forage or milled feeds.

Table 2-13: Feeding and rumination times of cattle on pure diets

|  | Feeding time | Rumination time |
| :---: | :---: | :---: |
| -Good quality hay | $27-31 \mathrm{~min} / \mathrm{kg} \mathrm{DM}$ | $55-74 \mathrm{~min} / \mathrm{kg} \mathrm{DM}$ |
| Pelleted, finely ground hay | $13 \mathrm{~min} / \mathrm{kg} \mathrm{DM}$ | No regular rumination |
| Pelleted concentrates | $4-10 \mathrm{~min} / \mathrm{kg} \mathrm{DM}$ | No regular rumination |

Data on okapi (Hummel, 2003) suggest a 3.5 fold increase in feeding time in forage like browse or alfalfa hay compared to concentrates or produce.


Figure 2-5: Basic functioning of ruminant/giraffe digestive physiology; changed from Hofmann (1989) and Schmucker (2004)

Figure 2-5 gives an overview on function of aspects of giraffe digestive physiology relevant for adequate feeding. As a rule of thumb, the upper limit to the inclusion of unstructured food (pelleted feeds, concentrates, produce) in the diet should therefore be $50 \%$. The recommendation of 60 to $70 \%$ of forage in diets for giraffes by Lintzenich \& Ward (1997) should best be followed, if forage of reasonable quality can be obtained Quantitative evaluations of the giraffe diet at a particular zoo revealed that a diet consisting of $70 \%$ forage (mainly alfalfa hay) was energetically adequate for a captive giraffe herd (Hummel et al. 2003).

## Fermentation patterns:

The energy contained in plant material is basically released during the process of bacterial fermentation. The speed of this fermentation varies for different feeds, and for ruminants, it is important that energy is not released too quickly, as this makes rumen acidosis more likely to occur. Food items containing high amounts of starch (grains, bread, grain-based pellets) or sugar (fruits, coloured vegetables) have a dramatically fast fermentation. On the other hand, plant cell wall has slower fermentation rates. The best way to provide extra energy is not with starches or sugars, but with easily fermentable fibres such as pectins (as contained in unmolassed beet pulp).

## Other nutrients:

## Minerals:

$\mathrm{Ca}: \mathrm{P}$ ratio of alfalfa hay is as high as $7: 1$. This is comparable to the high $\mathrm{Ca}: \mathrm{P}$ ratios measured in browse. In ruminants, rather high ratios of $\mathrm{Ca}: \mathrm{P}$ can be considered to be uncritical, since high amounts of P are secreted in the digestive tract by the animal itself via saliva $\left(\mathrm{NaH}_{2} \mathrm{PO}_{4}\right.$ - buffer). Mineral licks should be permanently available.

## Vitamins:

Vitamin E levels have been reported to be rather low in several species of ungulates. A supplementation of the diets or the inclusion of higher Vitamin E contents to a pellet / compound is therefore advisable. B-Vitamins are not considered as essential for ruminants with a functioning forestomach (production by microbes). In addition to Vitamin A, $\beta$ Carotine is regularly listed as important for fertility in dairy cows. Although the evidence for this relationship is not unequivocal to date, it seems reasonable that diets of giraffe in captivity should be within the range recommended for dairy cattle ( 400 mg /day in a 650 kg dairy cow). $\beta$-Carotin is provided in high amounts by fresh forage, silage, dried forage meal and carots, while hay has considerably lower contents.

## Unsaturated fatty acids:

Linolenic acid has been reported to have a positive effect in animals with a long history of skin lesions. Linseed extraction chips can be added to the diet to improve the supply of unsaturated fatty acids to the animal - up to 1 kg per animal.
A summary of nutrient ranges proposed for giraffe diets is given in table 2-14 (most data are based on recommendations from Lintzenich and Ward 1997)

Table 2-14: Proposed nutrients in giraffe diets

| Nutrient | Concentration range <br> (dry matter basis) |
| :---: | :---: |
|  | Based on experience of nutrient concentrations in <br> appropriate diets for medium / large browsers in captivity |
| NDF, $\%$ | $35-50$ |
| Protein, $\%$ | 14 |
| Calcium, \% | $0.70-0.97$ |
| Phosphorus, \% | $0.36-0.40$ |
| Ca $:$ | $\geq 2: 1$ |
| Patio | $0.18-0.24$ |
| Potassium, $\%$ | $1.6-1.8$ |
| Sodium, $\%$ | $0.10-0.44$ |
| Iron, $\mathrm{mg} / \mathrm{kg}$ | $126-139$ |
| Zinc, $\mathrm{mg} / \mathrm{kg}$ | $54-68$ |
| Copper, $\mathrm{mg} / \mathrm{kg}$ | $10-12$ |
| Manganese, $\mathrm{mg} / \mathrm{kg}$ | $54-57$ |
| Selenium, $\mathrm{mg} / \mathrm{kg}$ | $0.12-0.18$ |
| Iodine, $\mathrm{mg} / \mathrm{kg}$ | $0.3-0.4$ |
| Vitamin $\mathrm{A}, \mathrm{IU} / \mathrm{g}$ | $1.5-2.2$ |
| B-Carotin $\mathrm{mg} / \mathrm{kg}$ | $45-55$ |
| Vitamin $\mathrm{D}, \mathrm{IU} / \mathrm{g}$ | $0.4-0.5$ |
| Vitamin $\mathrm{E}, \mathrm{IU} / \mathrm{kgg}$ | $120-178$ |

Peculiarities in the feeding of reproducing giraffes:
To date, only general assumptions on the feeding of reproducing giraffes can be made, mainly based on knowledge from domestic ruminant species.

Additional food requirements during gestation are significant only in the last stages of gestation, when foetal growth is highest and in the first third of lactation.

After parturition, a sharp rise in energy requirements due to the onset of lactation can be assumed from the $1^{\text {st }}-4^{\text {th }}$ week of lactation. Milk production can be expected to be at maximum during the $2^{\text {nd }}$ and $3^{\text {rd }}$ month of lactation. Based on estimations of body weight gain in youngsters, energy requirements of a lactating cow at maximal lactation can be expected to be about $175 \%$ of that of non-reproducing giraffe. In turn, food intake of a reproducing giraffe is significantly increased during that time by $50-100 \%$ (on a dry matter basis). Since a much greater amount of food than normal has to be processed and digested, the digestive system of the animal reaches its limits. Therefore, lactating females need special care! The amount of concentrates may be increased carefully and gradually within the first month of lactation. Obviously, this is best done with the animal separated from the others. Concentrates with unproblematic fermentation characteristics (such as the pellet recipe in Table 2-15) are advisable, and the use of good quality forage is recommended. After the $3^{\text {rd }}$ and $4^{\text {th }}$ month of lactation, milk production will slow down continuously. According to Langman (1977), giraffes in the wild are weaned at the age of 6-8 months (total duration of lactation has even been described to last as long as 10 months in the wild), and this state may be prolonged to some extent in the captive situation.

Remind that besides food, animals need much more water during lactation, so ad lib provision is mandatory!

### 2.2.9 Common food items for giraffes:

## Forage:

Right at the outset, we have to state that "the" optimal forage - combining feasible logistics and costs and perfectly matching the nutritional requirements of giraffe - is not easily found. Indeed, this seems to be the one factor that renders giraffe nutrition most challenging. Usually, a combination of different forages will be the most reasonable way to meet the requirements of giraffe.

In general, both nutrient characteristics and energy content are highest in fresh forage - be it grass, lucerne, or browse. Drying ("hay") results in a loss of energy content, and a degradation of some nutrients and vitamins; e.g., vitamin $E$ and carotin levels are usually lower in hay than in the original substrate, and due to a disproportionate loss of omega-3 polyunsaturated fatty acids, hays contain distinctively less omega-3 fatty acids (and consequently proportionally more omega- 6 polyunsaturated fatty acids) than the respective fresh substances. In contrast, silaging generally preserves the fatty acid pattern and the vitamin E and carotin content of the original material, and results in lower energetic losses than drying.

## Browse:

Palatable browse is generally preferred over all other feedstuffs by giraffes, even over concentrates. Since it most closely resembles the natural food of giraffes, palatable species are the most desirable forage source for giraffe. Due to the preference by the animals, forage intake can be increased by browse feeding to some extent (quantified by Hatt, et al., 2005). Diets high in browse guarantee a reasonable forage intake by the animals.

Leafy twigs are also the feedstuff inducing most oral manipulation, which has a beneficial effect on the occurrence of oral disturbances, as explained in more detail in chapter 2.4 Behavioural enrichment.

While desirable from the animal point of view, huge amounts would have to be acquired for giraffes each day. If browse was used as the only food item, an average group (3 animals) would require 200 kg of fresh young trees per day! Obviously, this is a completely unrealistic scenario, since such amounts will surpass the logistic capacity of any zoo. In an experiment by Hatt et al. (2005), even the daily provision of 18 kg fresh, edible browse to three adult giraffes proved to be unrealistic for longer than two weeks. Every facility holding giraffes should strive to solve the problem of browse provision, either by contacts with the local forestry departments, or by a browse plantation (Höllerl et al., 2005).


Amount of browse fed to a group of giraffe (4 adult and 3 half-grown) 2 times a week (roughly estimated, this amount would fulfil the total energy needs of 3 adult giraffes for one day, if consisting of a variety of well palatable browse species)

During the winter months, some alternatives for fresh browse are possible: dried browse twigs with leaves are a good alternative, but the storage capacity for this food item is obviously limited in every facility. Freezing browse may not often be feasible for giraffesized animals. The feeding of twigs without leaves makes a small nutritive contribution to a giraffe diet, but is of high value from an occupational point of view.

Commercially available harvested leaves may be considered as an alternative for winter, although feeding behaviour is less complex than with leafy twigs.

Conservation of browse for winter by silaging has been practised by a limited amount of facilities during the last years (Hatt and Clauss, 2001; Nijboer et al., 2002). Depending on the amount of leaves in the silage, this is a promising way to increase the amount of browse in the diet of giraffes during wintertime.


Dried browse twigs (left), dried browse leaves (middle) and browse silage (right)
Browse can contain secondary plant compounds (anti-nutritive substances). In our experience, common browse species like beech, willow, maple, acacia, hazel, pseudacacia, poplar or oak (the latter three described by Mosig, 1980) have been fed to giraffes without negative consequences. It is most likely that other species will be added to this list, but other facilities or electronic resources such as www.foragerssource.org should be consulted before introducing new browse species to giraffe. Remember that even browsing ruminants like giraffe may need to adapt to new browse species, which should always be introduced cautiously and only in small amounts at first.

## Alfalfa / Lucerne:

Alfalfa hay is commonly used in giraffe diets. In most parts of Europe, alfalfa is not as readily available (and at the same price) as grass. Most alfalfa comes from the south of France, some has even been imported from South Africa or Canada. As with all forages, the quality of alfalfa hay can vary considerably.

Like other leguminous herbs such as clover, alfalfa is known as high quality forage for cattle. This has to do with its high intake potential, which is generally higher than for comparable grass forage, and with the faster digestion/fermentation of energy compared to grass. It is known to induce higher passage rates and less rumination compared to grass. Its physical characteristics may be in between browse leaves and grass.

Fresh alfalfa is recommended if available during the growing season. It should be mixed with hay when newly introduced to the animals, since excessive ingestion of large amounts of fresh alfalfa can induce frothy bloat.

It should be noted that in two different experiments, it became evident that the energy intake of giraffe on a lucerne-hay-only diet is not adequate (Foose 1982, Hatt et al. 2005). Therefore, one should always keep in mind that lucerne is not ideal forage for giraffe, but a "good compromise" between the animals' preferences and the logistical availability. Lucerne hay always must be supplemented with additional feeds.

## Grass:

The important advantage of grass hay in mid Europe is its high availability. As mentioned above, grass has a slower fermentation rate than alfalfa, although being as digestible as alfalfa hay if given enough time. It induces a lower feed intake, a longer retention time and more rumination compared to alfalfa hay.

The only study with giraffe in which the intake of grass hay was documented (Foose, 1982) showed that the giraffe had a dramatically low intake when fed grass hay alone, and the experiment had to be abandoned. Grass hay should not be intended to be a major proportion of the giraffes' diet and every effort should be made to provide the animals with lucerne or clover hay instead. Anecdotal reports also link the ingestion of grass hay to the occurrence of abomasal phytobezoars. Grass contains silica or quartz "phytoliths", which cause severe tooth abrasion. Typical grazing animals are adapted to this characteristic by their high-crowned (hypsodont) teeth. As a typical browser, the giraffe has low-crowned teeth, and therefore, a long-term diet of grass hay will most likely lead to excessive tooth wear. We do not recommend the development of long-standing collection plans with a diet of grass hay only. Any long-term plan for keeping giraffe should contain the logistics for the provision of lucerne hay and browse.

As revealed by the questionnaire, several zoos feed grass hay as their only forage source. It should be clear to all parties involved that such a situation, though maybe necessary, is not ideal. If no other forage source can be provided, at least the grass hay should be of utmost quality.

## Combinations of forage:

An intuitive goal of many zoos and animal keepers is to offer "variety" to their animals. This often leads to a diet consisting of hay, pellets, and a large variety of fruits and vegetables. However, it should be noted that for herbivores, fruits and vegetables represent mostly a very highly concentrated form of sugar. If one wants to have a varied diet for a herbivore, then a variety of forage feeds should be included - i.e. lucerne hay, possibly an additional clover hay or meadow hay with a high proportion of herbs, grass silage in limited amounts, and browse from a variety of tree species. Any combination of high-quality forages is likely to result in an increased forage intake.

Concentrates and produce:
A diversity of food items is often offered to giraffe to enhance selectivity. The ability of a ruminant to select a nutritionally balanced diet can be surpassed if confronted with large amounts of produce or concentrates. The situation may be compared to that of a small child left alone with the choice between wholemeal bread sandwiches on the one hand and chocolate and sweets on the other.

## Concentrates:

In most facilities, giraffe are fed considerable amounts of concentrate feedstuffs. Compounds or ,,pellets" (pelleted mixtures of different feedstuffs including important amounts of minerals and vitamins) should be preferred over the separated feeding of "pure" energy concentrates like grains and mineral/vitamin concentrates, since this is the best guarantee for the intake of a balanced diet.

An important characteristic of ruminant feedstuffs is their fermentative behaviour. Concentrates high in starch like pure grains, bread and also some pelleted feeds are known to result more easily in a low rumen pH than concentrates based on easy digestible cell wall like unmolassed beet pulp. Unmolassed beet pulp represents the leftover after the extraction of sugar with residual sugar concentrations of $7-8 \%$ of DM . It has been reported to have a more beneficial effect on the fermentation in the rumen than e. g. pure grains (Van Soest, 1987; Van Soest et al., 1991). Since beet pulp is reported to cause obstruction of the throat in equids, it is recommended to be soaked prior to feeding. Table 2-15 offers a suggestion concerning the composition of a suitable giraffe / ruminant pellet, which can be produced by any local feed mill.

Table 2-15: Suggestion for the composition of a pelleted feed suitable as concentrate for giraffes (and producable by any food company), in comparison to two examples for standard "zoo pellets" (grain-based)

| Proposed pellet |  | Pellets actually used in zoos |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | \% of formula |  | \% of formula |  |
| Unmolassed beet pulp | 23 | Molassed beet pulp | - | 8 |
| Dried forage meal <br> (Lucerne) | 23 | Dred forage meal <br> (Lucerne) | 10 | 7 |
| Soy products | 23 | Soy products | 12 | 23 |
| Sunflower hulls | 12.5 | Oats | 30 | 16 |
| Wheat | 8.0 | Wheat | 9.5 | 11 |
| Molasses | 2.5 | Molasses | 4.0 | 3.4 |
| Cellulose powder | 2.5 | Barley | 15 | 18 |
| Linseed | 2.0 | Linseed chips | 5.0 | 4 |
| Vitamin/Mineral premix | 2.2 | Mineral \& Vitamin <br> premix | 1.0 | 2.3 |
| Sodium bicarbonate <br> Copper is added as 22 <br> mg/kg DM | 1.0 | Wheat bran <br> Dicalciumphosphate | 4.5 | 1.5 |

An example of how the nutrient contents of a designed pellet for giraffe can be derived is given in Table 2-16 (all values on a dry matter basis).

First, the nutrient contents in the staple forage, lucerne, are estimated from literature values. Ideally, the pellet design would be custom-tailored to every batch of forage (which would have to be analysed individually), but such an approach is not financially realistic. Here, an average value for lucerne hay from the NRC (2001) was used, with additional information from internet resources for certain nutrients.

Second, a target value has to be defined. Here, the target values from Lintzenich and Ward (1997) were used, with additional information from the NRC (2001). One evident discrepancy is that for cattle, about $20 \mathrm{IU} / \mathrm{kg}$ dry matter of vitamin E are recommended (NRC 2001), whereas the recommendation in Lintzenich and Ward (1997) is $120-180 \mathrm{IU} / \mathrm{kg}$ dry matter. Here, the lower value from Lintzenich and Ward (1997) was adopted.

Third, the nutrient content of the pelleted feed is calculated, based on an assumed ratio of lucerne hay and pellets. From the table, it becomes evident that, depending on the proportion of the pellets in the diet (either 50 or $30 \%$ ), different nutrient levels result. This is quite revealing with regards to the potential and the limits for the pelleted diet item. For example, calcium levels (Ca) are so high in lucerne that, in a diet with $70 \%$ lucerne intake, no additional Ca is theoretically necessary in the pellets. In contrast, as the proportion of lucerne increases, the phosphorus ( P ) content of the pellet needs to be increased.

As 5-5.5 \% fat is usually regarded as the maximum level safe for ruminants, it is evident that the pellet may contain a higher percentage of fat than is usually the case. While this is an interesting additional option to increase the energy value of the pellet without endangering rumen function, care should be taken to use not only a grain-oil but rather a high proportion of linseed oil.

Protein levels of the pellet are uncritical; with lucerne as the staple forage, protein levels in the pellet could theoretically be rather low, but such low levels are rarely achieved in pellets anyhow. Evidently, some nutrients, such as potassium ( K ) and iron ( Fe ) do not have to be added to the pellet at all, but will be contained in the pellet ingredients anyway.

Some values are critical: the literature value for selenium ( Se ) in lucerne exactly matches the requirement and therefore, the pellet should theoretically only need to have the same concentration. However, in order to have a safety margin in the absence of exact data on the selenium content of lucerne hay, one could increase the pellet level (making sure the total Se content of the diet does not reach toxic levels). This would be preventative in case of lucerne hay from a Se-deficient region. However, in the US for example, high-Se hays from regions with high environmental Se content have been reported. Note that the Vitamin E level calculated is relatively high - many commercial pellets will usually not have such high levels, as vitamin E is expensive.

Fourth, the composition of a pellet is defined, so that in both scenarios (50:50 and 70:30), nutrient provision is guaranteed, as one can never be sure about the exact proportions that the
animals will ingest. The example pellet that we define here ensures nutrient provision in both feeding scenarios.

Such a pellet can be designed on the basis of the ingredients given in Table 2-15. The nutrient composition fits a combination with lucerne hay. This calculation only applies to a combination with lucerne hay!

Table 2-16: Example calculation for the design of a pelleted feed supplementing a lucernehay diet. See text for detailed explanations. All values are on a dry matter basis. First, the composition of lucerne is estimated from the literature (ideally an analysis should be made). Then, target values for the total ration are formulated, and then the necessary composition of the pellet supplement in a lucerne:pellet 50:50 and 70:30 diet are calculated. Based on these result, values for a pellet are defined, and then the resulting rations with this pellet at 50:50 or 70:30 are checked to make sure the pellet adequately supplements both scenarios. Note that the nutrient contents in the pelleted feed represent values of the final product, and not necessarily the level at which nutrients have to be added specifically to the ingredient mixture. For example, the use of lucerne meal in the pellet might make additional Ca addition unnecessary etc.

| Nutrient | Unit | Lucerne <br> (estimate) | Target | Pellets <br> $50: 50$ | Pellets <br> $70: 30$ | Pellet | Ration <br> at $50: 50$ | Ration at <br> $70: 30$ |
| :--- | :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Protein | $\%$ | 18 | 14 | 10 | 5 | 16 | 17 | 17.4 |
| Fat | $\%$ | 2.5 | 5 | 7.5 | 10.8 | 8 | 5.25 | 4.15 |
| NDF | $\%$ | 42 | 40 | 38 | 35 | 40 | 41 | 41.4 |
|  |  |  |  |  |  |  |  |  |
| Ca | $\%$ | 1.47 | 1.00 | 0.53 | 0.00 | 0.60 | 1.04 | 1.21 |
| P | $\%$ | 0.28 | 0.49 | 0.70 | 0.98 | 1.00 | 0.64 | 0.50 |
| Mg | $\%$ | 0.29 | 0.20 | 0.11 | 0.00 | 0.11 | 0.20 | 0.24 |
| Na | $\%$ | 0.10 | 0.18 | 0.26 | 0.37 | 0.36 | 0.23 | 0.18 |
| K | $\%$ | 2.37 | 0.89 | 0 | 0 | 0 | 1.19 | 1.66 |
| Fe | $\mathrm{mg} / \mathrm{kg}$ | 619 | 100 | 0 | 0 | 0 | 310 | 433 |
| Cu | $\mathrm{mg} / \mathrm{kg}$ | 9 | 13 | 18 | 23 | 22 | 16 | 13 |
| Zn | $\mathrm{mg} / \mathrm{kg}$ | 28 | 33 | 39 | 46 | 46 | 37 | 33 |
| Mn | $\mathrm{mg} / \mathrm{kg}$ | 44 | 40 | 36 | 31 | 36 | 40 | 42 |
| Co | $\mathrm{mg} / \mathrm{kg}$ | 0.31 | 0.11 | 0 | 0 | 0.11 | 0.21 | 0.25 |
| I | $\mathrm{mg} / \mathrm{kg}$ | 0.16 | 0.80 | 1.44 | 2.29 | 2.00 | 1.08 | 0.71 |
| Se | $\mathrm{mg} / \mathrm{kg}$ | 0.3 | 0.3 | 0.3 | 0.3 | 0.5 | 0.4 | 0.4 |
|  |  |  |  |  |  |  |  |  |
| Carotin | $\mathrm{mg} / \mathrm{kg}$ | 61 | 20 | 0 | 0 | 20 | 41 | 49 |
| Vit D | $\mathrm{IU} / \mathrm{kg}$ | 300 | 500 | 700 | 967 | 1000 | 650 | 510 |
| Vit E | $\mathrm{IU} / \mathrm{kg}$ | 30 | 130 | 230 | 363 | 400 | 215 | 141 |

## Produce:

Commercial fruits (apples, banana, etc.) and many vegetables include, besides 80-90 \% water, high amounts of very fast fermenting sugars (up to $75 \%$ of dry matter in some fruits; see picture below. Oftedal et al. (1996) describe the fermentation pattern of these feedstuffs as "explosive" (Figure 2-6). Therefore, higher amounts should not be fed, and the use of produce should be supervised. In limited amounts, they may be of some use in hiding medication or in the training of animals.


Sugar and water content of produce (an amount of simple sugars and water equivalent to the sugar cubes and the water glass is included in the apple!)


Figure 2-6: Differences in fermentation rate between feedstuffs (note the exceptionally high fermentation in the initial stages of fermentation of apple - and other fruits); gas production $=$ fermentation or digestion of the feeds, respectively

Table 2-17 gives an overview on nutrient composition of produce compared to other feeds used for browsers in captivity.

Table 2-17: Composition of some feedstuffs commonly fed to giraffes

|  | Dry matter <br> $[\%]$ | Sugars | Starch <br> [\%] of dry matter | Fibre (ADF) |
| :---: | :---: | :---: | :---: | :---: |
| Carrot | 12 | 54 | - | 7 |
| Apple | 15 | 71 | - | 4 |
| Banana | 21 | $55-70$ | $0-20$ | 6 |
| Vegetables | $8-9$ | 33 | - | 11 |
| Grains | 90 | - | $50-65$ | $1-14$ |
| Beet pulp | 90 | 8 | - | 25 |
| (unmolassed) | 90 | $6-8$ | $25-35$ | $10-13$ |
| Zoo pellet | 90 | 5 | - | $24-38$ |
| Alfalfa hay | 90 | 5 | - | $17-30$ |
| Fresh browse | $23-36$ | - | - | $41-64$ |
| leaves | $40-48$ |  |  |  |

## Quality of feedstuffs:

Since quality of each batch of hay or of other feedstuffs may vary considerably, it is highly desirable to check the energy and nutrient content of the feedstuffs on a regular basis to have some control on product quality.

## Example diet:

Based on the energy requirements of the animals, diets based on different forage sources can be proposed.


Example Giraffe diet using on the left alfalfa hay, small amounts of produce and different concentrates (unmolassed beet pulp, soy and zoo pellet / compound, plus on the right as extensive offer of browse as possible (7-10 kg of young trees / animal and day are a high value, and may result in a browse intake of $\sim 10 \%$ of total $D M$ ).

Table 2-18: Proposals for diets for giraffe of different body weight classes

| Body weight [kg] | $\mathbf{6 0 0}$ | $\mathbf{7 0 0}$ | $\mathbf{8 0 0}$ | $\mathbf{9 0 0}$ | $\mathbf{1 0 0 0}$ |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Offered amounts (all in kg FM) |  |  |  |  |  | Percentage in diet <br> (in \% DM) |
| Lucerne hay (ad lib.) | $>4.5$ | $>5.1$ | 5.5 | 6.1 | 6.6 | $50 \%$ |
| Fresh browse | 4.9 | 5.5 | 6.0 | 6.6 | 7.1 | $10 \%$ |
| Pelleted compound | 2.7 | 3.1 | 3.3 | 3.7 | 3.9 | $30 \%$ |
| Linseed extraction chips $^{\mathbf{1}}$ | 0.5 | 0.5 | 0.6 | 0.6 | 0.7 | $5 \%$ |
| Green leafy vegetables $^{\text {Gruits }}$ |  |  |  |  |  |  |

such as the example pellet in Table 2-15, note that energy in pellets should not be based exclusively on grains or grain-derived products best ${ }^{2}$ for training or medication purposes

If fresh lucerne or comparable fresh forage is fed, it should be clear that the dry matter of 1 kg hay is equivalent to that of about 5 kg of fresh forage (as an approximation). If no or less browse is available, it should be replaced by other forage sources, not by concentrates. The inclusion of some vegetables/fruits is not regarded as mandatory for proper giraffe feeding. But if included in reasonable amounts and types, it will not influence a diet negatively, other than probably making it more expensive. It may be substituted by a pellet in a ratio of $\sim 1: 7(100 \mathrm{~g}$ pellet per 700 g produce, both on an as-fed / fresh matter basis).

### 2.2.10 Presentation of feedstuffs

## Feeding times:

Compared to the wild, where food and energy intake is distributed over the whole day, energy intake in captivity has sharp peaks when concentrates are fed. From this point of view, feeding concentrates in 3 instead of 2 meals would be highly desirable. Since giraffes show few signs of food competition, they are among the species best capable of group concentrate feeding.

Overnight video observation reveals that giraffe spend a considerable part of the night ruminating, but regularly have one feeding bout during the night. Using an automatic feeder may therefore make an even distribution of concentrate meals possible. This may have special advantages for lactating females if slowly and carefully adapted to this device!

As with other ruminants, it is important that the management system provides the animals with the opportunity to chew the cud (ruminate). Some diurnal ruminating activity characterizes the activity budget of free ranging giraffe with a peak around the noon hours (Dagg and Foster, 1976; Pellew, 1984a), although diurnal rumination activity tends to be lower than in other browsing ruminants (Du Toit and Yetman, 2005), and most rumination occuring during the night (Dagg and Foster, 1976; Pellew, 1984a).

## Changes in diet:

Although this may be obvious, we want to put special emphasis on the fact that - as with all other ruminants and herbivores in general - changes in diet have to be done gradually and stepwise. The rumen microbes have to adapt to the new diet, and the number of rumen papillae will increase on a faster-fermenting diet. These adaptations will require 14-30 days, depending on the degree of change in the diet. Therefore, any large change in the diet should be extended over a time period of at least 14 days! In addition, the animals themselves will need some time to adapt to completely new food items with novel tastes.

Large day-to-day changes in the amount of concentrates offered must be strictly avoided in these sensitive animals. Too fast of a change can have deleterious consequences.

If animals are put on a diet higher in forage, adaptive enlargement of rumen volume will occur over time. Any major changes in diet should best be done in late spring - not in autumn/winter where temporary energy deficits and unnecessary stress, e. g. due to cold, cannot be excluded.

## Provision of feeds:

Vegetables should be chopped into small pieces to reduce any risk of throat obstruction.
Different behavioural enrichment devices have been designed for giraffes (e. g. Houts 1993; Nicklaus \& Mueller 1995; Wielgosz 1999; Friedman 2004; Okapis: Zimmermann et al. 1997). They can be of help to prolong daily feeding activities and to enhance more complex feeding behaviour.

## Feeding behaviour / oral behavioural disturbances:

There are many documentations of the occurrence of oral disturbances in giraffes (Sato and Takagaki, 1991; Kolter, 1995; Koene and Visser, 1997). Constant access to appropriate forage, an appropriate concentrate:forage ratio in the diet and reasonably low produce and grain proportions are among the first factors to check. Feeding behaviour of the animals has to be improved in terms of quantity and quality (longer feeding and probably also longer rumination; more complex feeding behaviour including more tongue movements).

Several authors report a beneficial effect of browse on oral disturbances (Sato and Takagaki, 1991; Kolter, 1995). Work of Stolze (1998) implies that a diet higher in concentrates/lower in forage induces more oral disturbances than one lower in concentrates/higher in forage. There are reports of a reducing effect of grass hay on oral disturbances (Koene, 1999; Blaxter and Plowman, 2001).

### 2.2.11 Some final conclusions: Rules of thumb of giraffe feeding

It seems that in general, giraffe often either eat too little, or eat disproportionately high amounts of concentrates/produce, which may result in acidosis (unphysiological fermentation). The reason for this discrepancy often may be a low acceptance of the staple diet item (forage) offered, and a (compensatory) overfeeding of concentrates.

1. This opens two important routes of giraffe nutritional management:
a) every effort must be made to provide a forage of high quality and high acceptance
b) the concentrate component of the diet (the pelleted feed) should be designed to maximize energy provision but minimize the risk of rumen acidosis/unphysiological fermentation
2. The most reliable way to guarantee a forage of good acceptance and sufficient intake is the provision of a high-quality lucerne (alfalfa) hay. Grass hay in particular has been linked with low food intake and gut upsets in giraffes. Most importantly, long-term use of grass hay (containing silica) will lead to excessive tooth wear in a species not adapted to grazing. Lucerne hay represents the best compromise between what giraffe accept and what is logistically feasible for zoological gardens. If grass hay has to be used, it should be of the utmost quality. No long-term plans should be made on the basis of grass-hay feeding.
3. Don't let the roughage content of the diet (that your giraffes really consume!) drop under $50 \%$ of dry matter intake; $60-70 \%$ may be more desirable, if forage of good quality is used. The only way to check this is by sporadically weighing the amount of forage offered and leftover. Access to forage must be granted at all times.
4. The provision of browse is desirable for both physiological and behavioural reasons. Some browse should also be provided in the wintertime. Well-developed logistics for browse supplementation (local forestry agencies, browse plantation) should be part of any long-term husbandry plan.
5. The concentrate feed (pellet/compound) should be based on unmolassed beet pulp and lucerne or grass meal, not on grains - because the pectins in beet pulp have more favourable fermentation characteristics than do the starches in grains. The lucerne or grass meal guarantees additional fibre. Concentrates should be fed restrictively, in at least two, better in three, portions per day. The pellets should contain a vitamin/mineral premix that ensures adequate provision. Regional peculiarities (e.g. low selenium regions - if locally produced forage is used) must be considered. See Table 2-15 for a suggested recipe.
6. The amount of sugar-rich produce, such as apples, bananas or carrots, should be restricted to very small quantities and special purposes (training; one or two bananas per day as a diet ingredient to have something to give medication in if necessary).
7. If "variety" is wanted, then a variety of forages should be offered on a constant basis, not a variety of fruits/vegetables. For example, in addition to high-quality lucerne hay, some clover hay and/or hay from a meadow with a high proportion of herbs could be offered, along with some silage, and a variety of browse species. Offering a variety of fruits to a strict herbivore like the giraffe can be likened to offering a variety of candy to a child.
8. Avoid all sudden day-to-day food changes, since the animal (and its symbiotic rumen microbes!) need at least 14 days for proper adaptation. Major dietary changes (introducing a completely new feeding regime) should be made in the late spring.
9. For a rough estimation of food intake, the following table can be used (c.f. Table 2-18):

| Body weight [kg] | $\mathbf{6 0 0}$ | $\mathbf{7 0 0}$ | $\mathbf{8 0 0}$ | $\mathbf{9 0 0}$ | $\mathbf{1 0 0 0}$ |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Offered amounts (all in kg FM) |  |  |  |  |  | Percentage in diet <br> (in $\% \mathrm{DM})$ |
| Lucerne hay (ad lib.) | $>4.5$ | $>5.1$ | 5.5 | 6.1 | 6.6 | $50 \%$ |
| Fresh browse | 4.9 | 5.5 | 6.0 | 6.6 | 7.1 | $10 \%$ |
| Pelleted compound | 2.7 | 3.1 | 3.3 | 3.7 | 3.9 | $30 \%$ |
| Linseed extraction chips | 0.5 | 0.5 | 0.6 | 0.6 | 0.7 | $5 \%$ |
| Green leafy vegetables | 3.2 | 3.5 | 4.0 | 4.4 | 4.8 | $4 \%$ |
| Fruits $^{1}$ | 0.40 | 0.45 | 0.50 | 0.55 | 0.60 | $1 \%$ |

for training or medication purposes
If fresh lucerne or comparable fresh forage is fed, it should be clear that as an approximation, 1 kg hay is equivalent to about 5 kg of fresh forage on a dry matter base. The inclusion of produce in the diet need not be regarded as mandatory (substitution by a pellet in the ratio 1:7 possible).

### 2.3 Social structure

Single individuals should not be kept in zoos. All institutions should keep a core group of at least three giraffes to avoid a death or shipment resulting in a giraffe being housed alone. The remaining giraffe could be alone for a long time, in cases of delayed shipping, veterinary or financial problems of the zoo.

### 2.3.1 Basic social structure

There are three basic models of social situations:
Small breeding herd (SH):
1 adult male, 2-3 adult females plus calves
Large breeding herd (LH):
$2+$ more adult males, $4+$ more adult females plus calves
Single sex group (SG):
Group consisting of only males or females.

The following system of keeping animals together is recommended:
Indoors:
Males should always be separated from females for the night or at times with no keeper supervision, females should always be kept together if there is no reason for separation (i.e. advanced pregnancy, illness).

If multiple adult males are present, they should never be housed in adjacent pens, as normal male "necking" behaviour in an enclosed space may result in serious injury. It is helpful if they cannot see each other.

## Outdoors:

One adult male and a herd of females with their calves may be run together, except for cases where males are overly aggressive to calves.

### 2.3.2 Changing group structure

The individual characteristics of each animal vary and the introduction of a new animal to the herd should be carefully monitored and observed.

Introduction of females or a young male to an existing herd:
It is necessary to provide ample space. In general, the following steps may be taken for introduction: provide auditory, olfactory, and visual contact between the newcomer and the herd. Subsequently, tactile contact should be allowed with the members of the group, and finally the individual is introduced to the entire group. During the introduction, experienced staff members should be present.

## Introduction of an adult male to the existing herd:

Prior to the first encounter, the new male should have been allowed access and become familiar with the enclosure. Again, a period of contact with the herd through (indoor) bars must continue until no further aggression is seen. For the actual introduction, it is advantageous to equip the enclosure with extra quantities of browse in different places. During the introduction, experienced staff members should be present.

## Re-introduction of a mother and calf to the female group:

If no birth complications occurred, the calf can be introduced together with its mother, to the other female group members between the third and fifth day after parturition. If this is planned for a new enclosure, mother and calf should have had access to the enclosure first to allow the calf to inspect the space. After such preparation, introduction itself should not cause problems. During the introduction, experienced staff members should be present.

Exception: females who allow suckling by other calves or adults should stay separated longer or be separated with her calf at least at night, to prevent exhaustion of the lactating female or shortage of milk for her offspring.

Introducing the male to the females and calves:
Generally, most males are friendly to calves and can be introduced back to a female group with calves without any problems. However, some males will attack calves, causing severe problems. Such male should not be introduced to a herd with calves younger than 8-9 months. All introductions should be carefully monitored and observed.

If the facility has only one giraffe holding area, then only one male can be present if there are also females. A breeding group cannot be formed near a bachelor group as the bachelors would fight when they became aware of the females in the neighbourhood via visual, olfactory and acoustic contacts. Careful attention should be paid to the timing of sending out the other males from a bachelor group and the arrival of the new females, to avoid having the male alone for too long. The introduction of young females to an adult male can not be recommended.

## Forming a herd of newly acquired animals:

The first step is to form a group of females - provide auditory, olfactory, and visual contacts between the newcomers. Subsequently, tactile contact should be allowed, and, finally all of the group members should be allowed to be together. If an adult male is acquired in the same period, he should be included in this process but introduced to the female group after it has been formed. If the male is a subadult, he can be included in the same step with the females. The same principle can be used also when forming a bachelor group

### 2.3.3 Sharing enclosure with other species

Giraffe have been successfully maintained in a variety of exhibition styles and with a variety of different species of mammals and birds. Dr. Gabriele Hammer of the University of Salzburg, Institute of Zoology, collected data on 1262 mixed species exhibits involving mammals in 257 zoos around the world. In her dissertation, almost a hundred mixed exhibits with giraffes and 64 different species of six orders have been analysed, resulting in 325 different combinations. Dr. Hammer could not find any differences in interspecific behaviour between the different subspecies of giraffes.


## Success rate:

The majority of the studied combinations turned out to be successful. See appendix 2 for the list of species successfully mixed with giraffes in European zoos (extracted from data collected by Gabriele Hammer). Examples of species that can live together with giraffes are: impala, (Aepyceros melampus), white rhino (Ceratotherium simum), plains zebra (Equus burchellii) and pygmy hippo (Hexaprotodon liberiensis). In many mixed exhibits, friendly interactions occur between giraffes and other species, such as grooming or playful sparring.

In Arnhem zoo giraffes live together with other African animals

Possible problems:
Kicking may occur, especially when other animals run between the giraffes' legs, or when giraffes and other species (mainly small antelopes) are waiting near the connecting gate between outside and inside enclosures to be let inside. Losses have been reported in juvenile gazelles when they panicked and ran in the wrong direction. One zoo combined giraffes with meerkat (Suricata suricatta) and lost some meerkats during the introduction process, until the remaining animals learned to avoid the legs of the giraffes. Additionally, there is the risk that young giraffes could step into the meerkat holes, stumble, and risk breaking a leg. Because of medical reasons, the veterinary advisor of both Giraaffe EEPs strongly discourages it to mix giraffes with wildebeast (Connochaetes sp.) or sheep (Ovis sp.). Both species are extremely susceptible to Malignant Catarrhal Fever (MCF) and by experience it is known that they can easily transmit it to giraffes. For more information, please refer to chapter 2.6.4 Diseases and other medical problems

Negative behaviour between species:


Fight between male eland and male giraffe

Fight between male giraffe and buffalo


Fights have been reported between male giraffe and male rhino, greater and lesser kudu, Arabian oryx, eland, roan antelope and zebra. Many zoos take precautions and separate species during feeding times, during the night, in the mating season or when rearing offspring. Some zoos let the males of different species outdoors alternately. At other institutions, giraffe have been documented as the aggressor towards calves of antelope species. There have also been isolated incidents of agonistic behaviour towards African crowned cranes, vultures, secretary birds and some waterfowl species. Various EAZA bird TAGs strongly discourage mixing giraffes with flight-restricted vultures, secretary birds and various species of waterfowl. Because of their inability to fly.they do not have sufficient ability to escape from a running giraffe, which might cause serious injury or even the death of the bird. Because of the increased stress to the birds, reproduction is unlikely and they should not been kept together with giraffes under any circumstances.

Influence on success rate:
The success rate of a mixed species combination is influenced, amongst other factors, by the size of an enclosure. The sizes of the studied enclosures varied between 560 m 2 and 36 hectares. The larger the enclosure, the less agonistic problems occurred. So especially for small enclosures, it is important to give the smaller species a safe place out of the reach of the giraffe. Furthermore, giraffes should use a different entrance to the night quarters than the smaller species, to avoid injuries due to crowding.

Overall recommendations:


It is important to give smaller species the opportunity to escape. The size of the enclosure also influences the rate of success of a mixed species combination. From an educational point of view, mixing giraffes with other African species only is recommended, as there are plenty of compatible African species. Appendix 2 shows the complete listing of zoos that participated in Dr. Hammer's review and keep giraffes in mixed species exhibits.

Even when not exhibited together, animals are interested in eachother

### 2.4 Behavioural enrichment

In almost every zoo, giraffes develop behavioural disturbances. Only a few papers are known dealing with analyses of their genesis. Few attempts have been made to find the answers to how they develop or how to find solutions to make a giraffe stop displaying them. In general, two forms can be distinguished:

1. true stereotypies, like pacing, head shaking, head stretching, crib biting or wind sucking and
2. oral disturbances, like tongue playing (vacuum chewing) and object licking.
3. True stereotypes occur under stressful conditions, e.g. when an animal is separated from the rest of the group, when it is afraid, when it feels unwell or even is in pain. When animals are highly motivated to do something but are unable to do so, such stereotypies may appear, e.g. when giraffes have to wait for an expected daily routine, like feeding, or going into or out of the house. The definition of a true stereotypy should include 3 elements: the behaviours have an invariant pattern, are regularly repeated and serve no apparent purpose.
4. In contrast, oral disturbances mainly occur in species (giraffes, okapis, cattle) that seem to have a need for a certain amount of tongue movement. If this need is not met, the animals use their tongues for movements other than feeding. They play with their tongues or they
lick objects such as walls or bars. Video analyses show that these tongue movements are identical to those giraffes make while feeding.

Under captive conditions, it is very difficult to interrupt true stereotypies or even to cause the animal to give them up completely. The reason is that there is no room for much variance in daily routines. In Europe, the only differences worth mentioning are those associated with summer vs winter management: The fodder changes from fresh grass or leaves to hay. The time the animals spend inside may change considerably, depending on the geographic and thus climatic situation of the zoo. However, in general, the daily routine remains the same: In the morning, the giraffes expect the keeper to come and feed them and later they expect to go outside. In the afternoon the procedure is reversed. In these recurrent situations, when the animals are "highly motivated" either to feed or to go inside/outside, but "are unable to perform", we can expect to see pacing, head shaking or head stretching. Crib biting and wind sucking are expressions of high tension, sometimes combined with fear or pain.

Any management steps which are suitable for any enrichment in the captive life of a giraffe should be undertaken. A simple window in the stable may already ensure some distraction in a boring ordinary weekday, especially during winter, when the animals have to stay mostly inside. Giraffes orient themselves mostly visually and like to observe things or actions which happen around them.

In contrast, oral disturbances can be influenced by changing the quality of food and by changing the design of troughs and hay racks. In the wild, giraffes spend approx. $43-53 \%$ of the day foraging and must use their prehensile tongues to remove leaves from trees. In many zoos, produce and pellets make up a considerable part of the diet. This food is offered in a way that giraffes can take it solely by mouth, the tongue is hardly needed. If the theory is true that a certain quota of tongue movements exists, then our goal must be to make the giraffes use their tongue much more during foraging until this need is reached. Consequently tongue playing and object licking, which resemble tongue movements during feed intake, should decrease. Some studies recently carried out in various zoos seem to support this theory.


Giraffes like to observe things or actions outside

### 2.4.1 Feeding

Browse:
During summer, when the diet of giraffes is enriched with browse, the amount of oral disturbances drops considerably. But browse is difficult to get in abundance and not available during winter. Hence other forms of enrichment must be found to help reduce oral disturbances.


Browse reduces oral disturbances

## Trough:

Pellets and vegetables (fruit should not be fed, see chapter 2.2 Nutrition) need to be offered in troughs. Giraffes can take mouthfuls without using much tongue effort. However, when the trough is covered by a narrow meshed lattice, the animals can take only one piece at a time. Thus the intake of concentrates lasts much longer. But most importantly, the giraffes need to use their tongues extensively to effectively fish for the small parts.


Trough covered with lattice

Hay rack:
Hay racks should also be specially designed. Commercially produced horse or cattle racks are unsuitable for giraffes, as the bars are too widely separated. Not only the small mouth of an adult giraffe can fit through the bars, but even the entire head of a younger giraffe could get caught. Consequential injuries including broken jaws and even death have been reported. The distance between bars should not exceed 4.5 cm in width. The top of the rack should be closed so that adults cannot take mouthfuls of hay from the open top and so that animals need to use their tongues to pull out the hay. Several troughs and hay racks or hay balls should be available both inside the house and in the outside enclosure. They should be fixed in various heights, so that younger giraffes can reach them too. A variety of food (grass hay, alfalfa, pellets, and vegetables) should be offered. Ideally, each trough and rack or ball should contain a different feedstuff.

The top of the rack should not be open


Hay ball:
So-called hay balls are ideal tools to hang up at lower levels and can be reached by younger individuals (smaller than about 2.50 m ). They are made of PVC, and will come apart if too much load is put on them so they are safe. However, the distances between the "bars" are quite large and allow giraffes to feed with their mouth instead of using their tongue alone to grasp the hay. In general, use them only as long as younger animals are
 present. Metallic or wooden hay-racks should not be hung up at an adult shoulder height, where they become a hazard. A hay ball is an ideal device in a transport crate or trailer.

When browse is available during summer, the animals can wander around to forage from the various offerings. The larger the enclosure, the more natural a situation that can be imitated.


Suitable hay or grass racks: the giraffes need to use their tongues to pull out the food

### 2.4.2 Rumination - Resting

A considerable proportion of tongue movement occurs during rumination. Thus it is important that giraffes get enough feedstuff to induce rumination. Alfalfa, grass hay or fresh grass and browse should be of the best quality. If this is not the case, giraffes don't eat enough and may even leave the roughage untouched, preferring to feed on concentrates instead (see also chapters about feeding,
 2.2). As a result, their need for a certain amount of tongue movement is not met and may initiate tongue playing and object licking. It is presumed that rumination is suppressed when giraffes cannot relax. Both inside and outside the house, special resting places should be made available. Soft bedding material or sand pits invite the animals to lay down, rest and ruminate. However, it seems to be important that resting places are not too close to visitors or other busy places. This can be assumed from the fact that giraffes lay down more often in large enclosures than in small ones.

### 2.5 Breeding

### 2.5.1 Mating

## Sexual maturity:

Males as well as females reach sexual maturity at approximately 3 to 4 years. Females, however, have been observed to be mounted as early as at 2 years of age, some males became sexually active at $2.5-3$ years of age.

Helle (EEP \#5-1012) gave birth to her first calf at the age of 2 years, 6 months, 21 days. It was premature and did not survive.
Astra II (EEP \#0-0426) gave birth to her first calf at the age of 3 years, 1 month, 5 days.

## Oestrus cycle:

The oestrus cycle usually lasts 19-21 days, although some authors list a considerable shorter cycle, like Dag and Foster (1976; about two weeks) and Puschmann (2004; 14-19 days). The male will show interest in the female for 24 to 36 hours. The female will be receptive for 12 hours on average.

## Pre-copulation:

Males in captivity may show interest in females outside of the peak of the oestrus cycle. Males frequently exhibit the following behaviour patterns at the peak of oestrus: genital and urine testing, lip-curling response, licking and head-on rump rubbing, circling, foreleg-lifting, standing immobile behind the female, mounting and giving an ejaculatory thrust. Females frequently show vulval swelling as well as mucosal discharge and exhibit behaviour patterns such as: positive male solicitation, presentation of hindquarters, tolerating the male when being mounted. Before and after the peak of oestrus, the female will escape when male tries to mount. There is no interference from the rest of the herd.

## Copulation:

One copulation lasts just the moment of one jump, and will occur many times at the peak of the oestrus cycle.


Separation of the male from herd for the night:
It is normally recommended that the male be separated for the night indoors to ensure the safety of all animals. In some cases, oestrus will terminate during the night, in some cases it will continue the next day. It is better to lose one oestrus in one female than jeopardise the safety of the other animals.

At the moment there is little experience with artificial insemination in giraffes. One calf was born through AI at a private facility in Texas USA in July 1993 (Foxworth, 1993)

### 2.5.2 Pregnancy

## Gestation:

450 to 470 days on average. Extreme values: 420 days, 488 days respectively.

Separating a pregnant female from the herd:
A pregnant female should remain a member of the herd at all times. Two to four weeks prior to parturition, she may start learning to shift to a separation/calving pen for the night and be released back to the herd each morning. The separation pen must be in the neighbourhood of the joint pen so that the female can have contact with the other members of the herd at all times. It should be prepared for parturition, with a non-slippery surface. Deep straw (a mixture of giraffe faeces, urine and straw) is the best, proven covering for the floor. It can be gradually produced over 2-3 weeks by not removing, but covering faeces and moist places with more straw, which is consequently compacted by the animals stepping on it. The resulting layer of deep straw is compact, clean, dry on the surface, absolutely non-slippery and warm. The newborn calf will be able to get up on such a surface more easily. Such a surface is also highly recommended for immobilisations. The whole surface of the pen must be covered. A minimum of 20 cm layer of ground bark or hemp is also a good alternative. Note that some cows remain with their herds throughout the birthing process.

## Interbirth intervals:

If the male is with the herd at all times, the female will usually conceive 3-4 months after parturition. The usual interbirth interval is thus 1.5-2 years. It is possible to manage breeding and synchronise the parturitions of all females to one period by separating the male and returning him to the herd at a suitable time. In central and north European zoos, it could be wise to manage births to occur in the spring-summer season to avoid difficulties, e.g. with slippery surfaces or lack of browse.

### 2.5.3 Birth

## Delivery:

Giraffes commonly give birth without difficulty and any kind of help is not recommended. The pregnant female should be closely observed during the days of expected parturition. If first signs of labour are observed during the day, separate the female and lead her to the prepared calving pen she has become accustomed to (see above). It is not necessary to check an experienced pregnant female during the night. If desired, or if problems can be expected, she can be monitored by means of video camera so as not to disturb or stress her by the presence of humans. In rare cases of severe difficulties, it may be necessary to immobilise or sedate the female. See chapter 2.6.4 Diseases and other medical problems


## Presence of humans:

If parturition takes place during the daytime, the female will tolerate the presence of wellknown persons - giraffe keepers, but not other persons. If the female is nervous, a familiar keeper can even calm her down by talking to her. For documentation of the birth, a video camera can be installed to avoid any disturbance of the mother.

## Duration of delivery:

Labour lasts about 1-2 hours, parturition time about 30 to 40 minutes. Delivery of the calf almost always takes place in a standing position. The placenta will be discharged several hours after birth. It can be removed during the next cleaning. It should not be removed immediately, as this would cause an unnecessary disturbance for the female.


Nursing:
Commonly, the calf will attempt to stand after about 30 minutes. It may take up to 1 hour. The calf starts searching for the udder immediately after standing and tries to suckle. First nursing is seen usually within 1-2 hours after birth, but can last several hours.

## Possible problems:

Problems can occur especially in primiparous females as they have no experience with calf rearing. The mother can ignore the calf or be afraid of the calf and try to escape, which prevents it from suckling.
 A possible remedy is oxytocin treatment, which can calm the mother and promote milk production (see Chapter 2.6.4 Diseases and other medical problems). If the first suckling has occurred, the situation will usually be resolved. If the mother ignores the calf, without being aggressive, a solution is to bottle-feed the calf and leave it with the mother in a separation enclosure in case she will accept it eventually. Bottle-feeding depends also on the general policy of the zoo on handrearing and it can also be discussed with the EEP coordinator if this is desired or not. If the female is overly aggressive, this can usually not be resolved. Begin hand rearing or try adoption by another experienced female that is lactating. In the case of a very difficult parturition (especially if the female had to be immobilised), the female will not be aware of having given birth and will reject her own calf. The recommended procedure is as above. See also chapter 2.3 Social structure.

### 2.5.4 Development and care of young

Rearing methods: (hand or parental)
Hand-rearing might become necessary if the young is rejected by the mother (see above), if medical problems exist in the mother or the calf, or if the calf fails to nurse. Hand-rearing a calf must be considered very carefully. The hand-raised calf should always remain in contact with other giraffes. See also chapter 2.3 Social structure.

## The parent reared calf:

Nursing intervals vary between 3 and 4 hours at the beginning to 610 hours later. Weaning naturally occurs, around the age of one year. The calf will start trying to feed on solid food at the age of 1 month. From this time on, it should be given daily access to the same feed offered to the adults. A special crib or basket for hay, as well as an extra feeding trough, should be available at an appropriate height. An extra water trough should be placed not higher than $1,5 \mathrm{~m}$. Offering special items such as vegetables, cereals etc. is recommended from the age of 2 months. For introductions to the rest of herd, see chapter 2.3 Social structure.


Lower-level crib

Growth chart:
Figure 2-7 is a growth chart of parent-reared calves. Average height of the calves at birth was 184 cm . After one year, the average height of the same calves was 303 cm , resulting in an average increase of 119 cm within one year. One male calf, named Ingo, was 199 cm tall when born, and after one year had reached a height of 329 cm , adding up to a growth rate of 130 cm .


Figure 2-7: Growth chart of 9 parent-reared calves raised in Dvur Kralove ZOO

Removal of a calf from its mother and transportation to a new location should not take place before the age of 15 months. Only if the calf is transported together with its mother, it can be done before this age.

### 2.5.5 Hand-rearing

In case the mother does not take care for its offspring, handrearing might be an option. This is also dependent on the general policy in the institute about handrearing and the recommendation of the EEP coordinator.

Hand rearing of giraffes is done in accordance with the known procedures for other species.
Hygiene is an absolute must to avoid contamination of the milk, as well as intensive care by one or more keepers. The prepared milk should simulate the natural mother's milk, see appendix 3 for the composition of milk in percentage of dry mass, protein, fat, casein, lactose and ash. Supplementation with vitamins and minerals is recommended. If possible, cow colostrum should be given for the first 36 hours after birth.

## Daily intake:

The next Figure 2-8 shows the daily intake of bottlefed milk between 1st and 81 st day of handraising giraffe calf 'Janin'. The arrow shows the day of first introduction of Janin to lactating females.


Figure 2-8: Daily intake of bottle fed calf in Dvur Králové

## Solid food:

See parental care. The calf should be introduced to a existing giraffe herd as soon as possible, in order to avoid imprinting on humans.

### 2.5.6 Birth control

Although at the moment there is still a high demand for giraffes within EAZA, birth control might be a useful tool to reach the long-term goals of especially the Baringo giraffe EEP, namely to phase out all hybrid giraffes in favour of pure-bred animals. Institutions with a mixed herd of pure and hybrid animals, could restrict the production of hybrid giraffes by means of immunocontraception with porcine zona pellucidae, also called PZP. This is not yet commonly used in Europe, but in the U.S.A. there are good experiences with this type of birth control.

The zona is a non-cellular layer of acidic glycoprotein which envelopes the mammalian oocyte and ovum up until the time of implantation (Sacco 1987). The glycoprotein membrane is produced by the oocyte (Leveille et al. 1987) and is composed of several protein fractions. A $55,000 \mathrm{MW}$ fraction has been shown to be the primary candidate antigen. This particular fraction, referred to as ZP3, has been shown to be the specific zona receptor for sperm recognition, attachment, and acrosome reaction (Sacco et al. 1984; Arns et al. 1990), although one or more of the other zona proteins may also play roles in fertilization (Hasegawa et al. 1992). The contraceptive efficacy of ZP glycoprotein and PZP was originally demonstrated in a wide variety of mammals.

Among the ungulates, PZP immunocontraception has been shown to be effective in the domestic horse, the feral horse, white-tailed deer, Przewalski horses, banteng, sika deer, axis deer, muntjac deer, Himalayan tahr, and West Caucasian tur. Successful contraception has also been carried out with ibex, addax, giraffe, zebra, river hippopotamus, pygmy hippopotamus, North American elk, blackbuck, kudu, impala, fallow deer, water buck, mouflon sheep, and Barbary sheep, and a number of other species, including African elephants and several species of bears.

The protocol that is used for the majority of zoo animals is, three initial doses given by darting 2-3 weeks apart then a booster dose given every 7-9 months. The very first dose should be imulsified with Modified Freund's Complete Adjuvant (MFCA) and all subsequent doses should be given with Freund's Incomplete Adjuvant (FIA). If the animal has a defined breeding season then 2 initial (preferably 3) doses can be given with boosters given a month before the onset of breeding season. When making the PZP/Adjuvant imulsion, good quality syringes with luer lock connectors should be used and attached with a connector then mixed back and forth using at least 100 strokes. The mixture should then be placed in a dart or injection syringe.

## Adjuvant protocols

In equids, where no reliable TB test exists, the adjuvant protocol of choice is an initial inoculation with Freud's Complete adjuvant, followed by one or two subsequent inoculations with Freund's incomplete adjuvant, over 6 weeks. In all other ungulates the protocol has been 3 inoculations over 6 weeks with only FIA and no differences in efficacy between the two protocols have been seen. For the past several years a new protocol has been used that utilizes an initial inoculation with Modified Freund's Complete adjuvant, or MFCA, which
contains the freeze-dried cell walls of mycobacterium butyricum, rather than m . Tuberculosis, and does not lead to false TB+ tests.

Among 38 giraffe in the U.S.A. for which data have been recovered, there were 10 failures during the first year of treatment and one during the second year of treatment and most could be attributed to technical failures. Of the 10,2 animals did not have all three inoculation series completed, and one had an inadequate inoculation because of a dart needle that was too short ( 1.5 " needles only are recommended for giraffe). Another failure was attributable to a breeding that occurred before the inoculation series was completed. Presumably, antibody titers had not reached contraceptive levels before the animal was released to the male. It is recommended at least 2 weeks following the last inoculation before females can be safely placed back with the males. Two failures occurred because the wrong darts were used and did not inject fast enough or completely. Another 2 failures occurred because the boosters were given late, after the 9 month recommendation. The one second year failure was due to a booster inoculation that was not given at all. Additionally, there were 2 outright contraceptive failures. Excluding the failures attributable to technical problems, the contraceptive efficacy for giraffe was $95 \%$ (Frank and Kirkpatrick, 2002).

Based on 14 years of data from horses the PZP vaccine has an efficacy of about $90 \%$ or better in ungulates when administered properly, has caused no deleterious health effects for pregnant animals or their offspring, and is reversible after up to five consecutive years of treatment, and 12 years of experience with captive exotic species appears to be producing the same general results, only with variations for different species. In summary, (1) the timing of the PZP booster inoculations must conform to the species' differences in maintaining adequate antibody titers and contraceptive effects, (2) treated animals must be given adequate time to mount significant antibody responses before they can be placed back with males, and (3) the choice of adjuvant system must conform to the species being treated (Frank and Kirkpatrick, 2002).

Research with PZP contraceptive vaccine and captive exotic species is a joint venture involving the support of The Science and Conservation center at ZooMontana and The Humane Society of the U.S. All inquiries regarding PZP contraception should be directed to Kimberly Frank, The Science and Conservation Center, ZooMontana, 2100 S. Shiloh Road, Billings, MT 59106, (406) 652-9718 or e-mail zoolab@wtp.net. In Kimberly Frank’s absence, inquiries can be directed to Dr. Jay Kirkpatrick at The Science and Conservation Center, ZooMontana.

### 2.6 Handling

Giraffes are the species most difficult to handle in a zoo, due to 3 factors:

1. As giraffes are potentially dangerous animals which can easily kick a person to death with one stroke of either front or hind leg, intensive veterinary care or hoof trimming is only possible under immobilisation or in a squeeze cage.
2. Due to its anatomy and height, immobilisation is very difficult and is a risky enterprise with a high mortality rate (see chapter Immobilisation).
3. Physical restraint can also lead to complications, as giraffes are extremely prone to stress, and escalating stress is often not recognized in time. The animal does not exhibit symptoms, but to the contrary, seems calm. Widely opened eyes and nostrils are sometimes the only indication that a giraffe is deeply frightened. Thus the staff is often unaware that a sudden collapse is imminent, and the individual often dies.

No procedure exists today that is absolutely safe for both animal and personnel and that allows intensive medical treatment or hoof trimming.

### 2.6.1 Target training

Many zoos are unable or unwilling to develop adequate physical restraint devices, due to lack of space or financial expenses, or because they have the opinion that such a crush causes stress to the animals. A much safer, but far more time-consuming alternative for this could be operant conditioning or positive reinforcement through target training. At this point, methods of positive reinforcement in elephants are developing in Europe, but in giraffes are so far little used. In North America, this method has been widely used for many species by different institutions for many years, including Calgary Zoo, Memphis Zoo, Disney's Animal Kingdom and San Diego Wild Animal Park. Some principles are explained here, for more information, contact the institutions mentioned above. Comparing giraffes with elephants, one notes that both species have a curious nature, so it is relative easy to start target training through positive reinforcement, as both species are very much focused on keepers.

A big difference between elephants and giraffes with respect to such training is that giraffes are more easily frightened so training may take more time than with elephants.


Target used for giraffe training in Nürnberg Zoo © Dr. Neurohr, Dr. Baumgartner

## Positive reinforcement:

This is based on the theory of rewarding an animal if it has done something at the request of a keeper. Usually it starts with determining a target, on which the animal has to focus. This can be, for example, a broom with a red dot on the end or a stick with a small ball stuck on it. By means of bridging and rewarding the giraffe with a piece of food for touching the red dot or
 the small ball with its nose, the animal will start making the connection between touching the target and getting something special to eat. The bridge is the connection between the action and getting the reward and can for example be a whistle, a click or verbal praise. As soon as the animal begins to understand that the broom with the red dot at the end is a positive thing, because this target means food, it will become possible to use this for many purposes.

Target training © Dr. Neurohr, Dr. Baumgartner

## Drawing blood:

At the San Diego Wild Animal Park and at the Memphis Zoo, keepers are able to do blood draws from the neck without sedating or even stressing the animal. They start by asking the giraffe to touch its nose to the target while at the same time, they touch the jugular area of the upper part of both sides of the neck with their hands. The giraffe is rewarded with food after this. In the first few days, the giraffe may be frightened, but sooner or later it will see the relationship between the target combined with touching the neck and getting that reward. Then the keeper takes the next step: they introduce a gauze, first without alcohol, later with alcohol. As soon as the animal accepts this along its neck, the keeper introduces a blunt needle and a syringe simulating a needle entering the skin. This is always done combined with the target and the reward. They first use very light pressure, if any at all, before bridging and rewarding the animal. As the animal becomes more comfortable, the trainer applies more pressure for a longer length of time. When the keeper feels the animal is completely comfortable with the blunt needle on both sides of the neck, a sharp needle is introduced into the procedure. Once the keeper is able to place the needle into the skin for a short time it becomes possible to draw blood.


Target training in Crush © Calgary Zoo

Hoof trimming:
By using the same principles, it is also possible to trim hooves to avoid overgrowth and infections. In Memphis Zoo, one of the keepers taught a giraffe to lift a foot in order to enable hoof care. After he touched the leg with the target, the giraffe was immediately rewarded. As soon as the giraffe understood the connection between touching the target and getting a reward, the giraffe started to touch the target with its leg in order to get that reward. One can use this to lift the foot further every time. It is strongly recommended to attempt this only in a crush, where one can approach the giraffe safely. Another possibility is to have an opening close to the floor in one of the stalls used for hoof care, that can be closed when not in use. The giraffe can be trained to have its feet touched from this opening by use of positive reinforcement. See also chapter 2.6.4 Diseases for more details on hoof care.

Target training and a crush:
Positive reinforcement can be a valuable tool in combination with a crush. Calgary Zoo is using a target to get a giraffe into the crush and to keep it calm during hoof care or blood draws. The picture here is taken in Calgary Zoo - one can clearly see the whistle used as a bridge between target and reward. The animal remains calmer and is more easily treated.

Whistle use in target training© Calgary Zoo


## Advantages and disadvantages of positive reinforcement:

Operant conditioning does not cause much stress for the animal once used to it, but it does take a lot of time to accomplish. When training is first started, preferably only one keeper will do the training as different keepers can have slightly different methods. Obviously, all keepers should eventually be able to work with the animals, but there will be an adjustment period whenever a new trainer begins.

It should be emphasized here that training cannot be done effectively on a hit-and-miss schedule. Success will depend on working with the animals regularly and consistently. All levels of the zoo should understand what is being attempted, from keepers to management, even though a primary trainer may be the only person working with the giraffe initially. Secondly, there is a lot of variation in giraffes' reactions to training - they have a widely different range of reactions to people and procedures. Some are calm and easy, others may simply not adapt to being worked in a chute. This needs to be recognized and training methods adapted as needed. With this species, you need to be prepared for anything and adjust as needed.

After a trainer has worked successfully with the first giraffe, and has had some experience, teaching the remaining animals will be easier. In general, positive reinforcement is of most use in normal daily routines - in the event of an emergency, for example a giraffe getting a piece of rope or wire around a leg, relying on target training may not be sufficient to resolve the situation. Hoof care in some giraffes is a regular event; conditioning can be very helpful for this. The training must be maintained, so regular practice is necessary. Positive reinforcement is very much dependent on both keepers and giraffes, as there are individual differences. Some keepers and some giraffes will learn this quickly, some keepers and giraffes will take more time. Although time consuming, operant conditioning or positive reinforcement through target training of giraffes is a good alternative. As this is barely in use in giraffes in Europe so far, it might be wise to have a look at this system in the United States where it has been used in dozens of species and in elephants in Europe and then translate into giraffes.

### 2.6.2 Physical restraint

Overgrown hooves - often in conjunction with degenerative joint disease - is one of the unsolved problems confronting zoo staff. Others include medical treatments and routine testing for export or other reasons (blood and tuberculosis tests). Many zoos use squeeze cages in combination with long acting tranquillizers and/or desensitisation of the animals.

Having animals trained to stand comfortably in a chute is important, and can more easily be accomplished if done on a regular schedule. Daily weighing, training, and passthroughs on the way to the outside yard can help in the
 process.

Training for medical purposes © Calgary Zoo
The advantage of a restraint lies in the ability to rapidly set the animal free. However, that requires a very well trained staff and at least one person with a good eye to recognize, when the procedure must be interrupted or completely finished. Physically or chemically restraining a giraffe is potentially very stressful, to the point of them collapsing and dying. Everyone involved needs to be aware of the potential danger and the person with the "good eye" needs to be authorized and able to halt the procedure if necessary. Plans should be developed ahead of time for any possible emergency such as the animal flipping over or going down in the chute.

Squeeze cages are expensive, but are a necessary part of each giraffe house built in the future. Minor manipulations such as administering medicine, blood collection or tuberculin testing can be done without risk to staff or animals The giraffes should routinely pass through the restraint daily, so that they are used to it from a young age on. Ideally a scale should be incorporated, so that weighing can be done on a regular basis.

Giraffe squeeze cage procedures are known from American zoos (Wienker, 1986; Calle, P. and J.C. Bornmann, 1988; see also the AZA Giraffe Husbandry Resources Manual). The design of the Cologne squeeze cage for giraffes resembles the one at Calgary zoo and the okapi restraint box at San Diego Zoo (Mehrdadfar, et al., 2003). No matter how the restraint box is constructed, it must fulfil the following conditions:

- The frame must be strong enough to withstand any kicking by the animal
- The walls must be high enough ( min .3 .00 m ), to not allow the animal to rear, jump, or fall over them.
- Removable restraining bars at the rear of the unit allow adjusting the length of the chute to the animal
- One movable side wall allows the animal to be firmly restrained and unable to turn around in the chute.
- Removable panels on the side walls allow access to all parts of the body
- Flooring (preferably with an incorporated scale) should have a non-slip surface (e.g. a rubber mat with profile) to give the giraffe secure footing.

As an example only, a hoof trimming procedure is described below:
See habituation and desensitisation process in chapter 2.6.1 Target training
After the animal has entered the restraint box, a broad rope over neck and shoulder should keep the animal on the ground, so as not to risk it rising on its hind legs and falling backwards. However, it is highly recommended not tie the rope down, but to belay it (wrap it) around a suitable support. A person should constantly adjust the tension on the rope according to the movements of the giraffe. Care must be taken that the animal is not able to lean too far backwards, or sit on the rear bars, because the hind legs could slip underneath the body. This could allow the giraffe to lose its balance and to fall. This situation may have led to the accidental and fatal break of a giraffe's hip at Cologne Zoo. The opposite reaction: going down with the fore-hand and leaning the neck and head on the front of the chute can result in the animal being unable to breathe.

There are differences of opinion on whether abdominal or belly straps should be used. These prevent the animal from going down in the chute. The straps are difficult to remove if a giraffe has collapsed on them. However, if the belly straps are fastened to one side wall, but have the other end secured to the opposite side wall with several loops belayed around a suitable support and held by a keeper, this device is safe and easy removable.

Finally the lower side panel in the front of the cage is opened, a rope tied around the front fetlock and traction applied to the rope to flex the carpus and elevate the forelimb. It may be necessary to supplement this by opening a second panel in the front door, and putting a rope around the carpus to move it forward, so that the hoof can be lifted if the animal puts full weight on it.

If younger giraffes are trained and habituated to lift a leg, it is possible to trim a hoof without any drugs. However, experiences in Cologne Zoo showed that older giraffes cannot be treated without sedation. 80 mg of Haloperidol (ratiopharm) administered to a big female giraffe led to a cardiovascular problem.

### 2.6.3 Chemical restraint

## Tranquillization:

Short-term tranquilization can be achieved with azaperone (Stresnil) at $0.1 \mathrm{mg} / \mathrm{kg}$ (Ebedes and Raath). To transport or confine adult giraffes, 10 to 30 mg of haloperidol with 100 to 250 mg of perphenazine enanthate (Trilafon) gives optimal results (Ebedes and Raath). In subadults, 10 to 15 mg of haloperidol and 100 to 150 mg of perphenazine enanthate is recommended. Young giraffe quickly adapt using $50-100 \mathrm{mg}$ of perphenazine enanthate (Kreeger). The effect of perphenazine enanthate can be seen 72 hours after injection and then holds for another week. Zuclopentixol-acetate (Cisordinol) is used as a short-term neuroleptic drug varying to the size of the giraffe between 50 and 200 mg .

Giraffes can kick and strike in any direction. Standing sedation is dangerous without using a chute. When crating or loading a giraffe, the use of perphenazine enanthate three days prior to shipment is very useful. Depending on age and size, the dosage is between 50 and 300 mg . The effect of the drug will hold for another week.

When giraffes are still difficult to load into a truck, the use of 0.2-0.4 ml Immobilon L.A. will facilitate loading. As soon as the animal is loaded, the etorphine component of Immobilon should be reversed, preferably by naltrexone (Trexonil), since it has a much longer biological action (half-life) then does diprenorphine (Revivon), per the EEP veterinary advisor.

Another approach uses a combination of azaperone IM ( 250 microgram $/ \mathrm{kg}$ b.w.) plus detomidine (Domosedan) (15-30 microgram $/ \mathrm{kg} / \mathrm{b} . \mathrm{w}$.) to produce tranquillization and moderate analgesia. To increase sedation, 10 mg of butorphanol IV is used in adults. Detomidine is reversed by atipamazole $(0.2 \mathrm{mg} / \mathrm{kg})$ and butorphanol is reversed with naltrexone ( 2 mg naltrexone $/ \mathrm{mg}$ of butorphanol) (Bush).

## Anaesthesia

Problems encountered with opioids (etorphine) in giraffes include: 1. vomiting or passive regurgitation that may lead to fatal aspiration pneumonia; 2. respiratory and cardiac depression; and 3. prolonged induction and/or stormy recovery that results in secondary selfinduced trauma, hyperthermia, and/or capture myopathy.

The opiates (Etorphine or M99) cause respiratory depression in giraffes. Immobilon contains $2.25 \mathrm{mg} / \mathrm{ml}$ etorphine and $10 \mathrm{mg} / \mathrm{ml}$ acepromazine. It was widely used in the past as anaesthetic drug of choice in giraffes.

In wild animals in Africa the following doses were recommended: Adult cows need 6-8 mg etorphine (Morkel even recommended $8-10 \mathrm{mg}$ !). Adult bulls need $10-12 \mathrm{mg}$ (Morkel). Young adult bulls need 8 mg (Ebedes, van der Bijl Morkel). All authors warn about respiratory depression using opioids such as etorphine, particularly at high doses. The
dosages mentioned here can be lethal!! They are used in the wild to knock down a giraffe in the shortest possible time and are not meant to be used to maintain the animal under anaesthesia. An antidote is given as soon as a giraffe is captured. These dosages are sometimes followed in captivity, not realising that in captivity other dosages are needed.

According to Kreeger, 4.5 mg etorphine plus 70 mg xylazine would be a normal dosage in captivity. Bush describes it as follows: $70-100 \mathrm{mg} /$ adult or $30-40 \mathrm{mg} / \mathrm{yearling}$ of xylazine IM . Atropine ( $7-8 \mathrm{mg} /$ adult and $2-3 \mathrm{mg} /$ yearling) is given simultaneously to prevent xylazineinduced bradycardia. Five to 10 minutes after injection, signs of sedation include stargazing, ataxia and tongue protrusion with slight salivation. Manipulation at this time is contraindicated because most animals react defensively, are uncoordinated and can fall. About 15 to 20 minutes after the xylazine, a narcotising dose of etorphine ( 1.5 to 2.5 $\mathrm{mg} /$ adult and 0.5 to $1.25 \mathrm{mg} /$ yearling) is administered IM. This dose may induce recumbency within 15 to 20 minutes. Intravenous naltrexone is given to reverse the etorphine ( 100 mg of naltrexone $/ \mathrm{mg}$ of etorphine). Xylazine is reversed with atipamazole.

> The use of etorphine resulted in the deaths of $4 \%$ of the animals in Africa According to Van der Bijl Morkel. Kreeger reported up to 35 \% of mortality.

Because of historically high mortality rates, many hesitate to anaesthetize a giraffe. This has prompted zoos to construct cages and chutes. But a major indicator for anaesthesia is hoof problems or dystocia. The success of anaesthesia improves when there is a minimal downtime. This is true for all megavertabrates in which downtimes should not exceed 1 hour. The major cause of anaesthetic death in giraffes is regurgitation with subsequent inhalation of the rumen contents, which causes a rapidly fatal inhalation pneumonia. To minimise this problem, the patient is usually fasted for 72 hours and water withheld for 48 hours to decrease the volume and fluid contents of the rumen. A high percentage of incidents of regurgitation occur when giraffes fall. In etorphine anaesthesia, the head is lifted up to prevent regurgitation as much as possible. The neck is held straight and supported with a long board or ladder under its entire length. The head is maintained above the rumen with the nose pointed down to allow fluid drainage from the pharyngeal region and to minimize the risk of inhalation.

With the use of etorphine, the head will roll backward, causing the giraffe to fall backward and possibly resulting in head and neck injuries. Another disadvantage of etorphine is that giraffes pace before going down. Both disadvantages do not occur with the use of medetomidine. The chance of regurgitation is also very small. By using medetomidine the head should be kept down in order to maintain a sufficient blood flow and pressure in the brains.

Preferred anaesthesia by Jacques Kaandorp for giraffe is 60 microgram $/ \mathrm{kg}$ b.w. medetomidine (Zalopine $10 \mathrm{mg} / \mathrm{ml}$ ) and $1 \mathrm{mg} / \mathrm{kg}$ b.w. ketamine. The antidote is atipamazole IV (Antisedan $5 \mathrm{mg} / \mathrm{ml}$ ) 5 mg per 1 mg medetomidine used. After giving the reversal agent, keep the head down as long as possible. Most animals readily recover and stand up smoothly. Depending on whether the dart is strictly intramuscular or subcutaneous, the induction can vary between 8 and 17 minutes. Do not give additional doses before 25 minutes have passed to avoid overdosage of the drugs. The main disadvantage of this anaesthesia is the costs involved.

One should always blindfold a giraffe while anaesthetised if either medetomidine or etorphine is used. Roping the legs is necessary if using etorphine. By using medetomidine and ketamine, ropes are not necessary. In emergencies, there is no time to build up stalls with straw cushions. Rotterdam Zoo constructed a chute to minimise trauma using poles and canvas. It is very quickly set up and has proved to be very useful in emergency cases. Rotterdam is willing to help other institutions either with information or through loan.

## Quarantine:

All newly arrived animals should be quarantined to protect resident animals. During this time the animal is monitored for disease while faecal examinations, blood samples (if possible) and vaccinations against clostridial bacterins including tetanus are done. Tuberculin testing should be done at the caudal fold. A gradual transition to the institutional diet during the quarantine period is recommended.

### 2.6.4 Diseases and other medical problems

The giraffe EEPs have a veterinary advisor who always can be contacted in case of problems or when advice is needed. Jacques Kaandorp from Beekse Bergen can be reached through phone and email - j.kaandorp@beeksebergen.nl phone: +31 135491200

Non-infectious medical problems include overgrown hoofs and foot rot. They should be treated as in other ruminants. Proper hoof care is important to the overall health because overgrown hooves lead to debilitating chronic lameness and secondary arthritis. The hooves of a giraffe are extremely hard, and the cautious use of a grinder aids in the corrective trimming. Trauma and fractures occur frequently in giraffe.

Mandibular fractures due to hay racks occur far too often. Hay nets should be used to feed giraffes to prevent these types of fractures.

Physitis of the metatarsus on both hind legs is seen in a young giraffe (Kaandorp). A periostotomy cured one hind leg. The other leg was not only treated with a periostotomy, but also had a clam placed around the physis. Later in the process, a deviation of the leg remained. This hind leg needed a wedge-osteotomy and plating of the metatarsus. Three years after the surgeries there is no deviation, but a shortening of this second hind leg is obvious. Some lower limb fractures in young adult giraffes can also be plated and be treated with success.

White muscle disease, impaction of the rumen, rumen acidosis, peracute mortality syndrome, laminitis, skin lesions, metabolic bone disease and chronic diarrhoea are other non-infectious diseases are potentially related to the diet. These problems are extensively described in Chapter 2.2.5 Husbandry problems potentially related to diet. Clearly, nutritional imbalances lead to health problems and necessitate veterinary care. Peracute mortality syndrome is characterized by acute death, sometimes after a stressful incident.

Capture myopathy is related to a vitamin E deficiency.
Dystocia in giraffe is dealt with similarly to cattle. A caesarean section should not be performed if repositioning of the fetus can't be achieved. The life of the mother should not be put at risk. A fetotomy should then be performed, requiring full anaesthesia. Technique is as in cattle.

Giraffes are susceptible to various infectious diseases common to domestic and wild ruminants. Infectious diseases include tuberculosis, salmonellosis, malignant catarrhal fever (MCF) and Bovine Viral Diarrhoea/Mucosal Disease complex (BVD/MD). Other bovid and/or artiodactylic diseases such as leptospirosis, Infectious Bovine Rhinotracheitis, Leucosis and Chlamydophila abortion are rarely described.

BVD is rarely a fatal disease and appears mostly subclinically. Especially in cases of stillbirth or abortions, one should consider that this virus could play a role. Chlamidophylla as well as brucellosis and leptospirosis should also be considered in case of abortions. Brucellosis often manifests subclinically and abortions take place in the second half of gestation. Other signs may include male infertility, orchitis, arthritis, synovitis and endocarditis.

## Malignant Catarrhal Fever (MCF):

Giraffes are highly susceptible to MCF. It is strongly discouraged to house sheep (Ovis sp.) and wildebeest (Connochaetes sp.) together with giraffes! Both vertical and horizontal transmissions occur in wildebeest. Horizontal transmission is the predominant mode in sheep. Horizontal transmission among clinically susceptible species is not well documented. There is no solid evidence that it occurs. MCF is a disease with high mortality. Transmission from wildebeest to other susceptible species occurs primarily by inhalation of aerosol droplets or ingestion of food or forage contaminated with the virus in nasal and ocular secretions. In Amsterdam Zoo $50 \%$ of the giraffe population died when housed next to black wildebeest. Transmission of the virus from wildebeest takes place around parturition. Recently a Danish zoo had positive tests in black wildebeest (Connochaetes gnou) and also in a giraffe sharing the enclosure. They never had any cases of disease related to MCF. Rotterdam Zoo had a high mortality among their giraffes in the eighties through a zookeeper who owned sheep at home. In this case the ovine herpes virus could be proved to be the same as the viruses from the sheep of this zookeeper. These sheep are carriers of the virus only and will never show clinical disease.

Endoparasites and ectoparasites: Parasites in giraffes are similar to those of cattle. Normal anthelminthics meant for cattle are appropriate to treat worm infestations. Ectoparasites are also treated in a routine fashion as in cattle.

### 2.6.5 Transportation

Giraffes should not be separated from their mother and transported before the age of $\mathbf{1 5}$ months. Transporting giraffes is a challenge not without risk. There are several experienced giraffe transporters in Europe and it is strongly recommended to use one of them rather than carrying out a transport yourself. All transporters operate in slightly different ways - one should not by defenition choose the cheapest transporter, but the one which best suits a zoo's facilities and methods. If a giraffe transport is carried out with experienced people and with suitable preparation, it can be done without stress for animal and staff.

There are two basic options how to transport giraffes:

## 1. Crate

Crates are used mainly for air transport. The crate dimensions must correspond to the size of the animal. The giraffe must have enough space for safe turning, lying down and getting up. The air transport must be always carried out in accordance with the IATA regulations.


IATA transport crate.
An example of crate dimensions for an adult animal: floor $2 \times 4 \mathrm{~m}$, height 3.50 m for a female, 4.00 m for a male.

The floor must slip-proof, a fixed rubber mat is recommended as ideal material. The crate must be strong enough to withstand any kicking, boards should be a minimum of 4 cm thick, water-proof plywood 2 cm thick. The animal must not have the potential to reach out with its head. The ceiling should be covered during the whole journey, soft material should be used to avoid any injury to head or horns. Sailcloth or canvas is a suitable material. Metal edges, nuts and screws may not stick into the crate, all must be secured to prevent injuries. There must be no materials which the giraffe could chew on or swallow. The gaps in the upper part of the crate must not be larger than 10 cm , for calves not larger than 8 cm , to prevent them getting their heads stuck. Nevertheless, the crate covering must allow sufficient air ventilation. For a journey lasting longer than 8 hours, it is necessary to have a removable feeding and watering trough (e. g. troughs used for horse transports), which can be hung up in the crate just for the duration of watering and feeding during the travel break.

## 2. A special trailer:

Suitable custom-built trailers allow loading giraffe. This is the normal option in the case of land transport. It is recommended to use the service of specialists who are skilled in giraffe transport and, at the same time, possess suitable equipment and licences for professional road transport of animals.


Special trailer for giraffe transport.

## Technical parameters:

See Chapter 2.1 Indoor facility for details on loading adjustments in the giraffe house (corridor, separation pens etc.). Outside of the house in the enclosure in front of the door, there must be a free space of at least $25 \times 6$ metres ( 2.5 m on each side of the door must be free, 25 m in length) to enable arrival of transport vehicle and the process of loading and offloading.

## Loading:

Giraffes must never be immobilised for loading into a crate or trailer. Crate training is highly recommended.

## Tranquillizers:

Consult with the veterinarian and the giraffe transport specialist on a case-by-case basis, considering both the temperament of the individual animal and any other relevant circumstances. See Chapter 2.6.3 Chemical restraint.

Do not give acepromazin to giraffes as it causes normal intestinal function to stop. Perfenazine-enantathe is recommended instead.

The physical loading:
The animal's overall condition should be closely monitored before and during loading, the veterinarian must be present. The corridor between the separation pen and the crate must be narrow enough to prevent the animal from returning. See Chapter Indoor housing. This is why it is recommended to equip the corridor with several gates which can be closed as the animal moves forward. The crate must be tightly attached, without any gaps, to the main door so that the giraffe can stick neither foot or head into the space between the crate and door, nor shift the crate aside and escape. For this reason, the facility should be equipped with two boards to be used during loading that can be adjusted on both sides of the door to the outside enclosure. See chapter Indoor housing, section 2 part A. Moving a giraffe into a crate must be done quickly and safely for both animal and staff, this is why the service of experienced persons is mandatory.


Inside view of boards and trailer
Outside view of boards and trailer


After the crate has been closed:
Consider allowing the animal to calm down in place as needed or departing as soon as possible. Usually the animal will calm down during the journey but this must be decided on a case-by-case basis. It is reasonable to allow this judgement to be made by the giraffe transport specialist, as after the crate has been closed and the animal has been loaded in good condition, the transporter assumes responsibility.

## Off-loading:

The giraffe must be always unloaded into the inside of the house, never into an outside enclosure. The trailer or crate must be tightly attached to the main door, without any gaps (see loading). The facility must be equipped with two boards to be used during unloading and adjustable on both sides of the door. See chapter 2.1 Indoor housing and pictures. Allow the giraffe to enter the smaller space of the separation pen first, where there is less danger that it could bolt and injure itself. It may be suitable to have another giraffe in the neighbourhood, which may help calm down the newcomer.

If possible, the newcomer should be introduced to the herd soon after arrival. See the Chapter on Social structure. The receiving institution should know the feed ration for the imported animal.and gradually transition to the preferred ration at the new location. Some of the animal's accustomed food (mainly pellets and alfalfa) should be delivered with the animal.

### 2.6.6 Safety

Safety for people around giraffes is of utmost importance. Enclosures should be developed that are safe for both people and animals. Chapter 2.1 Enclosure includes a lot of safety measures. Animals should not be able to hurt themselves or escape, keeper safety should also be incorporated into the design as described in the chapter. Facilities should be designed in such a way, that management of giraffes is possible from a distance and so that a keeper does not necessarily need to be in the same area of the enclosure.

## Risks in handling giraffes:

1. Outside enclosure: In most institutions, keepers go on foot with the giraffes in outside enclosures. This is never without risk. Due to a female in estrus, a male can be unpredictable or an animal can become suddenly frightened. Although there are only a few known cases of a keeper injured by a giraffe, one should always be aware of this. One should have some sort of tool present when entering an enclosure with animals, such as a wheelbarrow or broom or branch.
2. Inside enclosure: In a smaller environment like a stable, staff should not enter a box when an animal is present. When moving animals in or out, people should always stay at a distance, as they can kick backwards accurately and for a great distance.

Shifting animals in and out can result in excited giraffes. Sudden events can change their behavior instantly. In many institutions, giraffe transports and treatments are the most risky part of giraffe keeping. It is important to appoint one person to be in overall charge and to discuss as fully as possible in advance to avoid any surprises. In daily practice, giraffes are not dangerous animals, but it is recommended to develop an agreement or written protocol between administration and keepers to make clear what is allowed and what is not allowed to avoid misunderstanding. It is impossible to make general rules for this, as it will depend on the keepers and their experience, the zoo's policy, the characters of the individual giraffes and the giraffe facilities of the institution. Everyone working near giraffe should be aware of the possible risks and act accordingly.

### 2.7 Legislation

### 2.7.1 Conservation

Although low in numbers, no subspecies of giraffe are currently listed by CITES. This makes it possible to import giraffes without any special permits. However, there are many veterinary requirements for these even-hoofed mammals.

### 2.7.2 Health and welfare

EAZA institutions want to keep giraffes in such a way that their welfare is guaranteed and that they are maintained in good health. For the welfare of giraffes, these husbandry guidelines should be used as a yardstick. For the health part one is especially referred to chapter 2.2.5 Husbandry problems potentially related to diet, and to chapter 2.6.4 Diseases and other medical problems.

## Transport:

When transporting giraffes, the animals should be in good condition. An EU Veterinary Certificate must be issued by the local veterinary authorities. Normally within the EU, tests for tuberculosis and brucellosis are required, as well as proof that the sending institution is not under any veterinary restrictions. For transport outside of the EU, more tests are required, such as leptospirosis and leucosis.

As it is difficult for many institutions to draw blood from a giraffe, some receiving countries allow exceptions to this rule. An animal can be sent to Spain or Austria without blood tests, but the sending institution must provide a number of certifications. It is much easier to send giraffes out from BALAI institutions as many more countries are willing to make exceptions. Veterinary authorities are often unaware how difficult and risky it is to obtain blood samples from a giraffe, it is strongly recommended to explain this to the authorities. The EEP coordinators are willing to provide institutions with a supporting letter for this position.

It is of the greatest importance that the welfare of the animal is paramount. As some stress is inevitable, transports should be carried out by experienced transporters with adequate equipment. For transports by air, the IATA Regulations must be followed. To make road transports as short as possible, especially at borders, it is strongly recommended to contact customs at the border before the transport arrives and to fax all paperwork to the border ahead of time.

### 2.7.3 General

Within the EU, one must have an official zoo licence issued by the state authorities to hold giraffe.

## Section 3: European giraffe studbooks and management of the giraffe EEP population

### 3.1 Species management Programmes

The European Endangered species Program (EEP) for giraffes was established in 1988 for reticulated giraffes (Giraffa camelopardalis reticulata) and extended in 1991 to all subspecies, known hybrids and animals of unknown subspecific status. The EEP was first coordinated by Dr. Brotzler from Wilhelma, Zoologisch-Botanischer Garten, Stuttgart. After his retirement in 1995, he was succeeded by Dr. Günther Schleußner from the same institution. In 2003, the EAZA Antelope TAG decided to split up the EEP into two different programmes and this was accepted by the EAZA EEP Committee. Since September 2003, there are two Giraffe EEPs:

Günther Schleussner from Stuttgart is co-ordinating the Reticulated giraffes (Giraffa camelopardalis reticulata) and the Masai giraffes (Giraffa camelopardalis tippelskirchi)

Marc Damen from Arnhem Zoo is co-ordinating the following subspecies:
Baringo giraffes (Giraffa camelopardalis rothschildi), Kordofan giraffes (Giraffa camelopardalis antiquorum), Nigerian giraffes (Giraffa camelopardalis peralta), Angola giraffes (Giraffa camelopardalis angolensis), Cape giraffes (Giraffa camelopardalis giraffa), Hybrid giraffes and
Giraffes of yet unknown subspecific status
To be clear: all giraffes are managed at EEP level, as well as hybrid giraffes and giraffes of as yet unknown subspecific status

Within Europe, the Czech and Slovakian Zoo Association has had a Giraffe working group for a long time, including meetings on husbandry and transfers within their country. In the British Isles, there is strong cooperation between the institutions. The British Federation has even produced Husbandry and Management Guidelines for the Welfare of Giraffes.
However, EAZA institutions have agreed to work on a European level with the management of the population.

In the United States, Laurie Bingaman Lackey from ISIS produces the North American studbook. In 2004, North American Husbandry and Management Guidelines were produced, coordinated by Amy Burgess from Disney's Animal Kingdom.

In Japan, Osamu Ito of Tokyo Tama Zoo produces the Japanese studbook.

### 3.2 Management of the EEP population of giraffes

### 3.2.1 Working procedures for an EEP

All giraffes held by institutions that are members of EAZA are managed on the EEP level. Both EEPs are co-ordinated according to the document "Working procedures for EEP coordinators", which can be found on the EAZA website (www.eaza.net, go to the member area to Committees, then to EEP Committee, then to Documents) and which are available from the EEP co-ordinators.

The most important procedures are listed here:
$>$ The EEP should be managed as described in these working procedures, from the point of view of the co-ordinator and the species committee, as well as the participants.
$>$ The EEP co-ordinators should maintain and update the studbooks.
$>$ Transfers should be discussed between the EEP co-ordinator and the EEP species committee. Both giraffe EEPs have a species committee elected by the participants.
$>$ No animals should be moved from one institution to another without approval of the EEP co-ordinator and the species committee.
$>$ No animals can be sent to institutions not participating in the EEP without approval of the EEP Committee.
$>$ In the case where an institution violates these working procedures, the species committee will be asked to file a complaint with the TAG Chair.

These procedures apply for all EEPs, including both giraffe EEPs.

### 3.2.2 Goals and working procedures of the giraffe EEPs

The entire Giraffe population is now entered into the studbook software program SPARKS. This makes it possible to analyse the demography and genetics of the populations by means of computer programs such as pm 2000 , Genes or Demog in order to estimate the future development of the populations. This is being done and will be completed in 2006. The goal of both giraffe EEPs is to establish and maintain a viable and sustainable population of the different subspecies of giraffes in Europe. A possible goal of reintroducing animals to the wild seems very unlikely, given practical and financial contraints. The primary goal for the EEP population should be to have giraffes of known subspecies only and to phase out hybrids. There are several giraffes of unknown origin; another goal is to determine which subspecies they are, or if they are hybrids.

As no zoo board will accept an empty giraffe enclosure, the short-term goal is to keep the existing facilities filled with giraffe; after this, new facilities can be stocked. As with most hoofstock species, there is a relative surplus of male giraffes in Europe. In contrast to most other ungulates, there is a shortage of females and by means of this, it turns out to be easier to convince institutions to start with a bachelor group. In many cases there is simply no alternative. There are no females currently available as the total European population is growing very slowly, as current holders are expanding their facilities.

Therefore new participants in the EEP should start with a bachelor group as long as female giraffes can be placed at institutions currently keeping a breeding group of the same subspecies.

Institutions should only keep females of one subspecies in an enclosure and should have a male of the same subspecies. In the case where an institution has females of more than one subspecies in one enclosure, transfers should be arranged to move animals as necessary to more appropriate institutions. Hybrid females should not be kept in breeding conditions to avoid creating more hybrids. If an institution with a pure group also has hybrid females, these should be transferred to another institution or contracepted with e.g. PZP to avoid reproduction. For this one is referred to Chapter 2.5.6 Birth control.

Hybrid males should not be allowed to breed, but should be placed in bachelor groups. Institutions breeding hybrid females should use pure males which are currently not needed for breeding with pure females. By this means, we will have more spaces available for pure males. If we want a zoo to switch from hybrids to a pure subspecies, they will already have a male. Please note that the offspring of a pure male and a hybrid female will be considered a hybrid.

No animals should leave the EEP to a non-EAZA institution. EEP programmes are established exclusively for EAZA members, as these institutions have agreed to cooperate in breeding programmes in order to maintain viable populations. Non-EAZA members have not subscribed to these goals. In the past, several EEPs sent surplus animals out of other EEP programmes because they were genetically overrepresented or hybrids. Examples of this are pygmy hippos (Hexaprotodon liberiensis), ruffed lemurs (Varecia v. variegata) and emperor tamarins (Saguinus imperator). In many cases, these non-EAZA institutions joined EAZA a few years later and brought these animals back into EAZA programmes. If we send hybrids or unknown origin giraffes to non-EAZA members, they are lost to follow-up, but they or their offspring can return one day without us knowing their origin. Not a single animal should be sent to a non-EEP participant, unless one of the Giraffe EEPs benefits directly by getting a genetically important animal in return.

The EEP Committee formulated a statement on selling and trading of EEP animals on 7 March 2003. This statement was approved by EAZA Council 25 May 2003. The EEPs are strongly encouraged to follow this recommendation. This statement is: "For the benefit of the future viability of EAZA/EEP populations, all transfers of EEP animals must be arranged in full consultation with, and the agreement of, the EEP Coordinator. In order to ensure the noncommercial status of EEPs, any selling of EEP animals must be avoided". Only by means of this can we make sure that a giraffe will go to the best location instead of to the richest institution.

### 3.2.3 Individual identification

It is clear that for good management, it is of the utmost importance not to mix up two individuals. Of course every dedicated animal keeper can distinguish his giraffes, but to make it a bit more sustainable and controllable, it is strongly recommended to use other identification methods as well.

- The easiest way is to make a kind of photo gallery. At minimum, print pictures of both sides of a giraffe, preferably also from the front and from the back Record the studbook number, house name, sex, institution and their ARKS number on the photograph. A collection of these sheets can be placed in the keepers' area of the giraffe facilities, or maybe even in the visitor area, to explain about identification. Send copies of these sheets in advance to the receiving party in case of an animal transfer. Copies of these sheets should also be sent to the EEP coordinator
- If the opportunity presents itself, for example in the case of sedation or handling a very young animal, it is strongly recommended to implant a transponder or microchip in the giraffe. One may rarely have the occasion to check the identification by means of the microchip, but in case of international transports, it is very wise to have this chip already implanted. The IUCN standard implantation site is at the base of the left ear.
- One can use the same occasion to pull out a hair sample - mane hair is excellent - and to put this in a small paper envelope. Mark the bag or envelope with the name of the animal, the zoo and its ARKS number, Studbook number and date. Store it in a dry place, but not in a freezer and/or send it to the EEP coordinator. The follicles at the root of the hair contain DNA (so do not touch these with your hands!) and by means of this, identification is possible, including determining subspecies.
- Other means of identification include small notches in the ear or the use of ear tags. These will, if applied correctly, not harm the animal and are a useful method of identification, However one must question whether or not this disturbs the intrinsic beauty value of a giraffe. It is not the most reliable method, as ear tips can fray either due to bites of other animals or due to cold.

It is strongly recommended to use at least one of the methods mentioned above and at the very least, to take pictures of every individual.

### 3.3 Separation of subspecies

### 3.3.1 Different points of view for a separation of subspecies

The historic distribution of the giraffe once covered almost the entire continent of Africa between $36^{\circ}$ Northern and $34^{\circ}$ Southern latitudes. Notable areas that have always been excluded from its range are the evergreen rain forests of Western and Central Africa, parts of SE Africa between Lake Malawi and the Indian Ocean, the lower Nile area and possibly parts of the central Algerian and Libyan deserts and the Cape region.

As densely forested areas and larger rivers and streams seem to form natural barriers that reduce or partially eliminate gene flow between neighbouring giraffe populations, it is no surprise that quite a number of more or less differentiated subpopulations / subspecies have evolved.

A first attempt to describe subspecific diversity in giraffes was undertaken by Lydekker (1904). His work was later revised by
 Krumbiegel (1939) and Dagg (1971). The result of all these efforts is what could be called the "classic" or "traditional" subspecific taxonomy of the species. It can be summarized as follows:

- Northern giraffes
- Giraffa camelopardalis reticulata (N-Kenya, S-Ethiopia)
- G. c. peralta (from Senegal across the continent to the Great Rift Valley and Nile River)
- G. c. camelopardalis (W-Ethiopia, E-Sudan)
- G. c. antiquorum (W and SW-Sudan)
- G. c. congoensis ( = cottoni) (S-Sudan, N-DR of Congo)
- G. c. rothschildi (W-Kenya, Uganda, S-Sudan)
- Southern giraffes
- G. c. tippelskirchi (S-Kenya, Tanzania)
- G. c. capensis ( = giraffa, incl. wardi) (N-Namibia into Botswana and W and S Zimbabwe)
- G. c. angolensis (Angola)
- G. c. thornicrofti (Luangwa valley in Zambia)

This or slightly modified subspecific taxonomies have been in use for many decades. The EEP for Giraffa camelopardalis has been based upon this classification of subspecies, too.

It has been stressed many times that the classic giraffe taxonomy relies almost exclusively on certain characteristics of the pelage pattern that show considerable individual variation as well as age dependency (see e.g. Dagg and Foster, 1976). A complete and detailed revision of giraffe taxonomy, however, has not been undertaken until recently.

In 1997, Kingdon suggested an interesting ecologically based approach introducing four "ecotypes" of giraffe:
1 Somali arid type (including the traditional subspecies camelopardalis and reticulata)
2 (Sub)Saharan type (including peralta)
3 Northern savannah type (cottoni $=$ congoensis)
4 Southern savannah type (including tippelskirchi, capensis = giraffa, angolensis and thornicrofti)

According to Kingdon`s approach, several of the traditional subspecies would no longer be valid and would either have to be dropped (e.g. G. c. antiquorum) or have to be regarded as intermediate or hybrid populations (e.g. G. c. rothschildi). His suggestions, however, have not been widely accepted.

Only recently was a complete revision of giraffe subspecific radiation undertaken and presented by Seymour (2002). Traditional taxonomic criteria, i. e. coat pattern and skull morphology, have been reanalysed. Furthermore, investigations at molecular level (mtDNA) have been carried out in order to support the study.

The results derived from these three independent sets of data were remarkably congruent and Seymour's conclusions can be summarized as follows:

- Most of the southern giraffes may be all subsumed into the single definitive subspecies $G$. c. giraffa, but further specimens are required to investigate the final status of G. c. angolensis. It is unlikely, however, that the latter is subspecifically different. For the moment, it is suggested to maintain G. c. angolensis as a provisional subspecies only.
- G. c. thornicrofti (which is not kept in EAZA collections at present) should continue to be ranked as a definitive subspecies.
- G. c. tippelskirchi and G. c. reticulata are differentiable from all other giraffes by their coat pattern and skull morphology, and they are genetically distinct as well. Consequently, both clearly deserve recognition as definitive subspecies.
- G. c. rothschildi differs morphologically from the giraffes in Eastern Africa, but is indistinguishable in this respect from populations further to the west. Genetically, however, G. c. rothschildi specimens form a monophyletic group, and therefore, this subspecies should be maintained as definitive.
- G. c. camelopardalis and G. c. antiquorum have been inadequately sampled so far. For the moment, it may be justified to maintain them as provisional subspecies. It seems very likely, however, that the nominate race G. c. camelopardalis will be revised to include both G. c. antiquorum and G. c. peralta. Consequently, the West African form peralta, which forms a monophyletic group, should be regarded as a provisional subspecies, too.

The conclusions of Seymour's study are (and have to be!) very careful due to insufficient sample sizes. This argument, however, can be brought up with regard to the studies of Lydekker and others of the early giraffe taxonomists as well. In addition, their evaluation of peculiarities of the pelage pattern of a given individual sometimes seems to be more or less influenced by subjective perception and interpretation. A good example in this context provides the description of the so-called Lagos giraffe (Giraffa camelopardalis renatae) by Krumbiegel (1971), an apparently new subspecies that had to be dropped again very soon after its description.

### 3.3.2 Management of subspecies in Europe

Taking into account the small population sizes of several of the purebred subspecies in EAZA collections and assuming that more concrete taxonomic statements based upon data derived from larger sample sizes will not become available in the foreseeable future, a proposal was brought to the EAZA Antelope TAG in 2003, to divide the European giraffe population into six groups:

1. Giraffa camelopardalis reticulata
2. Giraffa camelopardalis camelopardalis (subsuming the so far separate programmes for G. c. peralta and G. c. antiquorum)
3. Giraffa camelopardalis rothschildi
4. Giraffa camelopardalis tippelskirchi
5. Giraffa camelopardalis giraffa (including the so far independent population of G. c. angolensis)
6. Giraffa camelopardalis unk subspecies and G. c. hybrids

The subspecies Giraffa camelopardalis thornicrofti is not under captive management.
However, the EAZA Antelope and Giraffe TAG decided to use a conservative approach and to continue considering all current subspecies as separate subspecies. This imposes some practical problems. For example, there are at the moment only two female Kordofan giraffes and no males. If we decide to keep them strictly separated this means that we will lose this subspecies within a few years. Therefore within the giraffe EEP, it has been decided to choose an intermediate approach. The discussion is more or less if Nigerian and Kordofan giraffes are one or two subspecies. As there is no choice with the two Kordofan females, they will be paired up with a Nigerian male; by means of this there is at least a chance that the offspring are not hybrids. The offspring between Kordofan and Nigerian giraffes will therefore for the moment not be considered hybrids, but as a separate group 'crossbreeds of Nigerian and Kordofan giraffes'.

By this means, we have created the following categories:
The reticulated giraffe EEP, comprising two groups:
Group A: Giraffa camelopardalis reticulata
Group B: Giraffa camelopardalis tippelskirchi
The Baringo giraffe EEP, comprising four groups:
Group A: Giraffa camelopardalis peralta and G. c. antiquorum and their crossbreeds
Group B: Giraffa camelopardalis giraffa and G. c. angolensis and their crossbreeds
Group C: Giraffa camelopardalis rothschildi
Group D: Giraffa camelopardalis unk subspecies and G. c. hybrids
By means of this, it will always be possible to merge to fewer subspecies if there is a scientific decision. If the different subspecies in group A or B are really subspecies, it is easy to consider their crossbreeds as hybrids.

### 3.4 Population status and development

Several EEP Studbooks have been produced and the giraffe EEP studbook data are up-todate. The table below shows the total numbers of living specimens of each subspecies. About $75 \%$ of the giraffes belong to one of seven different subspecies (old nomenclature). The remaining $25 \%$ are proven hybrids between two or more subspecies or are animals of unknown origin.

Table 3-1: Population status of Giraffa camelopardalis sp.

| Giraffa camelopardalis | As of end 1999 ${ }^{\text {1) }}$ |  | As of end 2001 ${ }^{2 \prime}$ |  | As of end $2003{ }^{3}$ |  | As of end $2005{ }^{4)}$ |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | \# | Sex | \# | Sex | \# | Sex | \# | Sex |
| reticulata | 82 | (37.45) | 96 | (44.52) | 99 | (45.54) | 101 | (49.52) |
| tippelskirchi | 15 | (5.10) | 17 | (7.10) | 13 | (4.9) | 10 | (3.7) |
| rothschildi | 165 | (57.162) | 189 | (70.119) | 219 | (87.132) | 230 | (90.140) |
| camelopardalis* | 28 | (6.22) | 32 | (10.22) | 50 | (17.33) | 57 | (19.38) |
| peralta | 25 | (6.19) | 29 | (10.19) | 32 | (10.22) | 34 | (10.24) |
| antiquorum | 3 | (0.3) | 3 | (0.3) | 2 | (0.2) | 2 | (0.2) |
| Giraffa* | 29 | (9.20) | 33 | (13.20) | 40 | (14.26) | 52 | (21.31) |
| angolensis | 15 | (5.10) | 15 | (5.10) | 19 | (5.14) | 17 | (5.12) |
| giraffa | 14 | (4.10) | 18 | (8.10) | 21 | (9.12) | 35 | (16.19) |
| Hybrids | 96 | (36.60) | 132 | (57.75) | 121 | (55.66) | 138 | (59.79) |
| unknown ssp. | 29 | (14.15) | 30 | (15.15) | 44 | (16.28) | 55 | (14.41) |
| Total | 444 | (164.280) | 529 | (216.313) | 586 | (238.348) | 643 | (255.388) |

${ }^{1)}$ : Data from $1^{\text {st }}$ EAZA Giraffe EEP Studbook by Stuttgart Zoo, data through 31-12-1999
${ }^{2)}$ : Data from $2^{\text {nd }}$ EAZA Giraffe EEP Studbook by Stuttgart Zoo, data through 31-12-2001
${ }^{3)}$ : Data from 3rd EAZA Baringo giraffe EEP Studbook by Arnhem Zoo, data through 31-12-2003 and from Günther Schleußner.
${ }^{4}$ : Data from 3rd EAZA Baringo giraffe EEP Studbook by Arnhem Zoo, data through 31-12-2005 and from Günther Schleußner.

* As discussed in chapter 3.3 there is some discussion whether or not Giraffa camelopardalis peralta and Giraffa camelopardalis antiquorum are one or two subspecies. In the EEP, these are still managed separately, but it is forseen that one day they will be combined; therefore from 2003 on they are managed more together within one group (Giraffa c. camelopardalis) with two subspecies. The same story goes for Giraffa camelopardalis angolensis and Giraffa camelopardalis giraffa.


### 3.5 Biological data derived from the studbooks

With thousands of giraffes listed in the various European giraffe studbooks, one can calculate a lot of biological values and records.

### 3.5.1 Longevity

One of the reasons for writing the guidelines for giraffes is to increase the average life span of giraffes. Although they can reach an age of over 25 years, half of the males die before they reach 10 years of age; half of the females do not reach an age of 12 years.

```
Ages at death for animals surviving to at least 30 days
    25th %tile Median 75th %tile Maximum N
    males: ~3Y ~ ~10Y ~16Y 
females: ~5Y,6M ~12Y ~19Y 33Y,7M,8D 778
```

Figure 3-1 shows a Life Expectancy chart, produced by Laurie Bingaman Lackie using European data. To use this, here's an example. If a male giraffe (the blue line) has lived to be 15 years old (the x -axis), go up to the blue line and then go left to the Y -axis to see how much longer that male can expect to live -5 years (Of course, he might die tomorrow....).


Figure 3-1: Life Expectancy chart

Longevity in males
Oldest males:

| $4-0240$ | Wild born | Died at ST PETERS at age of $\sim 29 \mathrm{Y}$ | "Malchik" |
| :--- | :--- | :--- | :--- |
| $5-0895$ | Captive born | Died at LYON at age of 27Y,9M,3D | "Cornelius" |
| $1-0815$ | Wild born | Died at PARIS ZOO at age of $\sim 27 \mathrm{Y}$ | "Lamy" |
| $4-0538$ | Wild born | Died at KOLMARDEN at age of $\sim 26 \mathrm{Y}$ | "Konrad" |
| *-1069 | Captive born | Died at TWYCROSS at age of 25Y,8M,22D | "Scotty" |
| $\overline{5-0844}$ | Wild born Died at WOBURNLTD <br> Cat age of $\sim 25 \mathrm{Y}$  | "Nijinsky" |  |
| $1-0657$ | Captive born | Died at DEBRECEN at age of 25Y,5M,17D | "Zaire" |
|  |  |  | "Liouc" |

Oldest living males as of Dec 2005 :

| $0-1239$ | Captiveborn | At SAARBRUCK at age of 28Y,0M,29D | "KasparII" |
| :--- | :--- | :--- | :--- |
| $4-1536$ | Captiveborn | At ODENSE at age of $24 \mathrm{Y}, 1 \mathrm{M}, 23 \mathrm{D}$ | "BorgeII" |
| $5-1555$ | Captiveborn | At RHENEN at age of 23Y,10M,29D | "Erik" |
| $8-1938$ | Wildborn | At DORTMUND at age of $\sim 21 \mathrm{Y}$ | "Ovambo" |
| $5-1820$ | Captiveborn | At KRONBERG at age of $\sim 21 \mathrm{Y}, 4 \mathrm{M}$ | "George" |
| $0-3252$ | Captiveborn | At LAFLECHE at age of $\sim 20 \mathrm{Y}, 0 \mathrm{M}$ | "Twiga" |
| $5-1957$ | Unkbirthtype | At ROMA at age of $\sim 19 \mathrm{Y}$ | 4739 |
| $5-1969$ | Captiveborn | At PRAHA at age of 18Y,10M,30D | "Simon" |

## Longevity in females

Oldest females:

| 1-0535 | Captive born | Died at PARISZOO at age of 33Y,7M,8D | "Sophie" |
| :--- | :--- | :--- | :--- |
| $5-0799$ | Wildborn | Died at MARWELL at age of $\sim 33 \mathrm{Y}$ | "Dribbles" |
| $4-0195$ | Unkbirthtype | Died at MUNICH at age of $\sim 30 \mathrm{Y}$ | "Edith" |
| $5-0413$ | Wildborn | Died at BARCELONA at age of $\sim 30 \mathrm{Y}$ | "Vieja" |
| $5-0591$ | Wildborn | Died at AALBORG at age of $\sim 30 \mathrm{Y}$ | "Negrita" |
| $5-0687$ | Captive born | Died at BEWDLEY at age of $\sim 29 \mathrm{Y}$ | "Ursula" |
| *-0573 | Wildborn | Died at BANDHOLM at age of $\sim 29 \mathrm{Y}, 1 \mathrm{M}$ | Gica-8 |
| $4-0241$ | Wildborn | Died at STPETERS at age of $\sim 28 \mathrm{Y}$ | "Lissy" |

Oldest living females as of Dec 2005:

| *-0819 | Captive born At ERFURT at age of 33Y,7M,28D | "Maja" |
| :--- | :--- | :--- |
| $1-1075$ | Captive born At PARISZOO at age of 30Y,3M,26D | "Agathe" |
| $5-1143$ | Captive born At SAARBRUCK at age of 29Y,4M,26D | "Viola" |
| $6-1149$ | Captive born At KATOWICE at age of 29Y,3M,5D | none |
| $1-1290$ | Captive born At PARISZOO at age of 27Y,4M,20D | "Lamba" |
| $1-1375$ | Captive born At PELISSANE at age of 26Y,0M,29D | "Giselle" |
| $\overline{1-1541}$ | Captive born At KRISTIANS at age of $\sim 24 \mathrm{Y}$ | "Molly" |
| 4-1542 | Captive born At PARISZOO at age of 24Y,1M,14D | "Annabel" |
|  | Can At STPETERS at age of 24Y,1M,9D | "Luga" |

EAZA Husbandry and Management Guidelines

### 3.5.2 Reproductive life span:

## Male giraffes:

In the European giraffe studbooks, 326 male giraffes sired a total of 2371 offspring and the figures below are based on these data. Sires can successfully mate at the age of 3 years. However, the average age at the first reproduction is slightly less than 5 years. They can successfully mate until the end of their lifespan.

Female giraffes:
In the European giraffe studbooks, 602 female giraffes gave birth to a total of 2423 offspring and the figures below are based on these data. Dams can give birth at an age of 4 years, which means that they were successfully mated at the age of less than three years. In exceptional cases, females were already mated successfully at the age of two years, according to the data of some institutions. However, the average age at the first reproduction is 6 years and 6 months. They can give birth until the end of their lifespan. Female Dribbles at Marwell reached an age of 31 years and gave birth to a healthy calf shortly before she died.

Female Lamba (studbook \#1-1290) gave birth to 15 offspring ( 1 stillborn, 5 died shortly after birth) between 1982 and 2003.

### 3.5.3 Seasonality:

As can be seen in the graphic below, there is no clear birth seasonality. There are slightly more calves born in the summer; however this might be decided by the fact that many giraffes are kept indoors and sexes separated in wintertime, causing more matings in springtime.

Birth seasonality ( $\mathrm{n}=2403$ )


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## Appendix 1:

List of variation in browse supply
Sallow Thorn (Hippophae rhamnoides)
Autumn olive (Elaeagnus umbellata)
Honeysuckle (Lonicera sp.)
Siberian pea (Caragana sp.)
Serviceberry (Amelanchier canadensis)
Redbud (Cercis canadensis)
Hawthorn (Crataegus sp.)
Sweet gum (Liquidambar stryacifula)
Tulip tree (Liriodendron tulipifea)
Crabapple (Malus sp.)
American sycamore (Platanus occidentalis)
Chinese elm (Ulmus parvifolia)
Water hyacinth (Eichhornia sp.)
Wild grape (Vitis sp.)
Box elder (Acer negundo)
Red alder (Alnus rubra)
Birch (Betula sp.)
Monkey apple (Acmena smithii)
Coprosma (Coprosma sp.)
Black tree fern (Cyathea medullaris)
Fennel (Foeniculum sp.)
Sow's ear (Hebe sp.)
Mulberru (Morus sp.)
Lemonwood (Pittosporum sp.)
Buttonwood (Platanus occidentalis)
Lancewood (Psuedopanax sp.)
Willow (Salix sp.)
Norway, sugar and silver maple (Acer sp.)
Juneberry (Amelanchier sp.)
Red-twig dogwood (Cornus sericea)
Cotoneaster (Cotoneaster sp).
Beech (Fagus sp.)
Bamboo (Phyllostachys sp.)
Silk tree (Albizia julibrissin)
Sugar hackberry (Celtis laevigata)
Honeylocust (Gleditsia triacanthos)
Plains cottonwood (Populus sargentii)
American elm (Ulmus americana)
Edible plaintain (Musa sp.)
Burmese rosewood (Pterocarpus indicus)
Indian almond (Terminalia catappa)
Wattle (Acacia sp.)

## Appendix 2:

Mammals and Struthio camelus in mixed species exhibits successfully kept with Giraffa camelopardalis in zoos in Europe.

| EAZA Zoos | m2 | $\begin{gathered} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{gathered}$ |  | $\begin{aligned} & 5 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \end{aligned}$ | $\begin{aligned} & \text { z} \\ & 00 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \end{aligned}$ |  | $\begin{array}{\|c\|} \hline \text { zu } \\ \text { E.0 } \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{array}$ |  |  |  | $\begin{aligned} & 7 \\ & 0 \\ & 0 \\ & 0 . \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \end{aligned}$ | $\begin{aligned} & 5 \\ & 5 \\ & 0 \\ & 0 \\ & 0 \\ & 00 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \end{aligned}$ |  |  |  |  |  |  |  |  |  |  | $\begin{gathered} : \approx \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 2 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{gathered}$ |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Aalborg | ? | n.i. | n.i. |  |  |  |  |  |  |  | n.i. |  |  | n.i. |  |  |  | n.i. | n.i. |  |  |  |  |  |  |  |
| Basel | 560 | 2,3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 3,9 |  |  |
| Berlin | 1.270 | n.i. |  |  | n.i. |  |  |  |  |  |  |  |  |  |  | n.i. |  |  |  |  |  |  |  |  |  |  |
| Boras | 25.000 | 1,2 |  |  |  | 1,1 | 1,1 |  |  |  | 3,11 |  |  |  |  |  |  |  | 4,2 |  |  |  |  |  |  |  |
| Cabarceno |  | n.i. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | n.i. |  |  |  |  |  |  |  |
| Cheshire | 2.703 | 2,4 |  |  |  |  |  |  |  |  |  | 3,17 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Dudley | 10.000 | 1,3 |  |  |  |  |  |  |  |  |  | 5,0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Emmen | 12.000 | (10) |  | (25) | (10) | (4) |  | (3) |  | (7) |  |  |  |  |  |  |  |  | n.i. |  |  | (2) |  |  |  |  |
| Frankfurt a. M. | 1.500 | 1,4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1,4 |  |  |  |  |  |  |  |  |  |
| Gelsenkirchen | 900 | 1,1 |  |  |  |  |  |  | 4,7 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Hamburg | ? | n.i. |  |  | n.i. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | n.i. |
| Köln | . | n.i. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Lisieux | 60.000 | 2,1 |  |  |  | 2,2 |  |  |  | 1,1 |  |  |  |  |  |  |  | 1,8 | 2,2 |  |  | 1,3 |  |  |  |  |
| London | 1.250 | 1,2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | (11) |  |  |  |  |  |  |
| Neunkirchen | 1.500 | 1,1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1,2 |  |  |  |
| Poznan | 9.065 | 1,2 |  | 1,1 |  |  |  |  |  | 2,4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Rhenen | 2.400 | 1,2 |  | 4,0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Schwerin | 1.000 | n.i. |  |  |  |  |  |  |  | n.i. |  |  |  |  |  |  |  |  | n.i. |  |  |  |  |  |  |  |
| Stuttgart | 2.000 | 1,4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1,6 |  |  |
| Vienna |  | 1,1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | n.i. |  |  |  |  |  |  |  |
| Total Zoos |  | 21 | 2 | 3 | 3 | 3 | 1. | 1 | 1 | 4 | 1 | 2 | 1 | 1 | 1. | 2 | 1. | 2 | 8 | 1 | 1 | 3 | 2 | 2 | 1 |  |

## Appendix 3:

Handrearing milk formula

| Composition <br> of milk in \% | Dry mass | Protein | Fat | Casein | Lactose | Ash |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Cow 1 <br> st day <br> after birth. | 23,5 | 9,5 | 4,8 | 3,5 | 3,1 | 0,9 |
| Cow 6 <br> stay <br> after birth | 12,1 | 3,3 | 3,5 | 2,4 | 4,9 | 0,8 |
| Giraffe first <br> 10 days of <br> lactation. | 22,8 | 5,9 | 12,5 |  | 3,4 | 1 |
| After 10 <br> of lactation. | 13,9 | 2,9 | 4,7 |  | 5,4 | 0,7 |
| Nubian <br> giraffe. | 17 | 6,3 | 7,2 |  | 3 | 0,9 |
| Secrete before <br> lactation <br> (jellylike), <br> 409 <br> gravidity. | 19,9 | 3,9 | 11,5 |  | 3,7 | 0,8 |
| Secrete before <br> lactation <br> (liquid, <br> viscous), $405-$ <br> $414^{\text {th }}$ day of <br> gravidity. | 31,7 | 12,9 | 16,7 |  | 1,2 | 0,8 |
| Early <br> lactation - <br> colostrums/ | 32,2 | 13,3 | 15,1 |  | 2,4 | 1,3 |
| Stable <br> lactation. | 17,3 | 6,3 | 7,2 |  |  |  |
| $150^{\text {th }}$ day of <br> lactation. | 22,9 | 5,8 | 12,5 | 4,8 | 3,4 | 0,9 |


| Age in weeks | Number of feeds per day | Average daily volume |
| :--- | :--- | :--- |
| $1-5$ weeks | five | 6.5 L |
| $6-12$ weeks | four | 10 L |
| $13-17$ weeks | three | 8 L |
| $18-23$ weeks | two | 4 L |
| $24-28$ weeks | one | 1.5 L |


[^0]:    ${ }^{1)}$ including reproducing females with substantially higher energy requirements
    ${ }^{2)}$ non-reproducing ${ }^{3)}$ reproducing (various stages, from second trimester of pregnancy to end of lactation)

[^1]:    *ad lib feeding of pellet / compound

