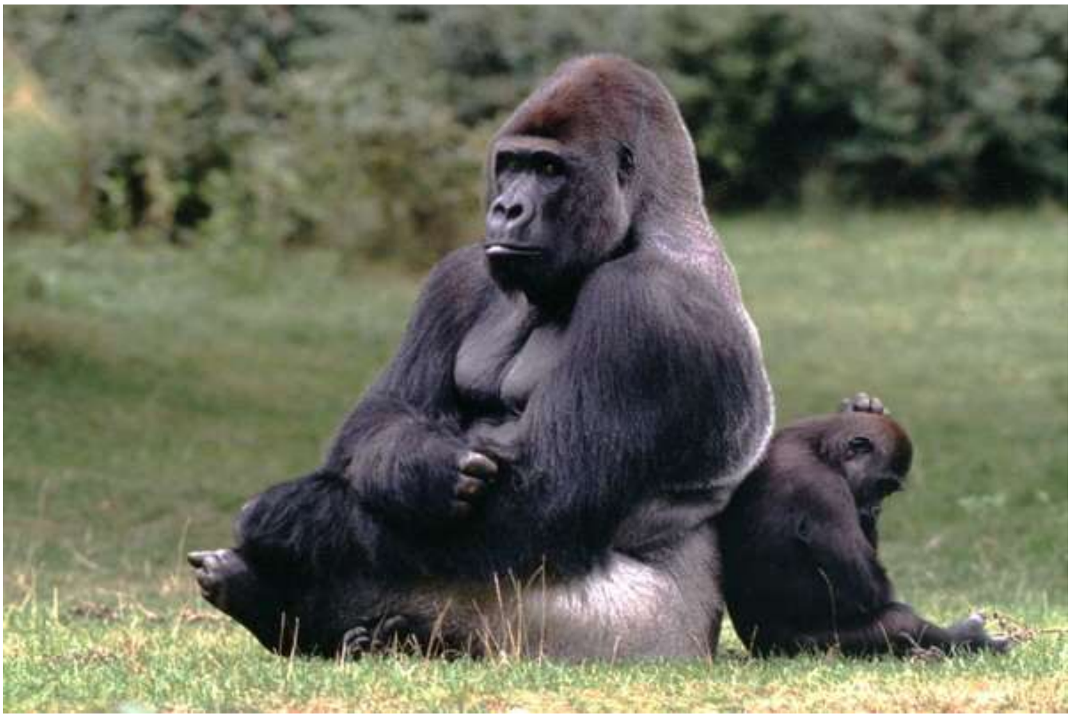

EAZA BEST PRACTICE GUIDELINES
Great Ape Taxon Advisory Group
GORILLA
(*Gorilla gorilla gorilla*)
2017 (2nd Edition)

Edited by

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EAZA Best Practice Guidelines disclaimer

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EAZA Best Practice Guidelines for Gorillas

Preamble

Right from the very beginning it has been the concern of EAZA and the EEPs to encourage and promote the highest possible standards for husbandry of zoo and aquarium animals. For this reason, quite early on, EAZA developed the "Minimum Standards for the Accommodation and Care of Animals in Zoos and Aquaria". These standards lay down general principles of animal keeping, to which the members of EAZA feel themselves committed. Above and beyond this, some countries have defined regulatory minimum standards for the keeping of individual species regarding the size and furnishings of enclosures etc., which, according to the opinion of authors, should definitely be fulfilled before allowing such animals to be kept within the area of the jurisdiction of those countries. These minimum standards are intended to determine the borderline of acceptable animal welfare. It is not permitted to fall short of these standards. How difficult it is to determine the standards, however, can be seen in the fact that minimum standards vary from country to country. Above and beyond this, specialists of the EEPs and TAGs have undertaken the considerable task of laying down guidelines for keeping individual animal species. Whilst some aspects of husbandry reported in the guidelines will define minimum standards, in general, these guidelines are not to be understood as minimum requirements; they represent best practice. As such the EAZA Best Practice Guidelines for keeping animals intend rather to describe the desirable design of enclosures and prerequisites for animal keeping that are, according to the present state of knowledge, considered as being optimal for each species. They intend above all to indicate how enclosures should be designed and what conditions should be fulfilled for the optimal care of individual species.

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SUMMARY

This document reflects our current knowledge about general biology and keeping requirements to provide adequate levels of wellbeing for Gorillas, the biggest size great ape species, in captive environments. While While providing information about different aspects that should be taken into account when managing gorillas in captivity to ensure a healthy and selfsustainig population, helping to de development of a global "ex situ conservation" program, also provides information about the situation of the species in the wild and "in situ conservation" projects supporting field conservation work in host countries to which all the zoo institutions keeping gorillas are encouraged to support following the IUCN strategy of One Plan Approach.

Section 1., Biology and Field Data, reflects our current knowledge of species in the natural environment using the most recent taxonomic information. The philosophy behind this is that *ex situ* conservation can be used more effectively as a conservation tool if it is part of an integrated approach to species conservation (IUCN, 2014). The potential need for a conservation role of an EAZA *ex situ* population has therefore been decided in consultation with *in situ* specialists. This section provides wide and actual information about the species in its natural habitat.

Section 2., Management in Zoos, covers housing and exhibition, nutrition, food presentation and enrichment, social structure and behaviour. There is also useful information on the formation of breeding groups and bachelor groups. Control of breeding is an essential component of successful managed programmes and comprehensive information to assist zoo veterinarians to decide on the most appropriate contraception method for their animals is provided. Managed programmes also rely on the movement of animals between zoos and advice on handling and transport is provided.
It is essential that gorillas are provided with complex environments and there is detailed practical information on environmental enrichment. One indispensable method of feeding enrichment is the use of browse and information on suitable plants species is provided.
A comprehensive veterinary section provides information on current knowledge on all aspects of medical care.
Our knowledge can only increase through appropriate research and the final section covers ongoing and recommended research topics.
This document is for the gorilla holders to get the better knowledge about keeping this magnificient species in the appropriate and best possible way. Therefore to regularly consult the Guidelines and contact TAG members with any concerns or queries is recommended.

GORILLA EEP BEST PRACTICE GUIDELINES (Nov. 2015)

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SECTION 1: BIOLOGY AND FIELD DATA

The genus Gorilla, biology and field data.

A. Meder

1.1. Taxonomy

The closest relatives of the gorillas (genus *Gorilla*) are chimpanzees *(Pan)* and humans *(Homo)*. Both have about the same genetic distance to the gorillas and therefore *Gorilla* and *Pan/Homo* are sister clades. The nuclear DNA differs by 1.2% between humans and chimpanzees, by 1.6% between humans and gorillas and by 1.8% between gorillas and chimpanzees. In mitochondrial DNA, it is 8.8% between humans and chimpanzees, 10.3% between humans and gorillas and 10.6% between chimpanzees and gorillas (Hayasaka et al., 1988; Koop et al., 1989). In Groves (2001) the great apes are classified as the family Hominidae and the African apes + humans into the subfamily Homininae.

The first detailed study on gorilla taxonomy was published by Groves in 1970. He classified all gorillas as one species, *Gorilla gorilla*, with three subspecies (*Gorilla gorilla gorilla*, *Gorilla gorilla beringei* and *Gorilla gorilla graueri*). Genetic studies by Ruvolo et al. (1994) and Garner & Ryder (1996) showed considerable genetic differences between eastern and western gorillas and the authors suggested that they should be separated as two distinct species. A few years ago, experts therefore decided to recognize two gorilla species (Groves, 2003): western gorillas *(Gorilla gorilla)* and eastern gorillas *(Gorilla beringei)*.

The 2013 IUCN Red List of Endangered Species distinguishes four subspecies. The western lowland gorilla occurs in West Africa *(Gorilla gorilla gorilla)*, the Cross River gorilla *(Gorilla gorilla diehli)* at the Nigerian/Cameroonian border; the mountain gorilla *(Gorilla beringei beringei)* lives on the Virunga Volcanoes and in the Bwindi Forest and Grauer's gorilla or the eastern lowland gorilla *(Gorilla beringei graueri)* in the eastern Democratic Republic of Congo.

Externally, the species differ in several characteristics (Meder & Groves, 2012). The nose of the western gorilla is much broader than in the eastern populations. The silvery back of adult males extends to hips and upper thighs in the western gorillas. While the hair of the eastern species is usually deep black (apart from the silvery back of the males), the western gorilla's hair can have a grey or brownish tinge in both males and females. The mountain gorillas of the Virungas have shorter arms than the other populations and very long, silky hair, mainly on the arms.

1.2. Morphological features and distinguishing characteristics

Gorillas are the largest living primates. Adult males and females show a very obvious sex difference in size and external features. Upright, gorilla males can reach 1.7 m on average. Western gorillas are the shortest subspecies with an average height of less than 1.7 m, whereas eastern lowland or Grauer's gorillas are the tallest subspecies with a height of 1.75 m or more (Meder, 1993).

Male western gorillas have a mean weight of 140–160 kg in the wild, male mountain gorillas 150–160 kg and male Grauer’s gorillas 160–180 kg. Free-ranging gorillas weighing more than 200 kg are rare. Females usually weigh between 70 and 110 kg (Meder, 1993).

The most striking characteristic of gorilla males is the so-called silverback. The silvery appearance is caused by short, white hairs which cover the males' backs. The silverback develops when the males are fully grown (usually at about 15 years of age in the wild). It is not a sign of old age. Whereas the hair on their backs is shorter than on most other body parts, males have especially long hair on their arms.

Gorillas share many features with the other apes and humans (Gregory, 1950; Groves, 1986). Their hands and feet resemble those of humans more than the hands and feet of the other apes do. As gorillas spend more time on the ground than all the other apes, their feet are more suited to walking: the distance between the big toe and the others is very short. This is especially true for the mountain gorillas of the Virunga Volcanoes; they climb less on trees than the other populations. Like chimpanzees, gorillas

are knuckle-walkers; their fingers are anatomically adapted in many respects to this kind of locomotion (Tuttle & Watts, 1985).
The skulls of gorillas show certain characteristics and are clearly sexually dimorphic (O'Higgins et al., 1990). Males and females have nuchal crests, silverback males and a few females have sagittal crests. Males have much larger crests in general. Like all the apes, gorillas have a large laryngeal air sac, especially the silverback males. It intensifies the chest-beating sound.

Gorillas feed almost exclusively on plants, which they eat in large quantities. To be able to process these masses of plant material, they have very strong chewing muscles and a large colon and caecum (possibly with symbiotic microorganisms; Collet et al., 1984; Tutin et al., 1991). Their teeth very much resemble those of humans, except for the very long, pointed canines of the adult males. The males don't use those for feeding but for fighting against competing males.

1.3. Distribution

Gorillas live in rain forests from the lowland up to the mountains of tropical Africa. Today, the distribution areas of the western and the eastern gorillas are separated by almost 900 km. The reason for this is probably that a formerly uniform area was split at some point, most likely during the ice ages. At that time, climatic changes caused the rain forest to shrink into a few refuge areas. The savannah, which spread between these refuge areas, was not an appropriate habitat for gorillas. Later, when the rain forest spread again over the whole of the African tropics, gorillas could only advance to the Ubangi and Congo Rivers.

The distribution area of western gorillas extends from 8° 50' E to 18° E and from 6° 25' N to about 5° S. Recently, a small population was found within the wide gap that separates the Cross River gorillas from the western lowland gorillas (Morgan et al. 2003). Eastern gorillas live from 26° 30' E to 29° 45' E and from 0° 20' or 1° N to 3° 50' S. The various subspecies/populations are also living in widely separated areas.

Although the borders of the gorillas' distribution area seem to have changed little over the last few decades, the habitat of this ape species has been fragmented and encroached upon considerably as forested areas are increasingly reduced and isolated from each other by cultivation. From some regions gorillas have already disappeared altogether because the forest has been destroyed. Therefore they often are confined to small and isolated forest islands.

1.4. Population

Only the numbers of the two mountain gorilla populations are fairly well known. In general, it is not possible to count non-habituated gorillas directly. Their numbers and population densities may be estimated by densities of nest sites or of the nests themselves. Researchers have to resort to the traces they leave, mainly their nests, in order to calculate population numbers. To do this, they walk along pre-determined, straight lines (so-called transects) through the forest and record all gorilla nests visible from the transect (Tutin & Fernandez, 1984).

Most recent estimates of gorilla population sizes are given by Harcourt (1996), Butynski (2001) and Plumptre et al. (2015). The numbers of western lowland gorillas and Grauer's gorillas have decreased considerably during the last decades. The latest numbers and estimates:

Cross River gorillas	250–300	
Western lowland gorillas at least	125,000	(Bwindi gorillas 400)
Mountain gorillas (Virunga Volcanoes)	480	
Grauer's gorillas	3,800	

The densities of gorillas vary highly across their range (Yamagiwa 1999). The highest population densities (up to more than 2 individuals/km^2) of western lowland gorillas are generally recorded in secondary forest; especially high concentrations were found in Dzanga-Sangha at the forest edge and near roads (4.18–10.96/km^2; Carroll, 1988). An extremely high density was reported by Bermejo (1999) in Marantaceae forest: 11.3 gorillas/km^2 (see also Devos et al., 2008). Another highly preferred habitat is swamp and inundated forest. There, the population density can be as high as 2–6/km^2(Carroll, 1988; Fay & Agnagna, 1992; Fay et al., 1989; Mitani et al., 1993; Nishihara, 1995; Rainey et al., 2010) – seasonally, Poulsen & Clark (2004) even found 12.2 gorillas/km^2. If these preferred vegetation types are not available, western lowland gorillas use primary forest (about 0.2 individuals/km^2; Carroll, 1988; Tutin and Fernandez, 1984), but they generally avoid *Gilbertiodendron* forest.

Schaller (1963) estimated the density of the mountain gorillas on the Virunga Volcanoes at 1.13/km^2. In the distribution area of the eastern lowland or Grauer's gorilla, estimates by various authors showed population densities between 0.27 and 0.83/km^2. Yamagiwa (1999) found that the population density of gorillas does not vary with altitude.

1.5. Habitat and Ecology

Gorillas live in a huge variety of habitats: primary lowland rainforest, secondary forest, swamp forest, marshy clearings (bais), and montane forest. The vegetation types are described by many authors, e. g. Jones & Sabater Pí (1971) for Río Muni, Fay et al. (1989) for the swamp forests of the Likouala, Carroll (1988) for the Dzanga-Sangha region, Casimir (1975) and Goodall (1977) for the highland of Kahuzi-Biega, Schaller (1963) and Fossey (1983) for the Virunga Volcanoes.

Primary forest, i.e. forest largely untouched by humans, is very rich in species. Secondary forest develops in areas that have been cleared of primary forest and is characterized by a few fast growing plant species; many of them are the gorillas' preferred food plants. Gorillas sometimes also visit cultivated land and raid fields at the edge of the forest.

Although gorillas live in the forest, they leave it occasionally when looking for food in the open grassland, especially for certain trees that they regularly visit when they are in fruit (Williamson et al., 1988). Mountain gorillas occasionally climb beyond the tree line: their tracks have been found at 4,000 m altitude (Schaller, 1963).

Gorillas live primarily on the ground. They spend only 5–20% of the day in trees, whereas chimpanzees spend about 50% of the day above the ground and Sumatran orang-utans almost 100%. But gorillas do like to climb in order to play or to harvest fruit. Almost always they climb quadrupedally; only very rarely do they brachiate or jump from branch to branch. Silverback males do not often leave the ground because of their great weight. But even they will climb high into fruiting trees if the branches can carry their weight (Remis, 1999; Tutin, 1996; Williamson et al., 1990).

Gorillas do not occupy discrete territories and do not defend areas against conspecifics. Instead, they roam in so-called home ranges. Where food sources are widely dispersed, the home ranges are larger. If especially nutritious and high quality food plants are abundant, the distance between feeding sites becomes shorter. In general, the home ranges comprise several vegetation zones which are seasonally exploited. The annual home range covers about 8 km^2 in the Virunga Volcanoes, but over the years it may be much larger (Watts, 1998; 2000b). Areas of 20–30 km^2 were recorded in western lowland rain forest (Tutin, 1996; Remis, 1997a) and 30–40 km^2 in Kahuzi-Biega (Casimir, 1975; Goodall, 1977). The home range size depends on food availability and group size; the more members a group has, the further the group has to roam and the larger is the home range (Watts, 1990a; 1991c; 2000b; McNeilage, 2001). Usually, the home ranges of several groups overlap; sometimes the range of one group even lies completely inside the area of another one (Tutin et al., 1992; Watts, 1998; Yamagiwa et al., 1996).

In general, gorilla groups move an average of 0.5–2 km a day to forage, depending on habitat and food availability. However, they can move over great distances to visit trees with particularly favoured food (Goldsmith, 1999; Robbins et al., 2006). In western lowland gorillas, day ranges of more than 5 km have been observed (Doran & McNeilage, 2001).
Gorillas sleep on bare earth or in nests, which they build on the ground or in trees, depending on various factors, such as the vegetation, rainfall and temperature. Silverbacks sleep on the ground more often than the other group members (Brugiere & Sakom, 2001; Mehlman & Doran, 2002; Sunderland-Groves et al., 2009; Tutin et al., 1995; Yamagiwa, 2001). Every evening mountain gorillas construct a new nest, even if it is only a few metres from the nest they used the night before, while western lowland gorillas more often re-use their nests (Iwata & Ando, 2007). Each animal builds its own nest; only infants sleep in the same nest as their mothers. About half an hour before it gets dark the gorillas settle in the nest. Occasionally, they also build nests for the midday rest (Schaller, 1963).

To build a ground nest, the animals pull the branches of bushes and other plants into the centre, layer them and anchor them to each other. Other plants are bent in to form the nest rim. Tree nests are built mainly in forks of branches or similar structures. Females and young animals prefer to sleep in trees, whereas silverback males hardly ever do.

Gorillas forage in the early morning; they rest during the late morning and around midday, in the afternoon they forage again before resting at night. They leave their sleeping sites when the sun rises at around 6 am, except when it is cold and overcast; then they often stay longer in their nests (Schaller, 1963; Jones & Sabater, Pí 1971; Watts, 1988).

Mountain gorillas spend about half of the day eating. Rest periods take up approximately a third of the day. They spend about 6.5% of their time moving from one location to another and they are engaged in social behaviour for 3.6% of their time. Social contacts occur mainly during rest periods. Therefore, the midday rest period is very important for the social life of the group.

Like the other apes and humans, gorillas cannot swim naturally, therefore they usually avoid large bodies of water and rivers. However, often young and adult animals like to play with water or use it for various purposes, such as display. In search of food they sometimes wade through rivers and swamps on two legs with the water reaching up to their waist.

If gorillas are surprised by a rain shower, they simply stay motionless and wait for the rain to finish. If there is a cave or a similar shelter close by, they will sit underneath, but they will never use large leaves or branches to cover themselves, as bonobos and orang-utans occasionally do.

Apart from humans, gorillas do not really have enemies. The only predator to prey on gorillas is the leopard. Walter Baumgärtel found the remains of several gorillas after they had been killed by leopards in the Virunga Volcanoes. Other hints were found in Gabon and the Central African Republic (Fay et al., 1995; Klailova et al., 2013; Tutin & Fernandez, 1991).

When a group of gorillas feels threatened, the group members behave in a special way. Silverback males give off a particularly intense smell and emit characteristic vocalisations. The other animals gather together and hug each other or gather around the male. It is one of the tasks of adult males to defend their group against attacks and to position themselves between the attacker and the group. Frequently, younger males take on this duty. They drive the group away from the source of danger and attack the enemy at the same time (Fossey, 1983; Tutin & Fernandez, 1991).

1.6. Diet

What gorillas eat depends on what their habitat provides and on the time of the year. Mountain gorillas mainly feed on green plant parts as leaves, pith, stems, shoots, whereas lowland gorillas eat a lot of fruit (Masi et al., 2009). However, in the dry season only a few juicy fruits are available and so the apes have to eat more seeds and tree bark instead (Rogers et al., 1988; Tutin et al., 1997; Yamagiwa et al., 2012). Other less important (sometimes highly favoured) food items are flowers, rotting wood, seeds, roots, tubers and mushrooms. Rogers et al. (2004) summarize the most preferred food items of western lowland gorillas.

Usually, fruits grow on trees; gorillas of all ages climb these trees to harvest them. Although western gorillas eat a higher percentage of fruit than of leaves, stems, pith and shoots, they still eat markedly less fruit than do chimpanzees and orang-utans (Tutin & Fernandez, 1993; Tutin et al., 1991).

The food range of western lowland gorillas is very broad: in Gabon, they eat parts from 221 plant species, among them 97 fruit species (Tutin & Fernandez, 1993). About the same variety was found in the Central African Republic; the diversity is very high in primary and secondary forest, but much lower in montane or disturbed areas (Remis et al., 2001). They particularly like plants belonging to the ginger and arrowroot families and mainly eat the pith. In contrast, the mountain gorillas in the Virunga Volcanoes eat only 62 different plant species, mainly *Galium*, thistles, celery and nettles (Watts, 1984; 1996).

The composition of gorilla diet depends on the availability of certain plants. Fruit is a favourite dietary item in lowland areas, and leaves and the shoots/pith/stem/bark category (mainly from herbaceous vegetation) predominate at higher altitudes. Even where fruit is the main food item, herbaceous vegetation is still highly utilized. Utilisation of fruit and of herbaceous vegetation varies seasonally among lowland gorillas (Doran et al., 2002; Yamagiwa et al., 2005). In the dry season in Gabon only 30% of the diet is fruit, but for the rest of the year the percentage is 68% (Tutin et al., 1991), in the Central African Republic fruit consumption is 0% in the dry season, in the rainy season 65% for males and 41% for females (Remis, 1997b), and at Nouabalé-Ndoki, Congo Republic, fruit consumption varies from 20% to over 80% (Nishihara, 1995). Much the same seasonal variation is true for Grauer's gorilla (Yamagiwa et al., 1994; 1996).

On the mountains of the Central African Rift, bamboo forests are visited by gorillas when young shoots are growing, and bamboo is their main food item during that season. Western lowland gorillas also eat a special diet in swamps; Blake et al. (1995) found that in the Likouala swamps the *Raphia* palm was their main food. In general, gorillas also eat field crops, especially the pith of banana trees.
Among herbaceous vegetation, gorillas select more proteinaceous, less fibrous leaves; in general, the herbaceous vegetation eaten by gorillas has fewer digestion inhibitors than forest trees' foliage. Calvert (1985) found that leaves eaten by western lowland gorillas contain more tannin than in the Virungas. Possibly this tannin binds excess dietary iron or helps to maintain a healthy population of gut microbes (Remis et al., 2001). Rogers et al. (1990) found that gorillas select fruit with lower fat content than chimpanzees.

An adult Grauer's gorilla male is estimated to eat 30 kg of plants every day, an adult female about 18 kg (Goodall, 1977). For western lowland gorillas, no estimates are available. The processing of plants is very complicated sometimes, e.g. stinging or indigestable plant parts have to be removed. This was studied in detail by Richard Byrne for mountain gorillas (e. g. Byrne, 2001; Byrne & Byrne, 1993; Byrne et al., 2001).

Although gorillas do not kill big animals, they regularly eat small animals, mainly insects. Often they actively open ant and termite nests. Many authors observed gorillas feeding on invertebrates and found local traditions (Cipolletta et al., 2007; Deblauwe et al., 2003). However, animals constitute less than

0.1% of their food. In chimpanzees, up to 6% of the food may be animal matter (Tutin & Fernandez, 1992).

Gorillas ingest soil occasionally. Perhaps it contains minerals that are missing in their normal diet, or the minerals neutralize poisonous substances in their food (Williamson et al., 1990; Mahaney et al., 1995). Missing minerals may also be the reason for the ingestion of rotting wood (Rothman et al., 2006). It is not unusual for mountain gorillas to eat their own faeces, but it is observed rarely (Harcourt & Stewart, 1978).

1.7. Life history

Gorillas grow faster and breed more rapidly than do other hominids. Adults have a relatively short life expectancy; silverback males, in particular, seem to have a hard life and to die young (Groves & Meder, 2001).

Newborn gorillas are quite helpless: they cannot coordinate their movements and see very little, just as humans. The facial skin is relatively pale, whereas palms and soles usually show irregular, pale patterns on a dark skin. In many places the body hair is very sparse; the longest and densest hair is on the head. Young gorillas show the same reflexes as newborn human babies. Among them are the instinctive searching for the nipple and the clinging reflex. The latter is much better developed in gorillas because the babies have to be able to cling to the mother's body without help.

Infant development in mountain gorillas is described by Fossey (1979) and Fletcher (2001). As a rule, gorillas “mother” their infants very little. Experienced females in particular do not concern themselves much with their offspring apart from carrying, nursing, grooming and protecting them. During the first few months, a young gorilla is constantly in physical contact with its mother. At first the mother supports the baby with one hand, but even on its first day it can cling to her fur without help for a certain length of time. Physical contact with the mother starts to decrease at the latest in the baby’s fourth or fifth month, when it starts to walk quadrupedally.

Infants are usually nursed for 2 to 3 years in Virunga gorillas, which develop faster than other populations, and for 4 years in western lowland gorillas (Breuer et al., 2009). At four to six months they start to put plant parts into their mouth and to bite on them. At eight months they regularly ingest solid food (Watts, 1985). At about three years mountain gorillas start to become independent and their mother may give birth to the next baby. In spite of this, mother and older offspring maintain a strong relationship.

During the first three years gorillas are usually called infants, ages three to six are juveniles, and the subadult category begins thereafter. At eight years of age, females are adult. Males who are apparently sexually mature but have not yet achieved full size are called blackbacks, and fully grown males, whose backs have acquired the silvery “saddle” of maturity, are called silverbacks (Groves & Meder, 2001).

From its first day of life, a gorilla is part of the group. Under the protection and control of the mother it slowly grows into the community. As soon as the mother permits the others to approach, they will look at the newborn baby, smell and touch it. At latest when the young gorilla starts moving away from its mother, the other animals seize the opportunity to make contact with it. Usually, adult gorillas will hold, carry and groom the infants, while young gorillas will try to play with them (Fossey, 1983).
Reaching adulthood, female gorillas usually leave the group they were born in and join a new partner. In their choice of males, gorilla females can be quite particular: they may transfer to a new group several times before they settle down with a certain silverback male (Watts, 1990a). This decision is probably determined at least in part by the quality of the male’s home range and by reproductive success.

If a mountain gorilla mother transfers between groups while she has a baby, if a dominant male dies or if another silverback takes over the group, the baby is frequently killed by the new male (Fossey, 1984; Watts, 1989). Infanticide causes 37% of mountain gorilla infant deaths in one-male groups – the risk may be lower in multi-male groups (Bradley et al., 2005; Robbins et al., 2007; Watts, 1989). So far infanticide has been observed
directly only in the mountain gorillas of the Virunga Volcanoes and in Grauer`s gorillas, but several suspected cases were reported from western lowland gorillas (Yamagiwa & Kahekwa, 2004; Yamagiwa et al., 2009).

Free-ranging Virunga mountain gorilla males are fully grown at approximately 15 years of age, western lowland gorillas about 2 years later (Breuer et al., 2009). Like the females, many of them leave the group on reaching adulthood – in Virunga gorillas, only 45% of the males, in western lowland gorillas the majority (Stoinski et al., 2009a). After leaving, they often stay on their own until they are joined by females. Watts (2000a) discusses male mating strategies. He describes two types of males: "followers" stay in the group as subordinates and "bachelors" leave the group before they become fully mature to live without females for some time.

At an age of 35 or more, gorillas show distinct signs of age. Old mountain gorillas often suffer from arthritis, which mainly damages the bones in their hands and feet. They also suffer from the loss of teeth as a consequence of periodontitis, so that they have a problem with feeding. It takes them longer to feed and to travel than the other group members. Gorilla groups adjust their activities accordingly and look after the aged members, in a similar way as they treat sick individuals. Only when death is imminent, the old animals are sometimes abandoned or they retreat on their own accord.

To date, no exact data on the maximum age of free-ranging gorillas are available, as animals in the wild have only been observed since 1967. Some researchers assume that they can reach 60 years, but on average they probably reach 40–45 years.

1.8. Reproductive parameters

Gorillas have no mating season. Mating and births occur throughout the year. When females reach sexual maturity, they develop a hormone cycle (similar to that of humans) which is usually 26–32 days long. Female mountain gorillas can ovulate for the first time when they are about eight years old, but usually the first ovulation happens in their tenth year. Gorillas in zoos usually reach sexual maturity earlier, sometimes in their sixth year (Meder, 1993).

The female comes into estrus in mid-cycle. This can last up to four days, but usually it lasts only one day. During this phase she shows a labial swelling which generally is not very obvious. The female's behaviour and the relations with the other group members change. She approaches adult males (and occasionally females) to initiate mating, while other animals seek more contact with her.
If the egg is not fertilised, the mucous membrane of the uterus is flushed out of the body with menstrual bleeding, just as in humans. Bleeding lasts for two to three days and is considerably weaker than in humans.

In male gorillas, puberty extends over several years. This is when a blackback turns into a silverback – the silvery back, the huge canines and the other secondary sexual characteristics develop. When exactly males in the wild reach sexual maturity has not yet been determined. In zoos, occasionally individuals just under 7 years old turn out to be fertile. Czekala & Robbins (2001) found that the testosterone level increased dramatically during maturation.

Compared to their body mass, gorilla testes and penises are small: gorilla testes weigh 30–35 g, those of a chimpanzee about 120 g. As a rule, an erect gorilla penis is only 3 cm long, whereas a chimpanzee penis reaches about 8 cm (Harcourt et al., 1981).

After a pregnancy that lasts on average 257 days (humans: 265 days), gorillas usually give birth in less than half an hour and the mother does not seem to feel any great pain. However, difficult births do occur and can take up to three days. Twin births occur approximately as often as in humans (eight cases in zoos between 1966 and 2004 – twins from Kena at Barcelona Zoo). Twin Grauer`s and mountain gorillas have been observed to be raised by their mothers in the wild (Meder, 2004). Newborn western gorillas weigh between 1,396 and 3,058 g (2,200 g on average), compared to 3,300 g in humans (Meder, 1991). This means that while adult females and males weigh approximately twice and three times as much as average humans, their newborn babies are only two thirds the weight of newborn humans.

Once they have reached an age of approximately 10 years, female mountain gorillas give birth to one baby every four years; in western lowland gorillas the first parturition is observed about one year later (Breuer et al., 2009). 26% of mountain gorilla infants die in their first year (Watts, 1991b). In Kahuzi-Biega, 19.6% of the infants die in the first year (Yamagiwa & Kahekwa, 2001). In one-male groups of Virunga gorillas and western lowland gorillas, more than 40% of infants die during the first 3 years (Breuer et al., 2010).

Inter-birth intervals are at least 3 years long in Virunga mountain gorillas and about 4 to 5 years in western lowland gorillas (Stewart, 1988; Breuer et al., 2009). As most gorilla mothers have only a few offspring who survive to adulthood, gorilla numbers increase only very slowly. One mountain gorilla mother had six surviving offspring (Watts, 1991b). Another female gave birth to eight babies, but only two of them reached sexual maturity. The fertility of free ranging mountain gorilla females has not been observed to decrease with old age.

1.9. Social structure

Gorillas generally live in groups, only adult males may stay solitary for some time. The high cohesiveness of a group is usually attributed to the attractiveness of the leading male to females (Yamagiwa et al., 2003). Adult male-adult female relationships are considered to be the “core” of the social group; they vary depending on kinship, length of tenure and reproductive status. Male aggression to females is common and often can be regarded as “courtship aggression”. It is higher if the female is in estrus; females usually respond submissively (Bradley et al., 2005; Robbins, 2003).

Usually a gorilla group consists of one adult male, several females and their offspring. However, in mountain gorillas a large percentage of all groups include more than one adult male (they are often related to each other); in the other gorilla taxa, this seems to be rare (Magliocca et al., 1999; Robbins, 2001; Yamagiwa et al., 2003; Yamagiwa et al., 2012). The dominant male has a higher testosterone level than the subordinate (Czekala & Robbins, 2001; Stokes et al., 2003). In multi-male groups, the subordinate males often sire offspring too and females often copulate with more than one male during estrus (Sicotte, 2001; Stoinski et al., 2009b). Adult females usually prefer the leading male and subadult females are more likely to mate with subordinate males (Bradley et al., 2005; Robbins, 1999; Watts, 1990b).

As groups contain more females than males, many males are “left over”. They roam the forests as loners that make up 5–10% of the gorilla population (e.g. Magliocca et al., 1999). Solitary males may travel very long distances (Douadi et al., 2007). Virunga gorilla males occasionally form all-male groups that usally contain one mature male and a few younger males (Harcourt, 1988; Yamagiwa, 1987a). In these groups, males stay closer together than males in heterosexual groups; they show more affiliative, homosexual and aggressive behaviour but their aggression is less serious (Robbins, 1996). They seem to be transition units in both gorilla species (Gatti et al., 2004; Levréro et al., 2006).

Gorilla groups can have very different histories (Robbins, 2001). If the dominant male dies, the group may disperse if no subordinate silverback is there to take over the leadership; if there are two younger silverbacks, the group may split. Stable groups without a silverback that were led by adult females for up to 29 months have been observed only in Grauer's gorilla so far (Yamagiwa et al., 2003).

One way a new one-male group starts is by a female transferring from her natal group to a lone male. This seems to be even more common in western lowland gorillas than in mountain gorillas (Parnell, 2002; Stokes et al., 2003). Growing offspring of either sex usually leave their natal group. Females always join another group or a lone male, whereas male gorillas usually turn into loners. In mountain gorillas, 72% of the females leave their natal group, usually as young adults; some transfer several times between different groups (Sicotte, 2001; Watts, 1996) In Kahuzi-Biega, the simultaneous transfer of several individuals was observed (Yamagiwa & Kahekwa, 2001; Yamagiwa et al., 2009). Western lowland gorillas behave very similarly (Stokes et al., 2003). When related females live in the same group, they tend to treat relatives differently than non-relatives. They spend more time in proximity to kin when feeding or resting, groom kin more, are less aggressive towards them, and aid them more in agonistic encounters (Bradley et al., 2007; Watts, 1994).

Most of the males leave their natal group, also usually as young adults. The separation process is slow: they spend more and more time on the edge of the group until they leave altogether. In contrast, a female leaves her group only if she encounters another male. The home ranges of various gorilla groups and of lone silverbacks overlap, so encounters are frequent. Lone males often make a special effort to seek out harem groups, as this is their only chance to gain females. The leaders of stable groups avoid contact with other adult males in order to avoid losing females. If they detect a competitor, they try to drive him away by displaying or attacking (Yamagiwa, 1987b; Watts, 1991b).

In a gorilla group there is a clear hierarchy (Watts, 1996). The leading silverback has the highest rank, and adult females are dominant over young animals. Among the females, rank depends on factors such as how long they have been in the group, for example (Watts, 1991a; 1994; 2001). Among the young animals, rank usually depends on age. Social bonds in unrelated group members are strongest between females and silverbacks.

A gorilla male achieves his high-ranking position not only because of his strength, which he proves when fighting against competitors, but also because of his experience and abilities. For instance, he has to know the area very well in order to lead his group to the right feeding sites at the right time of the year. These days, it is also very important that he knows how to deal with humans. Experienced gorilla males can, for example, remove poachers' snares from the hands or feet of their group members (Fossey, 1983). As young males lack the necessary experience, they will find it difficult to lead a group. If the females notice that their silverback is too inexperienced, they will transfer to another one. In the Virunga gorillas, the mean length of tenure of a dominant silverback in a group is 4.7 years, in western lowland gorillas 5.9 years (Breuer et al., 2010; Robbins, 1995).

The size of gorilla groups is very variable but similar in the subspecies, usually it lies between 3 and 42 individuals. An average group contains about 9–10 members (Gray et al., 2013; Parnell, 2002; Yamagiwa et al., 2003). The largest group observed so far was Pablo's group in Rwanda with 65 members. It is possible that Virunga mountain gorilla groups can become larger than those of other populations because plenty of herbacious vegetation – their staple food – is constantly available (Robbins et al., 2006).

Young animals always search out the group leader who usually is their father as well (Stewart, 2001). They frequently stay close to him, they lean on him and include him in their games. For them a close relationship with their father can be vital. He protects the infants and his care increases their chances of survival if their mother dies or if she leaves the group. In such a case the silverback is usually the only one who looks after them intensively. He even allows them to sleep in his nest.

As gorillas live in dense rain forest where group members often cannot see each other, they use mainly vocalizations for communication. In accordance with their role as group leaders, silverbacks are the ones to vocalize most frequently (Harcourt & Stewart, 2001). Sounds called “grunts” and “barks” in many variations are the gorillas’ most important vocalizations (Harcourt et al., 1993). They indicate the whereabouts of individual group members and can accompany social interactions. On average, adults make eight such vocalisations per hour, most often during travelling. Group members probably recognise each other from these sounds.

However, body postures and facial expressions also indicate the gorillas’ mood. Certain behaviour patterns involve certain body postures and often require another animal to do something. Postures signalling mood or intention to the partner are sometimes even used for communication over greater distances; this is particularly true for display behaviour.

Silverbacks are famous for their display behaviour culminating in the chest beating and loud hooting (Schaller, 1963). The chestbeat sounds especially impressive in silverbacks. Because of their sharp canines and great strength, they are very dangerous opponents. Severe aggression is rare in stable gorilla groups, but when two mountain gorilla groups meet, the leading silverbacks can sometimes engage in a fight to the death, mainly using their canines to cause deep, gaping injuries (Fossey, 1983; Sicotte, 1993). In western lowland gorillas, however, groups often intermingle peacefully (Magliocca & Gautier-Hion, 2004; Tutin 1996). Male agonistic displays during dyadic encounters are strongly correlated with the number of females present (Caillaud et al., 2008).

1.10. Conservation

In their natural habitat, gorillas are threatened by many different factors, such as

- isolation of gorilla populations in small forest islands,
- destruction of the forest through deforestation, fire or mining of mineral resources,
- hunting for their meat,
- hunting for fetishes and trophies,
- hunting in revenge for crop-raiding,
- injuries through snares set for other animals,
- war and its consequences,
- stress caused by the constant presence of people,
- diseases transferred by people or domestic animals.

Eastern gorillas are threatened by extinction if no effective measures are taken to protect them; western lowland gorillas are considered less threatened.
Many national parks have been established to protect the gorillas and rangers hired by the authorities. However, enforcing the protected status of large areas is not sufficient: the forests and their occupants can only be protected if local authorities and people support these efforts. Activities to ensure the conservation of gorillas have been summarized by Oates (1996) and analyzed by Tranquilli et al., 2011). Permanently updated information on ape distribution, research, threats and conservation is available on the A.P.E.S. Portal: http://apesportal.eva.mpg.de/
In some areas, authorities have been trying to set up controlled tourism as a means to conserve the gorillas. In the Virunga Volcanoes, this has probably helped to save the mountain gorillas from extinction, but tourism may cause severe problems too (Butynski & Kalina, 1998; McNeilage, 1996; Palacios et al., 2011; Robbins et al., 2011; Sandbrook & Semple, 2006).
As gorillas are very sensitive to changes in their environment, the mere presence of humans can be a threat. Even in the Virunga Volcanoes, gorillas are continually disturbed: cattle herds, loggers, collectors of grass and honey, smugglers and poachers are active in the national parks in spite of strict laws. In many areas, the exploitation of mineral resources is an additional disturbance.

Poachers set traps, in particular wire snares, in order to catch duikers. However, gorillas get into the snares too and often they don't succeed in removing the wire. In such a case they can lose a hand or a foot, or even die from gangrene. Veterinarians are sometimes able to remove the snares in those groups habituated to people.

The hunting pressure on Grauer's and western gorillas is very high. They are still killed for their meat by the local human population, although this is illegal. In addition, local hunters and farmers often kill gorillas because they raid the fields. One gorilla group can destroy the whole harvest.

Another problem is the increasing destruction of the gorillas' habitat. The deforestation of the rain forests leads to the isolation of small forest islands, to which the animals are now confined because there is no adequate habitat close-by (Junker et al., 2012). In 1959, Emlen and Schaller (1960) considered this problem critical for the survival of the eastern gorillas. In the meantime, the wars, refugees, political turmoil and the looting of natural resources are more immediate threats in the eastern gorillas' distribution area, and have led to a mass-slaughter of Grauer's gorillas. This slaughter is still going on. Gorilla orphans are also traded in this area.

In the Congo basin, forests still are disturbed through timber harvest by logging companies and cleared to make way for cultivation. Roads, initially built to transport the timber, subsequently facilitate the settlement of the forest. In its turn, this leads to increased hunting to provide the workers with food and slash-and-burn cultivation. Bushmeat (including gorilla meat) is frequently transported into the cities with the timber transports (Ammann, 2001; Bowen-Jones & Pendry, 1999; Remis, 2000). This trade has developed considerably during the last few decades. At the moment it is the most imminent danger for all gorilla populations except for the mountain gorillas (Kuehl et al., 2009).

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SECTION 2: MANAGEMENT IN ZOOS AND AQUARIUMS

2.1. Accommodation: *Gorilla Accommodation*

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2.1.1General remarks

2.1.1.1 Climate

While in the EEP region as a whole, a combination of inside and outside enclosures is a basic requirement for the keeping of gorillas, it should be remembered that the climatic conditions within the region differ considerably. When gorillas are kept in warmer climates and therefore spend much

more time outdoors, there can be more of an emphasis placed on promoting outdoor activities by providing ropes, platforms, climbing apparatus etc.
Shade is also an important element in such climates and should dominate the exhibit.

On the other hand in the more northern parts of the EEP region it is to be expected that the gorillas will spend much of their time inside. The size and complexity of the inside accommodation in these colder regions should exceed their counterparts in warmer climes. Outside enclosures there should be predominantly sun exposed, although an aspect of shade is still required.

2.1.1.2 Sex ratio and enclosure size

Measures to reduce the problem of "surplus males" (see chapter 2.9) have the following consequences with regard to the accommodation:

The accommodation for a group with a breeding nucleus of one male and two to three females should take into account that this group can potentially grow out to a group of about ten individuals.

Subadult and young adult males tend to challenge their fathers and can be the cause of social stress for all group members. The accommodation should be large enough for gorillas to avoid these conflicts and complex enough to provide for safe flight routes and areas out of one another's line of vision.

Young adult males can only be kept in their natal group until the social situation becomes critical. Since it may take a while before a final destination for such a male will be found and transport is arranged, this accommodation should be suitable for long-term housing of at least two adult individuals and there should be separate facilities available to accommodate lone animals.

Separation space is also required for housing old over-represented silverbacks with accompanying animals. In the case of a bachelor group, separation space is required for housing males that are not (any longer) compatible with the other males.

Bachelor groups are also very dynamic not only in terms of their hierarchy but because animals in the group can be traumatised (e.g. animals move in and out of the group).

Considering all these issues each new gorilla facility has to be as flexible possible. Therefore it is an essential requirement for holders with a new facility to have at least two inside and two outside enclosures with several smaller separation areas, regardless if they are planning to keep a breeding or bachelor group.

2.1.1.3 Providing plans and information for the species coordinator

Size is only one important aspect of the quality of an enclosure.
In the last years, there has been a tendency to build large enclosures. It is of primary importance for zoos planning to reconstruct their gorilla enclosures or build new enclosures for gorillas to contact the species coordinator as early as possible. Relevant persons of the species committee will check the plans and then decide on their request to receive gorillas for their enclosure. All new exhibits must include a separate unit (indoors and outdoors) for keeping an old silverback with a female or a male that is not compatible with the group. This additional unit should be interconnected to the unit of the main group. At least two sliding doors are needed for the connection in order to avoid animals being cornered. Doing this makes it possible for the main group to use both units as long as there is no need to separate individuals in the additional unit.

2.1.2 Indoor accommodation

2.1.2.1 Functions

The indoor living space for gorillas serves a number of **functions**:

- To provide space for the extended family unit **to live together during the day** in the winter, when the climate makes the outside enclosure unsuitable for the gorillas. As long as the climate permits, it is preferable that the gorillas have free choice between the use of this inside room and the outside enclosure.

- To provide space for the gorillas **to over-night**. It is preferable that the family unit spends the night together in the same space. However there may be special reasons to separate one or more gorillas from the group during the night: during introductions or periods of social instability in the group it may be better not to leave the group unobserved together for the night. There may also be veterinary reasons to separate an animal for the night.
  During nights, gorillas appreciate the company of their group members, but also require a certain degree of privacy. They should not be deprived of the opportunity to build their sleeping nest at a preferred distance from other group members. Although sleeping is a behaviour that does not seem to require much space, housing the gorillas together during the night in a space that is too small, will lead to social stress, conflicts and difficulties for the keepers to bring the animals together in this space (Weiche, 1999).

- To provide space for the gorillas **to be shifted to** when the other areas are being serviced.

- **To introduce** new members into the group. Introductions require an arrangement of the various rooms that can easily be changed. By providing either double wide mesh or completely closed separations between various combinations of rooms the introducee (the animal being introduced) can be given the possibility to see, hear, touch and smell the other group members, or only one or more selected and separated individuals. It is preferable to give the introducee the possibility to withdraw from the view of the other group members. When the animals are actually brought together, the facilities must allow a circular pattern of movement between rooms and should not include places where individuals can get trapped. The use of selective doors between rooms and selective barriers within rooms can give a smaller gorilla a quick escape from a bigger pursuer.

- **To quarantine** gorillas when this is legally required just before or after transportation to a new locality, or for veterinary reasons. However, for the mental well-being of the gorilla it is preferable to avoid the use of quarantine (isolation), in particular when a single animal is concerned. This should be taken into account when the decision to transfer an animal is made.
  For veterinary reasons it is much better not to have the quarantine in the same building or even within the same facility as the family group. In most cases this will also be the legal requirement.

- **To separate** animal long term when this is necessary, until a solution for them is found. Such accommodation should provide proper housing for one or more individuals over a longer period if needed, and ensure good standards of care. This extra accommodation should be able to accommodate two or three individuals and can also be used to house an old silverback with some company when he is no longer allowed to breed for reasons of overrepresentation. In order to avoid the possible stress caused by the presence of a nearby competitor (another silverback), it should at least be possible to reduce the visual, olfactory and auditory contact between the inhabitants of the extra accommodation and those of the main enclosure to a minimum.

- **Medical care**. It is preferable that immediate medical care takes place in a separated area in direct contact with the general holding area. If sedation is required, the cage should not be too high to avoid accidents when being sedated or waking up.

2.1.2.2 Combining the rooms

Any gorilla accommodation should provide space for the above mentioned functions. It is of course possible to use rooms for some of these functions or to subdivide rooms in order to create a more complex living environment for the inhabitants. All these rooms should be arranged and connected in such a way that it is always possible to move a gorilla between any spaces, without limiting the use of the other spaces. When the gorillas are given free access to a number of the rooms, there should always be at least two corridors between any two of the rooms occupied. By opening the appropriate corridors, the rooms can be arranged to form a circuit. In such a way one single animal is not able to block the passage between the two rooms, or chase another into a dead end. It is preferable that containment barriers between combined rooms are such that the gorillas have a choice to maintain visual contact or hiding from view while being in the other room.

Other functions for the inside space can be:

- **To display** the gorillas to the public when climate conditions restrict the use of the outside enclosure, or when the gorillas choose to be inside, then they have a choice to do so.
- To provide accommodation **to hand rear** young ones. See Chapter 4 Management
- **To restrain** gorillas for medical examination or transport. With the advances made in the use of anaesthetics, the use of squeeze cages has considerably diminished.
- To provide **linkages** from one space into another. Transfer chutes, either overhead (across keeper corridors or public roads) or on the floor, should be approximately 1 metre by 1 metre with mesh on all sides (or glass above public). Long transfer chutes should be sectioned by one or more doors. Each section should also have a door for access by staff.
- To provide opportunities for **training sessions**. For this purpose a special off-exhibit room could be considered. Alternatively special access points for safe interaction between keepers and gorillas with good visual opportunities (light) could be created.

2.1.2.3. Observation facilities

The keepers should be able to easily observe the gorillas in any part of the inside areas. This can be achived by the use of windows, mesh or by cameras. Being close relatives to humans and having complex behaviour, gorillas are sought after subjects for ethological studies. On the other hand, the management of this species can greatly benefit from the presence of observers. It could be considered to provide special facilities for observers when designing gorilla facilities. Observation can also be enhanced by means of video cameras and recorders. Even if a decision to use these cannot be taken for financial reasons at the time of designing the facility, at least the conduit-pipes and cables could already be installed.

2.1.2.4. Boundary

See section on containment barriers (7.3.2.) for outside exhibits. Steel barriers should be non-corrosive (stainless steel, or hotdip) and securely attached. The possible deformation of steel fence elements through regular pounding on the fence with the full weight of a 200 kilogram silverback should be seriously considered. Welded weld mesh boundaries should be checked regularly for signs of damage.

All barrier materials should be non-absorbent and easy to clean and/or disinfect if needed.
Ceilings can either be kept out of reach of the animals or can at least have the same characteristics concerning strength, moisture resistance cleaning accessibility as the walls. Additional strength should allow for the use of hanging furniture and enrichment items. A wire-mesh ceiling is suitable for this purpose and in addition provides excellent possibilities for roof feeding. In particular in inside enclosures, the use of windows as barriers can dramatically increase the size of the visual environment of the gorillas and provides a view on neighbouring groups, keepers, public and the surroundings outside. Windows definitely reduce stress and are great enrichment.

2.1.2.5. Floors and substrate

For the purpose of easy cleaning, concrete or epoxy floors should preferably be sloped approximately 4%. Drains should be placed outside the actual enclosure wherever possible. To allow for good cleaning and disinfection, the use of special coatings should be considered, but care should be taken in its choice. Coatings can either make a floor too smooth, forcing the inhabitants to move about in a careful, cramped gait, or too abrasive.

For the recommended use of deep (60 centimetres) bedding, the floor and drainage system can be designed in such a way that it is possible to close the drain and fill the floor with a layer of water, deep enough to have the water standing above the bedding. This will help to counter the possibility of mice or even rats in the bedding.

Those who consider a biofloor for their gorilla enclosure are advised to get in touch with Dr. Marianne Holtkötter, Stuttgart Zoo for the results of the Great Ape TAG biofloor survey.
The main conclusions from that survey are:
IF you plan a biofloor, take care of the following things:

- doors and sliding doors should be high enough above biofloor level to work properly
- bringing in and removing biofloor substrate should be technically easy (corridors and access to enclosure for tractors, ramp, possibility to blow substrate in …)
- It should be possible to remove the biofloor completely in case of diseases
- drainage system (to avoid dust, raise humidity, and control pests, you must water the biofloor!)
- pest control
- Great Ape TAG veterinary guidelines: do recommended tests before introducing a new animal!
- Detergent: biodegradable?

Deep bedding of bark creates a comfortable floor surface for the inhabitants, helps to increase the levels of humidity of the enclosure and provides enrichment when combined with scattered food. It also improves the quality of the air by removing bad smells. Access to allow for easy exchange of the bark bedding, possibly with a machine, should be provided for. (See also Chapter 8 Veterinary guidelines and Bloks, A., *Ouwehands Dierenpark, Onderzoek naar verschillende vormen van zelfcomposterende stalbodems voor in dierentuinverblijven.*Geffel: 2000.)

2.1.2.6. Furnishings and Maintenance

2.1.2.6.1. Furnishings

For gorillas, environmentall complexity is probably the most important aspect of their enclosure. They like to have tactile contact with surrounding structures when they rest and appreciate the opportunity to find a private corner. This environmental complexity can, in the case of inside enclosures, be attained either by connecting several rooms or by using furnishings like sight-screens, climbing structures and different levels in order to subdivide the main living area. Climbing facilities like wooden pole structures, ropes, nets and larger platforms optimize the possibilities for the gorillas to use the entire space available. It is very important to highlight that all ropes and other climbing apparatus have to be maintained regularly as the strands may separate and present a strangulation risk to the animals. Fire-hoses, if available, are a safer alternative to ropes as they are more difficult to chew and can be used to make very comfortable hammocks. It should be kept in mind that adult gorillas are essentially ground dwelling primates, and while climbing structures like tree trunks, ropes, poles etc. will enrich the enclosure for the play of younger animals, the actual increase of the effective size of the enclosure can best be acheived by providing platforms suitable for knuckle walking, the typical gait of gorillas. Very young gorillas are less proficient in their climbing activities and it should be ensured that sufficient climbing facilities with diameters adjusted to their size of hands and feet are provided.

Variety in the furnishings and enrichment items offered increases repertoires of behaviour. Variety helps to give different areas and spots different functions and allows for different physical activities. Favourite areas for sleeping, playing, feeding etc. can be provided. A corner between walls and screens on the floor with soft bedding, a platform of ca 1.5 m² or a hammock can be good places for resting. For play chases, complete chest beating displays etc. gorillas also need a more open area. Sight-screens, selective barriers etc. help to reduce social tension by providing opportunities for quick flight or hiding. The variety of ideas for behavioural enrichment is enormous. Many of them can only be applied when integrated into the architecture of the building. The opportunity to integrate such elements in the design of a new or renovated enclosure should not be missed. A large number of attachment-points, such as eyehooks, should be provided. These can be placed on walls, floors, ceiling but also on the furniture.
Access for easy exchange of furnishings and enrichment items and for refilling food-dispensers should be considered (see chapter 4.9.).

Gorillas should always have access to fresh water. Drinkers are the best way to provide this.

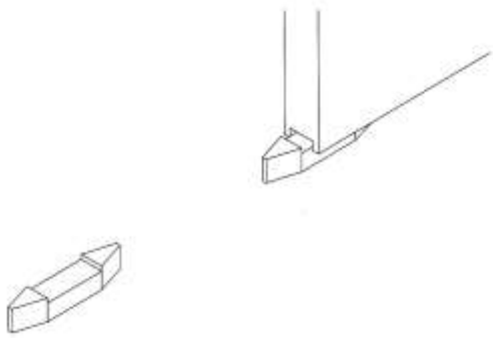
Hollow spaces inside artificial rockwork, trees etc. can be ideal places for mice and rats. They should either be filled, completely closed or open so that they can easily be cleaned.

2.1.2.6.2. Maintenance

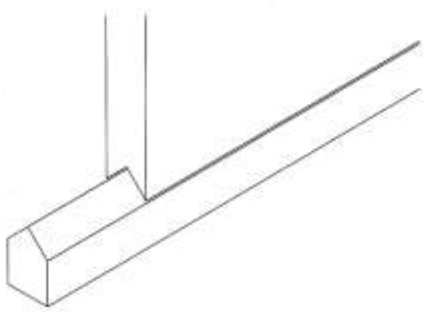
2.1.2.6.2.1. Doors and service access to the enclosures

Doors between enclosures should all have an extra security mechanism to prevent gorillas from opening the doors themselves. In designing the mechanism for opening the doors between enclosures, it should be kept in mind that gorillas might move the door with great force while a keeper is opening or closing the door. In some designs, parts of the mechanism might hit the keepers and injure them. In particular manually operated, horizontally sliding doors are particularly at risk. They should preferably move away from the keeper when being opened.

Cables, which are often used for vertically moving sliding doors, should be well protected. Nevertheless the condition of the cables should be checked frequently, similarly with other moving parts and attachments like bolts and nuts. Some gorillas bounce frequently on doors with great force, and in time even the strongest bolts can become weak. The same mechanism that prevents gorillas from opening a door with a cable, could also be used to prevent the door from falling down uncontrolled in case of a broken cable. For safety reasons keepers should not be forced to come within reach of the gorillas in order to operate the doors.
Bedding can often block a door and protect it from operating properly. The design of the door can be such that the collection of bedding in the door-opening can be limited. The door opening can be raised in the wall, so that bedding does not reach the door (this also allows for a change to deep litter). Horizontally sliding doors of the type hanging from wheels in a rail on the topside, should be guided by torpedo guides or guiding wheels instead of in a guide channel. Doors sliding horizontally with support on the bottom side could slide over a ridge rather than inside a channel (see drawings).



Sliding door with torpedo guides



Sliding door on a ridge

The design can also be such that bedding is moved away by the moving door, or at least that the door can be locked in an "almost close" position. In that case a keeper can enter the room on the safe side of the door and carefully remove the bedding from that side

Ideally, keepers must always have a complete view of the full opening of the door when opening or closing it either directly or by means of cameras. Hydraulic doors should be such that the movement of the door stops instantly when the keeper lets go of the button. Before the keeper opens the door giving access to the service area adjoining the enclosures, they should have the means to visually check through a small window or mesh that this area is safe to enter.

There are different kinds of mechanisms for sliding doors: mechanical, hydraulic, pneumatic and electric. Doors must allow either visual contact, limited physical contact or no contact to facilitate different management of the individuals when needed. In those areas where the introduction processes are done double slide doors should be very useful with one solid slide and one mesh slide. It should be possible to safely lock the doors in different positions, to allow selective passage of, for example, all but the silverback or the youngsters only.

Doors should generally be at floor level; however several different floor levels can be combined within one enclosure. A recommended size would be 80 cm wide x 100 cm high.

Normal access doors should be wide enough to allow for access with a wheelbarrow and high enough for any person to pass upright. In practice 1.20 m wide and 2.2m high will be sufficient. Official building regulations may require a greater height.

In order to replace deep bedding materials, soil, exhibit furniture or technical service equipment, additional service access should be made larger. Recommended width is at least 3m.
In some cases, service access for cranes must be planned and maintained over time to replace furniture and landscape materials.

There should be good visual access into all areas of the facility both indoors and out.

Details of the doors and doorframe should be carefully considered regarding their strength. If gorillas have access to doors, there should be at least 3m of non climbable surface between the doors and the top of the enclosure.
The doors should be locked at least at two, preferably three different heights. Locks should be kept out of reach of the gorillas.
Doors should open into the enclosure
Doors should be self locking (slam lock) (Fig. 1)

Fig.1 Self locking doors

2.1.2.6.2.2. Capture and handling facilities

For the purpose of medical examination or treatment or for transport there are various ways to capture a gorilla. The use of squeeze cages is no longer recommended by the TAG.

Squeeze cage: moveable walls of this type of cage make possible to investigate or handle the gorilla without the need to use anaesthetics. Since the use of anaesthetics has become much safer**, it is no longer recommended to use the often very stressful squeeze cages**. Once a gorilla has had the experience of being squeezed, it is not likely to enter the cage again voluntarily.

Allowing a gorilla into a transport-crate of his own free will can be a stress free method of capturing an animal. The best way of doing this is by installing the transport-crate, well secured, to a door of a separate holding room, and conditioning the gorilla to get his/her food in the crate. Once the gorilla is fully used to being in the crate, the crate can be closed. One disadvantage of this method is that it requires the gorilla concerned to be separated from his/her group for some time, which can cause stress. Another disadvantage is that in existing facilities where this procedure was not taken into account during the design phase, the crate can block essential access to part of the facility. In many cases a date for the transport has to be set well in advance. Conditioning the gorilla to the crate could take more time than expected in which case the method should be changed (to the use of anaesthetics) or the transport postponed to a later date.

Primates quickly learn to associate the presence of the veterinarian and the blowpipe with the unpleasant experience of being anaesthetized. Still, this seems a safe and quick way. Also, in the case of transportation, this method allows the opportunity to check the condition of the gorilla, take blood-samples for DNA analysis. It is important that there are no hiding places in the room, that the gorilla cannot climb and possibly fall after being anaesthetized and that there is a good layer of straw or other soft bedding on the floor, but not enough for the gorilla to hide under. An anaesthetized gorilla can be carried by the use of stretcher; a piece of canvas with handles on the edges or with seams in which long poles or tubes can be put. Such a hammock can also be used for weighing the gorilla.

For details on transport-crates see chapter 4.7. Since a transport-crate for an adult male can be 120 cm x 100 cm x 160 cm (l x w x h) and weigh (empty) ca 300 kg or even more it is advisable to provide access for a fork-lift to the service area, preferably to the area where the transport-crate will be placed. (see IATA Regulations–International Air Transport Association: container nr.34 for adults and nr. 33 for young gorillas)

2.1.2.7. Environment

2.1.2.7.1. Lighting
In addition to the natural light from well protected sky-lights and/or windows (think of the risks of broken glass falling into the enclosures) full spectrum High Frequency fluorescent lights or halogen HQI lights should be used. In their natural habitat gorillas always encounter variation in light levels. A choice between light (550 lux or more at ground level) and shaded places (ca 300 lux at ground level) might be beneficial to them. If necessary an additional light system could be provided for. This should create good working light conditions for servicing the enclosures, even in areas normally kept shaded for the gorillas. The colour of the lights can have a psychological effect on the gorillas. A colour spectrum of 5500-5600 K is most similar to that of natural sunlight.

When climatic conditions allow for very limited access to the outside area, insufficient exposure to UV light may lead to vitamin D3 deficiency. This can be overcome by feeding vitamin supplements, but since vitamin D3 is not transferred in the milk from mothers to nursing babies, they may still become deficient for this vitamin at a time at which they badly need it. Exposure to UV tube lights can help to solve the problem. It is best to use a very low intensity type of tube light so that it can be switched on for several hours a day without becoming harmful. Remember that the spectrum of such lights quickly changes and that the tubes should be replaced at regular intervals as indicated by the manufacturer. Also the distance between light-tubes and gorillas is essential. Whereas a distance that is too short can be harmful, a distance too long will not be effective.

All lights should be protected.

2.1.2.7.2. Temperatures
Inside temperatures should not exceed 30º C. During the colder season heating should provide for an average temperature of 18-20º C. In autumn and spring, when the outside temperatures may just allow access to the outside enclosure (minimal 7º C when rainy and cloudy, minimal 3º C when sunny and without wind), the inside temperature should be kept a few degrees lower than normal to reduce the difference in temperature between the inside and the outside. If the gorilla group is exhibited in an outside enclosure with no access to an inside area, one has to evaluate the weather conditions before allowing the gorillas to go outside. Rainy, windy, cloudy days and temperatures below 13ºC are conditions under which gorillas should not remain outside for a long period of time.

2.1.2.7.3 Ventilation
Instead of determining ventilation requirements in terms of air changes per hour, Besch (1980) recommends the use of rate per animal. A rate of ca 40 m^3 per individual per hour is suggested.
Apart from refreshing the air, the flow of air can also help to improve the even distribution of

temperature within the building; however, draughts should always be avoided.

2.1.2.7.4. Humidity

Relative humidity with the recommended temperatures during the colder season can range between 50% and 90%. A deep bedding of bark helps to increase the humidity.

2.1.3. Outside exhibits

2.1.3.1. Enclosure size

See 2.1.1.2
There are several persuasive arguments for a large outside area for gorilla enclosures:

- Gorillas have a need for privacy and can show preferences for keeping a distance between themselves and certain or even all other gorillas when they wish.
- A typical aspect of gorilla behaviour is that they move around as a group, guided by the silverback. Taking preferred individual movements into account, smaller enclosures do not allow for the entire group to move around, only individual movements within the group are possible.
- A large enclosure makes it possible to create different habitats in different parts of the enclosure, each large enough for the entire group and still maintaining their individual distances. The gorillas can choose their preferred part of the enclosure, which may vary with the time of day, season or even over the years. Allowing gorillas to make their own choices is a valuable aspect of their well-being.
- The more complex the enclosure, the more likely that young males can stay in the group until they are eleven or twelve years of age or even longer. This is the natural process and the best education for future silverbacks it also helps to reduce the male surplus problem.
- The larger the enclosure, the greater the opportunities for having good and varied vegetation without the need for protection. Varied vegetation is an enormously valuable form of environmental enrichment.
- It increases the possibilities for a mixed species exhibit.

2.1.3.2. Boundary

Containment barriers are the primary determinant of the shape and appearance of the exhibit and can represent the most expensive portion of an outdoor exhibit. Gorillas are neither great jumpers nor great acrobats, but they are strong and agile climbers. Although some individuals like to play in or with water, gorillas cannot swim and therefore may fall into wet moats and drown if they are not designed properly.

Combinations of barrier types can be employed, depending on factors such as site conditions, construction access, viewing opportunities, and landscape replication. Aesthetic considerations may encourage some variation in height. However, while not necessarily continuous by type, minimum barrier dimensions should be kept continuously around the enclosure's perimeter. In selecting barrier types, it is important to consider their varying psychological impact on the animals. The perception of available space can be enhanced, as can the ability to escape from public view.

The concept of flight distance must be considered in enclosure design. There must be adequate depth and visual cover for the animals to establish their individual flight distances. Reducing the intrusiveness of viewing opportunities should reduce flight distance in these areas, for example, by heavily planting viewing areas.

2.1.3.2.1. "U" shaped dry moat

Dry moats, made of "U" shaped parallel walls (Fig. 2), are not preferred for gorillas as there is a risk of gorillas falling into the moat. Although this risk can be limited by using a proper substrate like chopped pine bark, this type of moat may still be dangerous.

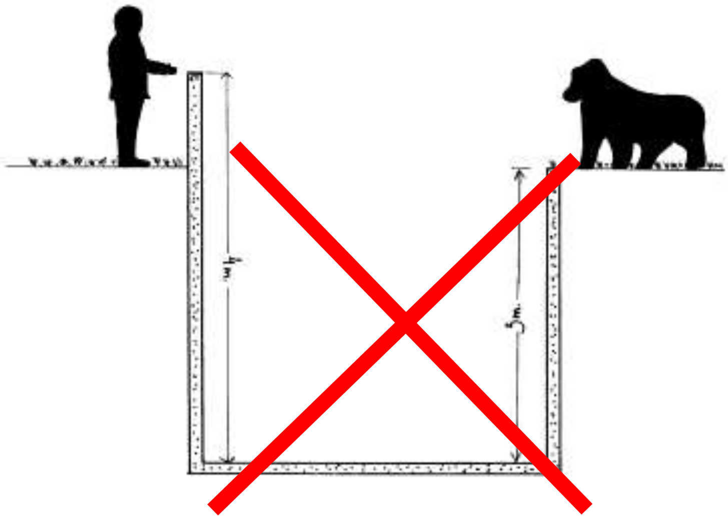


Fig. 2

2.1.3.2.2. "V" shaped dry moat

If the enclosure, or some part of the enclosure is surrounded by a "V" shaped dry moat (Fig. 3), then the vertical part on the visitor's side has to fulfil the same criteria (distance from climbing structures, minimum height) as in the cases of the other walls (see below). The animal's side of the moat should be shallow and gradually deepening. If the animals can go into the shallow moat, it will give them additional space.

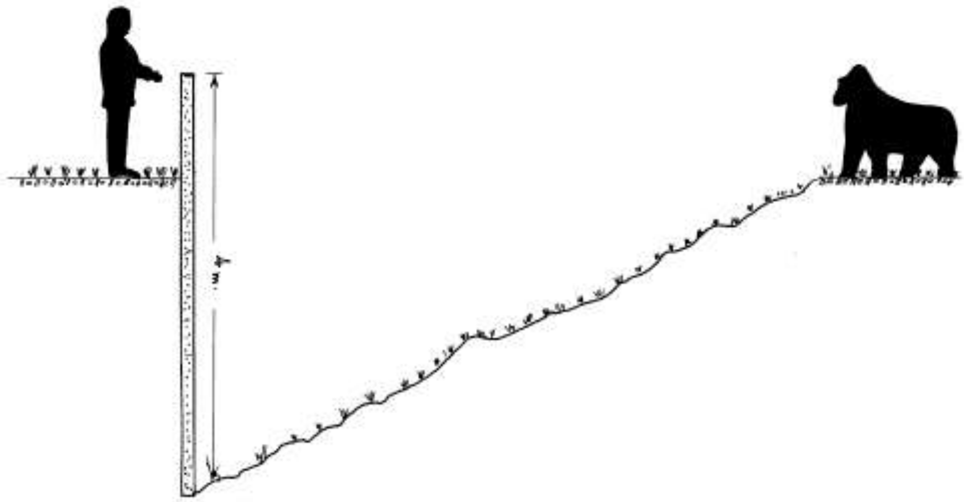


Fig. 3

2.1.3.2.3. Wet moat

Wet moats look natural and are aesthetically pleasing barriers, which puts more distance between animals and visitors however they require a lot of space. Wet moats should NOT be considered when little space is available for the exhibit, because they take up space that could otherwise be available to the animals.

Shallow, wet moats have been used successfully with gorillas, but there are potential safety problems. To avoid escapes or tragic events such as animals falling and drowning in a wet moat, it has to be properly designed. Field research has shown that most gorillas in the wild do not ford deep water and are not able to swim. However, some animals like to go into the water to play or to collect food.

Some gorillas have in the past crossed moats because they haven't been deep or wide enough. It's probable that no gorilla is likely to cross over a 6 m wide moat. But 6m is close enough to provoke an attempt to cross the moat, in special circumstances, like internal conflict or when the behavior of the visitors on the other side is provocative. Many silverbacks clearly react to visitors as if they were intruders and spend large parts of their day close to the moat (or window), positioning themselves in between their group and the visitors. They frequently display and clearly get agitated. Many visitors love this exiting behavior and do their very best to stimulate it. It may affect the health and even welfare of the male, his role inside the group, and from an educational point of view it is much better to show gorillas behaving naturally rather than continuous interaction with the visitors. Therefore the appropriate width of the water moat is an essential requirement and it is also very important having an additional planted strip along the moat on the visitor's side, to increase the distance further.

On the basis of all these issues it is very important that the wet moat has to be 6 m wide with an additional 1 m marshy area and 2 m deep on the public side,because then it is less steep and therefore much safer for animals (Fig. 4). The additional 1 m of marshy area will force the gorillas to slow down, so they cannot run into the moat at full speed, reach the deeper parts and inadvertently get out of their depth.

It is highly recommended that chain linked mesh or some type of net made out of rope, firmly attached to the moat floor, on the animal side, so that if the animals slips or falls into deeper water they can grasp it and climb back. In some cases the wet moat can be combined with electric wires. In these cases, it is better to have the electric wire or fence in the middle of the moat or on the public side, rather than on the animal side. The major argument for this is that if an animal jumps or falls over the wire into the moat, it might drown, as it will be afraid to pass the wire to go back onto the island.

Gorillas may drink from the water in the moat; therefore, it must be of a reasonably good quality.

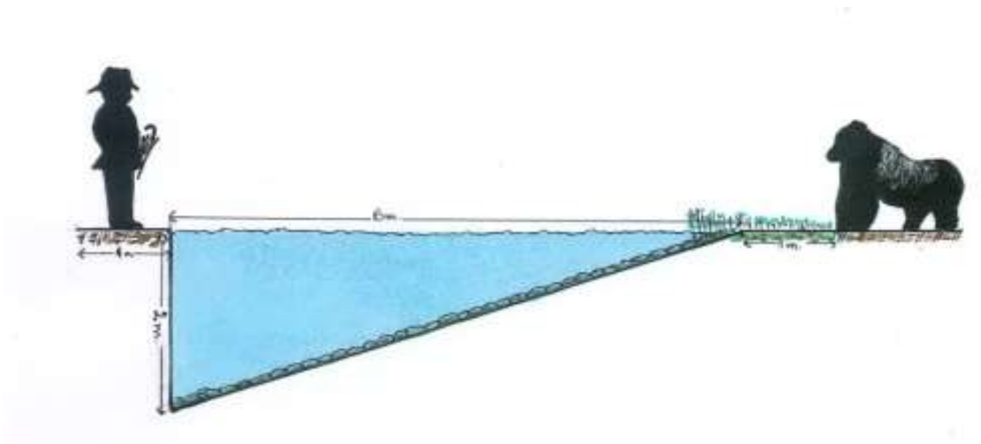


Fig.4

2.1.3.2.4. Walls

The goal is to create non-climbable walls. The texture must be relatively smooth to prevent foot or finger holds. Doors with their hinges, or nuts and bolts, which are used for attaching constructive elements to the walls, may be critical points. Overhangs may be added to prevent scaling. The layout of the walls should avoid perpendicular or acute angles to adjoining walls to prevent "shimmying" out, or they should be capped at these dangerous intersections.

The advantages of walls are that they take up very little room and can be less costly than moats or glass viewing scenery. The disadvantage is their visibility, which is usually disguised with artificial rockwork, friezes, paintings and heavy, protected planting, thereby increasing their cost. Although walls take up very little horizontal room, they minimise the vertical climbing space of the animals. The distance from climbing structures to the walls should be at least 4 metres, to prevent leaping out. Vertical climbing space is important for gorillas, and for smaller walled enclosures, it is therefore better to make a wire-mesh roof. The recommended minimum height of the walls should be 4 metres.

Completely enclosed wall space can be very stressful for gorillas, as they can often hear noises without seeing where they are coming from Therefore, each wall should have several windows. An additional disadvantage of the completely enclosed wall is that wind cannot cool the enclosure when the temperature is very high.In zoos, we try to instil in the visitors a respect for animals, and it has been shown that visitors have less respect for animals if they can only see them from above. They can easily throw food or other objects in the enclosure, and they can spit on the animals. All these behaviours are a threat to the health of the animals. Finally there are several cases of careless visitors, mainly children, falling over the edge of walls into enclosures (Jersey Zoo and Brookfield Zoo, Chicago). Enclosures that allow the visitors to see the animals from above are therefore not recommended for gorillas.

2.1.3.2.5. Glass walls and glass windows built into vertical walls

Glass walls are often used as barriers in order to provide close-up visitor experiences, however, they are expensive. To reduce the cost, a potentially good option is to use smaller glass windows built into vertical walls. They can protect the visitors from the debris that apes may throw, and they also protect the animals from food items and other material, which the visitors may throw into the enclosure. In some cases they can also serve to protect the animals from different infectious diseases, which may be transmitted by visitors or vice versa.

Sometimes the very close-up contact provided by glass walls can be stressful for gorillas, especially for silverbacks. They seem to be provoked to defend their group and therefore they will constantly display to the public. Planting a vegetation belt between the visitors and the glass wall can reduce this.

To avoid unwanted reflection it is useful to tilt the glass sheets a little bit towards the animals or to put a shading overhang above the visitors or to plant thick vegetation behind the public, which eliminates not only the reflection, but provides a more naturalistic environment as well.

The thickness of the glass sheets may vary between 30 and 50 mm, depending on the sheet size. On average 42 mm thickness is reliable. Glass sheets can be built into the vertical walls, or can be combined with electric wires running across the top of the glass panels. Minimum height always should be 4 metres (Figure 5a. 5b. and 5c). The use of glass walls should be limited to one or two sides of the enclosure, so the gorillas can have some areas where they can be out of the view of the public.

Because any glass is potentially breakable, consideration must be given to the ease of replacement. Acrylic panels are less breakable, but scratch easily, therefore they are not the best options for the gorillas. Practical experiences show that the different types of laminated glass seem to be the best solution so far. Other considerations when dealing with glass are the colour or tint and the possible use of one-way glass. A further aspect, which should be considered, is the possibility of condensation forming on the windows after cold nights that will make it impossible to see the animals. Windows that catch the morning sun will show fewer problems with condensation. It also helps if, once the cold in the air is gone, the windows are cleaned with hot water.

High-quality viewing window can help reinforce the message of respect for these animals. However, these visual gains may be offset by the loss of auditory and olfactory available to the visitors.

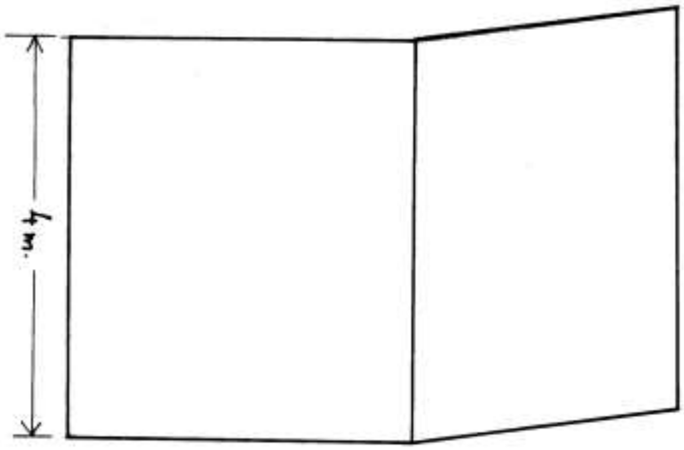


Fig. 5a

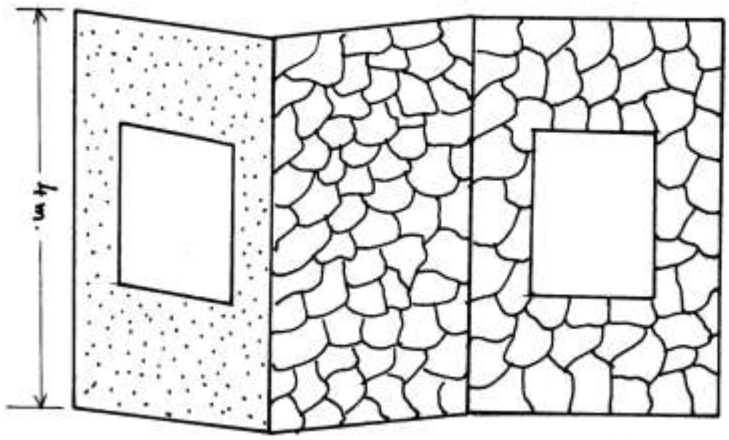


Fig.5b

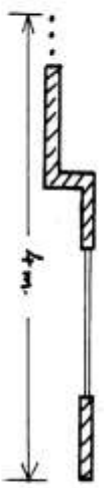


Fig. 5c

Figs. 5a, 5b, 5c Minimum high 4m

2.1.3.2.6. Fencing or steel mesh structures

Steel mesh enclosures can be large outdoor exhibits made of structural steel columns and beams with in-fill panels of mesh, or post-and-cable structures with less rigid forms. Because these are total enclosures, barrier distances are limited to the size of the mesh openings. In these enclosures, gorillas can use all areas as climbing opportunities. Weldmesh, or equivalent material, ceilings are useful for enrichments like ropes, and the facilitation of roof feeding which is also beneficial for the animals.

There are many forms of mesh available, each with associated advantages and disadvantages regarding viewing and structural characteristics. In smaller exhibit areas, these enclosures with accessible sides and ceilings allow the animals to use more of the volume of the exhibit. Further, because furnishings such as trees cannot be used as escape methods, this barrier increases the flexibility with which such furnishings can be used. While the posts and beams (or cables) are more intrusive to the viewer, they may be disguised with tree forms and perimeter plantings. Some zoos have been successful using fences with solid overhangs or expanded metal with mesh too small for gorillas to climb through.

2.1.3.2.6.1. Physical characteristics of the mesh:

See 2.1.2.4

To avoid gorilla-visitor contact, the public should be kept at some distance, or glass panels should be placed on the visitors' side to reduce the potential for disease transmission. Besides the possibility of two-way disease transfer between gorillas and the public, a second objection against the use of fences is their aesthetic appearance.

Several types of mesh or bars can be used. For instance:

- Chain link mesh: Should not be used for Gorilla enclosures.
- Welded hot dipped steel mesh: (see Fig. 6a) Mesh width ca 50mm x 50-100 mm, steel thickness 7-10mm, welded in a frame of rectangular tubes
- Hot dipped pressed woven mesh: (see Fig. 6b) Mesh width ca 50mm x 50 mm, steel thickness 5 mm, welded in a frame of rectangular tubes, 35mm x 35mm at least, openings of the frame 500mm x 1000mm or less.
- Mesh from stainless or chrome steel rods: (see Fig. 6c) Mesh width: 45mm x 95mm, steel thickness 5 mm.
- Mesh made from stainless steel cables.

There are essentially two types of this kind of mesh: one in which the cables are interwoven at the crossings. This means that the actual strength of the mesh is actually that of half the diameter of the cable.

The second type of this kind of mesh has small tubes (galvanised copper) to hold the cables together at the crossings (see Fig. 6d). This type of mesh was successfully applied for orang-utans, bonobos and chimpanzees and should also be suitable for gorillas. A mesh width of 60mm within the reach of humans (either visitors or keepers) and 100mm outside of human reach, i.e. for the roof, should be suitable with a cable thickness of 3mm.

- Solid steel bars 15-16mm in diameter, center distance 30-56 mm, distance between transversal bars (flattened steel or rectangular tubes) 440-700mm.(see Fig. 6e)

Fig. 6a 

Fig. 6c 

Fig. 6d 

Fig. 6e 

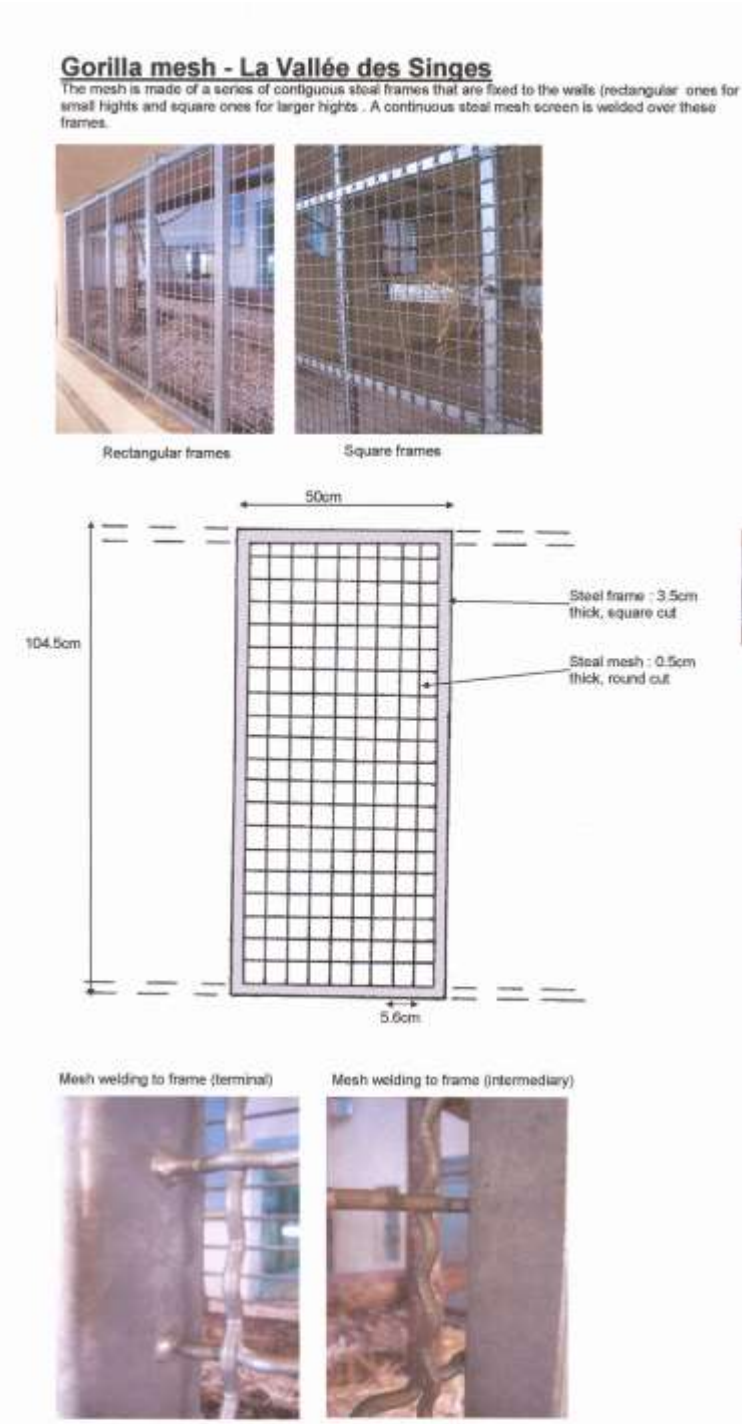


Fig. 6b

2.1.3.2.7. Electrical fences and secondary barriers

Electrical fences

Thus far, electrical fences are not recommended as the primary barrier for gorillas as it will be difficult to provide the gorillas with branches for browse, since they may use these to destroy the wires.

Secondary barriers

High voltage electric fencing has been used successfully in gorilla enclosures to:

1. Maintain protection around vegetation areas.
2. Discourage use of moated out-of-view areas,
3. As insurance on top of barrier walls and fencing.

2.1. 3.2.8. Barriers between the enclosures

It is very important to protect the gorillas not only from visitors, but also from unwanted or stressful neighbouring animal enclosures. Extra outside enclosures with additional gorilla groups or other silverbacks can be separated using the same types of barriers as with enclosures in general. It is important to create almost full visual barriers between the enclosures, with only a few “restricted viewing” areas, in order to provide an opportunity for the animals to escape the attention and the gaze of the other individuals or other species in the neighbourhood. These visual barriers can be made by planting high vegetation between the enclosures, or by building a screen from vertical stumps or rockwork. In such cases, the distance from climbing structures to the screen should be at least 4 metres.

It is however recommended not to keep other gorillas in directly neighbouring enclosures. The greater the distance between them is the better. At times, the presence of other great apes in the neighbourhood may be disturbing or even stressful for the gorillas. This may be the case with chimpanzees in particular, which can be quite noisy and which like to throw different things into the neighbouring enclosures during theirdisplay. Such kinds of unwanted attention can be avoided if there is a distance of at least 10 to 15 metres between the enclosures, and if there aremore visual barriers in place than are generally used.

2.1.3.2.9. Substrate

It is strongly recommended to only use natural substrates. Leaf litter, bark shavings, exposed roots, thickets, brambles; marshes, packed earth and cultivated field are examples of the complexvariety of substrates which can be used to recreate the natural landscapes that would be found in the wild. For enrichment it is important to have several types of substrate in an enclosure.

2.1.3.2.10 Furnishing and Maintenance

2.1.3.2.10.1. Furnishing

Physical complexity includes not only the well-designed topography and the landscape, but alsogood furnishing as well. In a good, naturalistic outside enclosure use of primarily natural materials isrecommendedsuch as deadfall trees, stumps and logs, reversed old roots, and rocks. Branches can serve not only as an important forage food, but also as a very useful furnishing and play thing.

Furniture has to be designed to fulfil the basic behavioural requirements of different sex and age groups. Adults show a higher degree of display and nest building behaviour, while young animals enjoy and are more likely to play. Young or subordinate animals need to be able to escape the attention of adults. Each individual needs occasional privacy, to be out of view from other gorillas or from visitors. Good furniture should serve this requirement as well.

Although adult gorillas are primarily terrestrial primates, recent research has shown that western lowland gorillas are arboreal as well. Therefore they need trees to climb on. This is especially true of the young individuals. For this reason the diameter of some climbing structures should fit to the needs of the young animals as well. Whereas high vertical climbing structures will often be used by young individuals, adults will prefer lower and more horizontally placed structures, in particular those that allow for knuckle walking such as heavy tree trunks etc.

Furniture and climbing structures should be strong and massive, but easy to replace. Dead trees, different wooden constructions, vines and ropes all are excellent climbing structures; these could include artificial trees, fibreglass poles and fire hoses.Large rope nets and strong linen sacks are good for climbing and nesting, and they can serve as a shade as well.

2.1.3.2.10.2. Maintenance

2.1.3.2.10.2.1 Exhibit access

People

Access to the exhibit needs to be provided for daily cleaning, as well as for more infrequent service. As exhibits mature and change, theirlong-term success depends upon the degree of flexibility built in to the original concept. Vehicle and equipment access for grading, landscape maintenance, replacement and earthwork machinery should be included. While these service ports may not be used frequently, they will allow for ongoing improvements. In some cases, service access for cranes must be planned and maintained over time to replace furniture and landscape materials as decay and safety concerns are revealed.

Windows between the keepers' area and the outside enclosure will allow keepers to keep an eye on the gorillas. A small area with steel mesh will allow the keepers to individually give extra food or medicine while the gorillas are outside. This can be very useful when introducing a hand raised young gorilla.

Animals

Regarding animal access to an outdoor exhibit, preferably more than one animal door to and from more than one inside cage should be provided to prevent one animal from denying access to others. When positioning these doors, most designers go to great lengths to screen them from the public; however, it should be noted that previous research has showed that the majority of gorillas in the study spent considerable time in the area adjacent to the holding buildings. These spaces can either be made visible (while somehow still screening the buildings) or they should be made less appealing as rest areas by, for example, making them slope steeply.

2.1.3.2.10.2.2. Outside separation enclosure

Just like for the inside enclosure (chapter 7.2.1), additional (second) outside enclosure in also needed to permanently separate gorillas when this is necessary, until a destination for them is found and a transfer can take place. Such accommodation should provide proper housing for one or a few individuals even over a longer period if needed. This extra accommodation should be able to accommodate two or three individuals and can also be used to house an old silverback with some company when he is no longer allowed to breed for reasons of overrepresentation. In order to avoid the possible stress caused by the presence of a nearby competitor (another silverback), it should at least be possible to reduce the visual, olfactory and auditory contact between the inhabitants of the extra accommodation and those of the main enclosure to a minimum.

2.1.3.3 Environment

2.1.3.3.1. Landscape, topography and vegetation

Gorillas are very demanding animals with regard to the environment. Well-designed, naturalistic enclosures can elicit species-appropriate behaviour, which are primary conditions for the health and well being of animals. The physical complexity of the enclosure is also a very important issue. An enclosure with different elevations is much better than a completely flat area. Small hillocks with or without rock outcroppings can provide silverbacks with places to observe, guard and display. Additionally, although gorillas are very social animals they occasionally also need a bit of privacy; therefore, the hillocks can also serve as visual cover from other gorillas as well as from visitors. Differing elevations is important, but it is not good to have an entire enclosure on a slope because gorillas prefer to sit or to sleep on a flat area. They will not like an enclosed space that is too steeply sloped.

The sunny and the shaded areas should alternate within the enclosure, so the animals can choose where to go. In warmer climates, such as in the Southern European countries, the emphasis should be on shade- a few small, shaded places will not be sufficient.
Plants and vegetation are very important for dividing the terrain in a natural way, and provide nesting and foraging material for animals. Gorillas especially prefer several varieties of herbs. Bushes, shrubs and trees can be protected by electric fences, fibreglass or metal bark wraps. If the enclosure is large enough and the vegetation is well chosen and abundant, it may not be necessary to employ such protective measures.

Importantly, poisonous plants have to be removed and controlled on regular basis. For the further details about the suitable vegetation please refer to the EAZA primate plant compatibility database, developed by Sergio Pacinotti for the EAZA Zoo Horticultural Group. This database can be found on **zooplants.net.**

2.1.3.3.2. Shelter and hiding places

Shelters and hiding places are strongly recommended for shade and protection from heavy rain, severe weather or blazing sun. Hiding places should provide privacy from other individuals and from thepublic. Hiding places also should be set up preferably so that they cannot be monopolised by high-ranking animals.

2.1.3.3.3. Water source

Clear water must always be provided. This can be done by automatic faucet drinkers or by a natural or artificial waterfall with a small pool. Water pools should be made from safe and solid materials, which can be cleaned easily. Concrete with resin or clay liners are preferable over plastics and rubber.
While in general gorillas have a tendency to avoid water, some individuals may touch or immerse themselves in and play with water. Therefore, waterfalls or shallow pools can enrich their behaviour and increase their daily activity. The introduction of water in streams and pools adds a tremendous dimension to the daily environmental experience for both gorillas and visitors.

2.1.4. Bachelor facilities

The surplus of male gorillas, which are either temporary or permanently overrepresented to the population, is a growing issue in the captive breeding programme. In fact, most zoos starting with gorillas will receive only males, as females are rarely available. Surplus males are often kept in bachelor groups, and zoos starting with keeping gorillas should therefore build an enclosure that is suitable for a bachelor group. What are the main requirements for a good bachelor enclosure?
1) Flexibility
From our experiences with bachelor groups, we have learned that these groups are often less stable than a breeding group. Animals, or subgroups of animals sometimes have to be temporary separated, and the enclosure should be flexible enough to do so. Therefore, a bachelor enclosure should have at least two, but preferably more large rooms. There should be at least, but preferably more than two outside enclosures. All inside and outside enclosures should be connected to make shifting of animals easy.
2) Security
There is a high risk of disputes in a bachelor groups. Enclosure should not have corners where animals can be trapped during fights. There should be multiple circulation routes within the enclosure. The use of (long) tunnels between different enclosures should be avoided. High numbers of climbing structures, both vertical and horizontal, can make escape easier.
3) Privacy

The presence of visual barriers within and between enclosures will decrease the amount of aggression between animals. A bachelor enclosure should preferably not be in visual, olfactory or auditory contact with an enclosure of a breeding group.

4) Functionality

The composition of bachelor groups changes more often than that of breeding groups. Males leave either due to aggression or because they need to be transferred to a breeding group. New animals will arrive from other bachelor groups or from breeding groups. Therefore the enclosure should have good facilities for the introduction of new animals. These facilities should make monitoring of the situation, and if necessary intervention by the keepers necessary. Initial contact should be possible through wire-mesh, while it should be possible to safely lock interconnecting the doors in different positions, to allow selective passage of, for example, all but the silverback or the youngsters only. A good introduction facility could consist of three rooms of 20 to 25m², not higher than 4 meters; within each connecting wall two slides. All three rooms should have a wire-mesh font to make observations and interventions possible, and there should be abundant structures. A “biofloor” or thick layer of straw could prevent fractures during the domination process.

5) Size

Although flexibility is more important than size, multi-male groups do need large spaces to be able to avoid each other, especially when making aggressive display charges.

6) Other design components

Other important components that need to be considered are providing access of all group members to key resources, providing high structures for dominant animals, creating safe zones for subordinates and complex vertical spaces. It has been reported that a bachelor group of gorillas exhibited more aggression in the presence of large crowds than did the mixed-sex group at the same facility. Possibilities to retreat from the visitors are therefore indespendable.

Zoos that are designing an enclosure for a bachelor group are advised to read the article by Coe et al (2013) and the publications they mention in the references.

2.1.5. Mixed species

There is an increased tendency to house other species together with gorillas. It enriches the environment of both species and often provides at least one of the species with a much larger area than would be the case when housed separately. Even when housed together outside with great success, it might be difficult to combine the species’ in the generally smaller inside facilities. The use of selective passages, either to parts of the enclosure or to neighbouring enclosures, could improve the chances to successfully house several species together. When designing a new facility it seems wise to leave both options open: housing the species separately or combined in the inside accommodation.

2.1.6. References

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2.2. Feeding: *Gorilla Nutrition*

F. Cabana, A. Fidget, E.Krebs & W. Kaumanns

2.2.1. Introduction

Apes are known to be selective in their food choices, choosing relatively energetically dense foods when they are in season (Doran-Sheeny et al., 2006). Gorillas may be characterised as folivorous-herbivorous primates. They extensively forage on the ground, but also in trees (Schaller, 1963; Denham, 1979; Williamson et al., 1990). According to Hladik (1979) they obtain most of the protein in their diet from leaves. Following Ripley (1984) gorillas can be best described as intensified folivores.

Due to their special feeding ecology, gorillas in zoos require special diets which obviously are not easy to find. Gorillas in zoos occasionally suffer from nutritionally induced health problems – possibly as a consequence of diets high in sugar and low in fibre. Obesity is observed often and tooth decay is a widespread problem (Ruempler, 1992). Furthermore, regurgitation and reingestion (R&R) of food is widespread in zoo individuals. It has never been reported from wild populations. Not much research has been done on gorilla diets to date. In particular there is a lack of data available on the nutritional needs of this species. Therefore, only preliminary recommendations on diets can be given.

2.2.2. Morphology

Gorillas have a typical hindgut fermentation gastrointestinal tract (GIT). This is characterised by an enlarged and highly ciliated large intestine, which helps digest normally undigestible plant fibres, and provides the gorilla with energy and nutrients (Milton, 1984; Remis, 2002). Furthermore, their colon is structurally complex with little chamber like folds called haustra (Stevens and Hume, 1995). These structures facilitate the digestion and fermentation of gut contents by increasing the gut retention time of digesta (Caton, 1999; Stevens and Hume, 1995). This digestive system archetype is typical of herbivorous hind-gut fermenters. Their dentition is adapted to their diet which includes many tough, hard plant parts (Strait, 1997). Their dental cusps are hypothesised to specialise in breaking open cell walls to release the nutritive cellular interior (Janis and Fortelius, 1988; Elgart-Berry, 2004).

2.2.3. Feeding Ecology

The first studies on feeding ecology of gorillas focused on the mountain gorilla and the eastern lowland gorilla (Schaller, 1963; Fossey & Harcourt, 1977; Goodall, 1977; Harcourt & Stewart, 1978, 1984; Vedder, 1984; Watts 1984, 1989, 1990; Mahaney et al., 1990, 1995; Casimir, 1975; Yamagiwa & Mwanza, 1994; Yamagiwa et al., 1991, 1994). The feeding ecology of the western lowland gorilla has only been studied quite recently. Recent studies demonstrate that there are significant differences between the species and subspecies, respectively. The taxa particularly differ in terms of amount of fruits consumed. Gorillas are supposed to be “scramble adapted” (Van Schaik 1989). Food is abundant and visibility between individuals during foraging might be low due to dense vegetation. Therefore access to food is possibly not regulated by hierarchical structures.

2.2.3.1. Mountain Gorilla

Mountain gorillas are primarily folivores that show considerable specialisation on plant parts, species and families (Schaller, 1963; Harcourt & Fossey, 1977; Vedder, 1984; Watts, 1984; McNeilage, 2001). Watts (1984) reports that mountain gorillas forage on no more than 38 different plant species (see table 1). A more recent study, McNeilage (2001) observed the gorillas in the Karasoke area feeding on 54 different plant species. However, this area is characterised by having the highest gorilla food biomass in the Virungas (Robbins et al. 2011). The food type eaten in greatest quantity is galium (*Galium ruwenzoriense*), followed by thistles (*Caruus nyassanus*) and stems of celery (*Peucedanum lineri*), bamboo (*Yushania alpine*), blueberries (*Rubus spp.*) and nettles (*Laportea alatipes*). Although the mountain gorilla habitat is characterised by a general richness of plant species, these six plant species are eaten in the greatest quantity and account for up to 87% of the overall mountain gorilla diet, depending on location (Watts, 1984; McNeilage, 2001).
A similar specialization is found in the plant parts ingested: although mountain gorillas usually eat more than one part (leaves, stems, flowers, roots, barks, pith, fruits etc.) of each species, leaves provide 67% of the diet, stems 25%, and pith another 2.5%. The mountain gorilla’s diet varies little between individuals and little in association with factors like seasonality, but it varies markedly in association with variability in the plant composition of the habitat (Vedder, 1984; Watts, 1984). In locations where many hard stemmed plants occur, they will be consumed more readily (23%) than in areas with soft stemmed plants (9%) (Elgart-Berry, 2004). The opposite is true for leaves which are preferred younger and immature (Elgart-Berry, 2004). There is an important exception to non-seasonality in food intake: bamboo (*Arundinaria alpina*) is ingested only during the dry season, and if available mountain gorillas prefer *A. alpina* shoots over most other foods (Fossey, 1983; Vedder, 1984; Cousins, 1988). Similar to other foods preferred by mountain gorillas *A. alpina* contains a high amount of protein (Casimir, 1975).

	plant species consumed	plant parts consumed	fruit species consumed	% fruits feeding time	seasonality in fruit species consumption	invertebrate consumption	study location	source
mountain gorilla (*Gorilla beringei beringei*)	38	NA	3	1.2 %	no	no	Central Virunga, Rwanda	Watts (1984)
	22	31	NA	NA	NA	no	Central Virunga, Rwanda, Uganda	Vedder (1984)
	54	NA	NA	NA	yes	no	Karisoke, Central Virunga, Uganda	McNeilage (2001)
eastern lowland gorilla (*Gorilla beringei graueri*)	26 / 30 *)	32 / 38 *)	4 / 0 *)	NA	no	NA	Kahuzi-Biega NP, Dem Rep of Congo	Casimir (1975)
	121	194	48	25 %	yes (minor/major fruiting season)	yes	Kahuzi-Biega NP, Dem Rep Congo	Yamagiwa et al., (1991,1994)
western lowland gorilla (*Gorilla gorilla gorilla*)	50	69	NA	NA	NA	NA	Campo, Cameroon	Calvert (1985)
	104	89	72	67 %	NA	yes (termites)	Belinga, Gabon	Tutin & Fernandez (1985)**
	134	182	95	55 %	yes	yes (3 ant species)	Lopé Reserve, Gabon	Williamson et al. (1990)**
	>186	>71	>42	NA	yes	NA	Lopé Reserve, Gabon	Rogers et al. (1990)
	152	182	123	63.2 % (Nov-May < 40%) (Jul - Oct > 70%)	yes (fruiting / non-fruiting season)	NA	Nouabalé-Ndoki NP, Republic of Congo	Nishihara (1995)
	129	230	77	51 %	yes	yes (9 invertebrate species)	Danzaga-Ndoki NP,Cental African Republic	Remis (1997)

Table 1: Number of consumed plant species, plant parts and fruit species of three gorilla subspecies. (NA = data not available; *) = primary/secondary forest)
**Study was seasonal and did not look at a full year.

In comparison to lowland gorillas the diet of mountain gorillas seems to be characterised by a very low proportion of fruits (Fossey & Harcourt, 1977: 1.7%; Watts, 1984: 0,2%). The proportion of animal protein is supposed to be low (Harcourt & Harcourt, 1984: 0,01%; Watts, 1984). Although Watts (1989) observed ant eating by mountain gorillas in a few cases, the author suggests that the intake may be not of nutritional importance. General preferred food item selection is also known to be based on high abundance and high sugar content (Ganas et al., 2008b). More specifically, leaves with relatively high concentrations of protein, fat, phenols and soluble carbohydrates and low levels of cellulose while the pith was preferred with high amounts of soluble carbohydrates (Ganas et al., 2008a). Chapman et al. (2004) found a significt relationship between the high protein/fibre ratio and preferred food items.

Among the mountain gorillas of the Virungas and the eastern lowland gorillas in the Kahuzi region geophagy has been reported several times (Goodall, 1977, Fossey, 1974, 1983). Fossey (1983) mentioned geophagy as a seasonal behaviour, mainly during the dry season when the intake of bamboo increases. The digestive tract of the mountain gorilla does not show the typical alteration for detoxification of plant compounds by fermentation (Fossey & Harcourt, 1977). The mountain gorilla's high selectivity in choice of the ingested plant species and plant parts may be regarded as an adaptation to the toxicity of secondary plant compounds (Casimir, 1975, Mahaney et al., 1995; Ganas et al., 2008b). Mahaney et al. (1990, 1995) suggest that ingesting soil may provide mountain gorillas with an important source of essential minerals or trace elements and additionally may help them to absorb toxins.

Mountain gorillas are the least arboreal of the gorilla taxa (Doran & McNeilage, 1998). Goodall (1977) reports that during foraging on the ground mountain gorilla groups often spread out over distances of up to 200 metres, and sometimes split into subgroups.

2.2.3.2. Lowland Gorillas

2.2.3.2.1 Overview

Lowland gorillas consume a wide variety of plant species: in comparison to the mountain gorillas their diet has a much higher diversity of plant species i.e. mountain gorilla: 38 plant species (Watts, 1984); eastern lowland gorilla: 121 plant species (Yamagiwa et al. 1994);western lowland gorilla: 198 plant species (Tutin et al. 1991). Nevertheless lowland gorillas are considered to be very selective feeders (Rogers & Williamson, 1987; Williamson et al., 1988).

2.2.3.2.2 Eastern Lowland Gorillas

In terms of feeding ecology **eastern lowland gorillas** are assumed to be intermediate between mountain and western lowland gorillas (Yamagiwa et al., 1994). No detailed nutritional analysis of the diet of free-ranging eastern lowland gorillas is available. Herbs (terrestrial herbaceous vegetation, THV) seem to form an important part of the diet, but fruits are also consumed. In the Itebero Region (Democratic Republic of Congo) fruits form nearly 25% of the total number of ingested food items. Many kinds of fruits (44%), but also leaves (48%) and bark (53%) are only eaten seasonally. Yamagiwa et al. (1994) distinguished between the ‘major-fruiting’ season, which coincides with the short rainy and the short dry season, and the ‘minor-fruiting’ season during the long rainy and the long dry season. In response to the decrease in fruits during the minor-fruiting season, eastern lowland gorillas tend to eat more leaves and bark from terrestrial herbaceous plants (*Zingiberaceae* and *Marantaceae*). Although the variety of fruits consumed by eastern lowland gorillas was high (fruits from 48 plant species), Yamagiwa et al. (1994) reported that the largest amount of ingested fruits came from only two tree species (*Syzygium guinense* and *Myrianthus holstii*). The authors report that gorillas in the Itebero Region tend to eat ripe fruits (Yamagiwa et al., 1994).
Eastern lowland gorillas feed regularly on invertebrates such as ants (Yamagiwa et al., 1991, 1994). Fragments of six ant species were found in faecal samples of all age-sex classes (Yamagiwa et al., 1991). The frequency of insect-eating did not appear to change seasonally (Yamagiwa et al., 1991, 1994).

2.2.3.2.3 Western Lowland Gorillas

The natural diet of the **western lowland gorilla** is characterised by a high number of plant species and in particular by a seasonally high number of fruit species (see table 1). Compared with *Gorilla beringei,* their habitat is less abundant in herbaceous plants, however the opposite is true for fruiting trees which are present is considerable amounts yet only provide food seasonally (Doran and McNeilage, 2001). Sabater Pi (1977) reported that the gorillas of Rio Muni Region, West Africa consumed 55% leaves, pith and tender shoots, and 40% of a wide variety of fruits. The amount of non-reproductive plant parts consumed increased dramatically when fruit were not in season (Williamson, 1989).
Detailed nutritional analyses show that the diet of the western lowland gorilladiffers from the diet of the mountain gorilla and the eastern lowland gorilla. Furthermore, within western lowland gorillas local differences in diets have been found (table 2).

	diet ①	**diet ②**
Leaves	N = 8	N = 16

Crude protein [%]	16.6	18.4
Gross energy [kcal/g]	4.7	NA
Fat [%]	4.5	2.6
Carbohydrate [%]	27.5	3.9
Acid detergent fibre [%]	42.6	28.9
Lignin [%]	19.4	NA
Total phenols	5.4	5.7
Condensed tannins	7.3	14.6
Dry matter [%]	22.6	31.3
Stems	N = 11	N = 12
Crude protein [%]	6.7	7.7
Gross energy [kcal/g]	3.7	NA
Fat [%]	3.4	1.4
Carbohydrate [%]	26.6	8.0
Acid detergent fibre [%]	44.4	44.9
Lignin [%]	11.3	NA
Total phenols	1.3	1.83
Condensed tannins	0.5	4.7
Dry matter [%]	13.4	28.4
Fruits	N = 8	N = 46
Crude protein [%]	6.3	5.2
Gross energy [kcal/g]	4.7	NA
Fat [%]	6.2	3.2
Carbohydrate [%]	20.4	34.8
Acid detergent fibre [%]	44.8	23.7
Lignin [%]	26.9	NA
Total phenols	2.2	4.1
Condensed tannins	2.0	8.8
Dry matter [%]	30.0	28.9
Seeds		N = 9
Crude protein [%]	NA	10.6
Gross energy [kcal/g]	NA	NA
Fat [%]	NA	4.0
Carbohydrate [%]	NA	7.9
Acid detergent fibre [%]	NA	24.6
Lignin [%]	NA	NA
Total phenols	NA	8.3
Condensed tannins	NA	12.7
Dry matter [%]	NA	43.4
Shoots	N = 5	
Crude protein [%]	11.9	NA
Gross energy [kcal/g]	4.0	NA
Fat [%]	3.0	NA
Carbohydrate [%]	4.9	NA
Acid detergent fibre [%]	52.0	NA

Lignin [%]	11.3	NA
Total phenols	1.3	NA
Condensed tannins	0.0	NA
Dry matter [%]	11.0	NA

Table 2: Plant parts consumed by western lowland gorillas at two study sites: Campo, Cameroon (Calvert, 1985 = **diet ①**) and Lopé Reserve, Gabon (Rogers et al., 1990 = **diet ②**). Comparison of content across plant parts (geometric mean). NA = data not available.

Rogers et al. (1990) found that western lowland gorillas in Gabon feed preferentially on young leaves, which are relatively higher in protein and lower in fibre than mature leaves. Immature leaves contain less secondary components such as condensed tannins, which adds to why they are preferred (Rogers et al. 1990).

On the other hand Calvert (1985) reports that the western lowland gorillas in her study at Campo, Cameroon preferred mature *Musanga cecropioides* leaves over immature ones. She showed that the immature leaves were lower in protein, energy, and digestibility; and higher in lignin than mature leaves. Leaves consumed by western lowland gorillas contain more condensed tannin than those consumed by mountain gorillas. Western lowland gorillas in Gabon seem to tolerate a certain intake of phenolic compounds (Rogers et al. 1990).

In Mondika (Congo), western lowland gorillas have a clear seasonal diet (Doran et al., 2002). Between November and February, the availability of fruit is low so they subsist mainly on leaves, *Celtis bark* and herbs such as *Aframomum spp.* and *Palisota spp.* When the rainfall increases, between April and June, the gorillas respond by eating a large amount of fruit and a lower variety of herbs. The main herbs kept in their diet were *Duboscia macrocarpa, Klainedoxa gabonesis* and the common *Myrianthus arboreus*. Rainfall is at its highest between July and September where fruit consumption peaks and non-reproductive plant parts are rarely eaten. Protein rich *Haumania danckelmaniana* was still eaten is appreciable concentrations (Doran et al., 2002). It was reported by Doran-Sheehy et al. (2009) that *H. danckelmaniana* and a *Hydrocharis spp.* accounted for 10% of feeding time, even when ripe fruit was in season.

Western lowland gorillas consume a greater amount of fruit than the other gorilla taxa during the rainy season (Sabater Pi, 1977: 40%; Tutin & Fernandez, 1985: 67%; Williamson et al., 1990: 55%; Nishihara, 1995: 63,2%; Remis, 1997: 51%). Chemical analysis reveal that fruits, ingested by western lowland gorillas at Campo, Cameroon are very similar to the leaves consumed (Calvert, 1985). The fruits were high in energy and high in fat in relation to other plant parts like stems and shoots (table 2). The most preferred fruit (*Aframonum hanburyi*) had three times more fat than other fruits consumed. Calvert (1985) reported that many of the fruits eaten by the gorillas at the study site are woody and hard thus requiring powerful chewing musculature and dentition.

Rogers et al. (1990) found that western lowland gorillas at Lopé Reserve, Gabon selected fruits with a significantly lower fat content rather then fatty fruits. Furthermore, the preferred fruits were low in protein, but high in sugar. Many of the ingested fruits were sweet and succulent, whereas some were drier and more fibrous. Similar to the eastern lowland gorillas (Yamagiwa et al., 1994) western lowland gorillas at Lopé usually avoid unripe fruits. Rogers et al. (1990) found no significant differences in sugar content between ripe and unripe ingested fruits of the same species, although not all species were analysed. The authors suggest that succulence and concentration of secondary plant compounds such as condensed tannins may be the factor in determining choice of ripe over unripe fruits. In the study by Rogers et al. (1990) ripe fruits contained significantly more water and significantly less concentrations of condensed tannins in comparison to unripe fruits. The consumption of fruit by western lowland gorillas at Bai Hokou, Central African Republic is correlated with rainfall and ripe fruit availability (Remis, 1997). During lean times, Bai Hokou gorillas consume fruits with higher levels of fibre and secondary plant compounds than those of the other populations of western lowland or mountain gorillas. Conversely, the leaves ingested by Bai Hokou gorillas were relatively low in fibre and tannins (Remis et al., 2001).

In several studies on western lowland gorilla populations fruit intake was found to be seasonal (Williamson et al., 1988, Rogers et al., 1990, Nishida, 1995, Remis 1997, see table 1). Nishida (1995) pointed out that during the non-fruiting season (October to May) the diet of the lowland gorillas at Nouabalé-Ndoki National Park contains only 20-40% fruit, whereas the amount of consumed fruit increased during the fruiting season (April to September), with up to 80% during August. The intake of leaves, bark, and pith consumed varies seasonally and are considered fall back foods (Doran-Sheehy et al., 2009). Intake of non-reproductive plant parts are higher (up to 80%) during the non-fruiting season and lower (20-30%) during the fruiting season. These foods are relatively poor in nutrients or have particularly effective chemical/mechanical defences. This is why they are eaten when other preferred food sources are rare (Yamakoshi, 2004; Ungar, 2004; Yamagiwa and Basabose, 2009). There are no seasonal differences in the consumption of "terrestrial herbaceous vegetation" (THV). Nishida (1995) suggests that the gorillas at Ndoki may take THV as basic foods and they may only eat fruits occasionally. Rogers et al. (1998, 1990) reported that during the dry season, when few succulent fruit species are available, western lowland gorillas at Lopé eat fruit that is drier and more fibrous. The results of a study of the western lowland gorillas' diet at Bai Hokou, Central African Republic showed that the number of fruit species consumed varied monthly, seasonally, and between the years. There was also a correlation with rainfall (Remis, 1997). Diversity of fruits consumed was higher in poor fruiting years, when preferred fruit species were rare. When looking for any differences of food intake depending on sex, results are contradictory and no general rule can be made. Remis (1997) showed that during the wet seasons females ate more leaves, especially young leaves, than males. The latter were observed eating fruits more frequently. The exact opposite was found by Doran-Sheehy et al. (2009). No difference was detected in Mondika (Congo) by Doran et al. (2002).

No studies have been able to estimate the actual biomass of THV consumed by gorillas because of sampling methodologies. Kuroda et al. (1996) have suggested that high-quality herbs, defined as those that are rich in minerals and proteins such as *Haumani* and *Hydrocharis*, are eaten throughout the year, whereas lower-quality herbs such as *Palisota* and *Aframomum* are eaten in greater quantities when fruit is unavailable.

Another type of diet of western lowland gorillas has been described in the last few years only: aquatic herbaceous vegetation (AHV). It has been found at the Mbeli Bai in the Ndoki Forest, Northern Congo. According to Olejniczak (1996) the gorillas spend less than 2% of their total time in the large swamp eating aquatic plants. Very little published data are currently available. Therefore, it is too early to assess the importance of these observations.

Western lowland gorillas were found to feed regularly on invertebrates like ants or termites (Caroll, 1986; Tutin & Fernandez, 1985, 1992; Williamson et al., 1990; Nishida, 1995; Doran-Sheehy et al., 2009; table 1). Remis (1997) pointed out that the gorillas of Bai Hokou consumed 9 different species of invertebrates. 73% of the faecal samples contained undigested parts of insects.

More recently, gut microbiome assays of both species of gorillas reveal that lowland gorillas have an increased capacity to metabolise lipids, sterols and more digestible carbohydrates and basically can deal with a more diverse diet (Gomez et al. 2015). These results corroborate what we know about their feeding ecology, especially when compared to the mountain gorilla's restricted diet. During lean seasons, the microbiome of lowland gorillas converges with the microbiomes of mountain gorillas. This may be explained by the imposed extreme high-fibre diets and the fact that the limitations in fruit abundance lead to a more cohesive foraging in gorilla species (Gomez et al. 2015). The gut microflora community is heavily impacted by the diet and providing an inadequate diet to captive gorillas can lead to metabolic issues which can be at the root of many health issues seen in captivity (Amato et al. 2014).

Western lowland gorillas have varied diets dependent upon location, season and individual preferences. Nonetheless, studies reveal all diets consist of:

- Staple foods rich in protein and minerals such as herb and tree leaves, which are eaten all year long.
- Seasonal ripe fruits from a variety of species and fall back foods which require more effort per energy unit gained when fruits are not available.
- All food items eaten were high in fibre.

To our best knowledge no data on individual food intake in the gorilla taxa has been published so far.

2.2.4 Gorilla Nutrition in Zoos

Diets for gorillas in zoos should be developed with reference to the diets of free-ranging gorillas. As demonstrated above gorillas are mainly plant eaters with a high proportion of their diet consisting of plants or parts of plants of the terrestrial herbaceous vegetation (THV) group. They consume leaves, stems, shoots and fruits. Fruit intake seems to vary considerably. There are seasonal and local differences within and between the species and subspecies.
Plants consumed by gorillas are particularly fibrous. Fibre content has to be considered as most important when discussing diets for gorillas in zoos since there is reason to believe in the presence of adaptations in the digestive system (Chivers et al., 1984, Popovich et al., 2000) and adaptation in feeding behaviour which not only allows the digestion of feeds particularly rich in fibre but possibly even require its consumption. Studies done on captive gorillas increasing the amount of fibre have seen reported positive health and behavioural effects (Less et al. 2014).

2.2.4.1 Literature Review

There are only a few studies on the diets of zoo gorillas (Müller & Schildger, 1992, Popovich & Dierenfeld, no year, Remis 2002, Remis & Kerr, 2002; Remis & Dierenfeld, 2004; Less et al. 2014) only few of which are based on quantitative data. A study by Hampe (1999) examines six different diets fed in European zoos with reference to the proportions of fruits and vegetables. It shows that there are strong differences among the institutions (figure 7), particularly concerning the proportion of fruits where there is a range of about 5 to more than 50 percent.

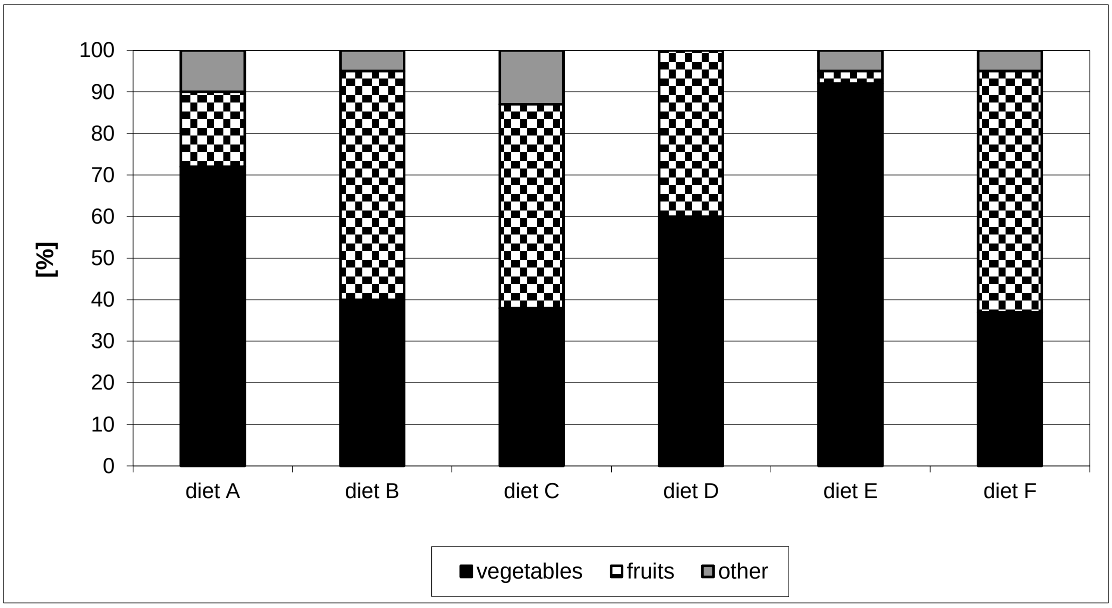

Figure 7. Gorilla diets from six different European zoos. Percentage of vegetables, fruits and others (meat, egg, milk, yoghurt, commercial products for human or non-human primates etc.).Modified from

Hampe, 1999.

Similar results were found by Popovich & Dierenfeld (no year). In a preliminary study on 37 North American zoos the authors found that the diet offered to gorillas varied considerably from zoo to zoo, with over 115 distinctive food items fed regularly, occasionally, seasonally, or as a treat. Twenty different types of vegetables, 23 different fruits, 25 different types of greens/browse, 18 different types of cereals/grains, and 19 different commercial products were fed, most of them on a regular basis (Popovich & Dierenfeld, no year). Obviously there is no agreement on what a "standard gorilla diet" should contain.

Interpretation of feeding ecology in section 2.2.2.1 and 2.2.2.2 must be made cautiously. Food choice studies on western lowland gorillas in zoos showed that gorillas prefer foods that are low in dietary fibre and protein, high in non-starch sugars, have a high sugar to fibre ratio, high total non-structural carbohydrates and high in energy. Other nutritional components do not appear to consistently influence selectivity (Remis, 2002). A high taste inhibition threshold for tannins, which increases with sugar content, could account for gorillas' tolerance for appreciable levels of tannins in fruits and other foods (Remis & Kerr, 2002). The results of these studies suggest that gorillas in zoos prefer sweet fruits, and "regard" those with moderate levels of tannins as palatable. Obesity and teeth problems are believed to be induced by this preference for sugar-rich foods in zoo gorillas (Less et al. 2014). Free-ranging individuals might have a similar tendency to go for energy-rich items. However, their availability will be much lower and more seasonal (Williamson et al., 1988, Rogers et al., 1990, Nishida, 1995, Remis 1997). In other words, in nature the preferred fruits are not available for gorillas every day.

A comparative analysis of wild and zoo diets can refer to limited samples only. Table 3 shows that there are similarities between zoo and wild diets in terms of fat content and carbohydrates but striking differences in terms of fibre and protein contents (Hampe, 1999). The fact that zoo diets seem to provide much less fibre and protein therefore is regarded as a key aspect for the development and improvement of zoo diets.

	Calvert, 1985		**Rogers et al., 1990**		**Zoos** (Hampe, 1999)	
	average	range	average	range	average	range
Gross energy [kJ/g]	**17.9**	12.3 - 21.9	NA	NA	**7.49**	0.73 - 1.87
Crude protein [%]	**10.4**	1.5 - 32.2	**9.2**	0.9 – 25.6	**5.94**	3.18 - 7.47
Fat [%]	**4.3**	0.5 - 20.9	**2.6**	0.2 – 31.9	**3.49**	1.03 - 6.04
Carbohydrate [%]	**19.9**	4.9-27.5	**13.7**	3.9-34.8	**22.8**	9.68 - 31.28
Acid detergent fibre [%]	**46.0**	6.0 - 81.1	**28.8**	4.84 – 61.8	**7.01**	5.06 - 6.55
Water H_2O [%]	**80.5**	54.2 - 96.8	**67.2**	17.8 – 95.0	NA	NA

Table 3

2.2.4.2 Diet Recommendations

Interpretation of feeding ecology in section 2.2.3 must be made cautiously. The results of food choice studies suggest that gorillas in zoos prefer sweet fruits, and "regard" those with moderate levels of tannins as palatable. Obesity and teeth problems are believed to be induced by this preference for sugar-rich foods in zoo gorillas (Less et al. 2014). Free-ranging individuals might have a similar tendency to go for energy-rich items. However, their availability will be much lower and more seasonal (Williamson et al., 1988, Rogers et al., 1990, Nishida, 1995, Remis 1997). In other words, in nature the preferred fruits are not available for gorillas every day.

2.2.4.2.1 Foods to Include in Diet

While most of current diets contain fruits and vegetables equalling about 50 to 90% of total food offered, it is suggested that the proportion of fruits in diets be eliminated, and **vegetables** increased. Increasing the proportion of fibrous, less calorie-dense foods has been shown to improve their health and increase their feeling of satiation (Remis & Dierenfeld, 2004). This can be accomplished by using a low starch primate browser primate **pellet**, replacing the fruit within the diet by vegetables, increasing **browse** presentation, offering **alfalfa lucerne**. Although they have been reported to consume a variety of **insects**, the overall nutritional impact appears to be quite limited and extremely difficult to quantify and seems of higher benefit to allow the gorillas to express natural feeding behaviours than for a nutritional purpose.

Selection of a **commercial feed** should be based on high plant fibre content (> 25% NDF based on native diet) and low fat (< 8% total fat).

2.2.4.2.2 Food that must not be Included in the Diet

FRUIT

The composition of wild fruits is significantly different than the cultivated fruits fed to zoo housed gorillas (Oftedal and Allen, 1997; Schwitzer and Kaumanns, 2003). The soluble sugars found in cultivated fruits are much higher than that of the wild fruits. There is also a difference in protein and fibre amounts, both being significantly less in cultivated fruit. Sugar, protein and fibre amounts of wild fruit were generally more similar to our cultivated vegetables. Obesity, dental diseases and diabetes are prevalent in the EEP population and a reduction in fruit is believed to help with these health issues (Oftedal and Allen, 1997; Schwitzer and Kaumanns, 2003; Less et al. 2014).

MEAT and DAIRY

Gorillas do not consume animal protein to any extent in the wild. They obtain most of their protein requirements from leaves and shoots and most of their energy requirements from high-fibre food items such as stems (Popovich et al., 1997, Rogers et al, 1990). They do not require to be fed animal parts (chicken, beef, eggs etc.) or derivatives (yogurt, cheese, milk etc.) to ingest their daily protein requirements. The average free-ranging gorilla's diet is only 3.1% fat, one third of which is saturated (Reiner et al. 2014). Animal products are all much higher in fat and should not be fed in captivity for this reason as well.

2.2.4.2.1 Amount and Composition of Diet

A general guideline for feeding adult gorillas is to aim for a total daily quantity of 4.5% of body mass (on an as fed basis i.e. fresh food) comprising, 70% vegetables, 15% browse, and no more than 15% dry high-fibre primate biscuits. If more pellets are necessary to reach adequate micronutrient concentrations, perhaps it would be wise to seek out a more appropriate pellet.

2.2.4.3 Zoo Diet Examples

The following examples are of diets that have been used successfully. Other diets may of course also be appropriate and perfectly healthy for your gorillas. These are to be used as suggestions and starting points for diet comparisons.

Diet 1: Amounts are for one adult silverback male

Food Item	Amount in g (fresh weight)	Proportion of diet % (fresh weight)
Browser Primate Pellets	750	8
Leafy Vegetables	2 500	91
Watery Vegetables	4 500	
Root Vegetables	3 000	
Germinated Pulses	50	
Browse	50-1000	1-10
Total	**10820-11820**	

Diet 2: Amounts are for a breeding group of 5 gorillas

Food Item	Amount in g (fresh weight)	Proportion of diet % (fresh weight)
Leafeater Primate Pellets	500	1
Leafy Vegetables	28 600	99
Watery Vegetables	32 500	
Root Vegetables	8 200	
Browse	100 (Summer only)	>1
Total	**69800**	

Diet 3: Amounts are for a breeding group of 7 Gorillas

Food Item	Amount in g (fresh weight)	Proportion of diet % (fresh weight)
O. World Primate Pellets	1846	3.6
Leafy Vegetables	16636	93.0
Watery Vegetables	14117	
Root Vegetables	16636	
Hard-boiled egg	840	1.7
Yogurt	875	1.7
Total	**50950**	

Both Diets 1 and 2 use a vegetable group system. This allows for the zoo commissary to purchase the vegetables which are local and seasonal, and allow for flexibility within the diet. This system promotes weekly and seasonal variation as opposed to having a large amount of food items daily. This is not the only grouping that makes sense, feel free to create one which makes sense for your institution.

Leafy Veg	**Watery Veg**	**Root Veg**
Cabbage (any sort)	Broccoli	Swede
Chicory	Cauliflower	Squash (any sort)
Collards	Celery	Pumpkin
Kale	Corn	Sweet potato
Lettuce (any sort)	Cucumber	Turnips

Spring greens	Fennel	Jerusalem artichoke
Spinach	Leeks	Mangels
Swiss chard	Mushrooms	Beetroot
Turnip greens	Okra	Carrots
Asparagus	Peas	Celeriac
Brussel sprouts	Onions	Parsnips
	Peppers	Kohlrabi
	Radishes	Aubergine
	Tomatoes	Potato
	Green beans	
	Broad beans	
	Avocado	
	Artichoke	

Nutrients of the above diets versus recommendations (in dry matter):

Nutrient	**Diet 1**	**Diet 2**	**Diet 3**
Crude Protein (%)	16.26	15.18	17.14
Crude Fat (%)	2.41	2.96	3.52
ADF (%)	16.36	10.10	10.07
NDF (%)	25.24	12.28	15.59
Calcium (%)	0.61	0.51	0.50
Phosphorous (%)	0.45	0.37	0.46

It is regarded as essential to supplement gorilla diet with roughage. **Institutions which are unable to provide roughage regularly over the whole year should not be encouraged to keep gorillas.** Such institutions should look into silage. Diets above do not have access to browse during the winter months so silage is used to provide some browse daily. If no browse is available then lucerne may be used in controlled quantities.
Diet 1 deviates from recommendations given by Popovich & Dierenfeld as it provides a total daily quantity which exceeds 4.5% of body mass of the gorillas involved. A reduction in the amount of food offered per animal could lead to behavioural disturbances and social tension. A larger amount of food per animal per day is offered to avoid competition between the animals. The amounts of pellets are also heavily reduced in both of these diets which ordinarily would be a small weight for concentrated energy. For this reason we do not consider the above amount of food to be too much.

2.2.5 Food distribution

Wild gorillas spend much of their time (up to 72%) engaged in foraging and food processing (Masi et al., 2009). Western lowland gorillas forage for 67% of their days and rest for 21% of their time (McFarland et al. 2004). Mountain gorillas forage for 55% and rest for 34% of their time. Their higher intake of cellulose could mean more time is possible needed for fermentation (McFarland et al., 2004). Group members forage in a dispersed way (Schaller, 1963). Food items are usually abundant and dispersed so direct competition is low (Doran & McNeilage, 1998). Feeding regimes and food distribution under zoo conditions have to mimic this.

Food should be distributed to maximise foraging and food processing time. At least four feeds per day are required. Food items should be dispersed widely. Monopolisation of several items at a time should be prevented. There are hints that food items should be not too small. Hempill & McGrew (1998) found in their study at Columbus Zoo that gorillas are not encouraged to spend more time foraging and less time resting by offering small pieces of food. The authors assume that overly small size of food items makes them hard to manipulate, and thus not worth the gorillas' time and effort. At Köln Zoo gorilla food items are predominantly offered as a whole item. The preparation of whole vegetables for consumption (e.g. bulbs) allows the gorilla to express its species-typical food processing behaviour. A study conducted at Paignton Zoo fed primates either chopped produce or whole produce or measured differences in feeding time for the group and individuals. Feeding time was significantly longer when fed whole vegetables Subordinate individuals also ingested a larger diversity of food items (Plowman et al. 2009).

For feeding enrichment see also chapter 2.6.

2.2.6 Regurgitation and re-ingestion in zoo gorillas

Regurgitation and re-ingestion (R/R) of food is widespread in zoo gorillas and occurs to approximately 60% of all individuals but has never been reported from wild populations (Less et al., 2014). Regurgitation and re-ingestion consists of the voluntary retrograde movement of food and/or fluid from the oesophagus or stomach into the mouth, the hands, or a substrate, followed by subsequent consumption of the regurgitate. Regurgitation is different from vomiting, a reflex behaviour elicited by autonomic activity preceded by hyper salivation, contraction of abdominal muscles, and nausea (Gould & Bres, 1986; Lukas, 1999). Little is known about the underlying mechanism of R/R that leads to its development and maintenance (Akers & Schildkraut, 1985; Gould & Bres, 1986; Wiard, 1992; Lukas, 1999).

It has been argued that R/R may be an adaptive response to environmental conditions such as boredom, space restriction, and to social stress or non-social stress from outside with a lack of individual control within the zoo environment. Other possible reasons may be non-natural food items, a low number of feeding times, temperature of food, quantity of food, and high energy contents of food with low nutritional value (Ruempler, 1992; Lukas, 1999). Loeffler (1982, cited by Lukas, 1999) suggests that gorillas in zoos may “enjoy the re-ingestion of favourite food”.

Few empirical studies have been conducted on R/R in gorillas and no single hypothesis has been either supported or disconfirmed (Akers & Schildkraut, 1985, Gould & Bres, 1986, Loeffler, 1982, Velderman, 1997, Wiard, 1992). Following Lukas (1999) the rigid, invariant, repetitive nature of the behaviour, as well as its unknown underlying mechanism, seem to qualify its inclusion in the category of stereotypic behaviour. Lukas (1999) assumes that the low fibre content in zoo gorilla diets may prevent satiety.

The effect of R/R on the health of gorillas has not been systematically evaluated (Lukas, 1999). Although gorillas seem to regurgitate their food usually before it has come into contact with the gastric juice (Taïs, 1982; cited by Ruempler, 1992), damage of the oesophagus and dental erosion cannot be excluded as a result of repetitive vomiting (Haller, 1992, for *Homo sapiens*; cited by Lukas, 1999; Hill, 2009).

There is evidence that the diet of gorillas in zoos may have an influence on R/R (Ruempler, 1992; Lukas, 1999; Lukas et al., 1999). Lukas et al. (1999) demonstrated that removing milk from the gorilla diet may lead to a decrease in R/R during the post-prandial period. The authors suggest that milk may contribute to R/R either because its thick, coating properties facilitate the regurgitation of food or because it is a favoured food item that gorillas prefer to consume again and again. The gorillas in this study doubled their consumption of hay in the post-prandial period after the milk was removed from the diet. Lukas et al. (1999) suggest that milk may have an influence on satiety. Decreasing satiety after removing milk may be one reason for the higher consumption of hay. The higher amounts of fiber the hay provided may in itself be beneficial to reduce R/R (Conklin-Brittain et al., 2000; Crissey et al., 2000; Lukas, 1999; Ward and Lintzenich, 2000). Evidence from the Kölne Zoo (Germany) suggests that a diet high in browse and incidentally, fibre, and low in simple carbohydrates, milk and meat products reduced or eliminated R/R (Ruempler, 1992). Less et al. (2014) significantly reduced R/R by implementing a low starch diet (removal of monkey pellets and reduction in fruit).

According to Taïs (1982) the consumption of a high fibre diet probably causes a localized dilation of the oesophagus inducing peristaltic concentrations at the lower end which force the food into the stomach. Feeding a large amount of fibrous food and removing fruits, animal protein and commercial foods led to an almost complete cessation of regurgitation and re-ingestion in the gorilla group at Köln Zoo (Ruempler, 1992).

2.2.7 Special Dietary Requirements

2.2.7.1 Pregnant and Lactating Animals

Pregnant females' will require larger quantities of food than non-pregnant females necessary to support her and her foetus. The actual ratio of ingredients does not need to change as long as the diet is adequate (NRC, 2003). Special attention should be paid to the calcium to phosphorous ratio of the diet and MUST be above 1.2:1. Calcium supplements must be added to the diet if this isn't the case.
During the first trimester, the diet can remain identical before gestation. Although it is normal for their appetites to increase during their first trimester, they will actually be metabolizing more energy and assimilating more nutrients than they normally would, rendering giving extra quantities of food unnecessary (Kemnitz et al. 1984). During the second and third trimester, the total energy of the diet should be increased by 14-20% (up to 350 kilocalories more) according to Kemnitz et al. (1984) and the NRC (2003). Most zoos would increase it by 30-50%. Gestating female primates have been shown to develop a more efficient digestion process than non-gestating females (Kemnitz et al. 1984).

Lactation is the most energetically expensive state for mammals. The NRC (2003) suggests the addition of 484 kilocalories/day more than the gestating diet during lactation. The actual diet proportions can be kept constant and the total quantity increased. There can also be a slight increase in the proportion of concentrate feeds fed such as the pellets to ensure abundance of minerals (NRC 2003). If the energy requirements were calculated using the BMR and FMR equation, the conversion factor from BMR to FMR for a lactating gorilla is 3. ie. Multiply the BMR by 3 to obtain FMR.

2.2.7.2 Young Animals

Young gorillas have been known to be fed adult diets after weaning.Diets offered to juvenile gorillas would follow the same general category proportions (45% vegetables, 25% green leafy produce and/or browse, approximately 28% high-fibre primate biscuit and 2% cereal grains, nuts or seeds. One tactic employed by many zoos in the UK (with all primates, not specific to Gorillas) is to add half of the diet of an adult when a youngster is born. This will go towards the female's lactation costs and eventually become the youngster's diet after being weaned. His diet can slowly be increased to full adult's amounts. The diet should remain with slightly more pellets in his diet as he matures. Total amounts offered to young gorillas can be increased to approximately 6.5% of total body mass (on an as fed basis). If the BMR and FMR calculation method is preferred, then the BMR must be multiplied by 2 to obtain the FMR (and not 1.25 used for maintaining adults).

2.2.8 References

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2.3. Social Structure: *Gorilla Behaviour and Social Organization*

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2.3.1 Group composition and age to transfer offspring

Gorillas in zoos should be maintained in naturalistic social groups with a variety of age-sex classes. A more naturalistic social group should lead to more species-typical behaviour.
The difference between the desired sex ratio in individual zoos and the actual sex ratio in the EEP-population has been a major cause of "surplus" males. In order to reduce these problems a number of measures are inevitable.

Recommendation:
The gorilla troop size recommended is one adult male with two or maximal three breeding females with their offspring.
Reducing the number of breeding females per male will help to promote genetic diversity by allowing more males to breed (de Jongh, 2001).

Females must remain in their natal group until an age of 6 to 8 years having the opportunity to experience the rearing of their sibling or another infant in their group.
Males ranking high in the mean-kinship list and/or destined for breeding should remain in their natal group until an age of 9 to 11 years, unless serious fights occur.
Males who have to join a bachelor group can leave at an earlier age (5-9 years).

(see also chapter 2.3.5. Age of dispersal)

2.3.2. Introductions and socializations in zoo gorillas

(Introduction of hand-reared infants see 2.4.8.4)

To establish social groups of gorillas, as well as to translocate animals to comply with breeding and socialization recommendations, introductions will often be necessary. Some animal transfers are usually necessary to maintain a stable gorilla group or to avoid inbreeding. Either males or females could need to be removed from a group or replaced by new ones.

Introduction of new animals is the most risky management action, and must be done after previous analysis of the character and situation of the resident members of the group and the new one that must be introduced. Introduction strategies are affected by factors such as the age, experience and temperament of the involved animals, the site for the introduction and the experience of the staff. Knowledge of each gorilla's behaviour is vital during each introduction to ensure the safety of all individuals.

Steps for the introduction of a new individual into a group

1. Habituation of the individual to the new surroundings and first contact with the new keeper.

Measures:

- Familiar keeper to accompany the gorilla to the new zoo.
- New keeper to talk to and "make friends" with the new gorilla.
- Do not put the new gorilla under even more stress by confronting him/her with a bunch of press people and flashlights.
- Lay out small amount of preferred food items.
- Offer water.
- Provide plenty of materials (e.g. branches, straw, wood-wool) to be used for nest-building, manipulation and displacement behaviours.
- Depending on the facility, give access to more than one room.
- Introduce the new gorilla to the outside area (new surface, new, environment; new barrier), but never shut off the safety of the house.

2. Habituation of the individual to the resident group:

- Establish visual contact between them and observe the relation developing between the individual and the group members.
- Allow physical contact through a contact area, preferably double bars just wide enough for the fingertips to touch, for short periods of time between the new individual and the group members that show a positive interest in it. If you need to separate a member of the group tobe used as introducer of the new one, allow this group member to join its group during part of the day to keep its rank and relationships.

Measures:

- Create a balanced situation between resident group and individual to be introduced;
- Individuals should have the opportunity to make contact with each other through bars or to stay out of sight (e.g. around the corner, behind a visual barrier, additional room);
- Offer similar overnight arrangement;
- Lay out plenty of materials (e.g. branches, straw, wood-wool) for all the gorillas, to be used for nest-building, manipulation, displacement behaviours and displays).

3. Allow full physical contact between animals that show positive reactions, providing a big area (lots of food, branches and other materials), neutral ground, with multiple escape ways through selective sliding doors (possibility of separation). For emergencies keep ready a water-hose. Keep them together for a limited time in the beginning (may be only one hour a day, depending on their reactions), and if the situation looks calm, increase the period of time. After introduction sessions and in a calm atmosphere it is very important to let the new individual stay in visual contact with the rest of the group.

Measures:
- *Give the gorillas the maximum space to establish their first relationship, which is basically characterised by watching, approaching, displaying, avoiding and defending;*
- *Prepare the system of interconnected rooms and optionally use a narrowed (female/young) opening, use at least two rooms (for periods out of sight, pausing, resting);*
- *Depending on the behaviour increase the period of free access day by day*
- *Besides normal feeding times, provide the gorillas with small forage feeds and always plenty of materials as mentioned above.*

4. Introduction of the other group members will follow the same protocol.
Evaluate in each step the agonistic, affiliative and non-agonistic behaviours (see "List of Behaviours"), to evaluate the process and make changes in the protocol if needed. There should be periods of relaxed mutual interest during encounters. Flexibility and an open mind will help you!

List of Behaviours: (*The list shows a range of behaviours occurring during introductions):*

- *Male:*
- *Agonistic behaviours: Excitement, Aggression, Fear*
  Repeated gorilla-specific displays, stiff standing, runs, charges, tense lip facial expressions ,chest beat and hooting-vocalizations, throwing materials/food/faeces, banging the metal bars and slides, bumping into de bars, hair erect, clutched feet, restlessness, displacement behaviours, odour release, licking sweat from the armpit, sweat on the face, soft faeces, low appetite.
- *Affiliative, Non-agonistic behaviours: Interest, Friendliness, Relaxation*
  Relaxed approach, watching from relaxed body posture, resting, "friendly" belch-vocalizations, "soliciting" staccato-vocalizations, "soliciting" body postures (e.g. leaning on the back of the hands while standing on four feet facing the opponent, sitting while facing with both arms straightened and the hands touch the knuckles), making contact through the bars by using any given material, performing mechanical noises with sticks or metal bars while watching, normal metabolism.

- *Female:*
- *Agonistic behaviours: Excitement, Aggression, Fear*
  "Threatening" pig grunt-vocalizations, panting hoot series, hair erect, restlessness, displacement behaviours, screaming attack, throwing, beating, flinching when male displays, screaming flight, crouched body postures, licking sweat from the armpit, sweat on the face, soft faeces.

- *Affiliative, Non-agonistic :*
  Hesitating approach, proximity, smelling, watching from relaxed body postures, " friendly " belch vocalizations, more self-confident behaviour (e.g. instead of flinching or flight, staying at place, turning away the head, fending off with arm), display towards the male, attempt for body contact.

To reduce the risk of injuries, give a reasonable amount of space available with visual barriers and with the possibility of escape routes and separation barriers if needed. You need an intervention plan if something goes wrong. A disadvantage of too much space during introductions could be that one animal could start chasing the other. In the case of an adult male, he needs to dominate the female, the sooner he does it the quicker both animals will calm down. It might therefore be better to bring them together in a smaller space, depending on the behaviour background of the animals and their earlier social experiences.

Sometimes the presence of large amounts of food helps to create a more relaxed atmosphere, but sometimes this could make things worse. It will depend on the character of the individuals. So, favourite food may cause tension, large amount of branches that need much work to eat may calm the animals down.

When introducing a female to a male, considering the oestrus cycle could help: If the female is in oestrus she will be probably more receptive to the male. But sometimes sexual excitement could also turn into aggression. It might be unwise to introduce a female in oestrus to an inexperienced male, as he might be too excited.

When introducing a new breeding male to a female group avoid the formation of a coalition of females against him by introducing them one by one. One should add a new female only when the male dominates the first one. Depending on the male's behaviour, a female coalition might be needed to counterbalance the male aggression. The number of females can be adjusted to balance his strength.

Do not introduce a new male into a group with infants of less than three years of age because of the risk of **infanticide**.

When introducing a new female into a breeding group try to introduce the silverback first. Once the female is accepted by the silverback, he usually intervenes in conflicts between the new and other females. This is probably more natural since the task of the silverback is to avoid conflicts in the group. Then introduce females one after the other beginning by the lower ranking one. If separating an individual from its usual group to facilitate the introduction of a new one, try to allow that individual to join its usual group again during part of the day to keep its rank and relationship.

2.3.3 Infant development and parental behaviour (also see chapter 1.7.)

Maternal behaviour includes carrying, nursing, grooming, and protecting the infant. Females with young offspring seek proximity to the silverback. The strong and long lasting relationship between mother and infant will decrease in intensity over the long maturation period of the infant.

2.3.3.1 Nursing

Newborn gorillas exhibit rooting and nuzzling movements of the head as well as spastic, involuntary limb movements when searching for the nipple (Fossey, 1979; Dixon, 1981) Nursing often begins within 24 hours after birth (Fossey, 1979; Arnold, 1979; Beck, 1984), but there is some variation and nursing can also start on the second or even third day (Nadler, 1974).

Inability to nurse has not been observed in the wild, but is often cited as a reason for hand-rearing gorillas in zoos (Bahr, 1995). Physical and psychological stress can potentially inhibit lactation (Bahr, 1995). Milk yield may not occur until 48 hours postpartum.

2.3.3.2 Weaning

Most gorilla infants are weaned at an age of about three years. It is a gradual process during which the mother-infant bond is loosened: mothers have been observed to forcibly stop their infant's suckling efforts at an age of 6 to 12 months. However, if females do not become pregnant again, their offspring may continue to nurse until an age of 4 to 5 years (Fossey, 1979). Median inter-birth interval in wild gorillas is 3.85 years (Sievert et al, 1991)

2.3.3.3. Food intake in infants

1-2 months of age: infant begins to chew the remains of food from the mother.
3-4 months: infant begins to take small amounts of solid food.
4-6 months: infant begins to manipulate stems and leaves, puts parts into its mouth and bites them.
8 months: infant regularly ingests solid food.
12-24 months: infant attempts to strip leaves from stalks and vines.

24-36 months: infant improves food selection and preparation, competition for favourite food items begins (Fossey, 1979, Watts, 1985).

Wild gorillas acquire the basic adult feeding repertoire by the end of infancy (Watts and Pusey, 1993).

2.3.3.4. Maternal transport

Generally, ventro-ventral transport is typical from birth until the infant is about six months old. The mother often displays a tripedal walk, using one arm to support the infant against her ventrum (Schaller, 1963; Hoff et al, 1981). At one to two months infants are capable of clinging unsupported to the mother's belly for sustained periods of time (Fossey, 1979). Dorso-ventral transport begins between two and four months of age for short periods and is the typical transport of the second half year of life (Fossey, 1979).

- between 4-6 months : 60% ventro-ventral transport and 40% dorso-ventral transport
- between 6-12 months: 30 % ventro-ventral transport and 70% dorso-ventral transport
- between 12-36 months: dorso-ventral transport when travelling a long distance; for shorter distances walking (following the mother) or clinging to the mother's rump-hair.

Variability in the methods of transporting infants, especially older infants, is not uncommon in both wild and zoo gorillas (Hoff et al 1981):

- arm walk: the mother walks quadrupedally while the infant sits in one palm and holds onto her arm.
- crutch walk: the mother walks quadrupedally while holding her infant in her lap and uses her arms as crutches.
- drag: the mother walks tripedally while the infant is held in one hand away from the body.
- leg walk: the mother walks quadrupedally while the infant holds onto her leg.

2.3.3.5. Proximity to mother

Primate mothers, in general, strongly regulate their infant's interactions with group members and actively encourage or discourage independence. Proximity declines with age (Watts & Pusey, 1993).

- Gorilla infants stay in constant body contact to their mothers during the first two to three months of life. They are held or carried in the ventro-ventral fashion. When seated, mothers typically cradle the infant against the chest or hold it in the lap. However, individual variation has to be considered.

- At the age of four to five months the infant begins to walk quadrupedally. It starts to move away from the mother, but stays within arm´s length or at a maximum distance of three meters. Social interactions with conspecifics are carried out within the safety of the mother´s presence.

- During the first six months of life, ventro-ventral contact declines and is replaced by less intimate forms of contact: dorso-ventral contact (infant on the mother's back), clinging to her side or sitting in contact next to her.

- At six to seven months the infant begins to walk, following its mother. At eight months infants can venture as far as six metres away from their mothers. At approximately 15 months infants sit beside their mothers more often than clinging to them. When an infant leaves the proximity of its mother, it appears to be aware of her location and will rush back to her at the first sign of alarm (Schaller, 1963).

The great variability of age at which infants separate from their mothers, often in an attempt to explore their physical environment, appears to result mostly from the variability in maternal restrictions. Hoff et al

(1981) concluded from their observations that the development of independence in infants is an interactive process between mother and infant. Mothers initially respond instantly to exploration attempts by restraining and retrieving their infants, but when the infants are nine months old, this control subsides.

2.3.3.6. Play

Infants begin solitary play at an age between 1.8 and 5 months, on average 3 months (Fossey, 1979).

- 2-4 months: Social play begins between mother and infant and exploration play begins with the surrounding vegetation.
- 4-6 months: Play is vigorous with the mother and infant begins to contact other troop members when they are close to its mother. Infant begins to manipulate plants and to play with its own body (e.g. clapping its hands).
- 6-12 months: Social play increases (mainly with infants of similar age), but solitary play still prevails. Big development of locomotion activities and solitary play.
- 20 months: social play increases.

During the second year of life, play with other infants and juveniles, especially siblings, continues to increase in frequency and vigour, and begins to replace solitary play sessions. Infants appear to prefer playing with juveniles, although juveniles, themselves, prefer to play with partners slightly older than themselves. As mothers become less restrictive, infants also begin to play with the silverback and begin to manifest a great interest in him. They actively maintain close proximity to him (Stewart & Harcourt, 1987).
During the third year, infants initiate play more often and with a wider range of individuals. Play between infants and older juveniles (approximately ages three to six years) and adolescents also occurs, but Fossey (1979) described these interactions as more complex, involving not only play but also components of maternal behaviour, grooming, transport, and copulating behaviour.

Solitary play includes climbing into trees or structures, jumping, clapping, turning over, running, walking bipedally, etc.

Social play includes pushing, tumbling, biting, chasing, rolling over, charging, arrest fights, etc.

Mother-reared infants play more and have more social experience, which facilitates their development, maternal behaviour and mating when arriving to the breeding age (Abelló, 2011). Hand-reared animals tend to display more solitary play than mother-reared ones. It is considered to be a result of lack of stimuli and social contacts. Hand-reared infants must be kept in groups rather than pairs whenever possible , because of the wide variety of social experiences available through play with more than one individual (Meder, 1989).

2.3.3.7. Grooming

Social grooming among gorillas does not appear to be a prominent activity (Schaller, 1963; Maple & Hoff, 1982). Mothers initiate grooming of their offspring, placing them in any kind of position, but sometimes infants try to escape and terminate the grooming sessions (Fossey, 1979). Schaller (1963) indicates that infants groom other animals but their mothers. Juveniles tend to groom silverbacks more than any other age-sex class. Social grooming was found at very low rates among all age-sex classes (Maple & Hoff, 1982).

Solitary grooming (self-grooming) was observed by Schaller (1963) in all age-sex classes of wild gorillas except infants under two years.

2.3.3.8. Nest building

In wild gorillas, nest building behaviour emerges during episodes of solitary play with vegetation at the approximate age of 10 months. During the first three years, infants construct practice nests and gradually become more proficient. However, most immatures continue to spend the night in their mother's nest until the age of about five years (Fossey, 1979).

Meder (1989) observed that both hand-reared and mother-reared infants show nest building behaviour beginning at the age of six months in females and nine months in males. Nests were constructed of rope, woodwool, branches, paper, sacks, cloth, and plastic toys. While hand-reared infants built nests, they were never observed to sleep in them until the age of five years, whereas mother-reared infants slept in their nests at the age of two years. It appears that gorillas may possess innate patterns for nest building, but that technique is improved with practice. Interestingly, it also appears that gorillas must learn by imitation how to use the nests they build (Meder, 1989).

2.3.3.9. Interactions with other group members

Immature female gorillas are particularly interested in young infants and will peer at and touch them when allowed to do so by the mother (Watts & Pusey, 1993). Both male and female juveniles and adolescents spend more time near related females than non-relatives.

Interactions between infants and black-backs are rare and usually limited to sibling associations (Fossey, 1979). Infants associate more with silverbacks (presumably their father) than with adult females who are not their mothers. Interactions between the silverback and infants increase with the age of the infant, especially in the third year (Fossey, 1979). Even when the infant's play becomes exuberant and rough, silverbacks remain remarkably tolerant (Schaller, 1963).

Males who maintain a close relationship with the silverback during infancy and adolescence are more likely to stay in their natal groups (Harcourt & Stewart, 1981). Juvenile male gorillas continue to interact affiliatively with the silverback, but as they grow older, proximity declines and silverback aggression increases. This pattern commonly precedes adolescent male emigration (Watts & Pusey, 1993).

Immature female gorillas also spend less time near silverbacks as they get older. During adolescence females continue to interact affiliatively with the silverback. Frequency of interactions with the silverback is directly related to the strength of the affiliative bond between the silverback and the respective mother (Tilford & Nadler, 1978).

2.3.3.10. Socio-sexual behaviour

Genital inspection and manipulation are the first sexually related behaviours to occur in an infant's life (Hess, 1973). Mothers in zoos undertake careful and extensive inspections of their newborns. Regions of special interest include the ears, face, shoulders, hands, feet, navel, and especially the ano-genital area. Genitals are stroked, plucked at, poked, held, mouthed, and sucked. During the first few days of life such stimulation sometimes results in urination and defecation. The frequency of genital inspection declines as the infant grows older and is only sporadically done after three years.

Maternal mounting has been observed during the first three years (Hess, 1973). Ventro-ventral mounting mother to infant has been described (Maple & Hoff, 1982).

Socio-sexual behaviour involves all age/sex combinations. All age/sex classes initiate mounts and all but silverbacks are mounted (Watts, 1990). Blackbacks and young silverbacks initiate most of the mounts and mostly mount juveniles and subadults. Subadult and juvenile females initiate some mounts but only on infants.

The most common form of genital stimulation in immature mountain gorillas involves episodes of pelvic thrusting. These episodes occur when one animal (the actor) presses its genitals against those of another (the recipient) while making rhythmic pelvic movements. Pelvic thrusting has been observed in immature gorillas ranging in age from 0.7 to 10.7 years and always occur within the context of play wrestling, chasing, embracing, and restraining. In almost all cases, the recipients are younger than the actors. The most frequent recipients are infants between the ages of 0.7 and 1.3 years. Males are the actor in the majority of cases. Immatures perform pelvic thrusting in the following combinations: female-female, male-male, male-female – but not female-male (Nadler, 1986). Males perform pelvic thrusting in dorso-ventral and ventro-ventral position, females only in ventro-ventral position.

2.3.4. Adolescent development

When female gorillas become juveniles, they tend to stay near their female relatives or the silverback and show great interest in new infants in the group. Males tend to engage in more rough and tumble play and also continue to interact with the silverback until approaching black-back status. The rate of adult-adolescent male aggression increases as adolescents mature. Transfer of females generally occurs around an age of eight years and males emigrate at 11 years (Maple & Hoff, 1982; also see chapter 3.4.).

2.3.4.1. Female sexual behaviour

Sometimes subadult females during oestrus initiate increased playful and affectionate behaviour towards human caretakers (Keiter & Pichette, 1979). The ovulation cycle can be determined by observation of monthly menses or by daily checking hormone levels in urine with a commercial test.

Sexual behaviour is initiated within the context of play. Adolescent females copulate mostly with immature males, who usually can copulate only away from the dominant silverback. Males initiate over 80 percent of the copulations with adolescent females. As females mature, they tend to initiate more copulations (approximately 60 percent) when in oestrus, and initiate 80 percent of the courtship play and activities that attract the males' attention (Keiter & Pichette, 1979). It appears that individual differences as well as differences in social history and context may affect the expression of a wide variety of sexual behaviours.

2.3.4.2. Physical and behavioural changes in males

Male gorillas aged 8 to 12 years are considered black-backs; those 12 to 15 years are young silverbacks, indicating that they are silvering but not yet fully mature until about 15 years (Watts, 1991). In these age classes males grow in size and stature, the reproductive system matures, and there are secondary sexual changes, such as the gradual development of the silver saddle of hair on the back.

A high level of playful copulatory behaviour occurs in immature mountain gorillas ranging in age from infancy through 10 years (Nadler, 1986). Once animals reach black-back status, they are no longer mounted by others (Watts, 1990). Blackbacks and young silverbacks initiate most of the mounts, usually with juveniles and subadults. The dominant silverback tolerates copulations between his sons and daughters (or granddaughters), but not between his sons and females who are his own mates. Presumably, subordinate males who attempt to sneak copulations with the silverback's mates risk aggressive retaliation.

Subadult males in zoos may show increased amounts of aggressive behaviour when approaching 10 to 12 years of age, sometimes necessitating their removal from the group. Aggression first becomes evident in an increased level of aggressive play.

2.3.5 Age of dispersal

Both sexes usually disperse from their natal group.

Males leave their natal group at about11years of age (Maple and Hoff, 1982). Usually, they emigrate before they have bred, becoming solitary or joining/forming an all-male group.
Attraction of young, emigrant, wandering males to each other leads to the formation of bachelor groups of unrelated males. No silverback over 13 years has been observed attempting to enter an all-male group but males from 6 to 13 years have joined all-male groups without serious aggression (Harcourt, 1988).

All-male groups can be stable for long periods of time (two to four years in the wild). The stability is affected by the abilities of individual males to obtain females. Once males reach an age to compete for females, and if they are not the resident dominant male, they depart the bachelor group and start to seek females.

When a silverback dies, the group can be reintegrated by his successor, but mostly the group fissions.

Females at the age of about 8 years transfer directly from their natal group to another group or to a solitary silverback and never range by themselves (Stewart & Harcourt, 1987)

Secondary female transfers: Some females transfer several times between different groups (nulliparous and parous females), following the silverback`s death or from a group that includes a silverback. Females make a choice about particular males depending on:
- their preference for older and more experienced males (Watts, 1985; Yamagiwa, 1983)
- their reluctance to join a group if the silverback is old (Tutin et al, 1994)
- the quality of the male’s range and their previous success in raising offspring in the group (Harcourt, 1976).

Transfers usually occur when two groups or a group and a solitary male come into close proximity. While the males display and sometimes fight, the female leaves her group, approaches the new male, and then follows him when the encounter ends.

2.3.6. Abnormal behaviour in zoo gorillas

Abnormal behaviour in primates is typically defined as behaviour that is aberrant or pathological, such as sometimes eating disorders (coprophagy, regurgitation, re-ingestion), and stereotyped movements, hyper-aggressiveness, inappropriate sexual orientation, and bizarre posturing (Erwin & Deni, 1979).

Stereotypic behaviour

Stereotyped or aberrant individual behaviour has been reported in zoo gorillas, frequently in hand-reared individuals (Meder, 1985; 1989).These behaviour patterns include digit sucking, lip sucking, and rocking (back and forth and up and down). These behaviour patterns generally decline by the third year of life, but the time spent engaged in stereotypes increases "strikingly" under stressful conditions, i.e. during introductions.

Appetitive disorders

There are numerous instances of coprophagy and regurgitation/re-ingestion (R/R) reported in zoo gorillas (Ruempler, 1992; Lukas, 1995) .Coprophagy has been reported in the wild (Harcourt & Stewart, 1978; Fossey, 1983); however, the frequency at which it occurs in zoos is much higher than that reported in the wild. R/R has not been reported in the wild. R/R is most frequent in zoo-born/ hand-reared animals, followed by wild-caught animals and is least frequent in zoo-born/mother-reared animals (Gould & Bress, 1986). Sometimes these appetitive disorders are not really stereotyped behaviours but an adaptive response to the environmental conditions in captivity(Hill, 2009) (see chapter 2.2.6)

Social disorders

One problem often resulting in serious consequences is that of inadequate maternal care, including rejection of and/or mutilation of the infant. This pattern of behaviour has often resulted in separation and hand-rearing of the infant (Maple & Hoff, 1982; Kawata & Elsen, 1984). In extreme circumstances, it can lead to the death of the infant (Benirschke & Adams, 1980). Although maternal neglect does occur in the wild, it is more frequent in zoos (particularly among hand-reared without previous observing maternal behaviour; Abello, 2006).

However, it has been shown during the last years that improvements in the management techniques for gorillas in zoos (e.g. environmental enrichment – see chapter 2.6.-, changes in diet and feeding routine- see chapter 2.2- , methods of training maternal behaviour or (re-) introducing a hand-reared infant to a group at an early stage – see chapter 2.4) can reduce the abnormal behaviour mentioned here.

2.3.7 Gorillas mixed with other species

More and more zoos are mixing gorillas with other species. Some large indoor tropical enclosures include free-flying birds and bats (*Eidolon* spec. in Krefeld Zoo). Few attempts have been made to include mammal species other than primates. Heidelberg Zoo added a genet (*Genetta* spec.) to hunt mice in the gorilla inside exhibit. Johannesburg Zoo is keeping duikers (*Cephalophus* spec.) and guineafowl with a pair of gorillas. In Apenheul, a bachelor herd of springbok (*Antidorcas marsupialis*) have shared a two hectar island habitat with two groups of gorillas. Other candidate species might be red river hog (*Potamochoerus porcus* – kept in Columbus Zoo with bonobos, *Pan paniscus*) and pygmy hippopotamus (*Choeropsis liberiensis*).

Houston Zoo maintains a troop of talapoins (*Miopithecustalapoin*) with a lone silverback eastern lowland gorilla, primarily to enrich his indoor environment. The National Zoo, Washington, and the Calgary Zoo have maintained a troop of colobus (*Colobus guereza*) with gorillas, again in indoor exhibits. Barcelona Zoo mixed *Cercocebus atys lunulatus* and *Miopithecus talapoin* with gorillas without problems but no breeding occurred during the association period. Other examples: *Cercopithecus ascanius* (St. Martin la Plaine, Romagne), *Mandrillus leucophaeus* (Touroparc), *Colobus guereza* (Koln, Romagne, Beauval – where one was killed by the male), *Cercopithecus mitis* (Amsterdam, Howletts), *Cercpithecus diana* (Edinburgh – where one killed), *Cercopithecus petaurista* (Howletts), *Erythrocebus patas* (Apenheul, Beauval, Touroparc), Lophocebus (Gaiapark), Cercopithecus neglectus (Bioparc Valencia).

When considering mixed-species combinations, barriers need to be designed appropriate to the capabilities of each species. The potential for gorillas in mixed-species exhibits appears to be good, given proper design considerations such as enclosure size, flight distance, environmental complexity, barrier safety and separation facilities for each species, selective sliding doors and animal management facilities.

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2.4 Breeding

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2.4.1. Introduction

In chapter 2 the general aspects of reproduction in gorillas are described. The following chapter deals with the consequences for breeding in zoos. As the EEP population consists almost exclusively of western lowland gorillas, this chapter focuses on this taxon.

2.4.2. Polygynous mating systems

Western lowland gorillas generally live in groups of one dominant male and a number of females with their young. This is called a polygynous mating system. Unlike groups of mountain gorillas, western lowland gorilla groups only rarely include more than one adult male. Group size fluctuations are more prevalent in western lowland gorillas than in mountain gorillas (Tutin et al., 1997). An average group of western lowland gorillas has 8 to 11 members. Such a group comprises one adult male, three or four adult females, and their offspring. Parnell (2002) has indicated that female gorillas have a preference for smaller groups. The EEP recommends that new groups are formed of one male and two or three females.

In polygynous species sexual dimorphism in body weight is more extreme than in species with other mating systems; a female western lowland gorilla weighs between 70 - 110 kg, while a silverback easily weighs twice as much. The saddle of silver hair which adorns the back of the adult males is a secondary sexual characteristic which is responsible for the name silverback. It is by virtue of this impressive appearance that the male is able to monopolizesexual access to the females in his group. Sperm competition is probably minimal in the gorilla, since females typically mate with just one male during the fertile period of the cycle. This seems to be confirmed by the observation that the gorilla has the smallest testes, both absolutely and in relation to its body weight, of any of the hominoids (Dixson, 1998).

Both females and males transfer out of their natal group once they become reproductively mature. Males often remain solitary for a prolonged period, even well into adulthood. 90% of solitary males in the wild have been reported to be silverbacks. Males may try to join established groups but this is rare. Formation of a new group usually occurs when a lone male acquires one or more females. When group takeovers occur, they can result in infanticide. Females may avoid this by leaving a recently taken over group. Females commonly participate in secondary transfer to new groups. When males cannot establish a breeding group they may seek other male company and form all-male bands. In zoos, both males and females should be transferred out of their natal group once they become adult, in order to avoid inbreeding.

2.4.3. Basic characteristics

2.4.3.1. Oestrus cycle

Female gorillas, as with other higher primates, exhibit a typical menstrual cycle which lasts between 26-32 days. Peak fertility and behavioural oestrus occur at mid-cycle and last between 1-4 days. It may be difficult to determine whether a female gorilla is cycling as it is not easy to observe menstruation. Although genital swelling does occur during oestrus, in general this is also hard to observe. Behavioural changes are often the easiest means to determine the cycle, as mating occurs mostly during oestrus.

The ovulatory cycle can, if necessary, be simply monitored by urine analysis; menstrual blood in the urine can be detected by using suitable reagent strips (Multistix 10 SG Euro, Bayer Corporation, Germany). However please remember that blood in the urine can also be indicative of health problems, particularly in those cases where the occurrence of blood is not at regular monthly intervals. The cycle can also be monitored by ovulation tests (eg. Clearblue Ovulation Detector kit, Unipath, UK).

These human-based tests demonstrate the presence of luteinizing hormone (LH) in the urine. The level of this hormone peaks just prior to ovulation.

If problems are suspected, more detailed examinations should be performed such as ultrasonography or a general blood screen. Medical treatment is possible in some cases and should always take place under the supervision of a veterinarian assisted by a gynaecologist if necessary.

2.4.3.2. Copulation

Mating usually occurs at mid-cycle during behavioural oestrus. However, mating is sometimes observed during the rest of the cycle and even during pregnancy.These matings serve purposes other than reproduction. It is possible to distinguish play mating, dominance mating, submissive mating etc. During oestrus it is usually the female that solicits copulation, although it appears that the male may also give signals to indicate that he is ready for mating. The female makes eye contact with the male and then presents to him, sometimes backing towards him in an attempt to initiate copulation.

Dorso-ventral mating is most common, but ventro-ventral mating also occurs. The male sits upright or leans slightly forward, the female on his lap or bent forward in front of him. The male firmly holds the female and, after some adjustments, starts to make rapid pelvic thrusts. Harcourt et al. (1980) timed the duration of copulations; on average copulation lasts 96 seconds with a minimum of 15 seconds and a maximum of 20 minutes. Other sources describe sequences of consecutive copulations starting with longer bouts (100 to 120 seconds) and ending with shorter ones (45 seconds).

2.4.3.3. Gestation

The routine testing, with normal human pregnancy test kits, of all gorilla females in the position to breed is recommended. These tests are based on the detection of a human pregnancy hormone, human chorionic gonadotrophin (HCG), in the urine. Fortunately gorilla chorionic gonadotrophin is similar enough in structure to HCG for human pregnancy tests to work. However as the sensitivity of the different kits varies, the use of the most sensitive of human kits is recommended for gorillas.The levels of chorionic gonadotrophin should be sufficiently elevated to facilitate the detection three to four weeks after mating. Urine for testing can be collected from a clean concrete floor with a syringe.

Some females show specific behaviour during pregnancy, which they do not show otherwise (e.g. hiding behaviour or changes in food preferences). These changes give experienced keepers an important clue regarding the breeding condition of their charges.

Pregnant females gain weight; this is most obvious in the second half of the pregnancy. From the fourth or fifth month the breasts and nipples may enlarge. Milk expulsion has also been reported, but not before the sixth month.

Gestation in gorillas lasts 237 to 285 days, with an average of 255 days.

2.4.3.4. Birth

Gorillas usually give birth to one young, twins are very rare. At birth a gorilla weighs on average 2.2kg, (range 1.4 – 3.06 kg). Table 1 shows data on gestation length and birth weight for a number of gorilla infants born in Barcelona zoo. In general low birth weight infants have greater risk of death. An infant born prematurely after a gestation of 201 days and weighing only 1.45 kg did not survive (Barcelona Zoo).

Births occur throughout the year, no seasonality has been observed. The inter-birth interval is normally 3 - 5 years. If an infant dies or has to be pulled for hand-rearing, the female can get pregnant immediately leading to an inter-birth interval as short as one year.

Mother	**Mating**	**Pregnancy test +**	Birth	**Infant**	**Pregnancy days**	**Weight of new born (g.)**
Machinda	12/6/97	16/7/97	17/2/98		250	-----
Machinda	2,6,28,29 / 5 / 98 (LH +)	15/6/98	31/1/99	Nimba	246	1740
Kena	7,30/5/98 14/7/98	17/7/98	8/2/99	Batanga	254	1800
Machinda	26/5/99 (LH+)	18/6/99	30/1/00		249	
Kena	1/6/99 (LH+)	28/6/99	13/2/00	Besseki	257	2250
Virunga	2/7/99 (LH+)	19/7/99	7/3/00		249	
Machinda	8.13,17/04/00 (LH+)	5/5/00	19/12/00	Muni	243	1900
Machinda	02/04/01 (LH+)	26/04/01	06/12/01	Mayani	248	2400
Virunga	26/10/01 (LH+)	19/11/01	31/05/02		201	1450
Kena	1,2,3/2/02 (LH+)	28/02/02	11/10/02	Kiondo	244	2.250
Machinda	15/3/02 (LH+)	11/04/02	27/11/02	Kivu	256	2.250
Kena	14,13/1/03	10/02/03	22/09/03	Ndowe	251	2.600

Table 1 Reproductive data from Barcelona Zoo. (LH^+ = luteinizing hormone present)

Behavioural changes may indicate pending parturition. A female in labour may show restless behaviour, unusual postures and muscle contractions, but often no such changes are perceived. Parturition starts with blood loss or emersion of the allantoic sac (the outer of the two foetal membranes, with the amniotic forming the inner). When the infant's head emerges, the female may reach for it to facilitate the birth. The placenta will be delivered some time after the infant has emerged.

No special arrangements need to be made to accommodate the birth. It is recommended that the mother should remain in the group during birth. If exceptional conditions make it necessary to remove a female from the group during labour, the mother and infant should be reintroduced back into the group as soon as possible.

Directly after the birth a mother should care for her infant. Usually, the infant is licked, held and cradled. Do not remove a newborn infant from its mother, unless there is a high risk of imminent death or sever injury. If the mother ignores or mistreats her infant, or if she does not hold her infant correctly, it is recommended that the situation should be observed closely and discreetly before any action is taken. The mother might improve her skills making such a removal unnecessary. Separating an infant from its mother is a last resort. Although hand-rearing techniques have improved substantially in recent years, hand-reared gorillas still face many social problems. For that reason hand-rearing should be avoided if at all possible.

2.4.4. Growth and development

A newborn gorilla is totally dependent on its mother for food and protection. The mother carries the baby all day and at night they sleep together in the same nest. At around 3 years of age, the infant will start making a sleeping nest of its own, but always close to that of its mother. In the daytime the youngster travels further and further from its mother, exploring the environment on its own. The infant is nursed for up to 4 years, although from 6 months old it will start eating solid food as well.

Male gorillas reach sexual maturity around the age of 10 years, but in zoos this can occur much earlier. According to studbook data the youngest male to sire an offspring was only 5 years 4 months and 3 days old at the time of conception. Several other males have sired their first offspring before the age of 7 years.

Although sub-adult males are very disruptive factors in gorilla social groups, it is important that young males remain in their family groups as long as possible. In a well functioning family group the adult females will cooperate to make sure that young males learn to control their strength. Males that are kept in their family group until adulthood seem to be better socialised and to have a more ‘balanced’ character. As a bonus, if males are kept longer in their natal groups, fewer bachelor groups will be needed. On the other hand, it might be advantageous to remove young males destined for life in a bachelor group at an earlier age, as socialisation with other males is easier with younger animals. In these cases, the young males should not be removed from their family groups before the age of 5. Such a male should preferable be transferred to a male group in the company of one or more of his (half) brothers.

Female gorillas reach sexual maturity at 7-8 years old. Again in zoos this may occur earlier; according to the studbook, the youngest female to give birth was 5 years 2 months and 4 days old. Several other females are recorded which have given birth before the age of 7 years.

Females should be removed from their family group when they reach sexual maturity but only if they have also experienced the birth of a sibling. Determining the onset of puberty can be difficult because individuals mature at different rates. If there is a need to know whether a female is cycling, a urine test may be required (see 6.3.1). If it is necessary to delay the removal of a young female from her natal group until after puberty, contraception will be necessary. Oral contraception is recommended, but it may take some time for full fertility to be restored after contraception ceases, and this may make the introduction of the female into a new group more difficult. Contraceptive steroid treatment, and GnRH agonist should not be given to pre-pubertal females.

It is very important for females to be reared in a social breeding group. Young females that have the opportunity to observe mating behaviour, birth and maternal care have a better chance of developing the appropriate social skills, sexual behaviour and maternal skills. Therefore, hand-reared females should be integrated into well functioning family groups as early as possible. The presence of a good gorilla foster mother can make it possible to integrate a hand-reared infant at a very early age.

2.4.4.1 Reproductive senescence

There is no evidence that gorilla females undergo a menopause or cease entirely to breed at older ages. According to the studbook the oldest female to have given birth was 41years, 9 months and 9 days at the time. Several other females have reportedly given birth over the age of 35 years. In fact one female was just over 32 years of age at the time of the birth of her first offspring and several other females have not had their first offspring until they were over 25 years.
Literature shows that older gorilla females show typical signs for Menopause which are known from women: change of cycle length, less oestrogen and progesterone, shorter follicle phase. (Atsalis & Margulis, 2008) Fertility of gorilla females seem to go considerably down with an age of 37 +.
According to the studbook the oldest female to have given birth was 41years, 9 months and 9 days at the time. Several other females have reportedly given birth over the age of 35 years. In fact one female was just over 32 years of age at the time of the birth of her first offspring and several other females have not had their first offspring until they were over 25 years.

2.4.5. Birth control

In those situations where birth control is required to seek advice from European Group on Zoo Animal Contraception EGZAC is advised. The method selected should be that with the least side effects, and one that induces fewest behavioural changes. The level of interference and risk should be as low as possible. Reversible methods are preferable to permanent methods.

2.4.5.1. Reversible methods

Separation of the sexes

Although very effective, separation of the sexes is not appropriate for social species like the gorilla; gorillas must be kept in stable family groups.

Birth control pills

Fortunately, many contraceptive pills developed for women are also effective for female gorillas but to diferenciate between progestagen only pills and the combination pill is necessary. Poregstagen only pills are recommended for nursing mothers and younger females. Oestrogen and progestagen combination pills are very effective in apes and the placebo week is not necessary so it may be given continously. It is recommended to use the combination with least amount of oestrogen that is effective for each individual (1/20-1/50). The 1/35 combination is the most widely used in apes (1mg of progestagen and 35 ugr of etinyloestradiol).This method of birth control has many advantages: it is reversible, induces few behavioural changes and is easy to use. Therefore birth control pills are the recommended method of contraception in most circumstances.

Contraceptive implants

Implants, either those developed for humans containing progesterone analogues (Implanon®, Nexplanon®, Jadelle®) or those for other species containing agosnists of the GnRH (Suprelorin®, Lupron® injections), have been used quite frequently in zoo mammals. These implants are reversible and behaviour is not substantially affected. However, anaesthetic is required for insertion and removal. Implants, although not very common, can sometimes get lost, which may result in a pregnancy. The duration of efficacy for progestagen implants may be shorter in gorillas than in humans.

The contraception database (EGZAC and AZA RMC) has 143 bouts of Implanon/Nexplanon use, 44 of Norplant 2 or Jadelle and more than 500 of MGA (this product is not available in Europe). Preliminary data suggest that duration of efficacy is shorter in chimpanzees than humans (Bettinger, pers. comm.). Species differences are possible, and the manager considering the use of progestogen implat should monitor changes in oestrous cycle of the implanted female. It is important to bear in mind that with the use of progestogens oestrus might not be fully suppressed despite full contraceptive effect being achieved. If oestrus signs are not desreable a higher dose of progestogen would be recommended.

Other parenteral products available are the agonists of the GnRH (Supralorin® implant (desloreling acetate) and Lupron® depot injection (leuprolide acetate)) that suppressthe reproductive endocrinesystem, preventing productionofpituitary andgonadalhormones. Duration of effect and latency to reversibility is unknown for gorillas as there is lack of data in this species. There are 22 bouts of Lupron use in gorillas in the joint data base, however information about duration and/or reversibility is still patchy.

For more detail information on chemical contraception please refer to the EGZAC recommendation listed below.

Reporting requirements: In order to increase our knowledge of the efficacy of contraception methods in the great apes it is recommended that all individuals on contraception be reported to the European Group on Zoo Animal Contraception EGZAC (www.egzac.org). EGZAC works in association with the American Association of Zoos and Aquariums Reproductive Management Center (AZA RMC) promoting ongoing research and information gathering

Primates:Pongidae

LastUpdated:March2014

For further information and discussion about individual cases and for the latest contraception information please contact EGZAC (www.egzac.orgcontraception@chesterzoo.org)

FactSheet Reviewedby:Hester van Bolhuis and Yedra Feltrer

Contraceptive methods	GnRHagonist (implant)	GnRHagonist (injection)	Progestagen (implants)	Progestagen (implants)	Progestagen (injection)	Combination Birth-Control Pills	Progestagen only Birth-Control Pills	Surgical/Permanent
Contraceptive Product:	Deslorelin acetate	Leuprolide acetate	Etonogestrel 68mg	Levonorgestrel 2x75mg	Medroxyprogesterone acetate	Combinations of a synthetic progestagen and oestrogen at various doses are available	Oral synthetic progestagens without any oestrogen component	N/A
Commercial Name:	Suprelorin®	Lupron ®	Implanon® Nexplanon®	Jadelle® Norplant2®	Depo-Provera®, Depo-Progevera®	Several commercial oral combination pills are available in the market for human use.	Several commercial oral progestagen pills are available in the market for human use. Norgestone® (30mcg Levonorgestrel) successfully used in gorillas.	Vasectomy
Product Availbility:	4.7mg('Suprelorin 6')and 9.4mg ('Suprelorin 12') available in theEU 9.4mg('Suprelorin 12')	Leuprolide Acetate licenced for human use	Manufactured by Organon.Available through human drug distributors	Manufactured by Organon.Available through human drug distributors	Manufactured byPfizer.Available throughout Europe through human drug distributors	Widely available in pharmacies for human use	Widely available in pharmacies for human use	N/A
Restrictions and/or permit required by Importing Country:	EGZAC recommends: always check with your local licencing authority	Data deficient	EGZAC recommends: always check with your local licencing authority	EGZAC recommends: always check with your local licencing authority	EGZAC recommends: Always check with your Locallicencing authority	N/A	N/A	N/A

Mechanism of action:	GnRH agonist suppress the reproductive endocrinesystem, preventing production of pituitary And gonadal hormons. As anagonist of the GnRH initially stimulates the reporductive system- which canresult in oestrus and ovulation in females or temporary enhancement of testosterone and spermatogenesis in males- therefore additional contraception needed during this time. Please see below and refer to Deslorelindatasheetfordetailed information	GnRH agonist suppress the reproductive endocrine system,preventing production ofpituitary and gonadal hormones	Interference with fertilization by thickening cervical mucus,interrupting gamete transport, disruption of implantation, inhibition of LH surge necessary for ovulation	Interference with fertilization by thickening cervical mucus , interrupting gamete transport,disruption of implantation, inhibitionof LH surge necessary for ovulation	Anti-estrogenicactivity. Interference with fertilization by thickening cervical mucus, interrupting gamete transport,disruption of implantation, inhibition of LHsurge necessary for ovulation	Inhibit follicular development and LH surge preventing ovulation. Progestagen partal so blocks fertilisation and/orimplantation.	Interference with fertilization by thickening cervical mucus, interrupting gamete transport. Disruption of implantation. Inhibition of the LH surge necessary for ovulation.These mechanisms are dose dependant, typically higher dose of synthetic progestagens are required to block ovulation than to block fertilization and/or implantation.	Surgicalprocedure inwhichthe ductusdeferensarecut, tied, cauterized, orotherwise interurrupted

Insertion/ Placement:	Sub-cutaneous, in a place where it can be easily detected or seen for removal at a later date(I.e.upper inner arm);refer Suprelorin factsheet for effective method of implant (tunnelisation)	Injectable	Intramuscular or subcutaneous. EGZAC recommends sub-cutaneous, upper inner arm for visibility (aid for later removal)	Intramuscular or subcutaneous. EGZAC recommends sub-cutaneous, upper inner arm for visibility(aid for later removal)	Injectable intramuscular	Oral	Oral	Surgical
Females	**Data deficient**	**Data deficient**						
Dose	Dosages and duration of efficacy have not been well established. As a guide: 1-2x4.7mg; 1-2x9.4mg	Dosing information is not available; extrapolation from human literature is likely the best place to start	Doses not well established. Recommended ½ to 1 implant, depending on species and weight	Recommended 2 rods. Doses not well established.	2.5-5mg/kg body weight every 45-90 respectively days has been effective in most NHP species	1 whole pill daily.The most commonly used combination of oral contraceptive products are:1/35(1mg Progesterone and 35ug Ethinyl Oestradiol) formulations (some may be able to use a 1/20 and others might need to go up to 1/50 formulation). It is recommended using the lowest oestrogen dose that effectively suppresses bleeding, possible welling and oestrus behaviour.	1 whole pill a day	N/A
Latency to effectiveness:	3 weeks average as GnRH agonist initially stimulates the reproductive system-**please refer to Deslorelin data sheet for detailed information –** additional contraception needed during this time(see product data sheet. ~2mg/kg Megestrol acetate pills daily 7 days before and 8 days after has been used)	Same as deslorelin with an initial stimulation phase and suppression should then occur 3-4 weeks later (please refer to deslorelin and lupron data sheet for more details)	In general inhibition of ovulation after 1 day when inserted on day 1-5 of cycle or when replacing oral progestogen. As the right stage during menstrual cycle is often unknown,it is advised to use other contraceptive methods for at least 7-14 days after insertion of the implant depending on administration route (IMorSC)	In general inhibition of ovulation after 1 day when inserted on day 1-5 of cycle or when replacing oral progestogen. As the right stage during menstrual cycle is often unknown,it is advised to use other contraceptive methods for at least 7-14 days after insertion of the implant depending on administration route(IMorSC)	1-3 days post injection.However,if the cycle stage is not known then extra time must be allowed ;therefore, separation of the sexes or alternative contraception should be used for at least 1 week .	1 to 2 weeks but can take up to one month if treatment starts near the time of ovulation(refer to product insert for exact information on this)	1 to 2 weeks, although this varies depending on the brand.**Please read the packet insert.** The packet will outline when to start and how long to use secondary protection and/or how long the individual may need to be separated.	N/A

Oestrus cycles during contraceptive treatment:	Initial oestrus and ovulation (during the 3 weeks of stimulation) then no oestrus cycle.To suppress the initial oestrus and ovulation you can follow the megestrol acetate protocol mentioned above.	Same as deslorelin.	Oestrus is inhibited. Menstruation in non-human primates is more or less present with regular cyclicity.This is an individual and dose-dependent response. Some will swell during treatment and some will not.	Oestrus is inhibited. Menstruation in non-human primates is more or less present with regular cyclicity.This is an individual and dose-dependent response. Some will swell during treatment and some will not.	Oestrus behavior maybe observed. Ovulation and cycling can occur in adequately contracepted individuals (but is unlikely and the degree of suppression is dose dependent).	Sings of oestrus can occur during the place boweek if treatment not administer continuously (place bo week not necessary)	Oestrus behavior may be observed. Ovulation and cycling can occur in adequately contracepted individuals (but is unlikely and the degree of suppression is dose dependent). Be aware that progestagen-only pills are not being as effective at suppression oestrus as the combination pills.	N/A
Use during pregnancy:	Not recommended	Not recommended	In non-human primates progestagens normally do not interfere with parturition. However in other species progestagens are not recommended for use in pregnant animals because of the risk of prolonged gestation, stillbirth or abortion.	In non-human primates progestagens normally do not interfere with parturition. However in other species progestagens are not recommended for use in pregnant animals because of the risk of prolonged gestation, stillbirth or abortion.	Progestagens are not recommended in pregnant animals because of the possibility of prolonged gestation, stillbirth, abortion, etc.in some species, although the effect may depend on dose.Progestagens in late pregnancy seem not to interfere with parturition in primates,but this is a taxon-specific phenomenon.	Not recommended - Risk to foetus unknown	Progestagens are not recommended in pregnant animals because of the possibility of prolonged gestation, stillbirth, abortion,etc.in some species, although the effect may depend on dose.Progestagens in late pregnancy seem not to interfere with parturition in primates,but this is a taxon-specific	N/A
Use during lactation:	No contraindications once lactation established	Nocontraindications once lactation established	Considered safe for nursing infant.	Considered safe for nursing infant.	Considered safe for nursing infant.	Not recommended –may interfere with milk production and affect the developing infant.Progestin-only birth control pills can be used instead.	Considered safe for the nursing infant	N/A

Use in prepubertals or juveniles:	**Data deficient** in this group,see product information sheet	**Data deficient** in this group, see product information sheet	The use of synthetic progestagens in pre-pubertals or juveniles has not been fully assessed. Possible long-term effects on fertility are not known.	The use of synthetic progestagens in pre-pubertals or juveniles has not been fully assessed. Possible long-term effects on fertility are not known.	The use of synthetic progestagens in pre-pubertals or juvenilesh as not been fully assessed. Possible long-term effects on fertility are not known.	Not recommended – **Data deficient** and potential long-term effects in fertility	The use of synthetic progestagens in pre-pubertals or juveniles has not been fully assessed.Possible long-term effects on fertility are not known.	N/A
Useinseasonal breeders:	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Duration	Duration of efficacy has not been well established as a guide: 4.7mg implants will suppress for a **minimum** of 6months; 9.4mg will be effective for a **minimum**	Not well established, duration of effect being likely related to the dose. Higher doses result in longer duration of effect. **Data deficient**	2-3 years in various primates	2-3 years in various primates	Dose dependant: 45-90 days in general. However, effects could last 1-2 years in some individuals.	More than 1 day as effective during the placebo week in human.Duration for other species not fully established.	Not more than one day.Pills need to be administered daily (follow packet insert instructions if one day is missed).	N/A
Reversibilty	Considered reversible but every species has not been tested.duration to reversibility extremely variable. Removal of implant to aid reversibility is recommended.	Considered reversible but every species has not been tested.Duration to reversibility extremely variable.	Designed to be fully reversible but individual variations can occur. To increase potential for full reversibility implants must be removed.	Designed to be fully reversible but individual variations can occur.To increase potential for full reversibility implants must be removed.	Designed to be fully reversible but individual variation scan occur	Reversibility presumably would occur after cessation of treatment, although return to cycling can vary per individual. Even in humans, it may take several months (cycles) before	It should be reversible after cessation of treatment, although return to cycling can vary perindividual. Even in humans, it may takes ever months (cycles) before normal ovulation returns.	N/A

Effects on Behaviour	None observed except lack of libido. There are anecdotal reports of change of hierarchy with the behavioural implications that this may have.	Same as deslorelin	Effects on behavior have not been studied, every individual may react differently. Because progestagens can suppress ovulation it can be expected that courtship and mating behaviour will be affected in some way.Further researchinthesubjectis necessary.	Effects on behavior have not been studied, every individual may react differently. Because progestagens can suppress ovulation it can be expected that courtship and mating behaviour will be affected in some way.At high doses can have masculinising effect. Further research in the subject is necessary.	Effects on behavior have not been studied, every individua may react differently. Because it binds readily to androgen receptors and is antiestrogenic, females may experience male-like qualities (increased aggression, development of male secondary sex characteristics, etc.) Further researchi n the subject is necessary.	**Data deficient.** Mood changes might occur.	Effects on behavior have not been studied, every individual may react differently. Further research in the subject is necessary.	N/A
Effects on sexual physical characteristics	Similar to gonadectomy; especially weight gain.	Some dichromatic Species may Change colour.	Some signs of oestrus behavior might occur. Ovulation may also occur even though pregnancy does not ensue.	Some signs of oestrus behavior might occur. Ovulation may also occur even though pregnancy does not ensue.	See above	Data deficient	Females with sexual perineal skin may exhibit partial to normal swellings on birth-control pills.With the continuous use of pills, swelling may no toccur.It depends what formulation is chosen.	N/A
Males	**Data deficient**	**Data deficient see comment for deslorelin**	**Not Recommended**	**Not Recommended**	**Not Recommended**	N/A	N/A	Reported
Dose	Usually a higher dose than in females is required in males. **Data deficient**	Usually a higher dose than in females is required in males. **Data deficient**	N/A	N/A	N/A	N/A	N/A	N/A

Latency to effectiveness:	Depending on the species there may be fertile esperm present in vas deferens for 6-8 weeks post treatment. Testosterone decreases after 3- 4 weeks but sperm can stay fertile for many weeks after. Additional contraception needed during this time or separation ofthe sexes.	Depending on the species there maybe fertile sperm present in vas deferens for 6-8 weeks post treatment. Testosterone decreases after 3-4 weeks but sperm can stay fertile for many weeks after. Additional contracept. Needed during this time or separation of the sexes.	N/A	N/A	N/A	N/A	N/A	Depending on species and individual, perhaps as long as 2 months or more
Use in prepubertals or juveniles:	**Data deficient** in this group,see product information sheet	**Data deficient** in this group, see product information sheet	N/A	N/A	N/A	N/A	N/A	Data deficient

Use in seasonal breeders:	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Duration and Reversibility	**Data deficient**, but deslorelin is considered reversible. See product information sheet.	**Data deficient**, but lupron is considered reversible. See product information sheet.	N/A	N/A	N/A	N/A	N/A	The procedure should not be used in males likely to be recommended for subsequent breeding as reversal
Effects on Behaviour	Testosterone related aggression is likely to decrease. **Data deficient** in this group, see product information sheet.	Testosterone related aggression is likely to decrease. **Data deficient** in this group, See product information sheet.	N/A	N/A	N/A	N/A	N/A	Vasectomy will not affect androgen-dependant behaviours
Effects on sexual physical characteristics	Decrease in body size, decrease testicular size, feminisation of males. Anaemia can occur in human males treated for prostate cancer with GnRH agonists- this has not observed in great apes or other NHP.	Decrease in body size, feminisation of males. Anaemia can occur in human males treated for prostate cancer With Lupron-this has not observed in great apes or other NHP	N/A	N/A	N/A	N/A	N/A	None observed in non-human primates
General:								
Side effects	Similar to gonadectomy; especially weight gain.	Similar to gonadectomy; Especially weight gain.	Possible weight gain, possible increased or decreased frequency of bleeding during menstruation. **EGZAC recommends always reading the manufacturer's data sheet**	Possible weight gain, possible increased or decreased frequency of bleeding during menstruation. At high doses can have masculinising effect. **EGZAC recommends always reading the manufacturer's datasheet**	Progestagens are likely to cause weight gain in all species. Possible deleterious effects on uterine and mammary tissues vary greatly by species; In the human literature,Depo-Provera® has been linked to mood changes.Because it binds readily to androgen receptors and is anti-estrogenic, females may experience male-like	Weight gain is less likely than with the progestagen only pills.Mood changes might occur.	Progestagens likely cause weight gain in all species. Possible deleterious effects on uterine and mammary tissues vary greatly by species.To date, few studies have shown link between synthetic progestagen treatment and serious health risk in non-human	N/A

Warnings	Causes initial gonadal stimulation; correcta dministration essential- see product information sheet	Causes initial gonadal stimulation	Interaction with other drugs is known to occur and may influence protection against pregnancy. In some diabetic animals progestagens has led to an increased insulin requirement, it is advised that the product be used with caution in diabetic animals and that urine glucose levels are carefully monitored during the month after dosing. **EGZAC recommends always reading the manufacturer's data sheet.**	Interaction with other drugs is known to occur and may influence protection against pregnancy. In some diabetic animals progestagens has led to an increased insulin requirement, it is advised that the product be used with caution in diabetic animals and that urine glucose levels are carefully monitored during the month after dosing. **EGZAC recommends always reading the manufacturer's data sheet.**	Interaction with other drugs is known to occur and may influence protection against pregnancy. In some diabetic animals progestagens has led to an increased insulin requirement, it is advised that the product be used with caution in diabetic animals and that urine glucose levels are carefully monitored during the month after dosing. **EGZAC recommends always reading the manufacturer's data sheet.**	Interaction with other drugs is known to occur and may influence protection against pregnancy. In some diabetic animals progestagens has led to an increased insulin requirement, it is advised that the product be used with caution in diabetic animals and that urine glucose levels are carefully monitored during the month after dosing.**EGZAC recommends always reading the manufacturer's data sheet.**	Progestagen only contraceptive pills can fail in obese animals. Be aware that progestagen-only pills are not being as effective at suppression oestrus as the combination pills. In some diabetic animals progestagens has led to an increased insulin requirement, it is advised that the product be used with caution in diabetic animals and that urine glucose levels are carefully monitored during the month after dosing.	Infection of the surgical wound might occur. Intradermal closure of the skin is advised together with prophilactic antibiotic treatment and NSAID
Reporting Requirements: In order to increase our knowledge of the efficacy of contraception methods in the Pongidae family it is recommended that all individuals on contraception be reported to EGZAC								
Disclaimer:EGZAC endeavours to provide correct and current information on contraception from various sources. As these are prescription only medicines it is the responsibility of the veterinarian to determine the dosage and best treatment for an individual								

2.4.5.2. Irreversible methods

Vasectomy

In a vasectomy, the vas deferens are cut and sealed. This procedure permanently sterilizes a male. A vasectomized male may be fertile for one month after the operation. In humans this procedure may be reversed, but in gorillas this has not been attempted. A reversible vasectomy, by injecting a plug into both vas deferents, is in an experimental phase. After a vasectomy, hormone levels remain unchanged and thus behaviour, including breeding behaviour is not affected.

Castration

Castration also permanently sterilizes a male, but in this procedure the testicles are surgically removed. As a result the normal production of testosterone is prevented and this may seriously affect male behaviour. The degree to which behaviour is affected is partially dependent on the age at which the male is castrated. Further research on the relationship between the age of castration and the subsequent behaviour of the male is needed.

Until recently there was only one castrated gorilla in the EEP, and he still is the only one who reached adulthood: The male Kukuma was born at Apenheul Primate Park in 1989, removed from her mother and castrated at the age of 7 months, and then transferred to the Stuttgart nursery. Kukuma died at the age of 22 years from causes unrelated to the castration. (Vermeer, 2014)

From the evidence and reports from the caretakers we can conclude that Kukuma had a good quality of life (both in the nursery and in the social group) and enjoyed it. He could cope with the transfer to a breeding group and several changes in his social environment and he played an important social role in the group (Vermeer, 2014).

Tubal ligation

Tubal ligation is a method of permanently sterilizing a female through surgery. The procedure involves the cutting or blocking of the fallopian tubes. The production of sex steroids is unaffected and so the menstrual cycle and behaviour are not affected.This is the best recommended way for permanent sterilization butsurgery/paratomy should be done by an expert gynecologist

Hysterectomy or ovariohysterectomy

In these procedures either the uterus or the uterus and the ovaries are surgically removed. This procedure is very radical and normally not recommended as a birth control method. After a hysterectomy the female gorilla will not menstruate, but should continue to exhibit normal sexual behaviour. The ovariohysterectomy will additionally lead to cessation of the production of oestrogen and progesterone and to marked changes in the occurrence of some or all components of sexual behaviour.

2.4.5.3. Ongoing research

Birth control is a very useful tool in zoo management. Unfortunately, for many species suitable techniques do not yet exist. Research is continuously being directed to the development of new and better methods of birth control, e.g. a male birth control pill (Bisdiamine) and immunocontraception (PZP = Porcine Zona Pellucida vaccine). To date, these methods are not an option for use in gorillas. Another possibility for the future might be Depo-Provera (Pfizer) which contains the synthetic progestin medroxyprogesterone acetate in an injectable form. This contraceptive method was recently approved in the USA for use in women. However, an appropriate dose for gorillas is not known, although the human dose might be used as a starting point.

2.4.5.4. Evaluation of side effects

Assessment of side effects associated with the use of any contraceptive method requires the maintenance of accurate records before, during and after contraceptive use. Upon the animal's death, a necropsy should evaluate the reproductive and other associated systems.

2.4.6. Assisted reproductive technology

Assisted reproductive technology can be helpful in cases where normal sexual reproduction does not produce the desired results. In human medicine much research has been directed to artificial reproduction. As a result, we are now able to manipulate human fertility in many different ways. As gorillas and humans are closely related, it would seem clear that many of these human techniques may also be applied to gorillas.

2.4.6.1 Artificial insemination

Artificial insemination (AI) has been successful in gorillas using both fresh (Tribe et al, 1989) and frozen (Douglass & Gould, 1981) semen for insemination. Collection of sperm is rather difficult in gorillas. It is possible, but time consuming, to train males to masturbate and produce sperm on demand. Another possibility is to anesthetize a male and use electro-ejaculation to collect the semen. The quality of sperm collected in this way is often poor (Raphael et al., 1989). When electro-ejaculation is attempted, ketamine hydrochloride is recommended as the anaesthetic, because atropine sulphate may block seminal emission (Ogden et al., 1997). The gorilla EEP does not currently recommend the use of AI; the gorilla population can be successfully managed by natural breeding. However the EEP supports further research into AI and, if a member of the Gorilla EEP wants to attempt artificial insemination in order to facilitate the reproduction of a non-breeding specimen, a protocol of the proposed procedure should be submitted to the Gorilla EEP Committee for approval.

2.4.6.2 Pre-determination of sex

The problem of surplus males might be avoided if it were possible to control the birth sex ratio. There is some evidence that the age of the mother might have an influence on the sex of her offspring (Mace, 1990). However, whether this could be utilised to skew birth sex ratios in the EEP population is questionable. Another possibility might be through assisted reproduction. O'Brien et al. (2002) have provided an overview of the possibilities for pre-determining sex of offspring. In a small number of mammal species this has been achieved by using sperm sorting and A.I. Sperm is sorted using flow cytometry and the technique is based on the difference in DNA content between the X- and the Y-chromosome. The greater the difference, the easier it is to separate the X-bearing spermatozoa from the Y-bearing spermatozoa. In gorillas this difference is rather low (2.6-2.7%) compared to other mammals. Current evidence suggests there are no significant sperm or embryo-related risks of the current sorting technology.

Application of this kind of technology could ultimately be directed towards the production of female gorilla embryos with low mean kinship within the SSP population, in order to transfer these embryos to female surrogates with high mean kinship rankings and proven parental skills.

The gorilla EEP does not currently have any recommendations regarding the pre-determination of sex. In recognition of the problems of surplus males, the EEP supports research into the control of birth sex ratios. For the foreseeable future, techniques for pre-determining sex ratios are not considered to be a necessary tool for the management of the gorilla EEP. Any research activities in this field should be approved by the Gorilla EEP Committee.

2.4.7. Birth management

There is ample evidence from studies of primates to indicate the importance of early experience in social development and the detrimental effects of maternal deprivation (Mason et al., 1968; Riesen, 1971; Nadler, 1981; Meder, 1989). Hand-reared gorillas, especially those with limited access to conspecifics early in life, experience moderate to severe social deprivation (Beck & Power, 1988), which can have detrimental effects on the development of social and sexual behaviour.

It is, therefore, strongly recommended that young gorillas be raised by their mothers, and that they be hand-reared only in life-threatening situations.

Maternal proficiency increases with experience (Nadler, 1974; Stewart, 1977). First time mothers that have never observed an infant being reared can be fully capable of rearing their own offspring.

2.4.7.1. Maternal competence

Maternal competence is influenced by different factors:

Physiological factors may include maternal health, adequate milk production and ability to nurse, and endocrine factors.
After delivery, some hormone levels increase: prolactin and estrogens stimulate maternal behaviour. Oxytocin has three functions: induce the delivery, induce milk ejection, and promote maternal behaviour (Le Vay, 1993). The bond between mother and infant must be established in this period of time. Afterwards the infant will be responsible for stimulating maternal behaviour in its mother.

Aspects of the physical environment that may influence maternal competence include: Exhibit size and amount of vertical space, access to privacy, opportunities for activity, play and exploration to reduce stress and boredom, access to live vegetation, access to nesting material, and diet.
Social factors with an influence on maternal behaviour may include group composition, maternal rank and temperament, access to familiar companions, sex of infant, relationship to human caretakers and, most important, social experience of the mother: Her maternal competence is influenced by the way she was reared herself, mother-reared or hand-reared, and by her degree of experience in living in a social group with the opportunity to observe maternal behaviour in other females (Meder, 1989; Abelló, in press).

2.4.7.2. Post-partum observation and evaluation

Many females prefer some privacy for giving birth, e.g. they give birth during the night, without the presence of keepers and visitors, and/or they retreat from the rest of the group. However, especially in the case of a primiparous female or a female who has shown a lack of maternal behaviour before, it is advisable to observe her for the first three to four days after birth (maybe longer, depending on her performance). Care must be taken that the mother/group does not feel disturbed by being watched or by the presence of video camera equipment. She/they should be used to the situation (e.g. the video camera can be installed weeks before the birth is expected). It is self-evident that the video monitor has to be placed in a separate room for staff to watch, and that preferably only one person does the observation in front of the enclosure. A whole bunch of staff and non-staff members – like a TV team – can be a very disturbing factor!

The following aspects should be checked after birth by careful observation and be written down in a protocol to be available for other staff members including the vet and the curator (Rosenblat, 1987; Rogers and Davenport, 1970).

1. Presence of mucus and placental membranes that could obstruct the mouth/nose of the infant and are normally removed by the mother.
2. Care provided by the mother for the infant: Does she clean the newborn baby? Does she ignore it or actively avoid physical contact? (The baby can lose its body temperature within three hours, if it is not held/carried by the mother.)
3. In which position does she hold/carry the baby? An inexperienced mother might hold/carry it upside down at first; some mothers carry it on a hand or leg, which is OK as long as they allow it to suckle from time to time. The risk should be evaluated carefully.
4. Does she protect the baby from (curious) other group members? Is she calm or nervous, and is this related to the presence/absence of other group members? In case a female who has given birth and is separated from the other group members does not show good maternal behaviour, the introduction of at least one group member might stimulate her maternal behaviour, as she will protect the baby and might carry it.
5. Has the placenta been passed? Some mothers will eat it, others not. If the umbilical cord remains attached to the infant, it should be dry and detached by the third day.
6. Ability of the infant to cling to its mother: A one-day-old infant is capable of clinging to the mother

unsupported for three minutes (Fossey, 1979). The strength of the clinging reflex and the ability to hold the head up are important indicators of the newborn infants' health or the beginning of weakness.

7. Crying: The infant will cry if it feels uncomfortable (being hungry, being carried in a wrong position). If crying is reduced or stops, this does not necessarily mean the infant feels comfortable, it can also mean that it has become too weak..
8. Passing of urine/faeces/colour of faeces: The colour of the first faeces is very dark/black (meconium passes during within the first 48 hours after birth). However, mustard-yellowish stool means that the infant drank and digested milk.
9. Suckling/Drinking: Normally nursing begins 9-24 hours after birth. It is very hard to see if the baby is really drinking. Even if the head is not hidden in the mother's hairy arm, even if you see the infant having the nipple in its mouth and suckle, even if you see it swallowing, you can still not be sure if it really gets milk, since milk flow may only start on the second day.

At least 48 hours can usually be allowed to elapse before non-suckling becomes a concern, as newborn gorillas can usually survive at least as long as this without having suckled.
In the event of a potential maternal neglect a mother should be given as long as possible (taking due account of the welfare of the baby and drawing upon the experience of colleagues) to try to nurse/rear her offspring. Even when it looks like the baby has to be pulled, the next baby can profit from every experience the mother will have with this baby.

It is urgently recommended that in the case of a potential maternal neglect institutions contact the EEP coordinator and/or other experienced members of the gorilla species committee to help them find the best solution, decide if hand-rearing is unavoidable, if early (re-)introduction of the infant to the mother or a foster makes sense, or if the infant should be transferred to the EEP nursery at Stuttgart's Wilhelma Zoo.

2.4.7.3. Alternatives to Hand-rearing

There are several options to take action in the case of maternal neglect to bring about natural rearing:

1. encouraging the mother vocally (she will pay attention to a trusted keeper)
2. separating the mother and baby to provide them with a calm atmosphere, or separating aggressive group members if it helps to calm the mother down.
3. going in with the mother (only if she is used to it and only if there is no risk for the trusted keeper), putting the baby in the right position to suckle, "teaching" her what she is supposed to do
4. anaesthetising the mother and putting the baby in the right position to suckle (If the mother does not – yet – have milk, but holds and carries the baby correctly, bottle-feed the baby and return it to the mother. Eventually she will learn that placing the baby onto her chest causes it to stop vocalizing and relieves tension in her breasts – Rogers and Davenport, 1970.)
5. supplementary feeding with the infant still being with its mother (e.g. by feeding the mother preferred food items at the same time, Schmidt,1986; 1993).
6. surrogacy/foster-rearing by another female willing to accept the baby, maybe even at another zoo (the latter meaning that the baby would have to be pulled from the mother for a short period of hand-rearing before being introduced to the foster – see section on early introduction).

All these options should be considered before finally deciding to hand-rear an infant. Moreover, the infant's long term future should be taken into consideration before finally deciding to hand-rear it, i.e. its genetic value to the breeding programme and the likelihood of successful reintegration. If this is in doubt, then euthanasia can be considered, if allowed under national law and if agreed with the owner, the (official) vet, and the EEP coordinator. The Great Ape TAG accepts use of euthanasia, for apes in preference to keeping them long term under conditions which significantly reduce the individual's welfare and if there is no other alternative (adapted from ape TAG guidelines on HR)(see EAZA Culling www.eaza.net/assets/uploads/Position-Statements/). In case of hand-rearing a male gorilla infant of low genetic value to the breeding programme, castration can be considered as a means to allow future life in a social group with mixed sexes if agreed by the EEP coordinator/ species committee.(See chapter 9.1)

2.4.8. Hand-rearing and early (re-)introduction

In any case before deciding to handrear a baby, to contact the coordinator is mandatory. If such would be the case, the coordinator and the committee member will facilitate their knowledge, expertise and advice to ensure the best future for the hand-reared individual.

2.4.8.1. Initial care and decision-making on early (re-)introduction vs. nursery-rearing

If the baby has to be taken away from the mother to save its life, initial care should preferably be provided by an experienced keeper and following methods which have proved to be successful noted (Holtkötter & Scharpf, 1993).

In the case that there is no realistic prospect for an early socialisation/reintegration into a group (see below), or when attempts to do so have failed, it is recommended to rear the baby together with conspecifics in the EEP nursery at Wilhelma, Stuttgart. Contact or socialisation with conspecifics as earlier as possible, or even better with adult conspecifics, is important to prepare the infant for the integration into a family group. The transfer of the infant to the nursery should be done within the first month of life, but at the latest before the infant reaches 4 months old.

It is not recommended to hand-rear gorillas alone or together with other species, as long as there is a possibility to rear them with conspecifics.

Early reintroduction of a hand-reared infant to the natal group or early introduction to another group (at another zoo) must be started as early as possible and is only recommended if conditions seem promising. Conditions which are more likely to result in a successful early (re-)introduction include:

- a well-balanced, stable group
- an adult and socially experienced group member that is willing to take, keep, and protect the baby, allowed to do so by the other group members, is lactating, or trained to allow bottle-feeding of the baby
- suitable facilities, e.g. an enclosure which allows visual, auditory and olfactory contact through wire mesh, offers protected physical contact through wire mesh, has selective sliding doors through which only the infant can pass, e.g. to be fed or to escape from aggression
- other (preferably mother-reared) infants in the group (juveniles may be aggressive to the introduced infant)
- availability of competent keepers who can maintain the appropriate critical distance in keeper/animal relationship during the introduction process, i.e. not trying to be the “better” mother.

Building up a relationship starts with carrying the baby to the group as soon as its health is stable enough and with making contact through the wire mesh for the initial weeks/months of life. The gorilla infant should be housed (at least during the day) so that it will have as much visual, auditory and olfactory contact with the group members as possible. It should be carried by the keepers when they come in close proximity of the group members, such as at feeding times. The integration should be finished (i.e. the infant being in the group all day) at 18 months of age, but it has been shown that full integration may be possible much sooner

Early introduction to a group other than the natal group should only be considered if there is no risk of infanticide (see chapter 2.4).

If a collection is experiencing a second case of maternal neglect, then it should consider

- re-examining the present husbandry management of the gorillas
- possible transfers within the EEP in discussion with the species committee
- preventing the female concerned from being mated to avoid pregnancy or contracepting her, e.g. until she has observed a model for maternal behaviour.

If an infant is removed for hand-rearing and later (re-)introduced to a group, the reasons for removing it as well as records of the hand-rearing and (re-)introduction techniques, physical and behavioural development and subsequent breeding of the individual concerned must be documented and made.

2.4.8.2. Physical needs of hand-reared infants

Diet:

- Human formulas (Milumil, Aptamil, Similac, etc. or a soy-based milk if there are symptoms of allergy).
- Amount of formula: week 1 – 7: 15-20% of body weight, after that: 10 % of body weight, distributed over 24 hours.
- Feedings spread over a 24 h period at 2 - 3 hours intervals (on demand of the infant) for the first 4 weeks. After that, the amount of feedings can be reduced gradually.
- Solid food: In the wild, infants begin to play with food items at 4 months of age. In zoos, pap of carrot or fruit can be offered from 6 weeks of age on. As soon as the first teeth appear (incisors), pieces of apple can be offered. Human formula remains the main food basis for at least 12 months (infants in the wild nurse for at least 2 years). The feeding of human formula out of a bottle or later a cup is continued at the Wilhelma Zoo´s nursery up to the age of 3 years. (Holtkötter & Scharpf, 1993).
- Eruption of teeth:

  I1: week 6-13, I2: week 7-20, PM1: week 16-29, PM2: week 40-54, C: week 40-64

Modern human paediatrics advise feeding a baby ad lib. The experience at la Vallée de Singes and Zurich showed the baby was drinking between 15 and 20% of its body-weight. These baby gorillas were a very good weight, not too fat. The advantage was that they could regulate the amount they took per feeding, and were always satisfied after feeding.

A hand-rearing protocol must include accurate records e.g. on the amount of food offered and consumed, stool consistency, weight increase, and overall health. Vaccinations could be considered (see chapter 2.8.).

2.4.8.3. Psychological and social needs of hand-reared infants

Before a hand-reared gorilla can be placed with conspecifics/peers (which should happen as soon as possible), human contact is the only (living) source of comfort for the infant (Maple, 1983).

1. Keepers must copy as much as possible the manner in which the infant would be raised by its mother especially by carrying the infant or by keeping body contact otherwise for several hours daily to avoid the development of rocking behaviour (Schmidt, 1993; Harlow & Harlow, 1961).
2. Towels, blankets, a piece of artificial fur and/or a special furry doll (washable) have to be given to infants to cling to (e.g. during diaper change), but this should not be a substitute for contact with humans or conspecifics.
3. Provide a stimulating and challenging environment. As the infant matures provide more complex toys and structures that encourage climbing.
4. Resocialization (already recommended to start in the first month of life) begins by introducing the infant to future peers/group members through wire mesh, carrying it there on the trusted keeper's arms and/or by placing it in a cage next to the conspecifics in visual contact with or in the company of its trusted keeper.

For keepers doing their daily work (and with no additional staff available) it is difficult to fulfil the physical and psychological needs of a baby gorilla. At least three keepers must be available and take turns to fully cover the needs of a young gorilla day and night, at least during the first months of life. It is not recommended that more staff members or volunteers get involved during these first months of life, since the infants seem to profit from having only a limited number of caretakers. However, imprinting on humans, resulting in a too strong bond between the infant and its keepers, must be avoided by introducing the gorilla to conspecifics as early as possible. The later this happens, the more difficult and the more frustrating it will be for both the infant and the keeper(s).

Hand-reared animals that have been deprived of the opportunity to learn how to adjust behaviour towards older animals show more aggression and less social play than mother-reared ones. Gorillas raised in pairs as opposed to groups, are indiscriminately and frequently aggressive towards conspecifics when later introduced to them. Females are less likely to present to males and to copulate. Social access to other gorillas during the first year of life improves a hand-reared female's chance of successful breeding (Beck & Power, 1988).

Sometimes, hand-reared infants perform stereotypic behaviour, including rocking behaviour (rhythmic back-and-forward or up-and-down movements of the rump and head) mostly during the first year of life, but also later under stress.

Although peer-rearing helps to ameliorate the deficits of maternal deprivation in hand-reared infants, it does not replicate the wide variety of social interactions seen in groups with animals of different age/sex classes (Beck & Power, 1988; Meder, 1989). It seems quite likely that the social experience provided in a naturalistic group enables a young gorilla to become a better communicator, able to send appropriate signals to others and able to understand and respond to signals - skills integral to successful breeding (Beck & Power, 1988).

"Investment of time during the critical period of infancy is essential to the development of a well-adjusted animal that can live 50 years"

2.4.8.4. Exposure and introduction to adults

A hand-reared infant will either be (re-)introduced to the mother or a foster (depending on factors listed in chapter 4.2.1) at an early age (6 months at the latest) or it will be transferred to the EEP nursery at Wilhelma Zoo, Stuttgart. At present, infants stay at the nursery until they reach the age of 3 years. In the integrated nursery of Stuttgart's new ape house, however, infants will be in (at least) visual, olfactory and auditory contact to the gorilla family group right from their arrival. It may even be possible to bring them in direct contact with one or several family members. But it will certainly not be possible to integrate all hand-reared infants into this group. So the EEP will have to identify suitable zoos with previous experience in this field, where nursery-reared gorilla infants with some experience of contact with adult conspecifics can be sent at an age of one to two years ready to be introduced to an adult foster.

In both cases (early introduction before 6 months, or later introduction after an interim stay at the EEP nursery) the infant should best be integrated into an age/sex diversified group of conspecifics. In such a group the infant can learn about male/female roles and about gorilla "etiquette"/appropriate behaviour in different situations.

For a successful introduction, the facility must have creep doors for selective passage and /or connected rooms that permit circular way to facilitate the separation if needed. The infant must first thoroughly get to know the facility in company of the human foster parent.

Protocol:

1. Visual, olfactory and auditory contact with the group or individual to be introduced to (e.g. through wire mesh). This first step of introduction can begin as early as one month of age.
2. When the infant is sufficiently mobile (moves, climbs well at approximately four months of age), set up a play area for the youngster adjacent to the adults. In a relaxed and safe environment (and in company of the trusted keeper/ human foster), the adults and infants can observe each other.
3. Normally hand-reared infants are first socialized with an adult female who can provide the infant with security and protection when the pair is introduced to the rest of the group. Suitable females

are those that have shown good maternal behaviour and a strong relationship to the silverback. Allow physical contact between the hand-reared infant and the foster mother through a safe contact area (narrow bars) for short periods of time. Allow the foster mother to join her group during part of the day to keep her rank and relationships. Sometimes the silverback can ease the infant's integration into the group by disciplining the rest of the group members. Although aggression towards infants is rare among social gorillas, infanticide has been reported in the wild (Watts, 1989; Yamagiwa & Kahekwa, 2004) and in zoos. Until a close relationship is established between infant and surrogate, do not continue the introduction of other group members.

4. Introduce the rest of the group members step by step, evaluating first their personalities and the relation to the surrogate to facilitate the protection of the infant. The introduction of the infant to the whole group all day should be achieved by an age of approximately 18 months.

Even if the first attempt to socialize the gorilla baby at an early age eventually fails, it will still provide the baby with valuable experience of normal gorilla behaviour.

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2.5 Gorilla EEP Population Management

J. Vermeer

2.5.0 Introduction

In 1970 Rosl Kirchshofer of Frankfurt Zoo, Germany, published the first international studbook (Kirchshofer, 1970) for the Western lowland gorilla *Gorilla gorilla gorilla*. In 1985, the EEP was established by the continental European zoos, which was joined seven years later by the institutions from the British Isles and Ireland. At that moment, the total population numbered 315 (125.190) animals at 54 institutions (Kirchshofer, 1993).

Since then, much progress has been made on the management of captive gorillas. Many births have been registered and institutions from other regions with smaller and not self-sustaining populations (Australia, Africa, Asia and South America) have joined the European programme to ensure the long-term sustainability of their captive populations. At 31 December 2012, there were 466 (208.258) gorillas at 70 participating institutions in the EEP.

In this chapter we discuss the major results and developments of the population and have a look at its future.

Materials and Methods

Data of the European gorilla population was obtained from the International studbook (Wilms and Bender, 2013) using SPARKS (Single Population Analysis and Records Keeping System. Version 1.65, ISIS, 2012) and analysed with PMx (Ballou *et al*., 2012)

2.5.1 Development of the Population

Since 1960, the population has shown a steady growth (figure 1).

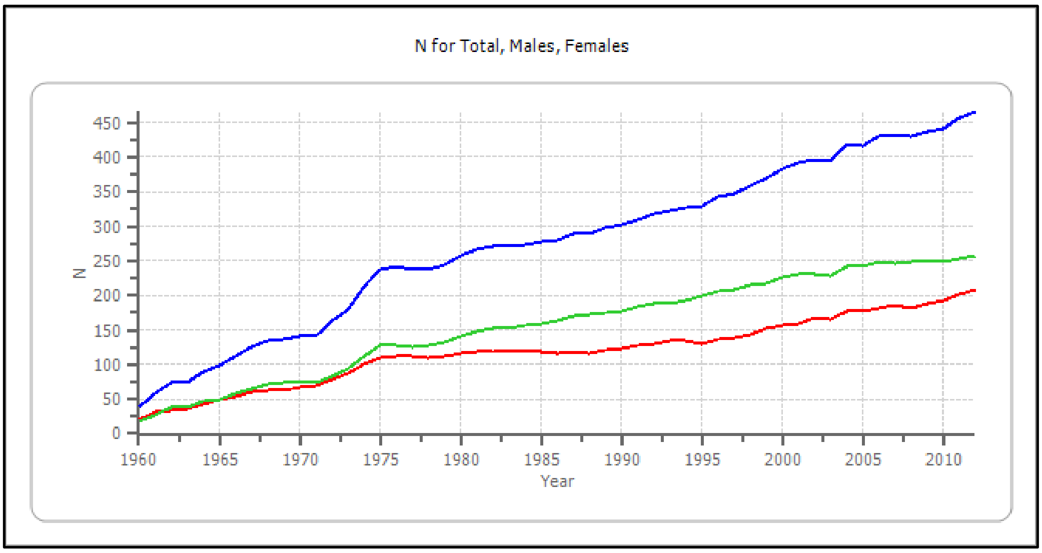

Figure 1: Development of the EEP population 1960-2012: ***Total number***, ***Males***, ***Females***

In the first years growth was mainly the result of imports from the wild, but few animals have been imported since 1976 and births have increased each year (figure 2).

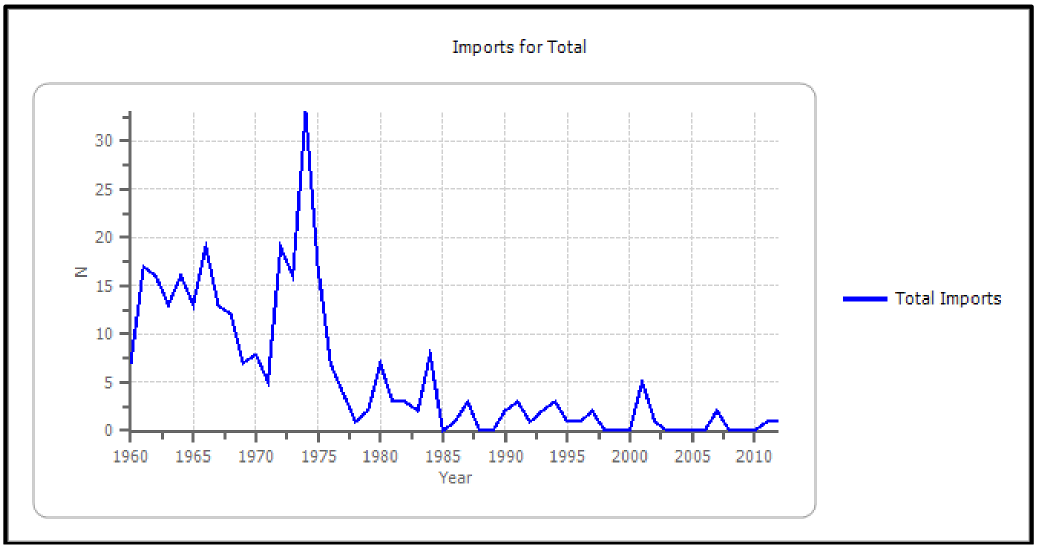

Figure 2: Imports of wild caught animals (including confiscated animals).

Due to the increasing number of births and the deaths of the wild born animals, there are since 1991 more captive born than wild born animals in the population.

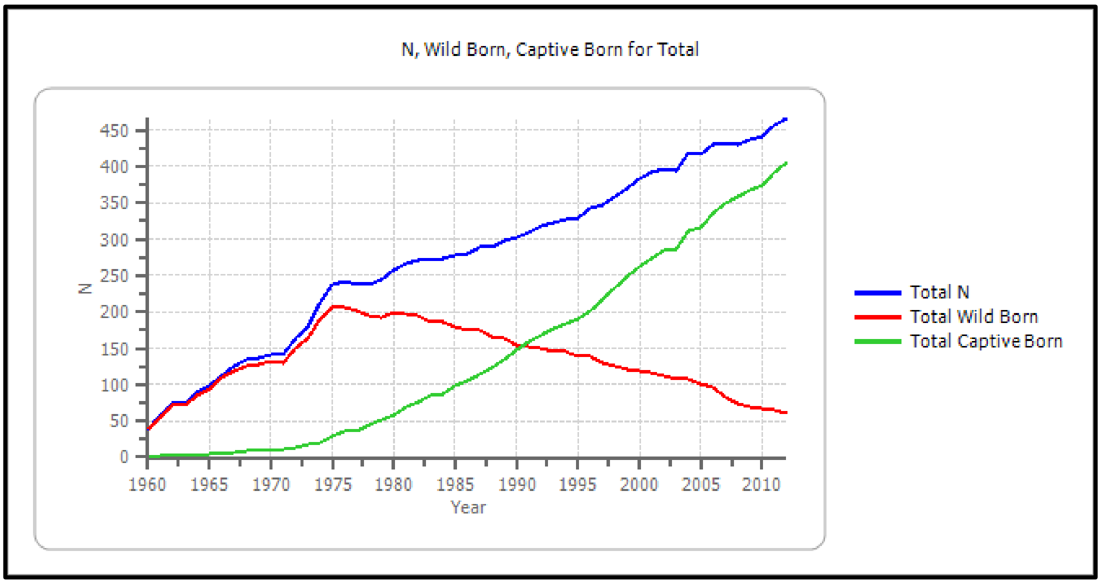

Figure 3: Ratio between wild and captive born animals in the EEP population.

The ratio been males and females slowly seems to shift towards the males, especially in the past decade (figure 4). This shift has not been caused by an unbiased sex-ratio, as this has been almost equal (359.366.32), with slightly more females born than males. Perinatal (< 7 days) and neonatal mortality has also been almost unbiased (65.70.32). The increase of the male ratio seems to be caused mainly by the higher numbers of original females that were imported in higher numbers during the first years of the population and slightly higher mortalities rates of females between the ages of 1 and 15 years old (Vermeer *et al.*, 2013).

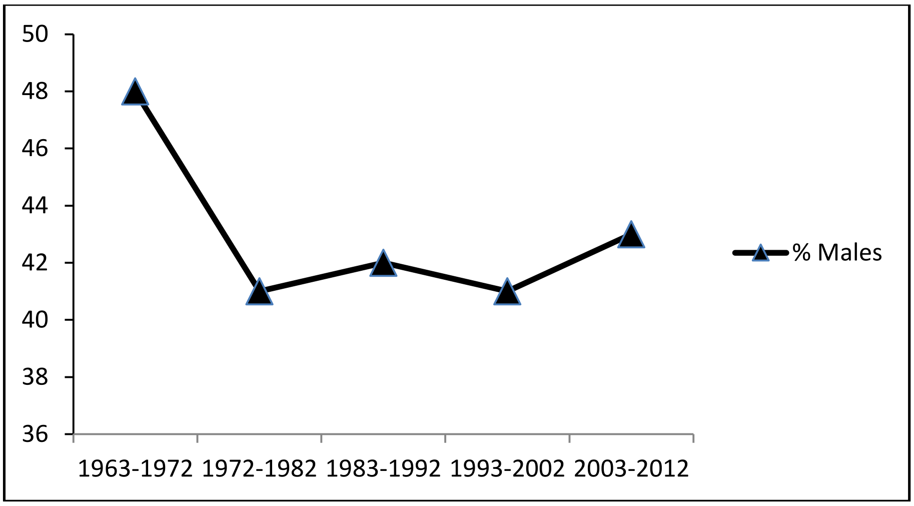

Figure 4: % of males in the EEP population.

The age pyramid shows that the population is robust and has a healthy structure.

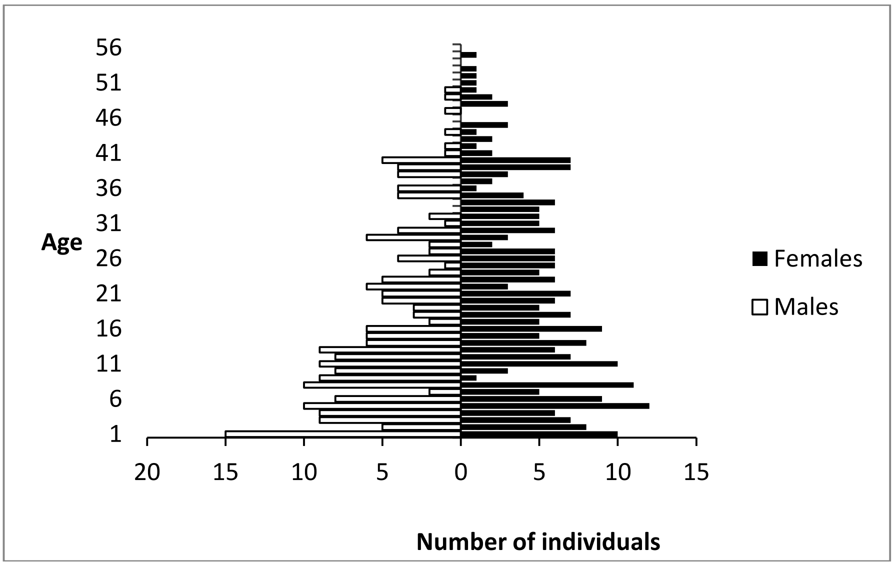

Figure 5: Age pyramid.

2.5.2 Reproduction

In 1959 the first captive birth of a gorilla took place at Basel Zoo. Since then, a total of 757 (359-366-32) births have been recorded, of which only four were twin births.

The youngest dam at first reproduction was only six years and one month old. However, most females only start to breed when they are seven or eight years old. The oldest female to have given birth was estimated to be approximately 42 years old. As she was wild caught, her exact age cannot be determined. The youngest male of known age to sire an offspring was only six years and five months at the time of conception. One male was estimated to be 49 years old when he sired his last offspring.

Captive gorillas do not show birth seasonality, births can take place throughout the year.

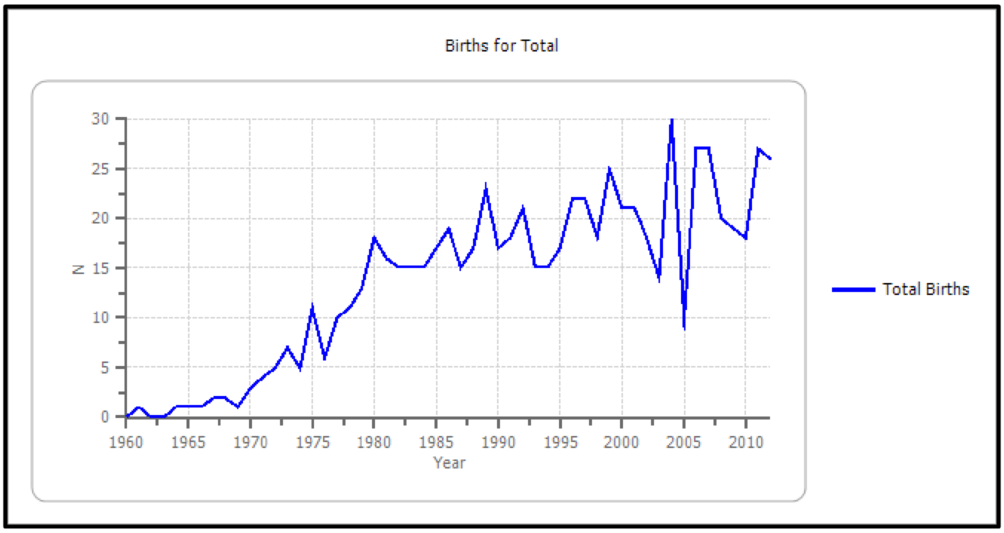

Figure 6: The number of births has increased through the years.

If we compare rates of the births, neonatal mortality (stillbirths and deaths < 30 days) and hand rearing (of viable births) of the past five decades, we see some interesting trends (figure 7). The most striking result is that the hand rearing rates have decreased from more than 50% to less than 10%. More parent rearing increases the inter birth interval, which might explain the slightly decreasing birth rates in the past years.

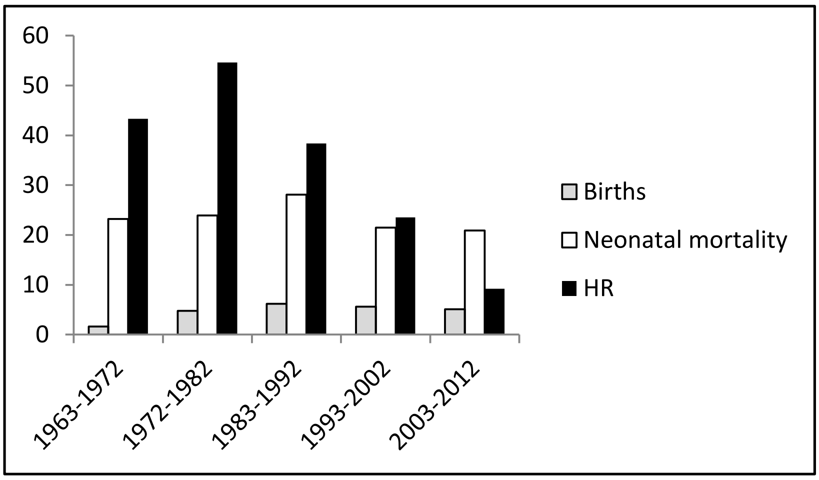

Figure 7: Mean birth rate, neonatal mortality rate and hand rearing rate in the past five decades.

Although in the past the hand rearing rates probably have been higher than necessary, most animals that were taken from their mother survived the first year (table 1). The neonatal mortality rates of these hand reared animals are low, especially if we consider that some of them were taken because of health problems. Although hand rearing is not ideal for the social development of the infant, we should not forget that these hand reared animals are an important basis of our current population.
Once a gorilla has been born alive and survived the first month of life, survival rates in the first year are high.

Rearing type	**Survived > 1 year**	**Stillborn / Premature**	**Died < 30 days**	**Died < 1 year**
Parent (492)	372 (76%)	0	69 (14%)	51 (10%)
Hand (166)	158 (95%)	0	7 (4%)	1 (1%)
Peer (4)	4 (100%)	0	0	0
Unknown (12)	0	0	12 (100%)	0
None (83)	0	83 (100%)	0	0
Totals (757)	534 (70%)	83 (11%)	88 (12%)	52 (7%)

Table 1: Rearing type and survival ship of offspring.

2.5.3 Mortality

After the initial decade, when mortality might have been higher because of a lack of knowledge on gorilla husbandry and because of the condition that new animals arrived, the mortality rates have remained low (figure 9).

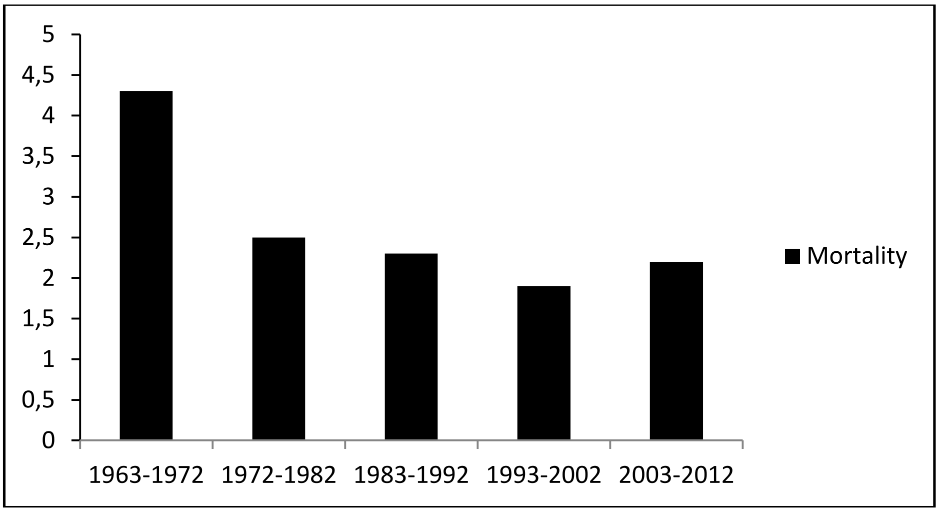

Figure 9: Mean mortality rates (> 30 days) in the past five decades.

With some exceptions, females seem to live generally longer than males. In the males we can observe a steep rise in mortality at the age of 31 years old, while this rise is more smoothly in the females (figure 10). The data of animals above 45 years old is based on very few animals.

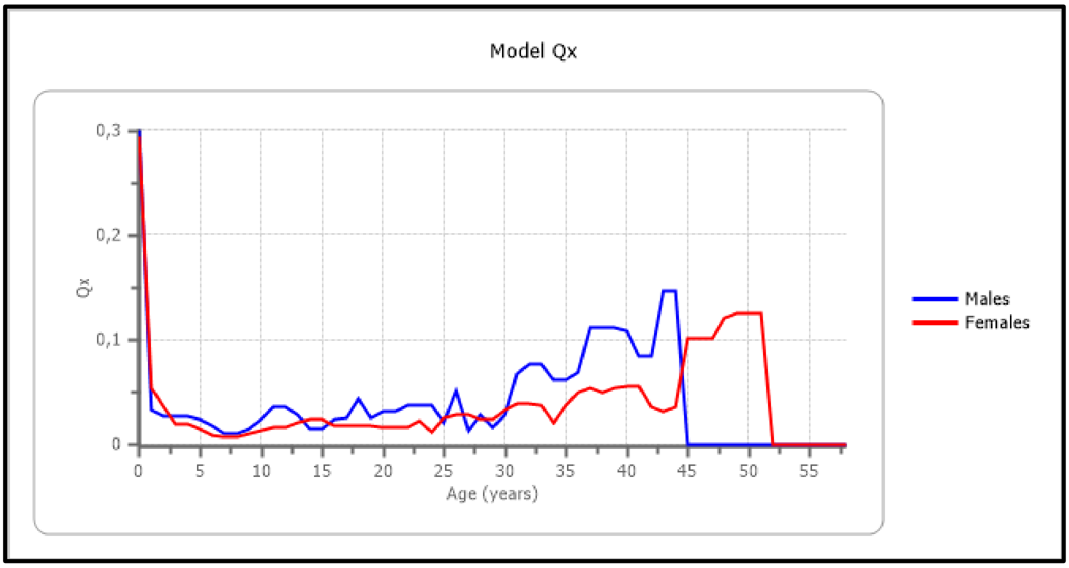

Figure 10: Mortality rates (Qx) of males and females.

2.5.4 Genetic analysis

The EEP Western lowland population is genetically very healthy. A total of 97 founders have contributed to the population, resulting in a genetic diversity of over 98%. With a good management, a genetic diversity of 90% can be maintained for almost 500 years.

	Value
Founders	97
Potential	119*
% Ancestry Known	99%
Gene Diversity	0,9848
Potential	0,9950*
Gen Value	0,9842
Population Mean Kinship	0,0152
Founder Genome Equivalent	32,91
Potential	99,79*
Founder Genomes Surviving	71,65
Mean Inbreeding	0,0036
Mean Ne	89,05
Current Ne	123,58
Ne/N	0,3075
** not obtainable, as most potential founders are probably non-breeding*	

Table 2: Genetic summary of the population.

The details on the genetics of the population have been summarized in table 2. Now that the population is large and well developed, the EEP species committee is paying more attention to the genetic management of the population. Pairings are based on mean kinship and breeding with genetically overrepresented is limited or even avoided. This way it should be possible to improve the genetics of the population even more.

2.5.5 The Future. A 20-year Projection

As the management of the population has changed considerably through the past 50 years and zoos have learned much about the husbandry of captive gorillas, it is difficult to make a reliable projection of the population. However, all analyses that we make show the same development: the number of males will increase faster than the number of females. In fact, it might even be possible that in the next 20 years the number of females will decrease, while the number of males will increase.

How is this possible? As can be seen in the age pyramid the population has many more females of more than 25 years old than males. From the demographic data we can safely assume that most of these animals will die during the next 20 years. If the sex ratio at birth will be equal, and there will not be many differences in mortality at young age, it is clear that the number of males will increase faster than the number of females. The projections are based on the demographics of a longer period and we know that in the last 20 years much improvement has been made on husbandry, housing and population management. Therefore we expect that the population will continue to grow. However, the situation of a growing unequal sex ratio is the reality and will be one of the biggest concerns for the future. Therefore it is important that all holders will cooperate to work on a solution for these problems. Possible solutions are discussed elsewhere in the Best Practice Guidelines, and include a limited size of breeding groups (≤ 3 females), keeping males as long as possible in their natal group, castration and building facilities for solitary males or (small) bachelor groups.

The EAZA Great Ape TAG has decided in its Regional Collection Plan that the population of Western lowland gorillas in Europeshould not pass the 500 individuals. The projection shows that this number may already be reached in 5 years. Therefore it is necessary to limit breeding, preferably with genetically overrepresented females, as this will improve the genetic quality of the population. One convenient side-effect is also adecreasing number of male births, and therefore a decrease of the future surplus.

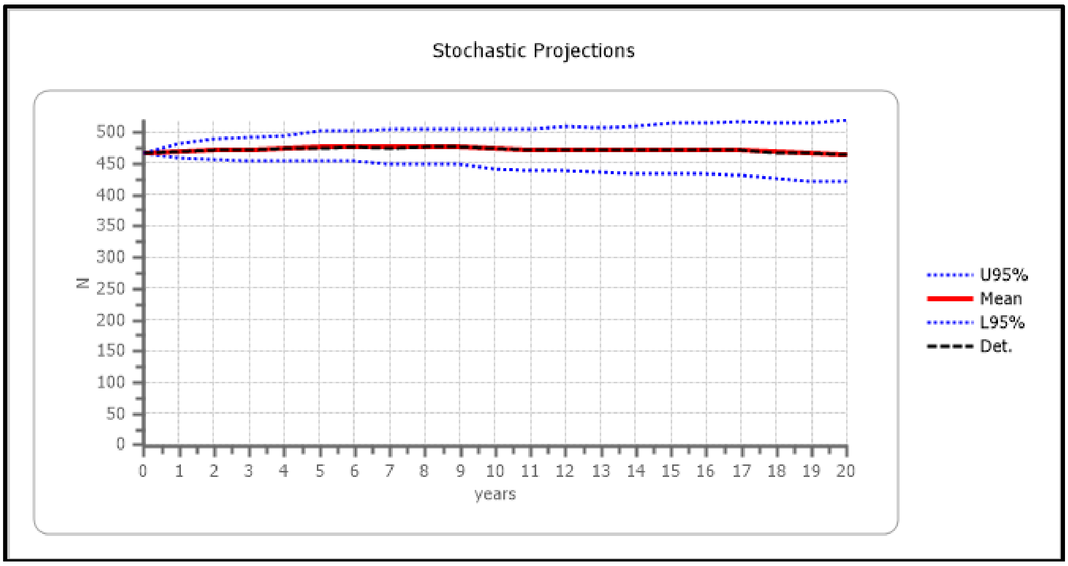

Figure 11: Stochastic project of the population over 20 years.

2.5.6 Collaboration with other regions

Although all Western lowland gorillas living in zoos are included in the International Studbook, only the AZA region and Japan manage their population separately. A few gorillas are being kept in Chinese zoos, but there is no active management of the population and most if not all individuals are unsuitable for breeding. Collaboration with the AZA region is mainly restricted to the exchange of information and husbandry experiences; both the SSP and the EEP population are genetically healthy and exchange of animals is not necessary. The captive population in Japan is decreasing and closer collaboration between the EEP and Japan will be necessary if Japanese zoos want to continue keeping gorillas. Such

collaboration will mainly exist of transferring animals from the EEP to Japan, but should also include the exchange of husbandry information.
The EEP has requests for animals from different regions in the world. A strategy will be developed to handle these requests, while considering the needs of European zoos. An expansion of the programme to other regions would only be possible if there is an advantage for the population of the EEP population and if the future quality of husbandry can be guaranteed.

2.5.7 Summary

The Western lowland gorilla EEP population has grown to a large, genetically healthy and self-sustaining population. Good cooperation between zoos has been important for its development and will be important to solve future challenges. The biggest challenge will be the surplus of males. This is a problem that needs now our attention, if we want to assure the future welfare of all the gorillas in our care.
Gorillas are important for zoos and are magnificent ambassadors for their endangered counterparts in the wild. Therefore they deserve that all holders will make any effort that is necessary to secure the welfare of this species in captivity.

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2.6 Behavioural Enrichment
M.T. Abelló, F. Cabana, M. Holtkötter & F. Rietkerk

2.6. Behavioural enrichment
Increasing attention is being paid to the subject of enriching the environment of zoo animals.
Environmental enrichment for gorillas covers a wide variety of topics, which can be broken down into two broad categories:
1. social - relationship with other gorillas, relationship with caretakers.
2. physical - living space, diet, browse, substrate, manipulable non-food objects. All of the physical forms of enrichment, except for living space, can be considered exhibit additives.

Environmental enrichment is truly effective when it provides an opportunity for the individual to make choices (Shumaker, 1989) and includes diversity and change. The amount of choice that an individual animal is able to exercise over its environment, both social and physical, is directly proportional to the sense of control it perceives hourly, daily, yearly, or for a lifetime. Individuals that possess a sense of control based on positive, species-typical activities are behaviourally more competent than those that do not (Markowitz, 1982; Novak and Suomi, 1988; Novak and Drewson, 1989). In a social setting, enrichment is a powerful force to give each member of a group the maximum amount of choice, and therefore control. Appropriate enrichment techniques can serve as the social catalyst that promotes positive and constructive interactions between individuals. Gorillas often prefer to sleep on elevated places, and zoos should give them this possibility with artificial nests high against the walls.

2.6.1 Feeding enrichment
For the majority of primates, there is general agreement that allotting a significant portion of a day's activities to foraging and feeding is healthy and important. Browse, variety in the daily diet, and novel presentation of foods are all effective ways to stimulate normal feeding patterns.

Browse refers to any sort of plant or plant part that is fed whole. For example, tree limbs, bush branches, flowers, herbs, whole plants - such as bamboo or cornstalks - and similar items would be categorized as browse.

The most important thing to consider about browse is its potential toxicity. Obviously, any browse plants should be naturally non-toxic. Additionally, it should be known whether or not the browse has ever been sprayed with insecticide or other chemicals.

In many situations, browse may be easily available, with the primary expense being staff time. Alternatively, growing and harvesting browse may lead to considerable cost. In either situation, the benefits should easily justify the expenditure, because browse provides a highly effective form of feeding enrichment that contributes little caloric effect to the diet of the animals. It should be noted, however, that the nutritional contribution of the browse to the total diet should be considered.

Browse has a variety of positive influences in regard to environmental enrichment. It can greatly enhance the choices available at daily feedings. With relatively little effort, the daily diet for the apes can be expanded by 10 or more items. For the individual animal, browse serves a variety of functions. Perhaps most importantly, browse can greatly lengthen the amount of time that a gorilla spends eating during the day (Gould and Bres, 1986). This clearly combats boredom with a constructive behaviour and may also assist in situations where regurgitation is a factor (Akers and Schildkraut, 1985).

The preparation of whole plants or branches for consumption allows the individual animal to express species-typical behaviour that provides an important degree of control over the environment. The animal has greater choice in what to consume, when to consume, and how much to ingest or discard. A side benefit is the exhibit value to the public in watching an animal engaged in a natural, purposeful, productive, and interesting behaviour.

Further, providing browse allows the gorillas to forage together. Because browse is generally a low-calorie food, it can be provided when all group members are together. Because unfortunately individuals in some zoos may be separated during regular feeding times, there may be relatively few opportunities for the full expression of group dynamics, and collective feeding is one of those times. Individuals are given the opportunity to express their social rank or privileges in a meaningful context, and browse provides an avenue to facilitate this.

In addition to the feeding and foraging opportunities that browse provides its presence also promotes other important behaviour. Whole browse items, or pieces, are frequently used as display items. Pieces that have been stripped of their leaves and bark are used in nesting and to solicit and promote play behaviour. Browse pieces are also used as reaching tools, providing caretakers with an opportunity to devise interesting tasks that are challenging for the gorillas. And many of the left-over pieces may still be used by gorillas after a day or two. Certainly the wild is a messy place, and leaving browse in different stages of use may be appropriate.

2.6.2. Forage materials

Increasingly, caretakers are distributing food items throughout an animal's environment to encourage natural foraging behaviour. Food may be placed on whatever features exist within a given area to encourage movement throughout the exhibit. For example, forage foods may be hidden on, in, or around logs to promote investigation and travelling in their vicinity. Foods may also be scattered in substrate that requires searching behaviour, such as deep grass or bedding.

Substrate materials provide a ready medium for encouraging foraging. Any type of dry foods (seeds, nuts, whole grains, low-sugar breakfast cereals) can be sprinkled in the substrate, and all are guaranteed to work well. The amount of time that the animals spend searching through a substrate is considerably greater than if the foods were scattered on a bare floor. Once again, the benefits here are similar to those discussed for group feeding on browse.

Offering foods that are as nutritionally complete as possible is highly desirable. The types of forage foods used will certainly vary between facilities, depending upon preferences expressed by the gorillas, staff, and local availability. When choosing which forage foods to offer, there must be a balance between dietary management and environmental enrichment. In general, the best forage foods are those that are low in salt, fat, and calories.

Example of foraging foods:

- breakfast cereals (shredded wheat, puffed rice, puffed wheat, puffed corn)
- prepared herbivore pellets, alfalfa pellets, dry dog kibble, flamingo pellets
- bird of paradise pellets
- low-oil sunflower seeds*
- air-popped popcorn
- raw, shelled peanuts*
- dried fruit*
- uncooked rice (preferably brown)
- nuts in the shell*

* these items are higher in fat and/or calories and should be used in moderation.

2.6.3. Novel presentation of foods

Enrichment may take many forms, including making everyday objects or events more interesting for the gorillas. Most daily diets provide consistency in nutrition, quality, and volume for health management. However, they allow little variation for what is arguably the gorillas' central event each day. Presentation is the key to making each feeding an opportunity for enrichment. In the best-case scenario, each animal's daily diet should be fed throughout the day in small portions rather than one huge feeding daily. This not only mimics the feeding patterns of wild gorillas but also provides multiple interesting events throughout the day.

Food can also be delivered in novel ways. It can be hidden or scattered throughout the living space. It can be given whole or in many small pieces. Items that are normally fed raw can be cooked (apples, carrots, potatoes, beans, etc.). Spices can be used to change the flavours of foods, such as air-popped popcorn. Altering the food itself is one avenue; another is to require more work from the gorillas before eating. Foods can be given sealed in cardboard boxes, burlap bags, paper bags, pillowcases, etc. Fill a large, shallow tub with water and drop in chopped apples, which float, and raisins, which sink. In cold climates, fill the same tub with snow and bury the day's produce. During hot weather, citrus fruits or grapes can be given after being frozen whole and in the peel. Or drop a food item in a bucket of water and freeze the whole thing, then leave the giant cube in the enclosure and let the gorillas do the work. Individual institutions will likely have policies regarding the presentation of food or other items, e.g. a policy to mimic natural presentations as much as possible.

Creativity in presentation is limited only by the individual caretaker's imagination and willingness to experiment. Every idea has potential, even if it takes the gorillas a while to try something new. The same ideas can be rotated every few days to keep the daily diet new, interesting, and exciting at every presentation.

2.6.4. Variety of food presented

In addition to novel presentation of foods, variety within the diet is a highly effective form of enrichment. While a completely novel diet each day is unrealistic, it is possible to offer at least one or more different foods on a daily basis along with the core diet. Seasonal foods, such as melons, sunflowers, or peaches, are popular choices. If seasonal foods are not available or are prohibitively expensive, try experimenting with what is available. If foods are offered sparingly and seasonally, then cost should be a minor factor. Foods such as dry or cooked pasta, rice, or kidney beans are sure to illicit interest from the gorillas.

Another possibility is to establish a list of equivalent foods that can be used to meet similar requirements in the daily diet. For example, almost every zoo feeds some citrus fruits to their gorillas. Instead of using oranges daily, rotate grapefruits or tangerines in their place. The same is true for leafy greens and other standard foods. The important point is that the same foods should not be given day after day without any variation. A slight change in the diet each day, or even every other day, is a powerful way to stimulate interest and investigation. It should be noted that many common fruits are high in calories and should be used in moderation. Although wild western lowland gorillas have been observed to commonly feed on fruits, these fruits are generally less sweet and lower in calories than typical commercially available fruits.

To provide gorillas with adequate amounts of browse during winter, institutions should consider silage. Silage is a method that preserves browse in an air-locked barrel until you are ready to use it. It requires a small start-up fee to buy the air tight barrels, but remains virtually costless thereafter. Space and time are the other necessary factors. You need space to store the barrels in a calm and cool place that does not get more than 20 degrees C but does not reach freezing temperatures. Time is a luxury some institutions cannot afford and stacking leaves in barrels is very time consuming. Using a woodchip machine, you can send in small branches (diameter less than 5cm) and use the result as silage. If the zoo has a burgeoning volunteer program, they can potentially take advantage of their free labour to collect leaves.

Fill up your barrel with leaves or woodchip material, pat down as much air as possible and make sure it is filled to the top, and airlock it shut. The processes that occur in the barrel have five distinct phases

Aerobic Phase lasts 1-2 days. The organisms begin to break down the leaves and use up all of the oxygen

pH drops down to 6.
Acetic Phase lasts 2-3 days. There is no more oxygen in the barrel and bacteria present convert carbohydrates into acetic acid which coats the leaves. pH drops down to 5.
Lactic Phase takes up to 18 days. pH is too low for the acetic bacteria, so the lactic acid bacteria become dominant and convert carbohydrates into lactic acid which coats the leaves. Ph drops down to 4.
Preserved Phase is stable. The pH is so low that all bacterial activity stops and the silage is preserved and ready for consumption. It can stay in a closed barrel for up to 12 months or more.
Aerobic deterioration occurs when you open the barrel again (Make sure to wait at least 23 days AFTER closing the barrel). The first inch will be heavily contaminated with fungi, throw it away. Underneath should have a nice scent. The pH jumps up from 4 to 7 in a matter of hours. The silage will not be fit for consumption 2 days after opening, so make sure you feed it all out before then!
Stick to one species/barrel.
Make sure there are no fruits or seeds in the silage and the leaves you place in the barrel are dry.
Best time to silage is late spring, early summer. Do not collect leaves when they are growing, or falling.

Puzzle Feeders
Puzzle feeders can be used as enrichment or during routine feeding practises. The common aims of puzzle feeders are to increase opportunities for the time-consuming part of foraging and feeding. It also allows the appropriate time and conditions for digestion. There is also the notion of cognitive enrichment, where the success of solving the puzzle is what gives a sentient animal the beneficial rush of hormones (a feeling of happiness) and not the actual food reward (Meyer et al., 2009). Problem solving opportunities in captive animals has been known to support the performance of natural behaviours not necessarily related to feeding or mating (Meehan and Mench, 2007).
Puzzle feeders for gorillas should either be “gorilla proof”, easily repairable or cheap and easily replaceable. There must be enough for all of the individuals and not just the dominant ones. For specific ideas on how to build them, refer to the immense enrichment ideas at “The Shape of Enrichment” website.

2.6.5. Non-feeding enrichment
Providing a **manipulable substrate** (bark shavings, hay, straw, wood wool, etc.) for apes has not always been well accepted. The most common concerns have been that it will clog drains or negatively affect a desired antiseptic condition for the enclosures. While it is true that plumbing is a concern, any problems should be alleviated if appropriate drain covers are in place. Of course, drains will continue to clog occasionally, but that seems insufficient reason to deny the gorillas substrate materials.

Gorillas make and use nests on a daily basis in the wild. It therefore is an important aspect to provide in a zoo environment. Many individuals, especially the very young or old, or pregnant females, have a special need for comfort while resting.

In addition to serving as enrichment, a soft substrate can function as a cushion to a hard floor. This can be quite desirable during introductions, especially when serious "rough-ups" may be anticipated. Aside from introductions, play bouts between individuals can be much more energetic and creative when mounds of substrate are involved. And as with browse, bedding materials are useful display items.

The presence of a soft substrate immediately affects what the visitor sees: The image of the enclosure is softened and more appealing. The environment looks much more complex and comfortable. Every zoo tries to communicate effectively with its visitors, and every effort is made to educate and express our concern about the animals.

2.6.6. Objects for manipulation

The use of manipulable objects has been associated with increased activity in great apes (Wilson, 1982; Tripp, 1985), although less so with gorillas than with the other species (Wilson, 1982). Such items allow opportunities for species-typical behavior, such as displays and play, as well as providing visual cover, places for animals to hide from other gorillas or from visitors. Some items, such as plastic barrels, become important tools for certain animals. Adult males may use them to enhance displays, because the presence of movable objects gives dominant animals something to throw. In the absence of objects, smaller or more submissive individuals may receive the physical blows.

"Holzrugel" are logs with holes drilled into, that are packed with raisins or mealworms. Since the holes are so small, the gorillas have to produce tools from branches in order to obtain the raisins. This occupies the gorillas for at least half an hour each time (Schmidt, 1986). A lot of similar behavioural enrichments have been developed in many zoos.

2.6.7. Browse species list

Acacia
Alfalfa (*Medicago sativa*)
Alder (*Alnus spp.*)
Amaranths (*Amaranthus spp.*)
American Beech (*Fagus grandifolia*)
Apple (*Malus spp.*)
Apple leaf croton (*Codiaeum cadierei*)
Aralia (*Polyscias balfouriana marginai*)
Arbovitae (*Thuja spp.*)
Areca palm (*Crysalidocarpus lutescens*)
Artillery plant (*Pilea microphylla*)
Aspen (*Populus spp.*)
Banana (*Musa acuminata*)
Bamboo (*Arundinaria spp., Phyllostachys spp.,Semiarundinaria spp., Sinarundinaria spp., Thamnocalamus spp., Shibataea spp.*)
Bamboo palm (*Chanaedorea erumpens*)
Beech (*Fagus spp.*)
Birch (*Betula spp.*)
Blackberry (*Rubus spp.*)
Black locust / False acacia (*Robinia pseudoacacia*)
Black willow (*Salix nigra*)
Bottle palm (*Beaucarnea recurvata*)
Bush honeysuckle (*Lonicera spp.*)
Butterfly bush (*Buddleia spp.*)
Cattails (*Typha spp.*)
Chicory (*Cichorium intybus*)
Clover (*Trifolium spp.*)
Coffee plant (*Coffea arabica*)
Comfrey (*Symphytum spp.*)
Coleus (*Coleus spp.*)
Corn plant (*Dracaena fragrans massangeana*)

Cotoneaster (*Cotoneaster spp.*)
Cottonwood (*Populus spp.*)
Crabapple (*Malus spp.*)
Croton (*Codiaeum spp.*)
Daylily (*Hemerocallis spp.*)
Dogwood (*Cornus florida*)
Dracaena (*Dracaena spp.*)
Dragon tree (*Dracaena draco*)
Dwarf palm (*Chamaedorea elegans*)
Dwarf rose (*Cryptanthus roseus pictus*)
Elaeagnus (*Elaeagnus spp.*)
Elm (*Ulmus spp.*)
Eucalyptus (*Eucalyptus spp.*)
Eugenia (*Eugenia spp.*)
Flowering dogwood (*Cornus florida*)
Forsythia (*Forsythia spp.*)
Fragrant honeysuckle (*Viburnum spp.*)
Fig (*Ficus spp.*)
Grass family (*Graminae*)
Grape (*Vitis vinifera*)
Greenbriers (*Smilax spp.*)
Gloxinia (*Sinningia spp.*)
Hackberry (*Celtis occidentalis*)
Hazelnut (*Corylus spp.*)
Hawthorn (*Crataegus spp.*)
Hibiscus (*Hibiscus rosa*)
Jade plant (*Crassula argentea*)
Kentucky coffee tree (*Gymnocladus dioicus*)
Kerria (*Kerria spp.*)
Kudzu (*Pueraria spp.*)
Lady palm (*Rhapis excelsa*)
Maple (*Acer spp.*)
Mock orange (*Philadelphus spp.*)
Mulberry (*Morus spp.*)
Nasturtium (*Nasturtium spp.*)
Oregon grape holly (*Mahonia spp.*)
Pear (*Pyrus spp.*)
Peperomia (*Peperomia spp.*)
Pickerelweed (*Pontederia cordata*)
Poplar (*Populus spp.*)
Primula (*Primrose spp.*)
Purslane (*Portulaoa oleracea*)
Raspberry, Blackberry (*Rubus spp.*)
Redbud (*Cercis canadensis*)
Rose (*Rosa spp.*)
Snowberry (*Symphoricarpos spp.*)
Sweetflag (*Acorus calamus*)
Sweetgum (*Liquidambar styraciflua*)
Violet (*Viola spp.*)
Water hyacinth (*Eichornia spp.*)
Weeping fig (*Ficus benjamina*)

Willow (*Salix spp.*)

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2.7. Handling

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2.7.1 Keeper - gorilla relationship

It is clear that gorillas in zoos need a complex physical and social environment, and keepers play an important part in this environment. Gorillas react adversely to loud noise and rapid movements of the keepers, which can result in increased excitement levels and negative behaviour among gorillas. Squatting down to the level of a gorilla, avoiding direct stares and using the soft contented "grumble" vocalizations of the gorilla can be very reassuring to the animals. Routines are also important for the animals, not just for keeper safety. The animals like to know what is happening, e.g. always cleaning in the same way.

2.7.1.1. Keeper qualities

Besides the keeper's formal training, the best attitude should be one of sensitivity and respect. Knowledge and understanding of gorillas and their behaviour is obviously mandatory, yet anthropomorphic generalizations and interpretation of behaviour, while perhaps inevitable, may result in human bias in comparisons. The best keepers have earned the trust and acceptance of the gorillas in their care through patience, compassion, and nurturing. This trust has two beneficial effects: Facilitation of daily husbandry and reduction of stress for gorillas in their zoo environment. Gentleness, continuity and consistency among keepers over time are very important in maintaining a healthy, stable group of gorillas.

2.7.1.2. Relationship

Ideally, the gorilla/keeper relationship is based upon trust and mutual respect. Keepers should have empathy for these intelligent animals. It is incumbent upon keepers to provide the gorillas with a sense of security and a safe and healthy environment. Beyond that, it is imperative that gorillas be allowed to exhibit their own species-specific behaviour and as much self-determination and freedom of choice as is possible in zoos. Gorillas should neither be overly dependent upon nor overly controlled by their keepers.

The degree and type of communication in all human/gorilla interactions are keys to a close relationship:
- Sense of smell may be negatively affected by excessive use of perfumes, bleach or soap.
- Loud noise and rapid movements of keepers or other species in the immediate surroundings can result in increased excitement levels and negative behaviour among the gorillas.
- Squatting down to the level of a gorilla, avoiding direct stares, and utilizing the soft contented "grumble" vocalizations of the gorilla can be very reassuring to the animals.
- Any negative reinforcement (shouting, hosing, etc.) meted out by the keeper may result in social aggression, individual behavioural changes, refusal to move, and resentment toward keepers. It could permanently damage the keeper/gorilla relationship, and should only be used in an emergency.
- Gender of both keeper and ape can influence a gorilla's behaviour. This factor can directly impact adjustment time to a new keeper: A male gorilla may exhibit more aggression toward a man than a woman, possibly feeling a certain threat from a "rival" in his territory. Similarly, female gorillas may solicit for sexual attention from human males and may take longer to accept women keepers, perhaps perceiving them as possible rivals.

In general, strong human/gorilla bonds at the expense of or in place of bonds between the gorillas are not desirable, as strong attachment to humans may decrease the amount of social behaviour exhibited toward other gorillas. Mother/infant bonds are without question more desirable. However, there are instances when some amount of bonding can be beneficial. This can be reached by a positive, reinforcing training of the gorillas. For example, a positive relationship between gorilla and keeper can be a lifeline when medical problems arise and keeper intervention is needed. Further, a female gorilla may allow a trusted keeper to implement a maternal training program to facilitate rearing; even, in extreme cases, to allow a keeper to physically place an infant on a nipple.

2.7.1.3. Hand-reared gorillas

Rearing history has a significant influence on how gorillas relate to their keepers. Hand-reared gorillas can be seriously imprinted on humans the longer they are in a nursery situation, especially if the youngsters are not raised with conspecifics in peer groups. Gorillas imprinted on humans are socially inept with their own species and often prefer the company of their keepers. Therefore, any sensory contact to conspecifics is important. In any case, a key factor is the age at which a hand-reared gorilla is reintroduced to a family group. The earlier the introduction takes place, the less likely youngsters are to show ill effects from being raised by humans. (also see 2.4.8)

2.7.1.4. Lone gorilla

Taking care of a lone gorilla necessitates that the keeper has a closer relationship with the animal in order to prevent boredom and alleviate social isolation.

Keepers have a unique relationship with and an intimate knowledge of the animals in their care, both individually and as a group. This information is invaluable to the curatorial staff when management decisions are predicated upon keepers' knowledge and experience.

Recommendations:

1. Recognize and encourage the experience and length of tenure of quality keepers as an asset.
2. Maintain continuity of caretakers. Keepers should not be rotated in and out of the gorillas' lives. New keepers must be taught by experienced ones.
3. Convene regular staff meetings with caretakers and curators to enhance communication and exchange information.
4. Allow a portion of the keeper's day for observation of gorilla behaviour and maintaining a keeper's relationship with the gorillas.
5. Send keepers with gorillas during all transfers. The animals' health and safety can be monitored by the trusted keeper throughout the duration of the trip and the first week in the new surroundings. This also reduces stress and helps them to adjust to their new surroundings and keepers.
6. Provide the gorillas as much free choice as possible.
7. Keep daily records on individual gorillas and their group and take note of incidences. These will help you to elucidate the causes of some problems when they arose.
8. Design an enrichment program to provide a stimulating environment for the gorillas and update it periodically.
9. Whenever possible, as with any species, integrate keeper staff into the decision making process with regard to the gorillas, including enrichment, enclosure design, diet, and introductions. This process ideally should include input from keepers, curators, veterinarians, and research staff.

2.7.2. Operant conditioning as a management tool

There is an increased interest in profiting from the opportunities that target training and other types of training under protected contact have to offer. The goal of the training can be as varied as:

- easier daily management procedures,
- correcting problematic behaviour,
- assisting mothers and/or foster mothers in the care of neonates,
- facilitating various simple medical procedures without the need to constrain the animal,
- monitoring the reproductive cycle of females etc.
- training can also be part of a scientific experiment.

At the same time gorillas seem to appreciate training sessions and this activity can therefore also be seen as environmental enrichment. Apart from being time-consuming for the keepers, another disadvantage might be that training will lead to more human focused behaviour of the gorillas. This could lead to unwanted interference in the social structure of the group and to less natural social behaviour, decreasing the educational value of the species.

Anyway positive reinforcement training is an effective way to help solve behavioural problems, provide enrichment, and enhance our relationships with the animals in our care. The information provided here should help gorilla keepers and curators to decide whether positive reinforcement training would be an asset to their husbandry program.

2.7.2.1. Positive reinforcement

Positive reinforcement is anything which, occurring in conjunction with an action tends to increase the probability that the action will occur again. In other words, positive reinforcement is something the subject wants and will work to obtain. Positive reinforcement is effective in changing behaviour while cultivating a beneficial relationship between the animal and keeper.

2.7.2.2. Training planning

A program is headed for success if the staff can agree on what the problem is and how it should be handled. Main questions to develop:
1. Current behaviour
2. Behavioural goal
3. Training programme

- Learning process requires clear, intense communication between the animal and trainer.
- While the animal is learning, it is important that only one person trains that specific behaviour: multiple teachers tend to confuse the animal.
- After a behaviour pattern is trained, other staff members can learn how to ask for and maintain it.
- If possible, begin working with what is perceived to be the easiest animal and/or behaviour to train.
- If possible begin working with the keeper that is best accepted as a teacher by the gorilla.
- Keep records of your training sessions to track progress.
- The delivery of reinforcement must immediately follow the desired behaviour in order for the animal to make a connection between the behaviour and the reinforcement. Once the animal makes this connection, however, it will repeatedly display the behaviour in order to earn additional reinforcement. If the reinforcement is delivered too late, the animal may associate it with a behaviour pattern other than the one the trainer was trying to reinforce. Lately, clickers have been showed to be really effective in indicating which action is the desirable one.
- The reward can be natural treats like raisins and prunes or scratches of the back. It will depend on the individual preferences.
- Training sessions must be short (5 to 15 minutes) not exceeding the attention span of the trained gorilla and must end on a positive note (big reward).
- Any object used to focus attention or lead an animal to a specific behaviour is known as a "target". After training an animal to touch an object for a reinforcement, the trainer is then open to use this concept in several ways: To ask the animal to hold a position at a station, to allow keepers access to a body part, or to encourage an animal to perform a specific behaviour:

- Routine behaviours: These include any behaviour patterns that make daily husbandry easier: "come here," "gentle/easy," "stand," "hold," "sit," "give," "shift/gate," and "retrieve"
- Medical behaviour patterns: Gorillas are conditioned to allow regular close inspection and specific behaviour patterns that simplify veterinary care are trained to obviate the use of anaesthetics: To open their mouths, show their hands and feet, allow tympanic temperature to be taken, and present

various body parts for inspection.

- Maternal care: Trained behaviour patterns labelled as "maternal" do not necessarily enhance a female's ability to raise her own infant, but they may allow access to an infant for supplemental care and bottle-feeding.
- Intra-group relationships: Food rewards and extra attention keep the focus away from other animals, helping to reduce and diffuse aggressive interactions, facilitating introductions and promoting social cooperation and tolerance.
- Reproductive status: Conditioning female gorillas to give urine samples on request or to present for vaginal swabs, enabling keepers to chart menstruation, LH surge, sexual behaviour, pregnancy, and parturition.
- Overcoming fear: Gorillas can be uncooperative and hard to manage when they are frightened. In these cases, the event the animal fears can be paired with a reward. (an overhead exhibit access chute, a new social group, etc.)

2.7.2.3. Other benefits

- Gorilla-keeper relationship: Some animals' attitudes toward their human caretakers improved because of the contact.
- Behavioural enrichment: Training adds variation to the animals' routines and provides a chance for extra food and attention. Physical exercises can be another benefit of training (getting up and moving around in its environment).

2.7.3 Crating and transportation procedure

If immobilization for shipment is necessary, it is better to fast the animal to avoid complications with anaesthesia. Enough time will be given for the animal to be fully recovered in the shipping crate prior to movement.

2.7.3.1. Crate

The crate must be made of high quality materials which can adequately contain the animal. There should be no sharp points either inside or outside of the crate. There should be spaces or vents in the crate large enough to provide adequate ventilation. The crate must meet the size criteria for the animal and the limitation of the carrier. A port should be available externally to easily add water and food for the animal in transit. The crate bottom should minimize fluid loss from the crate onto the carrier surface. Check IATA Regulations (International Air Transport Association): container no. 34 for adult gorillas and container no. 33 for young ones. (40ª Edition, 2013)
Adequate labelling of the crate:
- Name, address, telephone of the sending institution
- Name, address, telephone of the receiving institution

Shall be clearly marked on top and on one or more sides with the words ``Live Animal'' or ``Wild Animal'', whichever is appropriate, and with arrows or other markings to indicate the correct upright position of the container.

Documents accompanying the shipment must be attached in an easily accessible manner to the outside of the crate plus information about the animal, feeding and watering instructions. The crate must contain clean litter of a suitable, absorbent material, which is safe and non-toxic to the animals in sufficient quantity to absorb and cover excreta.

2.7.3.2. Transport

Good preparation of a gorilla transport is essential. The whole process from the beginning of planning until final delivery can take weeks or even months, if dealing with an international transport. Foreseeing any possible problems, as well as developing emergency plans, should be part of the planning process. Before the shipment takes place, there are some obvious and necessary steps involved, including: 1) locating an appropriate crate, 2) determining the best and quickest mode of transportation, 3) verifying any necessary medical testing, 4) obtaining all the necessary permits (veterinarian, CITES), 5) contacting experienced transporters and evaluating costs, 6) considering weather conditions at both locations, and 7) ascertaining available quarantine space at the receiving institution.

It is mandatory that a person who is familiar with the gorilla - preferably the ape keeper - accompanies the animal during transport. The presence of a familiar keeper will contribute to the animal's welfare by alleviating some of the stress associated with the transport. In addition, the keeper can provide the receiving institution with direct information about the animal's behaviour. The keeper must stay in the new institution for a few days until the animal is well adapted to its new home.

During the whole shipment the correct temperature of 18 to 25 ^{0}C and adequate ventilation must be always guaranteed. There are several factors that determine the best mode and time of transportation: The age of the animal, the climate in both the sending and receiving institution, the place of destination, and the weight and size of the crate. Today, the most used and reliable ways of transporting a gorilla are: 1) ground transportation (via the institution's vehicle, rented truck, or by an experienced exotic animal transporter); and 2) air transfer (commercial carrier or freight carriers). Enough time should be calculated for unforeseen delays as weather conditions, vehicle or mechanical failure, or traffic delays.

2.7.3.3. Transportation summary

1. Develop an itinerary, including an emergency plan, far in advance.

2. Verify all local, state and international laws.

3. Obtain any required permits (the timing of the shipment is based on the ability to obtain all appropriate external documents).

4. Obtain the crate and make any adjustments in compliance with IATA regulations.

5. Decide on the method that will be used for transferring the animal into the crate (conditioning or tranquilization).

6. Shipper and consignee should come to an agreement on possible shipping dates.

7. Outline all the necessary medical testing required based on: 1) the recommendations in the health section of this manual; 2) requirements of appropriate regulatory agency; and 3) requirements of the receiving institution.

2.7.4. Keeper’s safety

1. Treat all animals with cautious respect and remember that all wild animals are potentially dangerous.

2. Always follow the safety procedures taught to you by curators, supervisors, senior keepers, and other experienced persons.

3. Familiarize yourself with the location and use of safety items: first aid kits, telephones, radios, nets, tools, fire extinguishers, hoses, etc.

4. Lock and control all locks unless specifically instructed not to.

5. Never leave your work area without letting someone know when you leave and return.

6. Follow established routines when shifting animals. Before shifting an animal, be certain that the shift area is secure.

7. Know how many animals are in an enclosure before and after shifting them.

8. Before shifting an animal, know where all other keepers and other persons in the area are.

9. Always lock and control shift doors before entering an animal enclosure. Always lock and control shift doors between animals.

10. Know the applicable regulations before entering animal enclosures. For example, certain areas should not be entered alone and others should not be entered at all.

11. If the cage or enclosure has double doors or an anteroom, make sure the outer door is securely closed before attempting to open the second or inner door.

12. Make it a habit not to lean on cage fronts, even if you know there are no animals in the enclosure.

13. Always move with extra care around animals especially prior to, and during feeding time.

14. Know your limits with the animals in your care and do not overstep them.

15. When cleaning a cage or enclosure, always use the proper tools. Handle tools carefully and return them to their proper places when you have finished using them.

16. Never mix cleaning and disinfecting chemicals.

17. Avoid wearing excessive jewellery (ear-clips, rings, bracelets, chains, etc.) that can get hung up on hooks or can be grabbed by animals.

18. Do not rush! Think before you act. When unfamiliar with a situation or procedure, do nothing without consulting a more experienced keeper, supervisor, or curator.

Remember that failure to follow established safety procedures can result in an injury to an animal, to you, to a co-worker or even to the public. ALWAYS THINK SAFETY

2.8 Veterinary guidelines: Considerations for health and welfare

Sharon Redrobe and Hanspeter Steinmetz

2.8.1. Introduction

This chapter represents a preliminary effort to provide guidelines for the medical management of great apes (orang-utan, gorilla, chimpanzee and bonobo) in European zoos. The guidelines should facilitate the exchange of animals between zoos easily and without major health risks. A veterinarian in charge of non-human primates will find a lot of information in a wide spectrum of veterinary literature and existing guidelines of the EEP and SSP for various species. The Transmissible Disease Handbook of the IDWG (Infectious Disease Working Group) of the EAZWV (European Association of Zoo and Wildlife Veterinarians) might be a valuable tool for diagnosis and therapy. Additionally, the O.I.E. International Animal Health Code (Zoonoses transmissible from non-human primates, 1999), the application of Annex C to Council Directive 92/65/EEC (BALAI), as amended by council Regulation (EC) No 1282/2002 of 15 July 2002 (OJ L 187/3) in approved zoos and some relevant requirements of the Council Directive 2000/54 EC of 18 July 2000 (Biological Materials, Biostoff Verordnung) must be taken into consideration and should harmonize with the guidelines.

These guidelines are for the use of zoo staff involved in the management of apes. They are not intended to be a do it yourself guide for solving medical problems in apes by inexperienced or even non veterinary staff. A primate keeping institution approved under directive 92/65/EEC must secure the services of a veterinarian approved by and under the control of the competent authority. This veterinarian must possess particular knowledge in the field of animal health as it applies for the species concerned. This means he must update his knowledge regularly, including information about relevant health regulations (Directive 64/432-Article 14 (3), (b)). It is therefore presumed that this veterinarian does not need any guidelines on how to immobilize an ape, carry out surgery, treat an air-sacculitis, prevent pregnancy or perform neonatal care etc. Numerous pathogenic micro-organisms can cause diseases in both human and non-human primates, thus the potential will always exist for the transmission of disease between the two groups - in either direction. Furthermore, pathogenic organisms can be inadvertently transferred between different groups of primates by staff working with more than one group. The veterinarian in charge has to cooperate closely with the staff, zoo management, company doctor and the veterinary and medical authorities. In some situations he may need a close cooperation with medical specialists. The veterinarian carries considerable responsibility for the well-being of the primates and staff, and often even for public health.
Infections and infestations shared by humans and other animals are often designated zoonoses, and non-human primates have always been noted for their zoonotic potential. Most zoo ape populations in Europe are composed of zoo-bred individuals and imports of wild-caught animals are now extremely uncommon. For the majority of zoos importation of apes from any source is not a common event. Given these factors and the quarantine period imposed by veterinary authorities it should be stressed that in the majority of European ape collections the animals will be at a greater risk from humans than vice-versa. However, all primates should be treated as potential carriers of zoonotic diseases. Similarly, all staff should be considered as a potential source of infection for the animals. Additionally it should not be underestimated that diseases might be spread by zoo visitors if the enclosure design or the management allows direct or indirect contact.
Diseases can be spread between non-human primates and humans by numerous methods, including physical contact (bites, scratches, exposure to excreted material), ingestion and airborne or aerosol transmission.

A comprehensive list of specific zoonotic diseases would exceed the size oft he document then according to Brack (1987) there are several hundred. Up to date details of the most relevant diseases in apes can be found in the Transmissible Disease Handbook of the IDWG of the EAZWV (2006) which should be updated regularly. Fact sheets in this publication include information about epidemiology, diagnosis and therapy; and institutions which can be contacted if more specific details are required. Nevertheless as the world grows together publications from outsite Europe are getting more important and should be a screened regularely.
Whereas staff that care directly for apes must assume a large amount of responsibility for implementing

the guidelines described, cooperation is also required from the managers and owners of collections in providing adequate equipment, facilities, staff and training. The recommendations contained in this document are only intended as guidelines. Each institution should develop its own written set of instructions for ape keepers, modifying the guidelines where necessary to take local circumstances and practices into account. This process should be carried out in cooperation with the collection's veterinary advisor, and the resulting document should be read and signed by all staff concerned.

2.8.2. Guidelines for apes

2.8.2.1. General health

Animals that are in good general health and wellbeing are far less likely to carry or suffer from infectious diseases than those living on impoverished diets or in suboptimal physical or social conditions. Constant attention must therefore be paid to good husbandry practice.

2.8.2.2. Enclosure design

Enclosure design should minimize direct or indirect contact between different primate species, especially between African and Asian species, keepers and visitors. With the increasing popularity of mixed species exhibition new challanges in disease transmission shoukd be considered. Special attention is requiered to prevent the introduction of pest animals as good as possible.
Although great apes can adapt well to different environmental conditions, it is necessary to provide indoor climatic conditions to their natural habitat as similar as possible. Humidity, temperature and ventilation are climatic factores which should be monitored on a regular basis. The recommended number of air changes per hour should depend on the size of the inside enclosures, the local climatic conditions, the frequency of use of the outside areas and the total number of primates kept. The technical equipment requires regular maintenance and service for cleaning and prevention of pathogen build up.
Particular attention should be paid to the overall safety of enclosure. A balance between an enriching environment and safety of enclosure furniture should be evaluated. Sharp edges, drowning -, trapping – or drowning possibilities should be eliminated. Service passages must be sufficiently wide and high to prevent animals from reaching out to scratch or otherwise injure the keeping staff.
Inside enclosures should be designed so that apes can be separated easily in an off show area. These separation areas can be used for various purposes (introduction, training, treatment, hospitalization) but should be included into the daily routine for training and easy access by animal health staff. These areas should also allow easy darting without any obstacles by the veterinarian, prevent high falls, and should be easily desinfected.

2.8.2.3. Identification and records

All apes should be readily and reliably identifiable by the use of transponders. Specimen and medical records should be kept up to date. Prior to any animal transfer, a copy of the individual detailed medical record should be forwarded to the receiving institution. Nevertheless open communication between the veterinarians of the sending and receiving institution is essential to exchange information of important health issues and the medical management of the population.

2.8.2.4. Pest control

Many infectious diseases of apes can be carried by invertebrate and vertebrate pest species frequently encountered in and around primate facilities. Specialist advice should be sought to reduce or eliminate such pests, which include ticks, insects such as cockroaches, snails, rodents and birds. This can be especially challenging in enclosures with natural substrate and/or vegetation, ponds and moats which may require constant attention in this respect. Organisms such as Shigella, Salmonella, Campylobacter, Chlamydia, Leptospira, Yersinia and even nematodes such as Angiostrongylus and Capillaria can all be introduced or spread by pest species. In endemic areas of Echinococcus spp. dogs and foxes might cause serious problems by contaminating outside enclosures, bedding material, material for behavioural enrichment and even food.

2.8.2.5. Population health monitoring - Preventive health programme

In the case of BALAI-approved collections, the approved veterinarian must design and implement an annual disease surveillance plan which is subject to annual audits by an official veterinarian from the competent authority (annex C). For details see Guidelines for comprehensive Ape Health Monitoring program (IDWG August 2003). In the case of non-approved collections the drafting of an annual disease surveillance plan is still advised. This might include:

- Daily written reports about the health of all apes including any symptoms of disease, anomalous behaviour, births, deaths, veterinary treatments, etc.
- Bi-annual faecal testing for pathogenic bacteria and parasites. In case of specific problems more frequent testing might be indicated. Where an infection with pathogenic bacteria or parasites has been treated, follow up faecal samples should be examined to establish the effectiveness of treatment.
- Body conditions, exercise and diets should be reviewed on a regular basis and adapted to the animal needs. Close contact with keepers is necessary to gain knowledge of dietary selection of individual animals.
- If there is a vaccination program, the vaccine status of each animal should be reviewed annually and boosters given when appropriate.
- Serum and tissue samples should be collected and stored at preferable minus 80°C or below as and when the opportunity arises. Serum banks thus created can be valuable in the diagnosis of viral disease, the determination of vaccine efficacy and in the screening for new diseases as they are described. Furthermore, serum banks represent a valuable research tool.
- It is recommended to obtain a good knowledge about the health status of the population. Testing of most common diseases is recommended when opportunity arises. Thus, a minimal database about the animals in the every collection should be established.
- If apes are immobilized for any reason, blood samples should be collected for haematology, serum biochemistry and serology (incl. most common diseases like TB). TB-testing might be required by the veterinary authority (BALAI). Annual health exams are currently not recommended unless local circumstances dictate otherwise (consult veterinary advisor).
- Comprehensive post mortem examination of all apes dying within the collection (see below).
- A preventative health program for employee working with great apes should be in place (see below). Also a continuing education program for employees in regards animal welfare, enrichment, hygiene and transmissible diseases should be established.

2.8.2.6. Vaccinations

Vaccination program depends on the region, available vaccines, collection and design of enclosures. Under certain circumstances it might be recommended to vaccinate apes against tetanus, measles and poliomyelitis and other infectious diseases (refer to veterinary advisor). However, most apes in European collections are not vaccinated at all and tetanus and poliomyelitis have yet to be reported in European ape collections. When vaccines are used, the type, batch number and source of vaccine should be recorded in the medical records, as well as the site of vaccination in the case of injectable products.

- **Tetanus:** Clinical tetanus has been reported in wild and captive primates, and is generally fatal. Three intra-muscular doses of tetanus vaccine (standard human tetanus toxoid containing 40 IU of tetanus toxoid per dose is acceptable) are given for immunization. The first dose can be given from 4 months old. The second dose should be given 4-8 weeks after the first dose. A third dose should be given 6-12 months after the second dose. Then boost at 5 year intervals.
- **Measles, mumps, rubella (MMR):** All apes are susceptible to measles, but chimpanzees seem more robust. Mumps and rubella (German measles) are primarily sub-clinical diseases in most non-human primates but might cause serious symptoms in apes. Currently an important topic in humans and thus should be considered due to the anthropozoonotic risk. Apes should be given a single dose of human standard vaccine at 15 months of age or over. Live measles vaccine should not be given at the same time

as other vaccines, or to animals with other infections, or to any immuno-suppressed animal, or pregnant animals. An intramuscular booster is given at 6 - 7 years of age. Vaccination may cause false negative intradermal TB test.

- **Polio:** Clinical poliomyelitis has been reported in chimpanzee, gorilla and orang-utan, but there are not in Europe. There are live, oral trivalent polio vaccine (containing attenuated strains of poliomyelitis virus, types 1, 2 & 3) or enhanced potency inactivated polio vaccine (eIPV) available. The oral vaccines are given at 3, 6, and 9 months of age; then at 2 years of age. It is important to give the oral polio vaccine to all animals in a group at the same time. This is particularly important with the first dose of any course. The injectable inactivated polio vaccine (eIPV) is given by intramuscular injection at 3, 6, and 9 months of age; then at 2 years of age.
- **Rabies:** All primates are susceptible and vaccination of outdoor housed apes in areas where rabies is endemic might be considered. Killed vaccine at the time of the routine exam is practical, and safe. Doses should be given at 4 months old, then boost at 1 year old, and at the time of the routine examination.
- **Pneumococcal** disease: Especially juvenile and geriatric bonobos and orangutans seem to be susceptible to pneumococcal disease caused by *Streptococcus pneumoniae*. The infection causes mostly pneumonia and potentially meningitis. There are different vaccines for children and adults to prevent pneumococcal disease in human medicine available. Juveniles at high risk can be vaccinated at the age of 2, 4 and 6months of age with the children vaccine with 13 serovars followed by the adult vaccine with 23 serovars at the age of 18 months and then all 10years.
- **Influenza:** Juvenile bonobos seem to have an increased susceptibility to flu and vaccination can be considered on an annual basis always in fall before the expected influenza season.
- **Other diseases:** Vaccine programmes should be adapted to changes in disease prevalence and increased knowledge of the efficacy and safety of available products. In unusual circumstances, i.e. in the face of specific challenges, primates can be vaccinated against influenza, bacterial meningitis, Haemophilus influenzae, Pneumococcus, viral hepatitis A and B. If apes are carriers of hepatitis B (most common in orang-utans and gibbons) the offspring may be protected by vaccination immediately after birth. It is not advised that apes are vaccinated against tuberculosis with BCG as the vaccine interferes with tuberculin skin tests for TB and probably only induces a limited period of immunity.

In general it is recommended serum samples from vaccinated primates should be tested to establish the effectiveness of the vaccine schedules when the opportunity arises.

2.8.2.7. Post-mortem examinations

A thorough post-mortem examination with further diagnostics should be carried out by a competent and experienced pathologist without unnecessary delay on all apes dying in a collection. Particular care should be taken with primates dying in quarantine as these animals must be assumed to be of high zoonotic potential until proven otherwise.

Important is to measure and describe all organs as well when normal. If certain bodyparts will not be disected due to specimen preservation a postmortem CT scan should be carried out to establish references and to find any abnormalities.

After post-mortem examination carcasses should be offered to reputable scientific institutions or museums. However, this must be approved by the veterinary authorities and staff working with this material must be informed about possible zoonotic risks. Even if the cause of death seems obvious a post mortem examination is strongly advised as valuable information about the health of a group of animals can be obtained.

2.8.2.9. Animal transfers

<u>Planning</u>

All animal transports should be planned adequately. European legislation has facilitated transport with less paperwork. Nevertheless planning and written information exchange is necessary besides talking to each other.

Prior to transport the following procedures are advised (see EAZWV Recommendations for Testing

Procedures and Movement Protocols for Animals between Zoos of E.U: Member States- 2nd edition of the IDWG Transmissible diseases handbook, April 04):

1. All ape exchanges should be preceded by enquiries as to the BALAI status of the zoos involved. Where both zoos are approved most required testing and quarantine procedures will have been fulfilled prior to the agreement to exchange/move the animals. Where one or other of the zoos is not approved special conditions will apply which will be interpreted by the authorities of the member states concerned and clarification and agreement should be confirmed by both parties involved in the exchange.
2. Even where both zoos are BALAI approved, it may be a further requirement either by the zoo or by the member state authority that extra tests or quarantine/isolation be applied. This must be confirmed in writing before the movement of animals is allowed.
3. Where neither zoo is BALAI approved, then all the suggested protocols should be undertaken and agreed by both institutions in the planning stages of the movement.
4. Because of the risk of zoonotic disease both institutions involved should review their risk assessments prior to the movement of the animals and implement protocols for management of the species involved, which may be required or requested by the partner zoo.
5. In all cases personnel involved should have specific experience of working with apes and assisting in handling for pre-shipment and health management.
6. As well as information regarding the health status of the animals to be moved, any significant evidence of recent zoonotic disease occurring in staff working in the zoo environment within the previous six months should be notified to the zoos involved.
7. Identification details: A copy of the animal’s records (specimen report) should be forwarded to the accepting zoo 21 days prior to movement. If this is not available, full I.D. details including description, age, sex, distinguishing characteristics, microchip number and location and in some cases photographic I.D. should be supplied.
8. Basic information about the individual(s) should be supplied including the animal’s weight, temperamental characteristics, behaviour, whether mother or hand-reared, current diet, and any physical abnormalities even if not a clinical entity.
9. Clinical information: Full clinical details should be supplied to the recipient zoo 21 days prior to shipment. This must include any current treatment or medication. Any significant diseases occurring within the supplying collection within the previous six months, or when necessary longer, should be notified to the recipient collection. Current or past usage of any form of contraception should also be advised including the length of time used and interval of repetition together with any noted side effects even if anecdotal.
10. Certification: The exporting zoo should have held the animal concerned within the perimeter of the zoo for a period of 60 days prior to movement – and where possible for a certain time in isolation. However, isolation will not be possible in many cases due to the social and welfare implications. In such cases the group in which the animal is kept should be subject to strict isolation for the prescribed period and the group health status acceptable.

- The exporting zoo must not be subject to any statutory restrictions of either of the member states involved in the exchange with regard to diseases at the time of the exchange/movement. Current evidence of any vaccination programme used in the group or the individual within the sending zoo should be included with the clinical history.
- Some authorities may require that the animal being moved must have been born at the zoo or present there for a minimum period of two years prior to transport. Institutes should check these specific requirements (OIE).

Preshipment examination

The more medical information both veterianrians know about the sending and receiving institution the better preshipment examinations and necessary preventative medical treatments can be planned and innitiated. Although European legislation reduced requiered tests, preshipment examination can assess the health status of any animal in doubt. In addition, biological samples should be collected and saved

for repeating tests or for additional informations.
A range of tests for disease agents and bio-parameters should be carried out by agreement with the accepting zoo (even if both zoos are BALAI approved) at least 21 days prior to movement. Simultaneously, a general health check should be carried out.

- Full clinical examination under a general anaesthetic, including a careful assessment of weight, teeth, eyes, reproductive organs and identification (microchip).
- Intradermal palpebral test for T.B. using human and/or bovine tuberculin is recommended for all great apes exept oranutans. Any reaction to be considered positive. (Note: OIE recommends two tests within 30 days of export, although this may increase the risk of false positive reactions to the second test). Although not evaluated positive results of newer serological test should be considered positive on require further investigations.
- Advisory – no incident of T.B. in the primate collection of sending zoo to have occurred within the previous two years.
- Faecal screen for Campylobacter, Salmonella, Shigella & Yersinia, within 30 days prior to transport.
- Faecal screening for endo-parasites following a routine treatment for endo- and ectoparasites (avermectin cp.) within 30 days prior to transport.
- Radiography if requested by receiving zoo.
- Investigation of the incidence of Yersinia in any collection where a case has been diagnosed within the last two years.
- Current status of tetanus vaccine satisfactory (an initial course of vaccination may induce up to 10 years of effective immunity).
- Rabies vaccination to be considered if animal is to be moved to a rabies endemic area.
- Haematology and blood biochemistry profiles.
- Serological tests for Echinococcosis, Hepatitis B (HBV), Simian Immunodeficiency Virus (SIV), Simian T-Lymphotropic Virus (STLV), and where possible Simian Foamy Virus (SFV).

Other pathogens may be added to this list as our knowledge of their significance advances. A wider range of viral screening tests is generally appropriate for wildborn animals. Further testing may be required by the receiving zoo. Examples include:

- Electrocardiology or other cardiological assessment. (Male gorillas are prone to fibrosing cardiomyopathy).
- Radiography including dental pathology screen.
- Pneumococcal, influenza or other vaccinations.
- Endocrine or reproductive ultrasonographic assessment.
- Banking of genetic material.

Quarantine

All primates entering a collection, irrespective of their origin, should undergo a period of quarantine. The stress of separation and transport can cause immunosuppression and lead to a higher risk of pathogen shedding. Thus, during this period a variety of screening tests should be performed to establish their health status, review their vaccination status, and establish a serum bank. Ideally, quarantine should last for at least 30 days although if animals are being transferred between approved institutions within Europe a shorter period may be adequate. Quarantine facility should be easily cleaned and desinfected, but should fullfil natural animal needs.
The welfare of this highly social animal must be taken into consideration. If the facility sending an animal is effectively a “sealed unit” (i.e. no imports within the past year and a clean health record) there may be occasions when a shorter quarantine period, sufficient only for the performance of the screening tests detailed below, is appropriate. This applies particularly to highly social species like chimpanzees, bonobos and gorillas.
For the import of wild-born animals or animals from facilities of questionable veterinary standards, a specilized, very high standard quarantine facility, veterinary and keeper staff, are required. Quarantine

time and tests perform depend on animal origin and results. It might be necessary to repeat tests tp adequately consider incubation period of potential pathogens.
With the possible exception of unweaned individuals being hand-reared (the transfer of which should be a very rare and exceptional event), direct handling of conscious animals during quarantine should be avoided.

Additional diagnostics:

• Parasitology: Assessment of internal and external parasite burden. Repeated faecal tests (flotation, sedimentation, Baermann-Wetzel method) will be necessary to determine whether internal gut parasites are present. Even if those tests are negative and the animal has been treated it might be a carrier of Strongyloides due to hibernating larvae. Eggs of Enterobius will not be found by the above methods, but can be diagnosed by use of a scotch tape applied to the anus/perineum. Capillaria hepatica and Angiostrongylus cantonensis might only be diagnosed by serology or even post mortem. Advice should be sought from specialized parasitologists to maximize the chances of detecting and identifying the more delicate protozoan parasites (Amoeba, Balantidium, Lamblia, Blastocystis hominis).
• Bacteriology: Faecal samples should be tested for the presence of pathogenic bacteria such as Campylobacter, Shigella, Salmonella or Yersinia species. Some of these organisms are only shed intermittently, necessitating the examination of several samples. It is recommended to collect only fresh samples and to use an appropriate transport medium. Where pathogenic parasites or bacteria are detected, appropriate treatment should be given and its effectiveness confirmed by further tests during the quarantine period
• TB-testing: Very few individual TB tests are completely diagnostic and further veterinary advice should be taken for each set of circumstances, especially taking into consideration the animal's origin. Serological tests such as complement fixation, ELISA, and others, appear to be of limited diagnostic use at present. In the case of a positive intradermal tuberculin test a range of other screens should be considered including the microscopic examination of sputum, radiography of the lungs, culture of material recovered from bronchial washings and gastric lavage, CT and differentiation of acid-fast bacilli by PCR. Infection with non-pathogenic atypical Mycobacteria may cause a positive tuberculin test.
• Serology: Where possible the tests for SIV, STLV, SFV, and HBV should be carried out before an animal is transferred, thus avoiding the unnecessary stress of a move if positive. In addition, animals should be screened serologically for Echinococcosis.
• With regard to the faecal screens and TB tests, even if these are negative pretransfer, the receiving institution is strongly advised to repeat them during quarantine as some animals may become positive during or shortly after a move. In the case of animals testing positive for any particular infection advice should be sought initially from the collection's veterinary advisor.

2.8.3. Guidelines for human personal health

The Council Directive 2000/54/EC (Biostoff Verordnung of EU, EC Biomaterial Regulation) requires employers to assess the risk of infection to employees and other people who may be working with the animals and their by-products. Where a risk is identified, appropriate preventative or control measures must be applied. A code of practice should be drafted in cooperation with the company doctor and the collection's veterinarian. The veterianrian should inform the company doctor about all potential zoonotic diseases in the collection. Transfer of know-how is essential for preventative health care.
Staff should be made aware and remembered on a regular basis if primates in their care are known or suspected to be suffering from potentially zoonotic infections. Additional measures (if any) to prevent transmission of infection should be explained. Regular training in preventing disease transmission is recommended. This job will fall primarily to the company doctor and the veterinarian.

2.8.3.1. Pre-employment staff screening

To reduce the risk of disease transmission to primates, prospective new staff members should undergo certain health checks, rather like the health checks carried out during quarantine for apes. This pre-employment medical check has clear advantages for staff and employer alike, and should be developed

in cooperation with the collection's occupational health advisor.
• New staff members should not have any contact with primates for the first two weeks of employment. This should allow sufficient time for the development of most infectious diseases that the new employee may be incubating when taken on, and for the completion of specific tests detailed below.
• Ideally, the candidate should undergo a thorough medical examination by the collection's staff doctor.
• The vaccine status of the new employee should be reviewed. It is important that vaccinations against hepatitis A, hepatitis B, tetanus, measles and polio are current.
• Faecal tests should be conducted to establish whether the prospective staff member is carrying any pathogenic enteric bacteria or parasites.
• A skin test for tuberculosis should be carried out. If this is positive, the doctor must suggest further tests.
• A blood screen for hepatitis B and C should be carried out.
• Prospective staff should be offered HIV testing.
These measures are suggested purely on medical and veterinary grounds. No comment or advice is given concerning the financial or legal implications of the tests or any treatment that may be required as a result.

2.8.3.2. Health of staff during employment
• It is essential that all staff members are in good general health. People that are run down in any way are far more likely to contract infectious diseases than healthy individuals.
• Staff member who is immuno-suppressed for any reason should not be working with apes and should seek specialist advice. Radio- or chemotherapy, large doses of steroids or HIV infection may all cause immuno-suppression.
• Staff member who is pregnant should not be working with apes and should seek specialist advice.
• Annual faecal tests for pathogenic bacteria and parasites are advised.
• Staff members should undergo a similar faecal test after having returned from countries where such infections are commonly acquired, or from working in other primate collections. Specialist guidance should be sought as to whether a particular country is considered a high risk.
• Each staff member should ensure that all vaccines are current.
• An annual skin test for tuberculosis is advised.

2.8.3.3. Staff illness and injuries
Colds, flu, measles, viral hepatitis, salmonellosis, Herpes and many other infections can be passed to primates and may cause serious disease in an ape collection.
• All injuries, accidents and illnesses of staff should be recorded.
• Bites and scratches should be immediately (stop work) thoroughly washed (not scrubbed) and medical attention sought if severe. Further detailed information should be available to staff working with animals in quarantine (especially those imported from range countries) and animals in the collection that have been incompletely screened.
• Staff members who are ill should not work with animals or prepare food.
• Staff with active herpes simplex lesions, should not work with primates and should be encouraged to seek medical advice about treatment. Staff with children or other family members suffering under infectious diseases like measles, mumps, chicken pox, scarlet fever, student kissing fever (mononucleosis, EBV) should not work with apes.
• If a doctor is consulted about illness in a staff member, he/she must be made aware that the patient's work involves care of great apes.

2.8.3.4. Staff personal hygiene
High standards of personal hygiene are required from primate keepers if the transmission of infectious zoonoses is to be avoided.
• Frequent hand washing is probably the single most important measure to reduce or prevent the spread

of infection. Washing is particularly important immediately before and after working with any primates. Hands should always be washed after handling bedding and other enclosure materials, uneaten food, faeces, urine, blood, saliva and any other body secretions. Although disposable gloves should be worn when handling primates or primate material, hands should still be washed after gloves are discarded. In order that staff may wash effectively and sufficiently often, it is vital that suitable facilities are provided. These are best placed just outside animal holding areas.

- It is best practice for animal staff to wear a range of protective clothing when working in primate facilities. Generally speaking, this involves the use of overalls, rubber boots, and disposable gloves. Fully protective goggles and facemasks may also be necessary where a particularly high risk of zoonotic infection exists, such as when working with any primate in quarantine or any wild-born primate. Zoos are strongly advised to consult their veterinary advisor to assess the level of protection that is appropriate.
- To reduce the risk of mechanical transmission of infectious agents between different primate facilities/houses, separate sets of protective clothing should be available for staff in each place. Work clothes should be washed in the primate unit or sent in sealed bags to a laundry and should not be taken home by staff for any reason. Boots should be washed and preferably disinfected before entering and after leaving primate houses. Suitable facilities should be made available by the management.
- Working clothes used in great ape back ground areas or in the enclosure should be not be worn in restaurants or off zoo permises.
- People with open cuts or sores on their hands must wear disposable gloves when working with apes.
- Staff should be encouraged to keep hands away from their face when working in animal areas. It is remarkable how often people touch their faces without thinking about it! Similarly, staff should be discouraged from putting pencils, pens etc. into their mouths.
- No smoking, eating, drinking or spitting should be permitted in animal areas.

2.8.3.5. Enclosure cleaning and disinfection

- Protective clothing (overalls, boots, disposable gloves & masks, goggles) should be worn when cleaning animal areas. Protective cloth should be washed, cleaned and stored in the animal area.
- Bedding and excreta should be removed in sealed bags or adequate containers.
- Animal areas should be cleared and scrubbed before hosing down. High-pressure hoses or steam cleaners should be avoided if at all possible, as they tend to create aerosols or sprays of potentially infectious material.
- Regular disinfection of primate facilities is probably is necessary to prevent the build up of certain bacteria in the environment which in small numbers may not be a problem but in large numbers may cause enteritis etc from time to time. A thorough disinfection is recommended at suitable intervals.
- Enclosures with natural ground (e.g. bark mulch) must be thoroughly spot cleaned daily. Potential pathogen build up should be prevented by adequate ground work of substrate as recommended. In addition, substrate should be monitored regularly for pathogens and adequad degradation.

2.8.3.6. Equipment

Restraint equipment should always be in good working order. Nets, gloves, squeeze cages, crushes and crates should be regularly inspected. Defective equipment can lead to injuries to animal and man, and in the worst case escapes. Equipment must be cleaned after each job to avoid the mechanical transmission of infectious material. Needles, blowpipe darts and surgical instruments should be handled with extreme care as after use they might be contaminated with various bacteria and viruses.

2.8.3.7. Veterinarians

- Many of the animals examined and treated by veterinarians will be sick and therefore the risk of zoonotic infection is often higher than for most animal care staff.
- Veterinarians must adopt the most rigorous standards of personal hygiene and wear disposable protective clothing as often as is practical.

• Particular attention should be paid to avoid the mechanical transmission of infective material via clothing and equipment, both between different primate houses and between different collections.
• Veterinarians must ensure the correct disposal of clinical waste.
• The veterinarian is advised to visit the great ape collection on a regular basis so the animals adjust to the veterinarian presence.

2.8.3.8. Visitors

It should always be remembered that all visitors who have access to apes may pose a threat to the animals and they may be at risk of infection. Therefore the role and management of volunteers, students, temporary staff, visiting zoo personnel, contractors working in animal areas, media personnel and in some cases, visitors, needs careful consideration. Direct contact between apes and non-staff personnel should be strictly forbidden whatever the justification. Under no circumstances should children be allowed to have direct contact with juvenile apes. For health reason a distance of at least 1,5 m is suitable between animals and visitors to avoid transfer of contagious.

2.8.4. Specific veterinary health concerns in gorillas

Vitamine D supplementation to winter housed apes

All apes are susceptible to vitamin D deficiency if they are housed away from natural sunlight. Dietary supplementation via commercial pellets should be standard. For youngsters that are housed inside for extended periods; whether due to winter regimes or during introductions consider extra supplmentation with oral vitamin D.
Vitamin D deficiencie has been implicated in issues with the immune system, reprouctive systems and heart disease and so should not be merely associated with bone issues.
There have been cases of fracures in suckling infants; can be given oral vitamin D even when not yet eating solids if they can be trained to take oral drops from the staff.

<u>Viruses</u>

Measles

Measles can be fatal in gorillas.Measles is a highly contagious virus and is spread through coughing and sneezing. Transmission occurs four days before through four days after the rash appears. As a possible preventative measurement, keepers should be vaccinated and access to animals should be restricted.

Chicken pox

Juveniles and babies seem to have an increased susceptibility to chicken pox.

SIV

<u>Risk of SIV from de Brazza monkeys to gorillas</u>

Balantidium coli

Balantidium coli causes severe hermorrhagic diarrhea and death in gorillas. Treatment with tetracycline, iodoquinol, metranidazole (idoquinol not well absorped therefore will not be effective if have invasive disease)

Any sick gorilla should be assumed to be at risk of the ‚sick gorilla syndrome' (gastro-inetinal ulceration, anaemia, and stasis) and this should be specfically treated in additon to addressing any underlying managemtn or othr disase factors.

Alveolar Echinococcosis

Alveolar echinococcosis is a zoonotic disease caused by the small fox tapeworm (*E. multilocularis).* The small fox tapeworm is widely distributed in the northern hemisphere and is also rapidly emerging in large parts of Europe. Besides other primate species, gorillas seem to be highly susceptible to alveolar echinococcosis. Transmission occurs by direct contact with faeces of free roaming wild or captive definitive hosts (eg. fox, dogs, coyotes, cats) in endemic areas or by dietary items contaminated with eggs. Animals in endemic areas should be screened semi-annually by serology (enzyme-linked immunosorbent assay (ELISA) and indirect hemagglutination test) to detect infections. The necessary amount of blood for screening is small and can be gained via toe pricks. Animals quickly learn to accept toe pricks through medical training within a few months into training. A semi-annual screening allows for an early infection detection and adequate treatment, which both is crucial to minimize the deleterious effects of the disease. In positive cases, further diagnostic procedures with advanced diagnostic imaging for prognosis and treatment are highly recommended. No experience with surgery exists in great apes. Chemotherapy with albendazole is currently the treatment of choice to suppress parasite growth in the liver of infected animals. Although adverse side effects (teratogenicity) of albendazole treatment in other species (rodents) were reported, the World Health Organization (WHO) has determined that the benefits of treatment outweigh the risks in humans. Prevention is essential. Minimal preventive measures include the exclusion of foxes and dogs from animal enclosures. If exclusion cannot be ensured, regular antiparasitic treatment of stray animals on zoo grounds are recommended. In addition, dietary items should be thoroughly washed and bedding material, litter, and browse should be protected from faecal contamination before entering the enclosure.

Breeding Strategy for Female Gorillas with Alveolar Echinococcosis

It is recommended to breed female gorillas infected with alveolar echinococcosis who are otherwise in a good and stable general state of health. A non-breeding strategy of infected females is not suggested because animal welfare, genetic diversity and the transmission of mothering skills would be negatively affected. In general, infected animals pose no risk for their conspecifics. Alveolar echinococcosis does not cross the placenta and thus cannot be transmitted to the foetus by the mother. Infected female long-tailed macaques have been reported to produce healthy offspring while receiving constant albendazole treatment. In humans, albendazole treatment is administered during pregnancy from the second trimester onwards to reduce possible negative side effects for the embryo (e.g. abortion, limb and facial abnormalities). More case studies are needed to provide detailed information about how to best manage albendazole treatment during pregnancy in gorillas. Based on human case studies it is recommended to pause albendazole treatment from the moment an infected gorilla female enters a breeding situation until the second trimester of her pregnancy. Pregnancy tests can be used to determine correct timing for re-starting albendazole treatment. If albendazole treatment of an infected female gorilla should result in a disabled offspring, euthanasia should be considered of the offspring taking into account the long term welfare and quality of life of the individual animal. To date there are no reports of negative effects of albendazole during the lactation period. Please inform the EEP coordinator and vet advisors if any adverse effects of albendazole related to breeding are observed. This will allow a re-evaluation of breeding strategies for infected gorilla females.

Emergency care of sick gorilla

e.g. within 6 months of introduction, or fighting in group, or excluded from group, typcailly young animal but not always

Gorillas can get very weak for many reasons. Gorillas have a very well developed large intestine and a much more complicated gut system than humans. Balantidium coli is virtually endemic in the gorilla population (and is not always found on faecal examinations) and at times of stress will multiple up causing differing levels of bowel inflammation, ulceration and diarrhoea; if left untreated the intestines may rupture resulting in death (even without diarrhoea). Weight loss, severe anaemia (from associated gastrointestinal ulceration, from stress) is also very common.

Gorillas are not comparable to humans in many cases of sicknss and disease; the author urges caution in consulting with medical (human doctor) coleagues when dealing with a sick gorilla. Especially a gorila with non-specific signs of disease, in many cases a classic presentation for gorillas, yet very cosnusing for those used to dealing with human patients. Gorillas show very different bowel signs than humans. It is worth noting therefore - gorillas are *not* very close to humans in this respect and, indeed, human doctors may assume neoplasia (cancer) of the bowel is more likely given the thickened bowel loops, bleeding and ulceration, anaemia, etc. For gorilla veterinarians a better model for compaison with the gorilla is the rabbit (ileus, gastrointestinal ulceration from stress, lethargic, depression, anorexia; all forming a common complex).

Treatment – immediately

1. A course of anti-ulcer therapy for at least 4-6 weeks (ranitidine or similar) – same dose as humans, to reduce pain and inappetence from stomach ulcers
2. Plus a management review – is there fighting in the group? Dislike between members? anything that can be done to reduce the stress in the group (and avoid keeping animal alone unless risk of injury) will be of same if not more use than medications
3. A low dose of diazepam can also be extremely helpful in lowering stress levels and improving appetite (25-50mg for an adult gorilla, once daily; half this for 4-8year old). This dose should not make them sleepy but will aid appetite. Continue for at least 6 weeks.
4. It is not recommend starting at lower doses; in an emergency situation with a weak, inappetent gorilla, start at the higher dose immediately. If the animal sleeps, no harm is done (and the issue may have been not sleeping enough anyway) and give the lower dose the next day; too low a dose at first just takes longer to correct the animal.
5. If the animal is not eating give 1ml midazolam via dart (the lower stress of one quick dart may offset the overall stress and drug given to stimulate appetite; only if darting can be done swiftly and easily).
6. Metronidazole(30-50mg/kg q24h) or tinidazole (500mg/adult) to treat Balantidium coli
7. Ideally do not consider a general anaesthetic until the above (1)-(4) have been initiated

Please phone or email the EEP Veterinary Advisor for further advice.

Please send results of all blood work and clinical examinations if done.
It is preferable but not essential, to speak with the vet to be able to reach rapid decisions based on case details and discussions of drug availability in the country etc.

2.8.5Reproductive management

2.8.5.1 Contraception

All apes contraception should be taken under advisment via EEP coordinator.
Check the latest recommendations and doseages at EGZAC.

2.8.5.2. Pregnancy testing

Pregnancy can be determined by routine methodology such as radiology and ultrasound. In addition, human pregnancy tests (chorionic gonadoptropin) can be used for pregnancy diagnosis in all apes.

2.8.5.3. Permanent contraception

Castration, vasectomy, tubal ligation, and ovariohysterectomy are similar to those procedures for domestic species. Vasectomy and tubal ligation are recommended in primates in group situation to control reproduction but allow for normal hormonal activity. It may be argued that a female primate in her natural environment would not normally be cycling repeatedly without conceiving making this an unnatural situation; however, with the hormones present, the group dynamics appear to remain unaltered. Castration and ovariectomy are also performed, typically when group dynamics are not of consideration.

Vasectomy

Vasectomy involves removing a portion of the vas deferens. A scrotal or prescrotal / inguinal approach may be utilized. The scrotal approach is easier; however, the inguinal skin appears to be less sensitive and if the incision is made in this location, great apes appear to less likely traumatize the incision postoperatively. It can be challenging to identify the vas deferens and distinguish it from other structures, thus it is wise to submit the removed reproductive pieces for histologic confirmation.

Sperm granulomas have been reported following vasectomy. Ligating or hemoclipping the vas on both ends should minimize the risk of granuloma formation, but will reduce the successfull reconstruction surgery when needed. Following vasectomy, males remain fertile for 3-4 weeks.

Tubal ligation

Tubal ligation involves either ligating or removing a section of the oviduct to prevent the ovulated ovum from reaching the uterus. If there is any chance that the procedure may need to be reversed in the future, it is best not to remove a section of the oviduct and only apply a clip or ligature to it; however, with this technique there is a greater possibility the procedure will fail and the animal will become pregnant.

Ovariectomy

Ovariohysterectomy is not recommended in great apes due to the anatomy of the reproductive tract and the difficulty in ensuring that the ureters / bladder are preserved intact. Consequently ovariectomy or tubal ligation is recommended.

Castration

Castration is most easily performed through bilateral transverse scrotal incisions.

2.8.5.4. Reversible contraception

The most common methods of reversible contraception in primates are hormonal.

Human oral contraceptive formulations are also used in apes however some individuals may not swallow the pills resulting in contraceptive failure. Nevertheless it is one of the safest and most reliable contraception methods**.**

Combination pill: The combination pill contains artificial versions of the female hormones oestrogen and progesterone. Each pill has the same amount of hormone. One pill is taken each day for 21 days and then no pills are taken for the next seven days.

Progestogen-only pill (mini-pill):

- Combination birth control pills are NOT recommended during the first year of lactation because the oestrogen can suppress milk production.

Needle-applied implants (eg Implanon)

Typically placed subcutaneously in the region of the inner forearm or upper arm and have a 3 year life span. The needle site can be glued closed. Migration can occur and finding the implant for removal might be difficult. The implant can be visualized usually by ultrasound. Application and removal require an anesthesia.

- Gonadotropin agonists (GnRH agonists) such as deslorelin can also be used for contraception. Depending on the implant works for 6 to 12 month. It can also be used in males to reduce male, aggressive behavior comparable to castration. There is not a great experience in great apes, thus efficiency, reversibility and safety has not been tested yet.
- Medroxyprogesterone acetate injections and melengesterol acetate (MGA) implants are two common contraceptives used. Be aware that progestins can be cause weight gain.

- Melengesterol acetate implants are placed subcutaneously and have a ~ 2 year life span. One potential complication is abscessation of implant site; however, new recommendations allowing a longer period after gas sterilization has reduced the number of abscesses. MGA implants are typically placed interscapular. Some will apply a single cerclage of orthopedic wire around the MGA implant to allow radiographic location of the implant and the twist in the wire can help prevent migration. Typically implants are easy to palpate and so the wire is not essential. Migration can occur, interscapular-placed implants in the axilla region have been found in some cases.
- Medroxyprogesterone acetate injections need to be given every 2-3 months at a dose of 5 mg/kg IM.

Additional information on contraceptive recommendations for primates as well as other species can be found on the EAZAC website.

2.8.5.5. The prefered method

Females – modern human contraceptive pill (if ape will take reliably) or subcutanous implant.

Reversible male contraception remains problemmatic and great caution must be exerised even with potneialy reversible vasectomy methods; such methods should only be used with the approval of the EEP Coordinator.

Investigation of non cycling/ non reproductive ape females

Apes cycle every 28-30 days, ovulation occurs mid-cycle.

To investigate- first establish whether the ape is getting pregnant, then establish whether she is ovulating. At any stage, a full clinical examination under anaesthetic, including ultrasonography of the uterus and ovaries to evaluate for pathogens and ovulation site on the ovaries will be useful.

<u>Pregnancy testing</u>

1. it is important to conduct pregnancy tests each month to evaluate whether the ape is getting pregnant and losing early pregnancies
2. human pregnancy tests kits (measuring hCG), from regular pharmacy stores, will work on apes

<u>Ovulation testing</u>

1. ovulation occurs mid-cycle
2. human ovulation tests will work in apes
3. collect first-voided morning urine if possible
4. test twice a day for 2-3 days mid-cycle

<u>Cycle Investigation</u>

1. There have been a few cases of female apes appearing to cycle i.e. staff note signs of oestrus and regular matings without apparently conceiving.
2. It is important to use a sensitive (human) pregnancy test kits on fresh urine, 1-2 time daily from days 12-16 following oestrus, to establish whether in fact the ape is conceiving and losing early pregnancies or not conceiving at all.
3. Likewise (human) ovulation test kits may be used on fresh urine samples throughout the oestrus period (over 3-5 days) to detect ovulation; the lack of ovulation at all is more difficult to determine as the short window of time for the test may be missed if the animals are not trained to urinate at least twice a day.
4. For the avoidance of doubt blood tests taken shortly after oestrus should allow further investigation of ovarian activity; it is therefore useful to time routine procedures according to the oestrus cycle, if possible, to avoid anaesthesia purely for these investigations (unless absolutely necessary).
5. Hormone tests from blood samples obtained under general anaesthesia showed an elevated

follicular stimulating hormone level (FSH) and depressed oestrogen levels.
6. Hormone analysis of the monthly reproductive cycle is not possible using blood tests due to the difficulties and negative welfare implications of anaesthetising the animal every day or two for a month unless they are trained for conscious blood sampling.
7. Urinary hormone should be analysed (measuring daily pregnanediol glucuronide and oestrone conjugates).
   i. Daily urine samples are required for a whole monthly cycle. Measuring two or three cycles is even more helpful
   ii. It is possible to analyse a cycle if one day is missed but not two consecutive days ideally
   iii. urine can be syringed from the floor in the morning if the animal is closely observed to ensure identification; or animals can be trained to urinate on command (within reason)
   iv. see appendix for suggested laboratories (e.g. German Primate Centre; note these contacts may change over time)

2.8.5.6. Basic fertility treatment to stimulate ovulation

1. Urinary hormone analysis will reveal whether the female is ovulating
2. It may be useful to seek the advice of a local (human) fertility specialist
3. Specifically, the results may indicate that she is experiencing a decline in ovarian function giving a diagnosis of diminished ovarian reserve.
   i. This diagnosis is based on a high FSH, plus weight gain and failure to conceive.
   ii. This has been diagnosed in gorillas but may occur in others
4. Fertility treatment using clomiphene maybe initiated.
   i. 14 days after oestrus the urine is tested using a human pregnancy kit.
   ii. If this is negative, she is started on clomiphene tablets for 5 days (150mg total dose, 3 tablets).
   iii. Urine samples are collected daily and submitted for hormone analysis to check whether the treatment is producing ovulation.
5. If clomiphene treatment results in ovulation, as evidenced by the progesterone metabolite (PdG), suggesting that clomiphene stimulated follicular development and ovulation. The cycle was also accompanied by a surge in oestrogen (E1C) levels as would be expected for a normal cycle. During the period before the female was acyclic, as clearly indicated by the consistently low PdG levels.

NB. Clomiphene citrate is an orally active synthetic weak oestrogen. The drug's similarity to oestrogen leads to increased levels of FSH and LH, thus the normal events leading to ovulation. Infant survival and development are normal after delivery. The most common side effects are hot flushes abdominal distention, bloating or discomfort, nausea and vomiting. They are rare, universally disappear upon stopping clomiphene and leave no permanent effect. No side effects were noted in gorilla treated so far. Please report any side effects to the GATAG vet advisors.

2.8.6. Surgery

Suture removal is common in great apes althogh careful crturing and attention to aspesis will greatly reduced the incidence. Intradermal skin closure is recommended at all times. Tissue glue may be used to provide complete closure but may conversely attracting, grooming' and removal behavior.

2.8.7. Research

2.8.7.1 Ape heart disease

See website link (http://twycrosszoo.org/conservation/research-at-twycross-zoo/current-research/ape-heart-project/) for all forms and protocols

2.8.8. Recommended Health plan

Every collection must have a written health plan. The following document should be adapted to the local health situations and guidelines. Nevertheless regular health monitoring should be performed at least anually or as needed, based on the animal's age, health status, or other factors

2.8.8.1. Procedures

1. Review Primate Safety Protocol
2. Review current disease risk situation (eg. endemic areas)
3. Review medical record and research requests
4. Verify or place transponder / tattoo
5. Confirm sex
6. Obtain body weight
7. Physical exam and bodyscoring
8. Ophthalmic exam
9. Dental exam and prophylaxis
10. Review contraception and need for reproductive exam
11. Review nutrition

2.8.8.2. Diagnostics

Blood

1. Hematology and biochemical profile
2. Serum bank
3. Viral and parasitological serology
4. Cardiovascular health monitoring, if clinically indicated, (eg. cholesterol, triglycerides, HDL, LDL, and VLDL)
5. Thyroid levels if clinically indicated (eg. T3, T4, TSH; free T4 if on contraceptives)
6. Fructosamine, glycosolated hemoglobin, and insulin levels for diabetics or suspect animals

Feces

1. Feces for ova and parasite screen
2. Rectal culture for enteric pathogens

Urine

1. Urinalysis

Tuberculosis

1. Mammalian Human Isolates Tuberculin 0.1 ml ID: read at 24, 48, 72 hrs (> 6 months of age).
2. Gamma Interferon test (DPP or Lionex) when becomes readily available
3. Test urine TB Test
4. Thoracic radiographs in upright position at 2-4 year intervals or as indicated
5. Tracheal and stomach wash for cytology, PCR and culture for Mycobacterium every 5 years for animals that have previously responded on the intradermal test
6. Rectal culture for Mycobacterium every 5 years for animals that have previously responded on the intradermal test

Imaging

1. Hanging or sitting Cr/Cd or V/D and lateral thoracic radiographs V/D and lateral abdominal radiographs
2. Dental radiographs
3. Cardiovascular examination (use Cardiovascular Exam form of GAHP)
4. Abdominal ultrasound if indicated

Digital photographs if indicated

<u>*Other*</u>
1. Research samples if requested
2. Morphometric measurements if requested

2.8.8.3. Potential prophylactic treatments for clinician consideration
1. Antiparasitic treatment according to parasitological examination
2. Review vaccination status (based on situation, titers)
3. Adapt diet when necessary based on examination

2.8.8.4. Additional procedures:

<u>Echocardiographyand ECG</u>

See protocol at http://twycrosszoo.org/conservation/research-at-twycross-zoo/current-research/ape-heart-project/

<u>Blood pressure</u>

Blood pressure should be measured on at least three occasions during the procedure; at the beginning, in the middle of the procedure once anaesthesia has stabilised, and at the end. Oscillometric measurement, wrist is useful.

Routine examinations:

Health monitoring should be performed as needed based on the animal’s age, health status, or other factors.

2.8.9 Protocol for Great Ape Deaths in EAZA Collections

In the event of a great ape death within your collection, please do the following:

1. Ensure a full gross post-mortem examination is performed and tissues are preserved for histological examination (see 2.8.9.1) to include a bodyweight, full external examination for lesions, examination and weight of major organs (heart, lung, liver, kidneys), dental/oral examination.
2. Examine and sample the heart as per the Heart Project Protocol (http://twycrosszoo.org/conservation/research-at-twycross-zoo/current-research/ape-heart-project/)
3. Inform the GATAG vet advisor and send copies of the results
4. Arrange for all surplus samples to be sent to the EAZA Great Ape Biobank

Please save (or send) a duplicate set of tissues to allow for retrospective studies of selected organs so that tissues already in paraffin blocks will not be expended. A collaboration between EAZA GATAG/Twycross Zoo/University of Nottingham is establishing an Ape BioBank for tissues (confirmed at GATAG June 2014.).

Freeze pending further results: There are many questions about clinical course and post mortem findings that can only be answered using frozen tissues and serum. DNA and RNA fragment cross link and degrade in formalin and many advanced molecular techniques for pathogen discover, such as metagenomics, can only be performed on fresh frozen tissues. Toxicological and nutritional studies also rely on fresh or fresh frozen tissues.

Skeletal examination: examine joints. Degenerative joint disease and spondylosis are common in the apes. Although fairly well documented from museum specimens, from wild and captive animals, the findings are seldom correlated with individual animal clinical histories findings.

Images: photograph everything! In this age of digital photography the images you take and embed in the reports are an enormous help to your pathologists and to the GATAG Vets who can bank these images to advise others.

2.8.9.1 Tissues to be preserved and examined histologically

1. From the skin submit at least one piece without lesions, a nipple and mammary gland tissue, scent gland, any lesions and subcutaneous or ectoparasites.
2. Axillary and or inguinal lymph nodes
3. Mandibular, and/or parotid salivary glands should be sectioned to include lymph node with the former and ear canal with the latter.
4. Thyroids, take sections transversely through the thyroids trying to incorporate the parathyroids in the section.
5. Trachea and esophagus and laryngeal air sac sections.
6. Cervical lymph nodes may be submitted whole if small or sectioned transversely.
7. A single sternebra should be preserved as a source of bone marrow. A marrow touch imprint may be made from the cut sternebra and air dried for marrow cytology.
8. Section of thymus or anterior pericardium should be taken perpendicular to the front of the heart.
9. Heart: weigh and measure heart after opening but before sectioning. (see Ape Heart Project)
10. Lungs: preferably samples from all lobes.
11. Gastrointestinal system: Take sections of all levels of the GI track including: gastric cardia, fundus and pylorus (or presaccus, saccus, tubular stomach and pylorus in colobines); duodenum at the level of the bile duct with pancreas attached; anterior, middle and distal jejunum; ileum; ileocecocolic junction with attached nodes; cecum and appendix; ascending, transverse and descending colon. Open loops of bowel to allow exposure of the mucosa and allow serosa to adhere momentarily to a piece of paper before placing both bowel section and paper in formalin; or gently inject formalin into closed loops.
12. Liver: Take sections from at least two lobes, one of which should include bile ducts and gall bladder.
13. Spleen: Make sure sections of spleen are very thin if the spleen is congested; formalin does not penetrate as far in very bloody tissues.
14. Mesenteric (jejunal) nodes: section transversely; colonic nodes may be left with colon sections.
15. Kidneys: Take sections from each kidney: Cut the left one longitudinally and the right one transversely so they will be identifiable (or label). Please make sure the sections extend from the capsule to the renal pelvis.
16. Adrenals: small adrenals may be fixed whole but larger ones should be sectioned (left -longitudinal and right transversely) making sure to use a very sharp knife or new scalpel blade so as not to squash these very soft glands.
17. Bladder: sections should include fundus and trigone. Please make sure to include round ligaments (umbilical arteries) in neonates.
18. Male gonads and accessory sex glands: Section the prostate with the urethra and seminal vesicles transversely. Section testes transversely. If testes are being collected perimortem for sperm retrieval, try to arrange to take small sections before the gonads are manipulated.
19. Female reproductive organs: Fix sections of vulva, vagina, cervix, uterus and ovaries
20. Rectum and bladder (opened)
21. Gravid females: weigh and measure placenta and fetus. Perform a post mortem examination of the fetus. Take sections of placental disc(s) from periphery and center and from extraplacental fetal membranes. Take sections of major organs and tissues of fetus (see fetal protocol).
22. Nervous system: The brain should be fixed whole, or, if too large for containers, may be cut in half longitudinally (preferred) or transversely through the midbrain. It should be allowed to fix for at least a week before sectioning transversely (coronally) into 0.5-1.0 cm slabs to look for lesions. Submit the entire brain if possible and let the pathologist do the sectioning, otherwise submit slabs from medulla, pons and cerebellum, midbrain, thalamus and hypothalamus, prefrontal, frontal, parietal and occipital cortex including hippocampus and lateral ventricles with choroid plexus.
23. Pituitary and pineal gland: Fix the pituitary whole. Put pituitary in an embedding bag if it is small. If the pineal gland is identifiable, fix it whole. Also remove and fix the Gasserian (trigeminal) ganglia.

24. Spinal chord - if clinical signs warrant, remove the cord intact and preserve it whole or in anatomic segments (eg. cervical, anterior thoracic etc.) (Please note to which lumbar vertebra the cord extends)
25. Bone marrow: Take bone marrow by splitting or sawing across the femur, to get a cylinder and then make parallel longitudinal cuts to the marrow. Try to fix complete cross sections or hemisections of the marrow.
26. Additional sections for fixation: Take sections of any and all lesions, putting them in embedding bags if they need special labeling.

(Adapted from The Great Ape Necropsy: Gorilla and Orangutan ssps . AAZV Gorilla and Orangutan Workshop, September 29, 2013, Salt Lake City, Utah. Linda J. Lowenstine, Rita McManamon, Karen Terio)

2.8.9.2 Postmortem examination of primate foetuses and neonates

External examination

1. Weight and body measurements.
2. Measure the placental disc(s) and weigh the placenta.
3. Note umbilical length and vascular patterns on the placenta.
4. Note presence of hair, freshness of the carcass (if dam is dead, is the decomposition of the fetus consistent with that of the dam) and any evidence of meconium staining.

Internal examination

1. Follow the general primate adult necropsy protocol.
2. Make sure to note whether ductus arteriosus and foramen ovale are patent. Note also whether the lungs are aerated and to what extent.
3. Note dentition / erupted teeth.
4. Identify umbilical vein and arteries and check for inflammation. Make sure to save umbilicus and round ligaments of the bladder (umbilical arteries) for histology.

a. Make sure to save a growth plate (e.g. costochondral junction or distal femur) in formalin

Cultures: Take as many of the following as possible: Stomach content or swab of the mucosa; lung; spleen or liver; placental disc and extra-placental membranes. Do both aerobic and anaerobic cultures if possible.

2.8.10 Examples of anaesthetic and health check protocols

These are included for easy reference; each has been edited to one side for easy-to-use reasons and is <u>not</u> intended to replace veterinary experience, training and/or other protocols.

The use of these protocols here is at each vet's risk and discretion.
For more information, please consult the Veterinary Advisors or the reading lists.

2.8.10.1 General list for ape procedures.

As a helpful guide, the following is a list of medicines and kit that are usually required/may be needed for procedures and are useful to have at hand.

<u>Common medicine and concentrations</u>

- Medetomidine 1mg/ml and 10mg/ml
- Antisedan 5mg/ml
- Zoletil 100mg/ml
- Ketamine 100mg/ml
- Meloxicam 5mg/ml a@0.2mg/kg
- Amoxicillin: 150mg/ml @15mg/kg

- Metronidazole 500mg bag –for IV
- Furosemide @ 2mg/kg iv
- Tuberculin
- Ivermectin

Fluid therapy: Options below:

10ml/kg/hour = 400ml per hour = 6.7ml per minute = 0.1ml per second = 2 drops per second (using 20 drops/ml giving set)

50ml/kg/day maintenance = 2,000 ml per day = 83.3 ml per hour = 1.38 ml per minute = 0.02 ml per second = 1 drop every two seconds

Ape examination checklist

ARKS/ studbook number/name	
Body weight	
Condition Score (out of 5)	
Dental formula	
Blood sample: EDTA x 6, Plain x 2 large, heparin x 2, fl-ox x 1 and blood smears, glucometer reading	Note volume and tubes taken:
Hair pluck and plain mouth swab (store)	
TB test: Right avian Left bovine	
Body measurements:	
Forearm (shoulder to wrist):	
Hindlimb (hip to ankle):	
Forearm circumference:	
Thigh circumference:	
Crown-Rump:	
Abdomen circumference:	
Thorax circumference	
Chest radiograph ventrodorsal view findings:	
Abdominal ultrasound findings	

2.8.10.2 Anaesthetic Plan example: Adult female gorilla

(Weight: 90kg estimated)

- Oral midazolam 0.6mg/kg = 45mg = 11ml of 5mg/ml
- wait 30 minutes

- Dart with:

90mg Zoletil = 1mg/kg = 0.9ml of 100mg/ml zoletil
1.8mg medetomidine = 0.02mg/kg = 0.18ml of zalopine

Reversal - atipamepzole = 1.8ml of antisedan IM

Routine procedures

- Give oxygen by mask and isoflurane if necessary
- Be ready to intubate size with 9 tube with head tipped back secure in place
- Check teeth (torch, dental kit, mirror)
- Clinical examination
- Give Metoclopramide 5mg/ml 0.5mg/kg = 45mg = 9ml of 5mg/ml
- Blood sample
- TB test
- Body measurements
- Abdominal ultrasound
- Chest radiograph

Kit

- Blood pressure monitoring, stephtoscopes x 2, thermometer
- Anaesthetic machine
- Et tube (8,9,10), large dental gag, stiffener, light, bandage, largest laryngoscope blades
- Ambubag
- Dental kit (elevators and extractor)
- Sharps, yellow bag, gloves, masks
- Ultrasound machine
- Xray machine

2.8.10.3 Anaesthetic Plan: Adult male gorilla

(Weight: 200kg estimated)

- Oral midazolam 0.5mg/kg = 100mg = 20 ml of 5mg/ml given in a small amount of drink at 0800
- ONE HOUR LATER Dart with:

200mg Zoletil = 1mg/kg = 2.15ml of 100mg/ml zoletil
4.0mg medetomidine = 0.02mg/kg = 0.40ml of zalopine

Reversal - atipamepzole = 1.8ml of antisedan IM

Routine procedures

- Give O2 by mask and isoflurane if necessary
- Be ready to intubate size with 9 tube with head tipped back
- Check teeth (torch, dental kit, mirror)
- Clinical examination
- Give Metoclopramide 5mg/ml 0.5mg/kg = 100mg = 20ml of 5mg/ml
- Blood sample
- TB test
- Body measurements
- Abdominal ultrasound
- Chest radiograph

Kit

- Blood pressure monitoring, stephtoscopes x 2, thermometer
- Anaesthetic machine
- Et tube (8,9,10), large dental gag, stiffener, light, bandage, largest laryngoscope blades
- Ambubag

- Dental kit (elevators and extractor)
- Sharps, yellow bag, gloves, masks
- Ultrasound machine
- Xray machine

2.8.10.4 Fertility treatment for non-ovulating ape females – a short note.
There have been a few cases of female apes appearing to cycle i.e. staff note signs of oestrus and regular matings without apparantly conceiving. It is importamt to use a sensitive (human) pregnancy test kits on fresh urine, 1-2 time daily from days 12-16 following oestrus, to establish whether in fact the ape is conceiving and losing early pregnancies or not conceving at all. Likewise (human) ovulation test kits may be used on fresh urine samples throughout the oestrus period (over 3-5 days) to detect ovulation; the lack of ovulation at all is more difficult to definitivelt determine as the short windown of time for the test may be missed if the animals are not trained to urinate at least twice a day. For the avoidance of doubt, blod tests taken shortly after oestrus should allow further investigation of ovarian activity; it is therefore useful to time routine procedures according to the oestrus cycle, if possible, to avoid anesthesia purely for these investigations (unless absolutely necessary).

This anecdotal report is included here to begin advising vets on possible treatment regimes that may be effectives in cases of females that are not ovulating.

<u>Case report – gorilla</u>
A 28 year old Western Lowland gorilla was investigated for failure to reproduce. Captive gorillas generally start breeding at the age of 8 years and breed until their late 30s. She had an infant that died the day of birth in 1986 then a surviving baby in 1987. Since then she has appeared to cycle and has been repeatedly mated by two proven fertile males yet failed to produce any offspring.
Hormone tests from blood samples obtained under general anaesthesia showed an elevated follicular stimulating hormone level (FSH) and depressed oestrogen levels. Hormone analysis of the monthly reproductive cycle was not possible using blood tests due to the difficulties and negative welfare implications of anaesthetising the animal every day or two for a month. Therefore urinary hormone were analysed (measuring daily pregnanediol glucuronide and oestrone conjugates). Urinary hormone analysis revealed that the female was not ovulating, despite showing behavioural oestrus and allowing mating. Specifically the results indicated that she is experiencing a decline in ovarian function giving a diagnosis of diminished ovarian reserve. This diagnosis is based on a high FSH, plus weight gain and failure to conceive.
Fertility treatment using clomiphene was initiated. 14 days after oestrus the urine was tested using a human pregnancy kit. If this was negative, she was started on clomiphene tablets for 5 days (150mg total dose, 3 tablets). Urine samples were collected daily and submitted for hormone analysis to check whether the treatment was producing ovulation.
Clomiphene treatment resulted in ovulation, as evidenced by the progesterone metabolite (PdG), suggesting that clomiphene stimulated follicular development and ovulation. The cycle was also accompanied by a surge in oestrogen (E1C) levels as would be expected for a normal cycle. During the period before the female was acyclic, as clearly indicated by the consistently low PdG levels.
The female was mated naturally throughout the oestrus period. She conceived 3 times; the first 2 pregancies were lost within 2 months, the third pregnancy resulted in a live birth. The female later went on to conceive naturally and have another live infant a few years later; apparantly this result (requiring treatment to begin ovulations that then occur later naturally) is not unkown in the human medical field.
NB. Clomiphene citrate is an orally active synthetic weak oestrogen. The drug's similarity to oestrogen leads to increased levels of FSH and LH, thus the normal events leading to ovulation. Infant survival and development are normal after delivery. The most common side effects are hot flushes abdominal distention, bloating or discomfort, nausea and vomiting. They are rare, universally disappear upon stopping clomiphene and leave no permanent effect. No side effects were noted in this gorilla.

2.8.10.5 Cataract surgery in apes - a short note.

This short report describes successful cataract surgery on an adult female gorilla presenting with congenital cataracts. Pre-operative investigation proved useful in determining whether the eye was suitable for surgery and choosing the correct intra-ocular lens. Pre and postoperative treatment consisted of oral therapy and eye drops. The primate keepers successfully administered the eye drops four times daily after limited training of the animal. The animal appears to be fully sighted in both eyes and has changed behaviour, being more active, since surgery, was mated for the first time a few months after surgery and has now successfully reared offspring.

The background: Twenty-one year old female gorilla had been virtually blind in both eyes for many years. She only had very limited, peripheral vision because of bilateral, nuclear cataracts. The cataracts were thought to be congenital i.e. had been present since birth.

Materials and methods:

The gorilla was first examined under general anaesthesia. Examination of the eyes revealed cataracts in both yet no other ocular pathology and the eyes were deemed visual. It was decided to perform cataract surgery on one eye first and assess the success of this procedure before attempting to correct the second eye (6 months apart).

Prior to each cataract surgery, steroid and antibacterial eye drops were administered four times daily for 1 week prior to surgery and 2 weeks after. Keepers were able to administer eye drops four times a day via a long catheter attached to a syringe through the mesh door whilst offering food on a spoon to the gorilla. Oral anti-inflammatory and antibiotics were given for 2 days prior and one week following surgery. The animal was isolated for 2 weeks after treatment to avoid any head trauma from play or fighting with the other gorillas.

Two cataract procedures were performed. After the success of the first the second was planned after remedial dental work was conducted under a separate general anaesthesia a few months after the first cataract surgery.

For both surgeries, general anaesthesia was induced using 750mg ketamine and 4mg medetomidine via dart. The animal was placed in the traveling crate and the general anaesthesia reversed. The gorilla was fed and housed overnight in the crate prior to transportation to the veterinary school for surgery the next morning. This procedure was adopted to avoid two general anesthesias on the same day (for transfer to the transport crate then to take her out at the vet school).

Cataract surgery:

The measurements showed that visual correction was required as the gorilla was short sighted (by measurements using human equipment). Phacoemulsification surgery was performed via 2 port incision. A 17D foldable silicone IOL placed. No intraoperative complications were noted. A Corneal 4mm incision was made and not sutured. Subconjunctival betamethasone was given post-operatively.

Total anaesthesia was 2 hours for the first surgery, 45 minutes for the second. When the gorilla was transported back to the zoo and released into the isolation den, she remained very calm, looking around, identified food immediately and reached for it accurately. No eye shielding has been seen since the surgery.

<u>Cataract eye A-scan measurement of eyes:</u>

Right eye:	Left eye
Axial length 25.69mm (SD 0.15)	26.51mm (SD 0.14)
Ant chamber depth 3.87mm (SD 0.06)	1.71mm (SD 0.09)
Lens 3.91mm (SD 0.08)	3.35 (SD 0.35)
Vitreous 17.91mm (SD 0.16)	21.45mm (SD 0.28)

Corneal curvature:

Right eye	Left eye
K1= 45.25D	K1= 43.62D
K2 46.75D	K2= 42.87D

Cases that are relatively simple are those animals with bilateral cataracts, cannot see, the eye still detects light (active PLR or ERG) plus no evidence of intraocular disease, plus the animal is poorly adapted to the blindness. Then, even if it fails you have lost nothing yet there is much to gain from a successful surgery. Some have removed cataracts from gorillas that were there only a few years old yet the eye was non-visual. In this case after surgery for 21 year-old cataracts the gorilla was able to see - but we did assess this before surgery. The animal's behaviour has changed to include greater interaction with the other gorillas and was considered to be a significant improvement in her welfare.

2.8.10.6 Neuroleptics in great apes - a few notes.

The use of drugs to treat animal behavioral problems is a relatively new field of veterinary medicine. When using drugs to moderate or change behaviour it is important to realize the limitations of medical therapy. Drug selection should be based upon a careful behavioral assessment and the animal monitored for side effects of the drugs. It should also be noted that many of the drugs that may be used in this area have potential for human abuse and so their prescription and use should be carefully controlled. Drugs alone are unlikely to be successfully in producing long lasting behavioral changes unless they are used in conjunction with a behavioral modification program. Teamwork, therefore, between the veterinarian, the animal keepers and animal behaviorists, trainers and human medical professionals is essential to ensure a successful outcome.

Categories and use of neuroleptics

Neuroleptics, also referred to as antipsychotics in human medicine, include butyrophenones (haloperidol and azaperone), phenothiazines (perphenazine, fluphenazine), thioxanthenes (flupentixol, zuclopenthixol) and substituted benzamides (sulpiride). These drugs cause a range of degrees of sedation, alpha-adrenoceptor blocking activity, extrapyrimidal and antimuscarinic effects (Brearley et al 2001). These drugs generally tranquilise without affecting consciousness or excitement but should not be regarded merely as tranquilisers. In the short term, in humans, they are used to calm disturbed patients whatever the underlying psychopathology.

Newer neuroleptics such as risperidone, also called atypical antipsychotics, may be better tolerated as extrapyramidal symptoms are less frequent (in humans). Antidepressants may also be used to moderate abnormal animal behaviours particularly the selective serotonin re-uptake inhibitors (SSRI) e.g. citalopram and fluoxetine (Prozac) and monoamine oxidase inhibitors (MAOIs) e.g. clomipramine. Interaction between these two groups can complicate the switching from one drug to another; MAOIs are rarely used in human medicine because of the dangers of dietary and drug interactions. Other antidepressants should not be started for two weeks after treatment with MAOIs has stopped (three weeks in the case of clomipramine). Conversely a MAOI should not be started until at least two weeks after anticyclic or related antidepressant (three weeks in the case of clomipramine) has stopped. For this reason the selection of SSRIs or MAOIs for the treatment of zoo animals should be undertaken with great care as the time required to change drugs if one is not working is prolonged which may lead to an exacerbation of the welfare issue for which the drugs are being used.

Drug selection in human medicine is based upon the degree of sedation required and the patient's susceptibility to extrapyramidal effects. This susceptibility is generally unknown when dealing with great apes. Prescribing more that one antipschychotic at a time is not recommended unless under close medical supervision as it may increase the hazard and there is no evidence that side effects are minimized;. Given the lack of data in great apes, it is likely that a number of regimes may be tried before one suitable for the particular patient and condition is found. In particular, care should be taken to selecting the drug regimes in a certain order to avoid potentially dangerous drug interactions.

It should therefore be obvious that these drugs should be carefully selected for use in great apes as they do not pose a simple and safe solution to the behavioral management of zoo animals. However when used carefully they can provide an extra tool for managing difficult cases which are unresponsive to behavioral therapy alone.

<u>Case study – moderating male gorilla aggression towards a female using medicine and behavioural techniques.(Sharon Redrobe)</u>
(see also Redrobe S. 2007. Neuroleptics in Great Apes. In Zoo and Wild Animal Medicine. 6th Edition. Current Veterinary Therapy. Elsevier, USA pp243-250)

A 20 year old male gorilla had a history of aggressive behavior resulting in injury to females. This male had been housed in a bachelor group for 9 years after removal from his natal group at 8 years old. He was then moved to another zoo to be with a group of four females. During integration with those females there were several incidences of aggression, resulting in such severe injury to the females that the zoo stopped further attempts at introductions and offered him for transfer. The receiving zoo had a larger gorilla facility, and so was able to maintain the male gorilla in isolation from the females for short periods of time.

A number of regimes were used. As the clinical assessment of this male gorilla was that he was primarily a nervous rather than aggressive animal, the use of tranquilizing or behaviour modifying drugs were used in preference to sedatives which resulted in a subdued animal but would not permit him to learn normal behaviour. The final successful regime of sulpiride (with haloperidol for the first 11 weeks) was continued for 36 weeks.

Table 1. Summary of neuroleptic use in a male gorilla

Drugs	Dosages / mg	Duration of treatment / days
Diazepam	100	3
Thioridazine and haloperidol	100-300 (T) 20 (H)	25
Risperidone and haloperidol	6-12 (R) 0-30 (H)	11
Sulpiride and haloperidol	400-800 (S) 60-0 (H)	77 (haloperidol tapered to zero over last 20 days)
Sulpiride	800	176 800mg initially for 75 days then tapered to zero over last 100 days

A daily routine was established and it was quickly found that the male found changes to routine to be stressful, again as noted by an increase in sweating and raspberry blowing. Therefore, day-to-day routine was kept similar as much as possible during the treatment period. Food items were offered calmly. Eventually the animal's appetite improved, though only markedly improved to normal levels on the final regime of sulpiride and haloperidol.
It was also noted that the animal appeared fearful when offered food by keepers. Human movements were slow and calm during interactions with male. When he was aggressive towards staff by banging the doors or the intervening mesh, no punishment was administered, but the behavior was ignored. This behavior was gradually extinguished during the medication period.
Drug regimes were tried together with behavioral techniques. When addressing the behavior of the

overly aggressive male it was important not to reward the abnormal behavior or to reinforce the male's impression that interactions with females are stressful and fearful events likely to result in punishment. Given the history of repeated and severe attacks on the female, the introductions were managed in the inside accommodation where techniques could be employed to separate the male quickly if a problem occurred. Although the animals have more room outside, monitoring and intervention would be virtually impossible. Initially staff had to use aversive techniques to separate the male from the female during his prolonged attacks. This may inadvertently teach the animal that interactions with the females will always result in a negative outcome. Introductions were therefore finished, wherever possible, before aggressive encounters. The aim was to end each encounter before a fight to allow more positive interactions. It was also important to not 'reward' the male for fighting with a female by instantly opening the doors and letting him out. Instead, if there was an inappropriate aggressive encounter, he was separated from the female(s) then held apart for 10 minutes before letting him outside. Staff did not punish the male using any methods except in the immediate instance of trying to stop an inappropriate attack on a female. Behavioral observations of the gorillas were conducted at different times following the introductions.
Activity and location were recorded at one-minute intervals using a scan-sampling technique. More general observations were also recorded on an ad hoc basis. This information was used to determine the success of the drug regime and inform the decisions to increase or lower the dosages.

Case study - neuroleptics in 2 male gorillas (T. Petit, zoo La Palmyre, F)

Male 2: born 1990, mother-reared, estimated at 130 kg

Drugs:
TRILIFAN (perphenazine enanthate, 100mg/ml, IM darting, LA) was used at first but it appeared quickly that regularly darting a gorilla every several months period was not satisfactory. Moreover, under or overdosing is possible and a daily administration would make it possible to quickly and accurately increase or lower the dosage.

CLOPIXOL (zuclopenthixol chlorhydrate 2%, 20mg/ml, given orally tid). The weaning of the gorillas from clopixol was progressive with a decrease of 5 mg every week.

Male 1: Reasons for use: hand-reared and highly reactive and even aggressive to visitors
c155kg
Darted with 100 mg trilifan 4 times from July to October. Not at regular intervals but when considered necessary. Good results (quiet, decrease of general activity) on the 3 first cases after 24 hours, lasts about 14 days. Needed more than 2 days to be active on the fourth case.
one year later (heavier ? unknown weight)
100 mg trilifan in may. Good results after 24 hours but effect decreasing after only 8 days.
80 mg in June, good results after 24 hours but extrapyramidal syndrome on the 3rd day (hypertonic crisis 5 times in one hour in the evening, seems unconscious with loss of balance). No more problem the day after.
Clopixol. In july: from 10 mg tid up to 25 mg tid.
NB during this summer, we also modified the visitors' access around the enclosure so that the gorillas were not constantly disturbed. As a consequence, we did not need such drugs in 2004 and 2005.

<u>Male 2 Reasons for use : introduction of a new female, twice. Weight c135kg</u>
90mg trilifan and 100 mg. Ok after 24 hours, aggressive behaviour toward the female decreased. A year later also used 20 mg clopixol tid with similar effect.

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2.9. "Managing Males"
N. Bemment & K. Pullen

2.9.1. "Surplus males"
In zoos we should consider the situation in the wild, but at the same time we encounter some specific problems that we have to deal with. As a result of the equal sex-ratio in the animals born, the number of males that cannot be placed in a breeding situation is growing. Therefore we have to carefully consider the number of females per breeding group. The more females in a group, the more "surplus males" we will have, although in the wild a group typically consists of one male with three to four adult females.

As a gorilla breeding group is composed of one silverback and several females, more males than necessary for breeding purposes are born. De Jongh (2001) describes the effects of some measures on the number of males that are surplus to the breeding program. Young males should stay in the family unit until they seriously start challenging their father and have to be separated to avoid casualties. This will enable them to have the best possible preparation for leading their own group, and stretching their stay in the group until they are about eleven or twelve years of age helps greatly to solve the "surplus male problem". Family groups should contain only two or a maximum of three females, in order to reduce the number of surplus males, and young females should be transferred from their natal group at the age of six to eight years. Nevertheless, even with these measures the surplus problem will still exist.

There are different ways to deal with the surplus problem:
- euthanasia of surplus males
- development of techniques that control the sex ratio of the offspring
- keeping the males in bachelor groups
- reducing the number of breeding females per group
- stretching the stay of young males in their natal groups

- removing over-represented males from their breeding group and keeping them separate, with a son or an old non-breeding female from the former group

Whilst euthanasia is considered an acceptable tool for some, there are many who would not find it justified. In order to facilitate understanding The EAZA Great Ape TAG has formulated the following statement:

"The Great Ape TAG accepts the use of euthanasia for Great Apes in preference to keeping them long term under conditions which significantly reduce the individuals' welfare, and when there is no other alternative."

The first case of castration of a young male within the EEP and the subsequent successful introduction of that male into a breeding group was that of Kukuma, studbook no. 1089, born on 1989 at Apenheul and later transferred to Belfast Zoo. The decision to castrate Kukuma was done in order to study the development of this individual and find out if castration is a suitable tool to cope with the problem of surplus males (Mager, pers. comm.). This male Kukuma was removed from the natal group for hand rearing after 6 months, due to poor maternal care and then castrated at the age of 10 months (Jens, pers. comm.). He was moved to Stuttgart (EEP nursery) at the age of 11 months, before being introduced to the Belfast group at four years of age. At Belfast this male was able to remain within the breeding group throughout the introduction and establishment of a new silverback male, and was successful up until his untimely death. He had shown no evidence of the development of secondary sexual characteristics. There had been two sets of behavioural observations carried out with him, but nothing published so far (Challis, pers. comm.). It is difficult to comment on the feasibility of castration as a suitable management technique for surplus males from the example of just one animal, however this has provided an interesting test case and further investigation is in hand with other individuals castrated in more recent times (10 at the time of publication).

The male 'problem' would be best avoided if we could find a way to control the sex ratio of the offspring. The breeding program could then be restructured to produce predominantly female offspring. In theory this is possible through artificial insemination with sex-sorted sperm.

For now at least we will continue to maintain ousted males in bachelor groups where possible, (as opposed to a solitary existence), and investigate alternatives such as castration so that they may stay longer in their natal groups without fear of retribution from the breeding male.

2.9.2. Bachelor groups

2.9.2.1. Preface

The establishment of bachelor groups in zoos was begun in response to concerns over the numbers of males born in breeding programmes. It is an inherent fact of polygynous mating systems that a number of males within the population will not be placed in a breeding situation at any one time and as the breeding programme continues this situation will be exacerbated. Whereas the integration of young females to established groups is frequently successful, there are few cases of sexually mature males co-existing with unrelated males of similar ages or older in the presence of females. In situations where this has occurred, it has usually been for short periods of time or in a non-breeding situation (Johnstone-Scott, 1988). This has previously limited the moves between zoos to straight male-male swaps, the formation of new groups and replacement of males that have died. In both the EEP and the SSP this has led to a number of males requiring housing but currently surplus to breeding requirements.

The establishment of bachelor groups was considered to be a way of achieving long term benefits for the zoo breeding population without resorting to the methods of housing solitary males or euthanasia. It was hoped that the provision of bachelor groups would:

1. Reduce stress related problems caused by the presence of maturing males in heterosexual groups.Since the presence of maturing males in heterosexual groups is natural, management conditions should be such that this is possible in zoos as well, without excessive stress. In that case the presence of a maturing male can be enrichment for the group and a positive stimulant for the silverback. An approximate age that a sub adult male could stay in his natal group before joining a bachelor group is 6 to 9 years old
2. Minimise the risk of inbreeding.
3. Prevent the de-socialization of males who would otherwise be kept alone.
4. Provide a social environment for animals that were already in isolated situations.

The presence of bachelor groups would also provide an opportunity for research into a very different aspect of gorilla society (Johnstone-Scott, 1988; Pullen, 2005).

However, there is a general feeling that where possible, genetically important males for which there is a breeding future should not go to a bachelor group, but should stay as long as possible in their natal group.

2.9.2.2. Bachelor groups in the wild

Information on bachelor gorilla groups in the wild comes solely from the Virunga population of mountain gorillas and the existence of bachelor groups of western lowland gorillas is still disputed (Parnell, 2002). However, quantitatively the group structure and size of the two species is similar, and comparisons of behaviour between western lowland gorillas in zoos and wild mountain gorillas show little difference (Harcourt, 1988). It is therefore feasible to suggest that a social system that is successful for the mountain gorilla can be attempted as a management technique for western lowland gorillas in zoos**.** The establishment of bachelor groups in the wild is thought to usually consist of associations of young emigrating males (naturally more playful and less competitive; Harcourt, 1988) or males within a mixed-sex group remaining together after the loss of the group's females through death or transfers (Harcourt, 1988; Robbins, 1996)**.**

2.9.2.3. Bachelor groups in zoos

It was suggested that zoos wishing to become involved in the breeding programme should consider housing a bachelor group first, due to the lack of available females. The benefit of collections new to the breeding program housing bachelor groups of gorillas was thought to be the establishment of new facilities designed to cope with this different aspect of gorilla society.

The design of the enclosure must accommodate the need of the individual characters. A number of strategically placed shut-offs are advisable to allow the ability for separation if necessary. Used in addition with doors on a ratchet slide mechanism, shut-offs can be maintained so that sub-adults and black-backs can use them, whilst silverbacks are prevented from access. The design of the enclosure must also include the provision of "run-arounds" i.e. ensuring that an animal that may be being chased will not be trapped in a dead end section of the enclosure. As the gorillas will also "play-chase" this design provision can increase, very simply, the complexity of the enclosure and allow increased play behaviour to be exhibited. Although these features should be present in any new gorilla exhibit, it has been suggested that the increased complexity and flexibility could prove to be even more important for a bachelor group than a breeding group, particularly for the younger, more playful individuals who often form the core of the bachelor group (Johnstone-Scott, 1988, Porton & White, 1996, Downman, 1999, Bemment, pers comm).

Watts & Meder (1996) provided a list of considerations when forming bachelor gorilla groups including the age of the individuals at group formation (Johnstone-Scott, 1988; Porton & White, 1996), the background of the individuals (i.e. the possibility of success maybe increased with animals which have grown up together, particularly in the natal group), and the reduction of serious squabbles and fights in the absence of females (Johnstone-Scott, 1988).

As the establishment of bachelor groups in the wild is thought to usually consist of young emigrating males (naturally more playful and less competitive; Harcourt, 1988) or males within a mixed-sex group remaining together after the loss of the group's females through death or transfers (Harcourt, 1988; Robbins, 1996), the establishment of bachelor groups in zoos was considered to be most feasible with gorillas of a similar age group. However it seems that a good alternative could be an over-represented silverback with sons remaining in the group or related young animals with an older mother-reared one. Males between 6 and 9 years are generally considered to be the most adaptable to change, therefore this age group has been considered to be the optimum (Harcourt, 1988; Johnstone-Scott, 1988). However, the introduction of at least one fully mature mother-reared male has been suggested to be a benefit to the grouping. The suggestion was made that the establishment of a sub-adult group prior to the introduction of a mature male would offset any advantage of age and weight over the youngsters that the adult may have (Harcourt, 1988; Porton & White, 1996).

2.9.2.4. Disney's bachelor workshop (2000)

Over the last few years a number of bachelor groups have been formed both in Europe and the United States. In response to this, Disney's Animal Kingdom hosted a bachelor gorilla workshop (September 2000) to begin to evaluate progress so far. The results of a survey carried out within nineteen zoos holding bachelor groups both in the U.S. and Europe were presented. Key results are highlighted below.

- 37% of the zoos reported a change in dominance hierarchy over time due to injury, takeover, introduction of new silverback or removal of a silverback. This suggests a fluid hierarchy within established bachelor groups.
- 74% of zoos observed alliances within their bachelor groups.
- 50% of zoos observed sexual behaviour between their males.
- 64% of zoos observed challenges made towards the silverback.
- 26% of zoos have had to permanently remove a member of the group. This highlights the need for flexibility in the formation of the group to obtain stability.
- Of the 5 zoos with no silverback, 3 zoos reported one of the blackbacks assuming the role of the silverback (mediating conflict within the group) at ages 9 to 11 years.
- 67% of zoos reported the perceived aggression to increase or intensify as the individuals in the group have aged. The average age quoted for the increased levels of aggression was 13 years.
- 63% of respondent zoos reported the use of operant conditioning training with their bachelor groups. Of those 83% felt that it had had beneficial effects on the management of the group.
- 9 zoos (47%) housed both bachelor and mixed sex groups with varying degrees of visual, olfactory or tactile contact between groups. Of those 9 zoos only three reported any behavioural change in the bachelor group during female oestrus periods. Since then this has been suggested as possible reason for increased aggression within bachelor gorilla groups.

In addition the zoos were asked to list specific aspects of their facility that they felt had helped introductions (see Box 1); or had had a positive or negative effect on the long term housing of the animals (see Box 2) (Cory & Machamer, 2000).

Box 1.

Facility design features thought to aid introductions:
Doors separating animals allowing visual access (i.e. mesh doors, viewing windows), some solid doors for complete separation.
A mix of hydraulic and manual doors for ease during mixing.
Large community rooms, lots of vertical space.
Holding area with “round-about”. No dead-ends.
Multiple benches and nesting shelves at a variety of levels.
Ability to sub-divide building into different areas during introductions.
Multiple doors into habitats to give access from different rooms.

(after Cory & Machamer, 2000)

Box 2

Aspects of facility design with positive impact on bachelor groups	**Aspects of facility design with negative impact on bachelor groups**
Provision for visual contact: i.e. Holding cages separated by shift doors. Viewing windows for animals. Mesh doors. Ability to separate animals off or provide different areas for them: i.e. separate feed areas / bedrooms. Ability to link areas together with connecting corridors to prevent dead-ends. Provision of visual barriers to allow privacy from public and other animals according to individual animal preference. Large habitats to allow space between individuals according to individual animal preference. Large habitats with a variety of natural planting and enclosure furniture.	Lack of holding space for separated ill or injured animals. Too many one-way passages. Lack of viewing opportunities for the keepers. i.e. blind spots in holding areas. large habitat with little viewing areas. no remote viewing (i.e. cameras) so gorilla behaviour altered by keeper’s presence. Disturbance from public. i.e. public viewing above the gorillas. lack of distance between public and gorillas. Close proximity of another gorilla group. Lack of access doors between areas. i.e. one male can dominate access door and prevent movement between areas.

Multiple access doors to different areas to prevent one animal dominating access to areas. Provision of cameras to allow remote viewing in all areas by both keepers and public.	

(after Cory & Machamer, 2000)

2.9.2.5. Case studies of bachelor group formation

St Louis Zoo, Missouri, U.S.A,

In 1987 the bachelor group situated at St Louis, USA, was established and, over the first eight years, seven individuals were involved (three blackbacks, two subadults and two juveniles). A stable group of four animals was established in 1990. This group was situated in close proximity to the breeding group already established at the zoo. In fact during the evenings, the groups had full visual contact (Porton & White, 1996).

Introductions within the bachelor group were achieved through stages (visual contact; limited tactile contact; full contact) that were flexible, behaviour dependent and always in the off-show holding cages. Many combinations of individuals were tried in order to allow individuals to become familiar with each other, both in their personalities and their social skills. The "basic tenants of introduction" (furnishing manipulable objects, encouraging foraging, providing escape routes etc) were found to be highly applicable during the introductions. In addition, the use of coalitions was discovered to be particularly important when introducing younger, smaller males to older, larger males (Porton & White, 1996). This "loser-support system" has been described for bachelor groups of mountain gorillas in the Karisoke area (Yamagiwa, 1987), where group members came to the defence of a conspecific attacked by a new male.

The interactions observed at St Louis Zoo were similar to those described for the bachelor groups in the wild. The greater portion of the interactions was of an affiliative or neutral nature, and did include some sexual behaviour, with most of the social interactions occurring between the younger males (Porton & White, 1996).

The only significant fights and wounds seen during the first years of the bachelor group at St. Louis Zoo occurred between blackbacks and silverbacks, and the frequency and severity was thought to have been reduced by the "mediating" behaviour exhibited by the younger males in the "loser-support system" (Porton & White, 1996).

Through formal and informal observations it was clearly seen that one of the younger animals was playing a pivotal role within the bachelor group. Although it has been suggested that subadults will play a focal role in the cohesive nature of the bachelor group (Stoinski, Hoff, Lukas & Maple, 2001), in this case it was also thought to be attributable to the individual being mother-reared and therefore having a greater social competence (Porton & White, 1996),

Loro Parque, Tenerife, Spain.

Gorillas have been housed at Loro Parque since 1992. The initial bachelor group consisted of three animals, a silverback (ca, 23 years) and two juveniles at six (Noel) and four (Ivo) years of age (age at group formation, 1992). The first fourteen months saw the establishment of these three males as a bachelor group. However, following the loss of the silverback, group composition was seen to change

(Downman, 1998).

Towards the end of 1994 a new silverback, Schorsch (22 years) was introduced to the existing two young males. Initially moved as a temporary measure due to enclosure renovations at Nuremburg Zoo, it was then felt that he would be a suitable animal for the bachelor project. A further three animals were introduced to the group during 1995, Pole Pole (6 years), Rafiki (4 years) and Maayabu (7 years).

Shortly after arrival Rafiki was introduced to Pole Pole, and Maayabu was introduced to Noel and Ivo (now 9 and 7 years respectively). Throughout the following two months limited contact was maintained between these two groups of males until the introduction process was begun. This was carried out off-show, in an outdoor enclosure. Initial introductions were attempted between Maayabu, Pole Pole and Rafiki. Although no immediate problems were encountered it was apparent that Maayabu was stressed by his separation from Noel and Ivo, and was returned to them. However, on the following day Noel was introduced to the two youngsters and two days later Maayabu re-introduced successfully. Within six days all five young males were together all day. The introduction of the sixth member of the group, Schorsch, proceeded with no problems. Described as a solitary animal, he maintained zero contact with the other group members (Downman, 1998).

The final stage was the introduction of the established bachelor group to the on-show exhibit. Each of the animals had been given the opportunity to become familiar with this exhibit prior to the introductions, however their introduction to the area as a group did initiate a few minor skirmishes before settling down. They soon utilised the space made available to them and individuals discovered their "own spots." Bonds could also be seen to be forming, particularly between the two younger animals, Pole Pole and Rafiki (hand-reared brothers). Schorsch, on the other hand has continued to remain distant, although on occasion he has been "persuaded" to play (Downman, 98). This is most often on the instigation of Maayabu, the only member of the group to be mother-reared and therefore deemed to be most socially competent (Downman, 1999; Porton & White, 1996).

<u>Paignton Zoo Environmental Park, Devon, U.K.</u>

The bachelor group at Paignton began with the arrival of Claus and Pertinax during April 1997, both 16 years at the time of arrival. Within a few days, two younger males, Richard (7 years) and Awali (5 years) had also arrived.

Initial introductions were begun between Claus and Pertinax, with Richard and Awali being placed together but separate from the older males. However, it soon became apparent that Claus and Pertinax would not settle together, and the decision was made to move Claus on to another zoo for breeding purposes in 1998.

Following Claus's departure from the enclosure, the introduction of Pertinax to the two younger males could proceed. This began with increased visual and limited tactile contact through the mesh slides within the off-show area. Full contact was allowed with access maintained to the back dens to provide "run-arounds" and escape routes to "shut-offs" as well as displacement objects such as browse and scatter feeds being distributed throughout the enclosure. The introduction progressed well with initial displays and Pertinax pinning down both males but making no attempt to bite them. It was seen that Richard had a greater confidence in interactions with Pertinax than Awali, this felt to be due to his background as a mother-reared individual, as opposed to Awali being hand-reared (Bemment, pers comm., Porton & White, 1996). In addition, it was noted that Richard and Awali would form a coalition against Pertinax during scuffles, as described by Yamagiwa's "loser-support system" (Bemment, pers comm., Porton & White, 1996, Yamagiwa, 1987). However, Pertinax's personality and experience as a group-socialized (originally hand-reared), animal again proved of benefit to the establishment of the group, as he demonstrated tolerance in his interactions with the young males (Bemment, pers comm.).

In 1999 two more males were introduced to the group, increasing the number to the holding capacity of five. The first was Asato (8 years at time of arrival) who was initially introduced to both Awali and Richard with no problems. However, at the arrival of the next male, Mambie (8 years at time of arrival) necessitated Richard being removed from the trio in order to begin an introduction process. Mambie was a more assertive individual than Asato however within two weeks all four individuals were together. It was hoped that by completing their introduction to each other before introducing Pertinax, alliances would form within the group enabling the "loser-support system" to be effective.

The introduction of the four young males to Pertinax proceeded on a daily basis. Mambie, a hand-reared individual, appeared to be less socially competent in dealing with the introduction than the other animals. Pertinax reacted to this by pinning him down, and was confronted by an alliance of the other three gorillas coming to Mambie's defence, indicating the success of the initial introduction of the four young males. Once more the mother-reared individual (Asato) demonstrated greater social competence in the situation (Bemment, pers comm., Porton & White, 1996).

During 2002 it became apparent that both Mambie and Richard were beginning to develop silverbacks and become fully mature. Mambie tended to be more dominant to Richard although Pertinax was still in the alpha position. However, whereas Richard was accepting of Pertinax's role, Mambie began to challenge Pertinax with displays and occasional physical contact. As the levels of tension within the group began to increase it was felt to be appropriate to move Mambie to a new situation when the opportunity arose. In October 2002 Mambie was moved from the bachelor group at Paignton Zoo to become the dominant animal in a new bachelor group at La Boissiere du Dore Zoo, France.

After Mambie's transfer the group was seen to settle down well but, within a short time, it became apparent that Richard had established himself as No.2 in the hierarchy. However, to date Richard has not been seen to be challenging Pertinax in the same way that Mambie did. This could be due to Richard's personality (generally playful) or the fact that he is mother-reared and a socially competent animal.

It was felt that the following aspects have been principle factors in the success of the group so far:

- An undisputed alpha male since January 1998.
- Pertinax has not been overly aggressive in maintaining his place as alpha male in the group.
- The new facility allows flexibility in the management of the group.
- There is no family group housed nearby, to stimulate re-directed aggression in the bachelor group.
- Patience.

<u>La Vallée des Singes Primate Park, Romagne, France.</u>
A gorilla bachelor group was formed in Romagne before to be sent to Amneville zoo (France) in 2011.

In Romagne, the new facility designed for bonobos was used to do the process as there were only few bonobos there and half of the dens were available. The gorilla keepers from « La Vallee des Singes » were experienced for 13 years working with gorillas. They already had conducted several introductions of females in the breeding group and even reintroductions of hand-reared babies in their native group. As this was a good solution to teach Amneville keepers how to take care of gorillas too, keepers from both zoos were working together with the bachelor group.

The introduction process:
On 28th of June 2011, 4 young gorillas arrived from Stuttgart Wilhelma zoo. Lengaï (8 years) and Meru (7 years) were already together in Wilhelma, where they were born. Monza (4years) and Upala (3 years) were together, hand-reared in Stuttgart nursery.

The first goal was to put these 4 gorillas together. So on 29th June, the four gorillas were put all together during day, with a small gap between the cages. They were separated for the meals and for the night. Everything went well. They were all very gentle and happy to meet each other. After few days, the day meals were taken all together (the oldest isolated from the youngest for breakfast and last meal) , the sliding doors wide open.

On 20th of July, Ya Kwanza, silverback (27 years), arrived from Jersey where he was in a breeding group without any offspring produced or even mating behaviours at the end. YaKwanza was given one cage, isolated from the cages where youngsters were.
On 21st of July, a second cage was given to YK. Upala was very curious and went through a tunnel to watch at YK. Access to the outside wooded enclosure (3.500m²) was given to YK because he was too warm in the building for him, where he was sweating a lot. YK seems to be nervous and irritated during the afternoon

On 22nd of July, the 5 gorillas were kept inside in the morning. YK showed nervousness with lips tightly pressed together, running displays and started to hit the slides. Monza stayed away from YK, slightly afraid. The other ones played together. On the afternoon, YK was given access to the outside island, and the youngsters had access to the angle cage where they were able to see YK through the wire mesh of the keeper's corridor. Ya Kwanza went out and came in several times, showing several displays but came back to calm very soon and even had a rest in the cage. Lengai was seen trying to open the slide with a stick between YK and the others, while Monza stayed away and always left an empty cage between him and Ya Kwanza. Meru seemed to always try to be between Ya Kwanza and the 3 others.

On 23rd of July, the same situation was kept. The 4 young were still isolated for the main meals (morning and evening) but they spent their first night together, and everything went well. The day after, the metal plates were removed from the slides, allowing the gorillas to see each other through small holes where they can't even put the fingers. They came to the slides and watch to each other with calm.This configuration was kept for one week, to create a routine for the gorillas. During the day, the young gorillas were kept in only 2 cages to reduce space and force them to be closer to Ya Kwanza. Ya Kwanza was often irritated, showing displays as he was frustrated to see slides closed. Monza was always as far as possible from YK.

On 27th of July, the last meal was also given with the 4 youngs together, and everything went well. They were no longer separated to eat or to sleep.

On 1st of August, afternoon, YK was put in a cage surrounded by cages with the slides half open (small gap of 30cm where the 4 young were able to go through while the silverback wan not). Upala (3 years) was the first to come with Ya Kwanza. YK was very gentle, sniffed the baby. Upala was not afraid at all and Meru tried to get him back safe in the cage with the others! Monza came with the others when they were in YK's cage. Lengai was the first to stay back. No meal has been offered during this time. YK was isolated for the last meal and the night.

On 2nd of August, the slides were half-open at 12:30. Upala went immediately with YK who kept him besides him, even if Meru was trying to get Upala back. While YK started to have a rest, Upala tried to prevent him to sleep. Ya Kwanza grounded down and get over him. Upala was scared but absolutely not wounded. YK behaved perfectly with him. No more interactions after this event.

On 3rd of August, same configuration but meals were given during the afternoon through the mesh. Upala was the first to go with Ya Kwanza, 20 minutes after doors opening. Later, while YK was lying in his nest, Meru entered. YK stayed in his nest. As Upala started again to harass YK, the silverback caught him by the arm, slowly and gently and the baby understood it was time to stop and go back to the safe cages. There were no more interactions after that event, so 2 cages were given to YK (slides wide open) and only one cage for the young from which they were allowed to go in YK cages through two wire-meshed tunnels with slides open with a small gap. This was decided to bring them closer to each other. Lengai went to YK cage to catch celery while YK was resting in the second cage.

On 4th of August, since the morning, the same configuration as late afternoon the day before was kept. When YK entered quickly into a cage where Upala and Monza were, the babies screamed a lot. Upala was shoved to the ground before to run to the safe tunnel, and Monza climbed in a hammock where he thought to be safe. Ya Kwanza gave 3 hits in the hammock while Monza was screaming, and then went in his second cage. Everything came back to calm. YK was isolated from the others to allow them to have a rest between 01:00 and 02:00PM. Slides were re-opened for the afternoon but there was no contact during the afternoon, even if Meru came in the first YK's cage while YK was in the second one.

5th of August: same configuration. Upala was happy to go with YK. Meru went in and out with prudence but no fear. Lengai stayed in the slides but YK grabbed his arm, and wrestled him to the ground. Then Lengai ran to the corner of the cage, followed closely by YK. Lengai showed submissive posture and YK left him alone. The same configuration was kept for the following days, without any contact even if the young males went into YK's cages.
On 10th of August, the 5 gorillas were put together all day long (except during the keeper's lunch break), in 3 cages with all sliding doors wide open. Everything went well even if Monza ran, screaming, through the cage where YK was.

On 11th, they had access to the outside enclosure all together for the first time. The 3 oldest went outside, but all the gorillas met each other inside. They were very calm and quiet.
After that, it took several days more to Monza to stop to scream while he was running close to Ya Kwanza in the building, but things improved every day, the youngs accepted more and more often to be close to YK and on 23rd of August, the 5 gorillas spent their first night together. The animals were in 3 cages with slides wide open and a 4th one with slides half-open. Since that time, they were all together 24 hours a day, except for the main meals (morning and evening) for which Ya Kwanza was kept isolated from the others.

The bachelor group was sent to Amneville in February 2012 and since then, the 5 males are doing well together. The group is well monitored in Amneville and we now have to wait and see how the hierarchy will be established when Lengai and Meru will reach adulthood. At the time this article is written, Lengai is about to reach 11 years and Meru is now 10 years.

2.9.2.6. Research with bachelor groups

<u>Disney's Animal Kingdom, Florida, U.S.A,</u>
During the formation of the bachelor gorilla group at Disney's Animal Kingdom, evaluation of a systematic process of group formation was carried out through behavioural observations using five behavioural categories (active aggression, passive aggression, submissive behaviour, stress-related behaviour and affiliative behaviour). A baseline of these behaviour patterns was established for each animal and then repeated at the three different stages of introduction (visual, auditory, olfactory contact; limited tactile contact; physical introduction). As expected, it was found that the frequency of social behaviour increased at the transitions between stages and then levelled with time. The magnitude of the increase also became greater as the animals were placed in closer contact (Burks, 2000).

<u>Preliminary research at Santa Barbara Zoo and Zoo Atlanta, U.S.A,</u>

Preliminary comparisons have been carried out between bachelor groups of gorillas established at Santa Barbara Zoo and Atlanta Zoo in the United States. This research has suggested that there were no significant differences in affiliative and agonistic behaviour in the two groups studied, although there were differences in feeding, solitary play and object-directed behaviour exhibited. However group cohesion in both groups was found to be high, particularly in the subadults who spent approximately 10% of their time in social behaviour and 25 to 50% in close proximity (within 5 metres).

The behavioural profiles and proximity patterns for these animals were found to be similar to those found in bachelor groups of Virunga mountain gorillas (Stoinski, Hoff, Lukas & Maple, 2001). This had also been seen to be the case with the St. Louis Zoo bachelor group established in 1987 (Porton & White, 1996). In addition, levels of affiliative behaviour between the bachelor groups at Santa Barbara Zoo and Zoo Atlanta were similar, and this again readily compares to observed patterns between Virunga mountain gorilla bachelor groups. The differences in the activity budgets between the age-classes in the zoo groups was also seen to be comparable to those produced for the Virunga mountain gorilla bachelor groups.

The proximity data illustrated that the percentage of time spent in contact or at distances within 1 metre of other individuals was greater in the zoo bachelor groups than in zoo breeding groups either between male-male or male-female dyads. This again was found to be similar when compared to results from wild bachelor and breeding groups. The young animals in the zoo groups were also seen to spend more time in close association with each other rather than with the silverback and were thought to be primarily responsible for the cohesion within the group (Stoinski, Hoff, Lukas & Maple, 2001). Porton & White (1996) reported that the majority of the interactions between males in the St. Louis Zoo bachelor group were affiliative or neutral, and mostly initiated by the younger males.

Despite observations from the wild of frequent homosexual behaviour between silverbacks and subadults, preliminary observations in zoos showed a lower rate of sexual activity generally both in the St. Louis Zoo group and the two groups involved in the research carried out at Santa Barbara Zoo and Zoo Atlanta. This deviation from the patterns observed in the wild was thought to be due to the rearing history of certain individuals within the groups, i.e. mother- or hand-reared individuals. This preliminary work suggests that bachelor groups can be used successfully at some periods during the gorilla's life span, however further long term research is needed (Stoinski, Hoff, Lukas & Maple, 2001).

<u>Ongoing research at Paignton Zoo</u>

Long term research has been begun at Paignton Zoo focussing on the male-male interactions of the established bachelor group. In particular, this research will be targeting comparisons of levels of aggression between bachelor groups and breeding groups. It has been hypothesized that groups with an absence of females will exhibit lower levels of male-male aggression (Johnstone-Scott, 1988, Yamagiwa, 1987, Pullen, 2005), higher levels of techniques for avoiding aggression, such as play-fighting, and an increased level of third party interventions and alliance formations (Yamagiwa, 1987, Pullen, 2005). Preliminary observations have already indicated differences in levels of contact aggression, non-contact aggression and play-fighting between bachelor group and breeding group silverbacks The research undertaken at Paignton Zoo will also provide information on the group stability as individuals mature, individuals are transferred from the group and new individuals introduced.

2.9.2.7. Summary

The establishment of bachelor gorilla groups in zoos has been achieved through knowledge of the situation in the mountain gorillas encountered at the Karisoke Research Centre. These groups did eventually disintegrate and current researchers are unaware of any similar groupings in the area. The data for western lowland gorillas has been patchy and unreliable until recent work achieved mainly at Mbeli Bai in northern Congo (Brazzaville) coupled with research in Gabon. Of 14 social groupings studied in detail at Mbeli Bai , none could be considered true bachelor groups. In addition, five solitary males were also studied and again none formed or joined bachelor groups. This situation is supported by data collected at other bais, suggesting that bachelor groups may not be a usual social construct for western lowland gorillas (Parnell, 2002). Therefore there is the suggestion that the effect of the bachelor groups already established in zoos should be closely assessed.

2.9.3 How to form a bachelor gorilla group

The definition of a bachelor group is the "coalition of two or more males in the absence of any females".

Male offspring usually become less welcome in the family unit as they mature into silverbacks i.e. ~13 years of age. In the wild such male disperse in order to avoid aggression from their fathers and in some instances their siblings, and will become solitary bachelors unless other group members choose to leave with them. It is also well documented that in the wild that when a silverback dies, the family unit usually breaks down with females and dependent offspring migrating to other groups while the remaining males of varying ages either adopt a solitary life style or stay together as a 'sibling' bachelor group. The latter may exist for several years before eventually disbanding i.e. when the older individuals pursue opportunities to challenge another family leader and take over his group, or to associate with unattached females.

By contrast, in zoos the opportunity to 'disperse' has to be facilitated by an individual's temporary, or permanent, removal from the group, be that the breeding or bachelor holding. Remaining in proximity can cause potential stress, such that it is usually best to completely relocate them out of sensory contact with any potential protagonists.

Bachelor groups can be established in different ways. Those holders that have had a high breeding record are more likely to have males of a similar age, or full siblings, requiring relocation so it usually follows that a new bachelor group can potentially be formed of individuals that are already familiar with one another. This also applies to males that have been rejected by their mothers in their natal groups, and which have been brought together at one facility to be hand reared and subsequently grow up together, albeit this is to be avoided in preference to early fostering in a family group or introduction to a bachelor group. However, several of the current groups in the Gorilla EEP are the result of having brought together strangers under the direction of the breeding programme at an age <10 years in order to pre-empt displacement from a natal group.

As of 31 December 2014, twenty Gorilla EEP bachelor groups had been established.

They are in chronological order of being formed, and excluding single males:

- La Palmyre, France (~1989)
- Loro Parque, Spain (~1995)
- Port Lympne, U.K. (2 groups: March 1997 / July 2007)
- Paignton, U.K. (April 1997)
- La Boissiere du Doré, France (April 2002; current group April 2010)
- Schmiding, Austria (March 2004)
- Opole, Poland (May 2005)
- Beekesbergen, The Netherlands (September 2006)
- Warsaw, Poland (September 2008)
- Valencia, Spain (October 2009)
- Pretoria, South Africa (June 2010)
- Sosto, Hungary (June 2010)
- Werribee, Australia (October 2011)
- Amneville, France (2 groups: February 2012 / March 2012)

- Warminster, U.K. (July 2012 – one solitary individual + a trio)
- Rhenen, The Netherlands (2013)
- Beauval, France (July 2013)

Steps in the formation of a new group

In the case of forming a new group the younger animals should arrive and, if from different sources, be integrated on the same day if practicable. If there is to be a delay between their respective arrival dates then it should be noted that whoever arrives first will have just been removed from his family group, may be nervous and will probably be all the more nervous if he has to spend up a number of days on his own before others arrive. There may also be instances when resident animals are being joined by strangers in a new facility such that all are to be in unfamiliar surroundings.

Young animals are more likely to be nervous whilst older animals more likely to exhibit display behaviours. If it the oldest individual who is to arrive first then there is the possibility that he will not be entirely happy with his new surroundings i.e. banging slides etc. For this reason it would be best under these circumstances if any younger animals are settled in first prior to the arrival of the intended alpha male.

As a first step in the introduction process the younger animals should have sufficient time to bond with each other before either has any contact with the silverback. This could be a matter of minutes, if they take to each other immediately or anything up to a couple of days. The first close contact with the silverback should only be through mesh whereby they can see and smell each other, but not be able to grab at or bite one another. Unless being particularly bold, young group raised males should be fully aware of how to behave in the presence of a silverback and the silverback himself should have confidence in his own status not to see them as a threat resulting in little or no actual physical aggression.

The next stage would be to have a slide set a width of opening through which the silverback cannot pass, but which allows some physical contact. Ideally it will allow all younger animals to pass through if they choose to do so. The minimum gap needed for a silverback, whilst allowing young animals to pass through, is easily tested. You set it for the smaller animals such that they can just squeeze through, move them to an adjacent den; place a banana (or other enticement) on the floor out of reach in the now unoccupied den. Allow the silverback access via the reduced slide and if no immediate interest is shown due to observers being present, leave the building. If the banana has not gone by the time you return then the gap is OK!

In practise it may be difficult to set the slide just wide enough for the oldest youngster such that it prevents the silverback from also being able to pass through. It should be based on the next size down of 'black-back' that can pass through. It should NOT be set just for arms as any grabbing can lead to broken or dislocated limbs. If a younger animal is unexpectedly dragged through the restricted slide opening by the silverback, it is essential that this slide can be opened quickly in order to allow all animals together so that they can support each other if need be. With this scenario in mind all animals must be familiar with the lay-out of the whole exhibit before the free contact introduction i.e. where the various slide openings are and where they lead to, so as to avoid any individual finding themselves 'cornered'.

If the younger animals go in with the silverback by choice and there is a positive and/or no reaction from him then consideration can be given to opening the slide fully so that all individuals can explore the different dens. If only one youngster goes in then this can still be done if the behavioural signs are non-aggressive, but a restricted area should be kept available for any less confident youngsters, preferably at both ends of the exhibit.

Human presence should be minimal throughout the process whilst allowing for quick action by those who may need to operate the slides where required. Interaction with the animals themselves must also be kept to a minimum once free access is given to the silverback so that any potential jealous behaviour is avoided.

The most important factor is not to rush the introduction which should take place indoors only i.e. where one can maintain better control of the animals.

Summary:

Step 1 - introduce youngsters to one another
Step 2 - let youngsters investigate as much of the indoor enclosure as possible
Step 3 - 'nose-to-nose contact' between young animals and silverback
Step 4 - 'restricted contact' through a narrow gap slide
Step 5 - 'full contact' indoors
Step 6 - let younger animals to explore the outdoor exhibit without silverback
Step 7 - 'full' contact indoors and outdoors as a group

In Step 6, it is recommended that younger animals should initially investigate the outdoor exhibit alone if water is the containing barrier. This is to allow any individual that has not been behind a water moat before to become familiar when not under any pressure. It will also be easier to assist young males should one get into difficulties in the water if the silverback is not present. This familiarization with the outdoor area could be done before or after a full interaction with the silverback, but the important point is that they must be used to and tolerate his presence before being let out. If they don't like him and they are let outdoors before they have had a chance to get to know him, it may not be possible to get them back indoors for a few days.

It should be emphasized that this is a 'theoretical' plan and may need to be adapted taking into account behavioural observations at the time. It is also recommended that someone with experience in bachelor group introductions is present at least for the stages that involve actual contact between a silverback and younger animals.

General Points to Note for the Introduction Process

Ideally the younger animals should arrive on the same day. If there is to be a delay between their respective arrival dates then it should be noted that whoever arrives first will have just been removed from his family group, he may be nervous and if he has to spend up to ~3 days on his own before the other arrives then he will probably be all the more nervous if an adult male is there and possibly not that happy with his new surroundings i.e. banging slides etc. For this reason it would be best under these circumstances that young animals were settled in first and then to move the adult male in. If however, the young animals arrive on the same day, or at most within 24 hours of each other, then the adult male taking up residency first would hopefully not be such a problem.

As a first step in the introduction process the younger animals should have sufficient time to bond with each other before either has any contact with the adult male. This could be a matter of minutes, if they take to each other immediately or anything up to a couple of days.

The first close contact with the silverback should only be through mesh whereby they can see and smell each other, but not be able to grab at one another. If juveniles are parent reared they should be fully aware of how to behave in the presence of a silverback and hopefully the adult male must have confidence in his own status not to see them as a threat.

The next stage would be to have a slide set an opening through which the adult male cannot pass, but which allows some physical contact. Ideally it will allow younger animals to pass through if they choose to do so. It should NOT be set just for arms as any grabbing could lead to broken or dislocated limbs.

The minimum gap needed for a silverback, whilst allowing young animals to pass through, is easily tested. You set it for the smaller animals such that they can just squeeze through, move them to an adjacent den; place a banana (or other enticement) on the floor out of reach of the adult male in the now unoccupied den. If no immediate interest is shown due to observers being present, leave the building. If the banana has not gone by the time you have returned the width of the gap is almost certainly OK!

If either younger animal is unexpectedly dragged through the restricted slide opening by the adult male, it is essential that this slide can be opened quickly in order to allow all the animals together so that the younger can support each other.

With this scenario in mind all animals must be familiar with the lay-out of the whole exhibit (i.e. where the various slide openings are and where they lead to) before the free contact introduction so as to avoid any individual finding themselves cornered.
If younger animals go in with the adult male by choice and there is a positive and/or no reaction from him then consideration can be given to opening the slide fully so that all they can explore their respective dens. If only one goes in then this can still be done if the behavioural signs are non-aggressive, but a restricted area should be kept available for the less confident youngsters, preferably one at both ends of the run of sleeping dens.

Human presence throughout should be minimal allowing for quick action by those who may need to operate the slides where required, and interaction with the animals themselves also kept to a minimum once free access is given to the silverback so that any potential jealous behaviour is avoided.

The most important factor is not to rush the introduction which should take place indoors only where one can maintain better control of the animals.

It should be emphasized that this is a 'proposed' plan and may need to be adapted taking into account behavioural observations at the time.

It is also recommended that someone with experience in bachelor group introductions is present at least for the stages that involve contact between the animals.

General Recommendations

- New bachelor groups should be established with a socially competent silverback or an older mother-reared male and a range of younger males, particularly as young males have been seen to play a pivotal role in group stability (recommended age 6 to 9 years, however older animals will have more opportunities to gain social experience in natal groups).

- Introductions should be achieved between the younger age groups before the addition of the silverback in order to allow alliances to form and the “loser-support system” to be effective.
- Bachelor groups should not be formed solely from hand-reared individuals as mother-reared animals have been seen to be more socially competent and are thought to increase the bonds within the group.
- Bachelor groups should not be housed within visual or olfactory contact of breeding groups, to prevent redirected aggression through the proximity of desirable females.
- Flexibility both in enclosure design and management methods should be maintained for all kind of groups but especially with bachelor groups.
- Enclosures should be designed with enough space for separation areas for each individual animal housed, if necessary, i.e. night areas, feed areas.
- Enclosures should be designed with no “dead-ends” but several “run-arounds” or “round-abouts” to prevent trapping in instances of aggression for all kind of groups but especially with bachelor groups.
- Enclosures should be designed with no “blind-spots”. Ensure that keepers can have visual access to the animals in every area. Remote viewing through cameras can be invaluable in achieving this and can also be designed to enable recording of activity during the night-time when keepers are not present.
- Enclosures should be designed with a mixture of solid doors for complete visual separation and doors with visual access as mesh or glass. In addition separating walls between areas should also be designed with a mix of solid for separation and mesh for visual contact, particularly during initial introductions for all kind of groups but especially with bachelor groups.
- Multiple access points should be provided for movement between areas within the enclosure to prevent one animal dominating access to key areas for all kind of groups but especially with bachelor groups.
- Enclosures should be designed with doors that can be set on a break so that smaller animals can escape to areas that larger animals cannot get to for all kind of groups but especially with bachelor groups.
- Keepers with experience of gorilla bachelor groups should be involved in the establishment of a new group.
- Patience should be encouraged!

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2.10. In-situ conservation programmes

A. Meder

Nowadays one of the main goals of EAZA is the establishment of strong links between ex-situ and in-situ conservation. While we continue improving husbandry for gorillas in zoos we must emphasize at the same time the significance of preserving the wildlife and its habitat by contributing to it.

Here below we present some organizations working in-situ for gorilla conservation.

We encourage all institutions to participate and give their support to in-situ conservation.

Dian Fossey Gorilla Fund: The Fund is dedicated to the protection and preservation of the mountain gorillas of Rwanda, Uganda and Congo. (Formerly known as The Digit Fund). DFGF International is based in Zoo Atlanta. (www.gorillafund.org)

The **Gorilla Organization** (formerly DFGF UK/Europe) based in London (www.gorillas.org)

Berggorilla & Regenwald Direkthilfe: For many years Berggorilla & Regenwald Direkthilfe (Mountain Gorilla & Rainforest Direct Aid) has been supporting national parks in Uganda and Congo (Kinshasa) where mountain gorillas and Eastern lowland gorilla live. The work is strictly honorary and follows a policy to channel any funds raised directly into the relevant projects. (www.berggorilla.org)

The **Frankfurt Zoological Society (FZS)** has among its world-wide activities a long-standing conservation project for mountain gorillas in the eastern Democratic Republic of the Congo. (www.fzs.org)

The **Wildlife Conservation Society (WCS)**, based in New York, supports many projects for gorilla conservation. (www.wcs.org)

Fauna and Flora International (FFI) contributes to eastern gorilla conservation. (www.fauna-flora.org/)

International Gorilla Conservation Program (IGCP). The aim of the International Gorilla Conservation Program (IGCP) is to ensure the survival and long-term conservation of mountain gorillas and medium altitude forest habitats in Rwanda, Uganda and Congo. (www.igcp.org)

Mountain Gorilla Veterinary Project: it was originally a Morris Animal Foundation project in Rwanda for gorilla health care in the Virunga Volcanoes and the Bwindi Impenetrable Park. In 2009, MGVP partnered with theWildlife Health Center at the University of California, Davis, School of Veterinary Medicine. (www.gorilladoctors.org)

The Aspinall Foundation, based at Howletts and Port Lympne in the UK, manages two western lowland gorilla reintroduction projects in the Republics of Gabon and Congo, and a law enforcement project for the protection of wildlife in Congo. (www.aspinallfoundation.org)

Virunga National Park, Democratic Republic of the Congo has its own website with plenty of information and regular news. (www.virunga.org)

Reserve des Gorilles de Tayna: The initiative of creating the Tayna Reserve was taken in April 1998 by conservationist Pierre Kakule Vwirasihikiya, with the aim to save the rich and rare habitat found in the Rift Valley (Northeastern part of the Democratic Republic of the Congo) from which he himself comes. Two chiefs, Mukosasenge and Stuka, agreed to support his efforts; then intellectuals of the area joined, and finally the population joined in the support, following their leaders.

Cross River gorilla conservation: The Wildlife Conservation Society (WCS) manages conservation activities for Cross River gorillas in Nigeria and in Cameroon.

Ebo Forest Research Project, Cameroon: San Diego Zoological Society

Nouabalé-Ndoki National Park: Situated in the North of the Republic of the Congo, the NNNP was created in 1993 by the Congolese government and WCS (Wildlife Conservation Society) to conserve the forests of the Northern Congo. Parts of this park are the Mbeli Bai study area and the Goualougo Triangle (www.congo-apes.org/).

Fight against **bushmeat trade** and **trade with living apes**: law enforcement specialists of the EAGLE network are working in several countries. (www.EAGLE-enforcement.org)

PALF: a collaborative law enforcement project in the Republic of Congo, and part of the EAGLE network, PALF works to save gorillas, elephants and other large mammals through effective application of national wildlife laws. (http://palf-enforcement.org/)

Help for gorilla orphans:

PASA: The Pan African Sanctuary Alliance, or PASA, is an alliance of sixteen primate sanctuaries from all over Africa. Due to the rapid influx of orphan animals from increased logging, habitat destruction and commercial development of the bush-meat trade, and lack of awareness in primate range countries, sanctuaries have emerged on an ad-hoc basis resulting in crisis management. This has made it difficult for long-term planning and adequate collaboration between sanctuaries and primate experts.

There is a very evident need for general guidelines for the establishment of authorities, site location, long term sustainability management practices, primate management and health issues. PASA is designed to bring these sanctuaries together to address both short-term and long-term issues in areas such as site management and veterinary care and to enhance the stature of sanctuaries in the professional zoo and primate research communities. (www.panafricanprimates.org)

Lesio-Louna Gorilla Reserve in the Republic of Congo has been rehabilitating, releasing and protecting orphan western lowland gorillas for over twenty years. Managed in partnership by the Congolese government and The Aspinall Foundation, this long-term project has helped to virtually eliminate the trade in orphan gorillas in Congo. (http://www.ppgcongo.org/)

Limbe Wildlife Center: Home to orphans of the gruesome bushmeat trade, the Limbe Wildlife Center plays an important role in wildlife education in the Cameroons. Limbe Wildlife Center is member of PASA (Pan African Sanctuaries Alliance). (www.limbewildlife.org)

The **GRACE Center** in eastern DRC is specialized in Grauer's or eastern lowland gorillas. The center is supported by DFGFI and Disney Animal Kingdom. (http://gracegorillas.org/)

2.10 Recommended Research

Gorilla genetic determination: C. Hvilsom, T. Marques

Castration: B. Letang, A. van der Wal

Gorilla wellbeing: MT Abello, M. López Véjar, M. Martín, C. Riba

Necropsies compilation and analysis: S. Redrobe, V. Strong,

Possible factors determining Sex ratio: MT Abelló, M. Moreno

2.12 Useful Documents to be found on the EAZA web

(http://www.eaza.net/members/)

Gorilla Documents/ **Protocols and documents**:

- Introduction questionnaire,
- Gorilla facilities review points,
- Monitoring gorilla welfare.